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LITERATURE REVIEWS CARRIED OUT FOR THE HEALTH SERVICE EXECUTIVE NATIONAL TELEHEALTH STEERING GROUP | APRIL – JULY 2020

National Health Library and Knowledge Service | Evidence Team
| April – July, 2020

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Foreword

This collection of literature reviews was created between April and July 2020 by members of the National Health Library and Knowledge Service Evidence Team to support the Health Service Executive National Telehealth Steering Group. Each literature review relates to innovations in telemedicine as applicable to a specific condition or specialty and each is presented as a separate chapter. Additional studies relating to specific conditions or specialities may be added by the Evidence Team as individual chapters are revised and updated. Additional chapters relating to additional conditions or specialities may be added by the Evidence Team.

Using combinations of the subject headings and keywords set out in Appendix 1, the databases CINAHL, EMBASE and MEDLINE were searched and search results filtered for studies published between 2015 and 2020, in English, relating primarily to adult populations and with an emphasis on systematic reviews and randomised controlled trials. Each chapter presents the evidence as illustrated below. Within each section, studies are arranged in reverse chronological order by year and, within a year, in alphabetical order by author surname. Please see Appendix 2 for an alphabetical list of sources referenced per condition or specialty. Please see Appendix 3 for an alphabetical list of all sources referenced.

Systematic Reviews	Systematic Reviews; Meta-Analyses
Randomised Controlled Trials	Randomised Controlled Trials
Miscellaneous	Miscellaneous

Definitions: According to the OED, 'telehealth' is defined as the provision of health-care services remotely by means of telecommunications technology; the term was first recorded in 1975. 'Telemedicine' is defined as medicine practised with the assistance of telecommunications technology, often to provide care in remote locations or to reduce the need for hospital visits; the term was first recorded in 1968. 'Mobile health' is defined as health and medical services provided and accessed primarily using smartphones and mobile devices; the term was first recorded as such in 2000.

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CHAPTER 1
Telemedicine and Asthma

Systematic Reviews

Low, JK and Manias E (2019) [Systematic Review and Meta-Analysis] Use of technology-based tools to support adolescents and young adults with chronic disease: systematic review and meta-analysis[1]
This study aimed to evaluate the current evidence on Web- or mobile-based interventions designed for adolescents and young adults (AYAs). Owing to the lack of intervention efficacy trials, no conclusion can be drawn if an intervention delivered via a mobile app is better than that delivered via a website. However, through this systematic review, it is confirmed that AYAs were receptive to receiving medical information electronically.

Slater, H et al (2017) [Systematic Review] End user and implementer experiences of mHealth technologies for noncommunicable chronic disease management in young adults: systematic review[2]
The aim of this study was to identify, appraise, and synthesize available qualitative evidence on users' experiences of mHealth technologies for NCD management in young people. Slater et al explored the perspectives of both end users [young people] and implementers [health policy makers, clinicians, and researchers]. A systematic review and meta-synthesis of qualitative studies was conducted. Themes derived for end users of mHealth included: 1. experiences of functionality that supported self-management; 2. acceptance [technical usability and feasibility]; 3. importance of co-design; and 4. perceptions of benefit [self-efficacy and empowerment]. For implementers, derived themes included: 1. characteristics that supported self-management

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[1] Low JK, Manias E. Use of Technology-Based Tools to Support Adolescents and Young Adults with Chronic Disease: Systematic Review and Meta-Analysis. *JMIR mHealth and uHealth.* 2019;77.:e12042.
[2] Slater H, Briggs AM, Campbell JM, Stinson JN, Burley MM. End User and Implementer Experiences of mHealth Technologies for Noncommunicable Chronic Disease Management in Young Adults: Systematic Review. *Journal of Medical Internet Research.* 2017;19(12):1-95.

[functional, technical, and behaviour change]; 2. implementation challenges [systems level, service delivery level, and clinical level]; 3. adoption considerations for specific populations [training end users; specific design requirements]; and 4. co-design and tailoring to facilitate uptake and person-centred care. The authors conclude that synthesizing available data revealed both complementary and unique user perspectives on enablers and barriers to designing, developing, and implementing mHealth technologies to support young people's management of their chronic NCDs.

Zhao, J et al (2015) [Systematic Review and Meta-Analysis] Effectiveness of telemedicine for controlling asthma symptoms: a systematic review and meta-analysis[3]

This study examined the effectiveness of telemedicine in relieving asthma symptoms. A systematic review of databases was conducted until December 31, 2013. Inclusion criteria were randomized controlled trial, a diagnosis of asthma, the majority of the patients ≥18 years of age and intervention involved any format of telemedicine. A meta-analysis of eligible studies was conducted with the primary outcome being change of asthma symptoms. Telemedicine interventions do not appear to improve asthma function scores, but other benefits may be present.

Randomised Controlled Trials

Apter, AJ et al (2020) [Randomised Controlled Trial] Patient portal usage and outcomes among adult patients with uncontrolled asthma[4]

The objective of this study was to describe portal activities and association with 12-month outcomes among low-income patients with asthma formally trained in portal use. In a longitudinal observational study within a randomized controlled trial, 301 adults with uncontrolled asthma were taught 7 portal tasks: reviewing upcoming appointments, scheduling appointments, reviewing medications, locating laboratory results, locating immunization records, requesting refills, and messaging. Patients with

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[3] Zhao J, Zhai YK, Zhu WJ, Sun DX. Effectiveness of Telemedicine for Controlling Asthma Symptoms: A Systematic Review and Meta-analysis. *Telemedicine journal and e-health : the official journal of the American Telemedicine Association.* 2015;216.:484-492.

[4] Apter AJ, Bryant-Stephens T, Perez L et al Patient Portal Usage and Outcomes Among Adult Patients with Uncontrolled Asthma. *Journal of Allergy and Clinical Immunology: In Practice.* 2020;83.:965-970.e964.

uncontrolled asthma used the portal irregularly if at all, despite in-person training. Usage was not associated with regular appointments or with clinical outcomes. Patient portals need modification to accommodate low-income patients with uncontrolled asthma.

Bender, BG et al (2020) [Randomised Controlled Trial] [Adults with asthma experience no increase in asthma-related exacerbations when digital communication technology tools are employed to offset provider workload: a pragmatic randomized trial](#)[5]
The objective of this study was to test whether digital communication technology tools (DCTs), compared with usual care, can reduce health care clinician burden without increasing asthma-related exacerbations among patients with asthma in a large integrated health care system. Primary outcome measures included asthma-related health care resource utilization [eg asthma nurse contacts], medication use, and exacerbations. DCT tools can successfully contact adult asthma patients to screen for symptoms and facilitate intervention. The absence of differences in medication fills and health care utilization indicates that the strategic replacement of nursing interventions by digital outreach did not reduce treatment adherence or compromise health care outcomes.

Khusial, RJ et al (2020) [Randomised Controlled Trial] [Effectiveness of myAirCoach: a mHealth self-management system in asthma](#)[6]
Khusial et al assessed the clinical effectiveness and technology acceptance of myAirCoach-supported self-management on top of usual care in patients with asthma using inhalation medication. The myAirCoach system consisted of an inhaler adapter, an indoor air-quality monitor, a physical activity tracker, a portable spirometer, a fraction exhaled nitric oxide device, and an app. The primary outcome was asthma control; secondary outcomes were exacerbations, quality of life, and technology acceptance. In study 1, 30 participants were randomized to either usual care or myAirCoach support for 3 to 6 months; in study 2, 12 participants were provided with the myAirCoach system in a 3-month before-after study. Using the myAirCoach support system improves asthma control and quality of life, with a reduction in severe asthma exacerbations. Well-validated mHealth technologies should

5 Bender BG, Wagner NM, Shoup JA et al Adults With Asthma Experience No Increase in Asthma-related Exacerbations When Digital Communication Technology Tools Are Employed to Offset Provider Workload: A Pragmatic Randomized Trial. *Medical Care*. 2020;584.:352-359.
6 Khusial RJ, Honkoop PJ, Usmani O et al Effectiveness of myAirCoach: A mHealth Self-Management System in Asthma. *Journal of Allergy and Clinical Immunology: In Practice*. 2020.

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therefore be further studied.

Nemanic, T et al (2019) [Randomised Controlled Trial] Telemonitoring in asthma control: a randomized controlled trial[7]

The aim of this project was to test the applicability and potential effects of a 12-month telemonitoring of patients with asthma supported by information and communication technologies. 100 patients with asthma were followed in the outpatient pulmonary clinic in a randomized controlled clinical trial. The patients' data were collected by study questionnaires and lung function tests at the inclusion and at the end of interventional period. In the interventional group, asthma control test (ACT) and peak expiratory flow measurements (PEF) were stimulated to be regularly reported by Short Message Service (SMS). As a response to reported values, the patients automatically received a preformed text or a call from a study nurse in case of detected predefined critical values. The compliance of reporting PEF and ACT values was higher than 80% in 96% of patients. Although we did not detect significant differences in ACT score improvement between the two study groups, we found more prominent improvement of ACT score in the subgroup of patients with two or more exacerbations prior to inclusion in the interventional group, compared to the control group. 40 (78%) patients in the interventional group listed at least one positive effect of telemonitoring on management of asthma. The developed program for home monitoring of patients with asthma was applicable and offered the patients support in managing their disease. Further studies with more selected patients are needed to confirm its usefulness in improving asthma control.

Van De Hei, SJ et al (2019) [Randomised Controlled Trial] Effectiveness and acceptability of a smart inhaler asthma self-management programme: A cluster RCT study protocol[8]

This study aims to investigate the effectiveness of a smart inhaler asthma self-management program on medication adherence and clinical outcomes, to investigate who would benefit most based on patient characteristics, and to evaluate its acceptability. An open-label cluster randomized controlled trial of 12 months will be conducted in general practices in the Netherlands. Practices will be randomly assigned to intervention or control. The

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[7] Nemanic T, Sarc I, Skrgat S, Flezar M, Cukjati I, Marc Malovrh M. Telemonitoring in asthma control: a randomized controlled trial. *Journal of Asthma.* 2019;567.:782-790.

[8] Van De Hei SJ, Poot CC, Meijer E et al Effectiveness and acceptability of a smart inhaler asthma self-management programme: A cluster RCT study protocol. *European Respiratory Journal Conference: 29th International Congress of the European Respiratory Society, ERS Spain.* 2019;54(Supplement 63).

intervention consists of: 1 an electronic monitoring device (EMD) attached to the patients' inhaler that measures medication use; 2 a smartphone application to set medication reminders, receive motivational messages and track asthma symptoms; and 3 a portal for healthcare professionals to view data on medication use. The control group will receive an EMD for measuring medication adherence objectively that can only be viewed by the researchers. Eligible patients are adults with partially controlled or uncontrolled asthma with evidence of non-adherence. The primary outcome is change in medication adherence over time. Other outcomes include asthma control, quality of life, SABA use, exacerbations, medication beliefs, eHealth literacy, acceptance and cost-effectiveness. This study will provide insight in the long-term benefits of a smart inhaler program on medication adherence and clinical outcomes in a real-world clinical setting and inform future studies on use and acceptance of eHealth self-management interventions.

Cao, Y et al (2018) [Randomised Controlled Trial] WeChat public account use improves clinical control of cough-variant asthma: a randomized controlled trial[9]
WeChat is a convenient and popular social medium, and it may be an appropriate platform for education and management of patients. This study sought to identify usefulness in clinical control of cough-variant asthma (CVA). A randomized controlled trial was conducted among 80 CVA patients. After being assigned to either the traditional group or the WeChat group, they received the same inhalation therapy, but patients in WG received additional education and instruction via our public account on the WeChat application. Questionnaires on asthma and chronic cough, data on pulmonary function, blood-related items, follow-up adherence, and Emergency Department (ED) visits were collected at the initial visit and at 3 months. Cao et al conclude that using WeChat as part of treatment and management of CVA can help patients learn about their disease and medications, as well as improve disease control and therapy outcomes.

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[9] Cao Y, Lin SH, Zhu D et al Wechat public account use improves clinical control of cough-variant asthma: A randomized controlled trial. *Medical Science Monitor.* 2018;24:1524-1532.

Beydon, N et al (2017) [Randomised Controlled Trial] Digital action plan for asthma exacerbations (PANAME)[10]

A written action plan (WAP) reduces emergency visits for asthma exacerbations. However, a WAP is underused and often focused on asthma control. The innovation is an AppWeb that includes expert software aimed at diagnosing the level of severity of asthma exacerbations and delivering a personalized digital action plan (DAP) when patients are in urgent need of medical advice. The main objective of the study is to evaluate the effect of the DAP on the frequency of urgent medical attendance. Secondary objectives are to evaluate adherence to the DAP compared to a WAP and the qualitative satisfaction of patients using the DAP. Expected results are a decrease in the number of urgent medical attendances and better adherence in the WAP + DAP group compared to the WAP group.

Pool, AC et al (2017) [Randomised Controlled Trial] Impact of online patient reminders to improve asthma care: a randomized controlled trial[11]

The purpose of this study is to examine the efficacy of an online tool designed to improve asthma control. This is a 12-month single blind randomized controlled trial of the online tool (IC) versus an active control tool (CC). The main outcome measure was asthma control, as assessed by the 5-question Asthma Control Test (ACT). Secondary outcomes included quality of life, medication use and healthcare utilization: eg emergency department visits. Results After 12 months, 323 participants completed follow-up measures (79.2%). Participants in the IC reported a greater mean improvement in the ACT score than participants in the CC (2.3 vs. 1.2; p = 0.02) and 9 of 11 individual asthma control survey items showed non-significant improvements favouring the IC. No differences were observed in medication adherence, number of asthma controller medications or health care utilization. Simple and brief online patient reminders improved asthma control among insured patients. Although future studies are needed to understand the mechanism of the improvement, the magnitude of the effect on asthma control was similar to the addition of an additional controller medication. Given the widespread use of the Internet, simple tools such as this may be useful for improving the control of other chronic diseases as well.

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[10] Beydon N, Delclaux C. Digital action plan for asthma exacerbations (PANAME). *Revue des Maladies Respiratoires.* 2017;34(9):1026-1033.

[11] Pool AC, Kraschnewski JL, Poger JM et al Impact of online patient reminders to improve asthma care: A randomized controlled trial. *PLoS ONE.* 2017;12(2).

Ahmed, S et al (2016) [Randomised Controlled Trial] The effectiveness of web-based asthma self-management system, My Asthma Portal (MAP): a pilot randomized controlled trial[12]
Whether web-based technologies can improve disease self-management is uncertain. My Asthma Portal (MAP) is a web-based self-management support system that couples evidence-based behavioural change components (self-monitoring of symptoms, physical activity, and medication adherence) with real-time monitoring, feedback, and support from a nurse case manager. The aim of this study was to compare the impact of access to a web-based asthma self-management patient portal linked to a case-management system (MAP) over 6 months compared with usual care on asthma control and quality of life. This study supported the use of MAP to enhance asthma quality of life but not asthma control as measured by an administrative database. Implementation of MAP beyond 6 months with tailored protocols for monitoring symptoms and health behaviours as individuals' knowledge and self-management skills improve may result in long-term gains in asthma control.

Koufopoulos, JT et al (2016) [Randomised Controlled Trial] A web-based and mobile health social support intervention to promote adherence to inhaled asthma medications: randomized controlled trial[13]
The objective is to conduct a rigorous proof-of-concept randomized controlled trial of an online community intervention for improving adherence to asthma medicine. This 9-week intervention included a sample of asthmatic adults who were prescribed an inhaled corticosteroid preventer. Based on their findings, Koufopoulos et al conclude that joining an online community did not improve adherence to preventer medication for asthma patients. Without the encouragement of greater community support or more components to sustain engagement over time, the current findings do not support the use of an online community to improve adherence.

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[12] Ahmed S, Ernst P, Bartlett SJ et al The Effectiveness of Web-Based Asthma Self-Management System, My Asthma Portal (MAP): A Pilot Randomized Controlled Trial. *Journal of medical Internet research.* 2016;18(12):e313.
[13] Koufopoulos JT, Conner MT, Gardner PH, Kellar I. A Web-Based and Mobile Health Social Support Intervention to Promote Adherence to Inhaled Asthma Medications: Randomized Controlled Trial. *Journal of medical Internet research.* 2016;186.:e122.
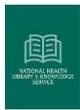
Merchant, RK et al (2016) [Randomised Controlled Trial] Effectiveness of population health management using the Propeller Health Asthma Platform: a randomized clinical trial[14]
This pragmatic controlled study was designed to measure real-world effectiveness of the Propeller Health Asthma Platform to reduce use of SABA and improve asthma control. A total of 495 patients were enrolled in parallel arms (1:1) for 12 months of monitoring SABA use. Intervention group patients received access to and feedback from the Propeller Health system. Routine care patients were outfitted with sensors but did not receive feedback. Physicians were able to monitor the status of their patients in the intervention group and receive proactive notifications. Compared with RC, the study arm monitoring SABA use with the Propeller Health system significantly decreased SABA use, increased SABA-free days, and improved ACT scores, the latter among adults initially lacking asthma control.

Zairina, E et al (2016) [Randomised Controlled Trial] Telehealth to improve asthma control in pregnancy: A randomized controlled trial[15]
This study evaluated the efficacy of a telehealth programme supported by a handheld respiratory device in improving asthma control during pregnancy. Pregnant women with asthma (n=72) from two antenatal clinics in Melbourne, Australia, were randomized to one of two groups: 1. intervention-involving a telehealth programme (management of asthma with supportive telehealth of respiratory function in pregnancy (MASTERY©) supported by a handheld respiratory device and an Android smart phone application (Breathe-easy©) and written asthma action plan; or 2. control-usual care. The primary outcome was change in asthma control at 3 and 6months [prenatal]. Secondary outcomes included changes in quality of life and lung function, and perinatal/neonatal outcomes. There were no significant differences between groups in lung function, unscheduled health-care visits, days off work/study, oral corticosteroid use, or perinatal outcomes. Differences between groups were not significant at 3months. Telehealth interventions supporting self-management are feasible and could potentially improve asthma control and asthma-related quality of life during pregnancy.

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[14] Merchant RK, Inamdar R, Quade RC. Effectiveness of Population Health Management Using the Propeller Health Asthma Platform: A Randomized Clinical Trial. *Journal of Allergy and Clinical Immunology: In Practice.* 2016;43.:455-463.
[15] Zairina E, Abramson MJ, McDonald CF et al Telehealth to improve asthma control in pregnancy: A randomized controlled trial. *Respirology.* 2016.

Lau, AY et al (2015) [Randomised Controlled Trial] **"Why didn't it work?" Lessons from a randomized controlled trial of a web-based personally controlled health management system for adults with asthma**[16]

A 12-month parallel 2-group randomized controlled trial was conducted. Participants living with asthma were recruited and randomized 1:1 to either the PCHMS group or control group [online static educational content]. The primary outcome measure was possession of an up-to-date written AAP post study. Secondary measures included 1. utilizing the AAP; 2. planned or unplanned visits to a health care professional for asthma-related concerns; 3. severe asthma exacerbation, inadequately controlled asthma, or worsening of asthma that required a change in treatment; and 4. number of days lost from work or study due to asthma. Ancillary analyses examined reasons for adoption or non-adoption of the intervention. Outcome measures were collected by online questionnaire pre-study, monthly, and post study. Despite the intervention being effective in other preventive care settings, system use was negligible and outcome changes were not seen as a result. Consumers must perceive the need for assistance with a task and assign priority to the task supported by the eHealth intervention. Additionally, the cost of adopting the intervention eg, additional effort, time spent learning the new system must be lower than the benefit. Otherwise, there is high risk consumers will not adopt the eHealth intervention.

Tamblyn, R et al (2015) [Randomised Controlled Trial] **Evaluating the impact of an integrated computer-based decision support with person-centered analytics for the management of asthma in primary care: A randomized controlled trial**[17]

The objective was to determine whether a personalized asthma management computer-based decision support increases the quality of asthma management and reduces the rate of out-of-control episodes. A cluster-randomized trial was conducted in Quebec, Canada among 81 primary care physicians and 4,447 of their asthmatic patients. This study evaluated the effectiveness of a novel computer-assisted ADS system that facilitates systematic monitoring of asthma control status, follow-up of

[16] Lau AY, Arguel A, Dennis S, Liaw ST, Coiera E. "Why Didn't it Work?" Lessons From a Randomized Controlled Trial of a web-based Personally Controlled Health Management System for Adults with Asthma. *Journal of medical Internet research.* 2015;17(12):e283.

[17] Tamblyn R, Ernst P, Winslade N et al Evaluating the impact of an integrated computer-based decision support with person-centred analytics for the management of asthma in primary care: A randomized controlled trial. *Journal of the American Medical Informatics Association.* 2015;224.:773-783.

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patients with out of control asthma, and evidence-based, patient-specific treatment recommendations. Tamblyn et al found that physicians were more likely to use ADS for out-of-control patients, that in the majority of these patients, they were advised to add an inhaled corticosteroid or a leukotriene inhibitor to the patients' treatment regimen, and the intervention significantly increased the mean ratio of inhaled corticosteroids to FABA during follow-up. It also reduced the rate of out-of-control episodes during follow up among patients whose asthma was out-of-control at the time of study entry. Future research should assess whether coupling patient-specific treatment recommendations, automated follow-up, and home care with comparative feedback on quality and outcomes of care can improve guideline adoption and care outcomes. They conclude that a primary care-personalized asthma management system reduced the rate of out-of-control asthma episodes among patients whose asthma was poorly controlled at the study's onset.

Miscellaneous

Abraham, R et al (2019) [Literature Review] A targeted literature review to evaluate the impact of information technology-based interventions on patient reported outcomes among asthma patients[18]
Abraham et al reviewed the literature to evaluate digital health interventions' impact on patient-reported outcomes (PROs). IT-based interventions included Internet-based self-report tools and electronic PRO questionnaires (n=14, 29.8%), smartphone and tablet-based apps (n=12, 25.5%), mobile electronic adherence sensors (n=5, 10.6%), electronic asthma diaries (n=5, 10.6%), multimedia educational interventions (n=4, 8.5%), mobile telehealth visits (n=3, 6.4%); four studies (8.5%) assessed more than one IT-based intervention. Studies collected asthma PRO measures including asthma control and self-management skills (n=22, 46.8%), treatment self-efficacy (n=7, 14.9%), dyspnoea severity/symptoms/functional limitations (n=4, 8.5%), quality of life (n=1, 2.1%), and lung clearance index (n=1, 2.1%). Twelve studies (25.5%) assessed more than one asthma PRO. Several IT-based health interventions have shown promise in favourably impacting

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[18] Abraham R, Shahani JG, Jariwala SP. A Targeted Literature Review To Evaluate The Impact Of Information Technology-Based Interventions On Patient Reported Outcomes Among Asthma Patients. *Journal of Allergy and Clinical Immunology.* 2019;143 (2 Supplement):AB53.

PROs for asthma patients. Further studies need to prospectively evaluate these findings on a larger scale.

Bodini, R et al (2019) [Review] Digital therapy in the treatment of asthma and COPD-epidemiology of development and use of an emerging health technology in respiratory medicine[19]

The aim of this review is to analyse the current state of the art about digital therapeutics (DTx) for asthma and COPD and to provide guidelines for their development. Bodini et al state that DTx has the potential to transform treatment of asthma and COPD. Evidence-based results supporting adoption are highly variable. The authors propose guidelines to ensure that DTx manufacturers understand the evidence they need to show to meet the needs of the health and care system, patients, and users.

Heaney LG et al (2019) [Review] Remotely monitored therapy and nitric oxide suppression identifies non-adherence in severe asthma[20]

Suppression of fractional exhaled nitric oxide (FeNO) with directly observed ICS therapy over 7 days can identify non-adherence to ICS treatment in difficult-to-control asthma. Heaney et al examined the feasibility and utility of FeNO suppression testing in routine clinical care within UK severe asthma centres using remote monitoring technologies. A web-based interface with integrated remote monitoring technology was developed to deliver FeNO suppression testing. They examined the utility of FeNO suppression testing to demonstrate ICS responsiveness and clinical benefit on electronically monitored treatment with standard high-dose ICS and long-acting β2-agonist treatment. They conclude that remote Fe_{NO} suppression testing is an effective means of identifying non-adherence to ICS in subjects with difficult-to-control asthma and the substantial population of subjects who derive important clinical benefits from optimized ICS/long-acting β2-agonist treatment.

[19] Bodini R, Grinovero M, Corsico A et al Digital therapy in the treatment of asthma and COPD-epidemiology of development and use of an emerging health technology in respiratory medicine. *European Respiratory Journal Conference: 29th International Congress of the European Respiratory Society, ERS Spain.* 2019;54(Supplement 63).
[20] Heaney LG, Busby J, Bradding P et al Remotely Monitored Therapy and Nitric Oxide Suppression Identifies Nonadherence in Severe Asthma. *Am J Respir Crit Care Med.* 2019;1994.:454-464. doi:10.1164/rccm.201806-1182OC

Holgate, ST et al (2019) [Review] The future of asthma care: personalized asthma treatment[21]

Although once considered a single disease entity, asthma is now known to be a complex inflammatory disease engaging a range of causal pathways. The most frequent forms of asthma are identified by sputum/blood eosinophilia and activation of type 2 inflammatory pathways involving interleukins -3, -4, -5, and granulocyte-macrophage colony-stimulating factor. The use of diagnostics that identify T2 engagement linked to the selective use of highly targeted biologics has opened up a new way of managing severe disease. Novel technologies, such as wearables and intelligent inhalers, enable real-time remote monitoring of asthma, creating a unique opportunity for personalized health care.

Blakey, JD et al (2018) [Review] Digital technologies and adherence in respiratory diseases: the road ahead[22]

Outcomes for patients with chronic respiratory diseases remain poor despite the development of novel therapies. In part, this reflects the fact that adherence to therapy is low and clinicians lack accurate methods to assess this issue. Digital technologies hold promise to overcome these barriers to care. For example, algorithmic analysis of large amounts of information collected on health status and treatment use, along with other disease relevant information such as environmental data, can be used to help guide personalised interventions that may have a positive health impact, such as establishing habitual and correct inhaler use. Novel approaches to data analysis also offer the possibility of statistical algorithms that are better able to predict exacerbations, thereby creating opportunities for preventive interventions that may adapt therapy as disease activity changes. To realise these possibilities, digital approaches to disease management should be supported by strong evidence, have a solid infrastructure, be designed collaboratively as clinically effective and cost-effective systems, and reflect the needs of patients and healthcare providers. Regulatory standards for digital interventions and strategies to handle the large amounts of data generated are also needed. This review highlights the opportunities provided by digital technologies for managing patients with respiratory diseases.

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[21] Holgate ST, Walker S, West B, Boycott K. The Future of Asthma Care: Personalized Asthma Treatment. *Clin Chest Med.* 2019;401.:227- 241. doi:10.1016/j.ccm.2018.10.013

[22] Bender BG, Dima AL, Weinman J, Safioti G, Costello RW. Digital technologies and adherence in respiratory diseases: the road ahead. *Eur Respir J.* 2018;525.:1801147. Published 2018 Nov 22. doi:10.1183/13993003.01147-2018

Burch, J et al (2018) [Cochrane Clinical Answers] What are the benefits and harms of home telemonitoring and remote feedback between clinic visits in people with asthma?[23]

Moderate-certainty evidence shows that for adults with asthma, most often of mild to moderate severity, home telemonitoring plus remote feedback [Internet-based device, program or website, text messaging or mobile phone software, or phone calls] reduces the number of people with exacerbations requiring hospitalization on average, 21 vs 83 per 1000 people compared with usual monitoring [educational session, personalized asthma action plan, peak flow meter, or asthma diary]. Researchers observed no clear differences between groups for exacerbations requiring hospitalization in the overall population nor for exacerbations requiring oral corticosteroids, emergency department visits, or unscheduled healthcare visits [when assessed, low-certainty evidence]. In terms of asthma control, measured by the Asthma Control Questionnaire or the Asthma Control Test, researchers observed no clear differences between groups at 12-month follow-up. However, lung function was improved with home telemonitoring and remote feedback: on average, a 7.21% greater increase in forced expiratory volume in one second [FEV_1] [moderate-certainty evidence] and 13.20 L/min greater increase in peak expiratory flow. Researchers also observed improvement in quality of life, but this finding was not clinically significant. No RCT reported on adverse events.

Sumino, K et al (2018) [Meeting Abstract] Accuracy of smartphone-based spirometry (WING) use at home in asthma[24]

Sumino et al evaluated the accuracy of a new, innovative, pocket-sized, smartphone sound-based spirometry system (WING Sparo Labs), which can monitor FEV1 and PEFR on a smartphone at home using a built-in application with video instruction. They randomly assigned participants with asthma and a broad range of lung function to 3 groups: group 1: WING with in-person instruction by trained technician in outpatient office; group 2: WING with built-in video instruction viewed by the participant only in outpatient office; group 3: WING with built-in video instruction at home by the participant. They evaluated the accuracy of lung function testing with the WING device against standard spirometry [KoKo PFT spirometer, n-spire health] performed in the

[23] Burch J, Martin JE. What are the benefits and harms of home telemonitoring and remote feedback between clinic visits in people with asthma? *Cochrane Clinical Answers* 2018. DOI: 10.1002/cca.2087.
[24] Sumino K, Cohen A, Patterson BM et al Accuracy of smartphone-based spirometry (WING) use at home in asthma. *American Journal of Respiratory and Critical Care Medicine Conference: American Thoracic Society International Conference, ATS.* 2018;197(MeetingAbstracts).

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same setting by a single trained technician. When used for the first time, the smartphone-based spirometry system (WING) in patients with asthma provided acceptable accuracy in measuring FEV1, even if used with the built-in video instruction. Future studies are needed to evaluate if repeated use at home increases the accuracy.

Unni, E et al (2018) [Review] A review of the use and effectiveness of digital health technologies in patients with asthma[25]

A new generation of digital health technologies (DHT) offers the opportunity to improve adherence and asthma control. Recent literature was reviewed to summarize the use of technological aids and evaluate their impact on health outcomes in patients with asthma. Interactive websites were the most frequently evaluated type of DHT (50% of all studies), followed by mobile apps in adult patient cohorts. Relatively few studies assessed electronic monitoring devices, phone calls, or text messaging. Most interventions reported at least some benefit, although results varied based on the specific outcome. Overall, technology that included more interactive features, such as website-based daily diary entries and apps that provided real-time feedback, was associated with increased asthma control, as was the case for multidimensional interventions that combined the use of several complementary types of DHT.

Merchant, R et al (2017) [Conference Abstract] Digital health intervention for asthma: patient perception of usability and value for self-management[26]

The aim of this study is to assess patient's feedback on usability of and satisfaction with an asthma digital health platform after 12 months of use. Patients reported high satisfaction and usability of a digital health platform for asthma self-management. Patients perceived value from the platform in contributing to their self-management by increasing self-awareness, identifying asthma triggers, and improving communication with their providers.

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[25] Unni E, Gabriel S, Ariely R. A review of the use and effectiveness of digital health technologies in patients with asthma. *Annals of Allergy, Asthma and Immunology.* 2018;1216.:680-680.

[26] Merchant R, Inamdar R, Henderson K, Barrett MA, Van Sickle D. Digital health intervention for asthma: Patient perception of usability and value for self-management. *American Journal of Respiratory and Critical Care Medicine Conference: American Thoracic Society International Conference, ATS.* 2017;195(no pagination).

Pinnock, H et al (2016) [Review] [Digital technology in respiratory diseases: promises, (no) panacea and time for a new paradigm](27)

Recent evidence suggests that telehealth may not be quite the panacea that was promised; this has led to discussions on the mechanisms and role of digital technology in respiratory care. Implementation in rural and remote settings offers significant benefits in terms of convenient access to care, but is contingent on technical and organizational infrastructure. Telemonitoring systems rely on algorithms to detect deterioration and trigger alerts; machine learning may enable telemonitoring of the future to develop personalized systems that are sensitive to clinical status whilst reducing false alerts. By providing access to information, offering convenient and flexible modes of communication and enabling the transfer of monitoring data to support professional assessment, telehealth can support self-management. At present, all too often, expensive off the shelf systems are purchased and given to clinicians to use. It is time for the paradigm to shift. Pinnock et al argue that clinicians should identify the specific challenges they face in delivering care, and expect flexible systems that can be customized to individual patients' requirements and adapted to diverse healthcare contexts.

Van Sickle, D et al (2016) [Conference Abstract] [Randomized, controlled study of the impact of a mobile health tool on asthma SABA use, control and adherence](28)

The aim of this study was to determine whether a sensor-enabled, clinically-integrated mobile health asthma quality improvement programme could reduce the frequency of short-acting beta agonist (SABA) use, and increase asthma-free days, asthma control and controller medication adherence. Adult patients with asthma and a SABA prescription were enrolled (n=125). Participants randomized to the intervention group (IG) (n=67) received electronic inhaler sensors to track their medication use, and access to smartphone and online applications that provided visualizations of their data, reminders to promote adherence, and personalized, guidelines-based education. Clinical care managers viewed IG patients' data in an online dashboard to guide care. Participants in the control group (CG) (n=58) received sensors, but neither the patient nor the care manager received

27 Pinnock H, McKinstry B. Digital technology in respiratory diseases: Promises, (no) panacea and time for a new paradigm. *Chron Respir Dis.* 2016;132.:189-191. doi:10.1177/1479972316637788
28 Van Sickle D, Barrett M, Humblet O, Henderson K, Hogg C. Randomized, controlled study of the impact of a mobile health tool on asthma SABA use, control and adherence. *European Respiratory Journal Conference: European Respiratory Society Annual Congress.* 2016;48(Supplement 60).

access to their data. Mixed effects regression models with random intercepts were used to compare outcomes between groups at 6 months. The IG demonstrated significant improvements compared to the CG on all clinical outcomes, including controller medication adherence, daily SABA use, asthma free days, and asthma control (all p<0.001), including a 21-point improvement in adherence for the IG. This mobile health programme, with sensor-enabled data collection and patient and provider access to the data, improved asthma outcomes, including asthma SABA use, control, and adherence in a real-world clinical setting.

CHAPTER 2
Telemedicine and Audiology

Systematic Reviews

Charalambous, Anna Pavlina et al (2020) [Systematic Review and Meta-Analysis] Tools for App- and Web-Based Self-Testing of Cognitive Impairment: Systematic Search and Evaluation[1]

Background: Tools for app- and web-based self-testing for identification of cognitive impairment are widely available but are of uncertain quality. Objective: The objective of this study was to undertake a scoping review of app- and web-based self-tests for cognitive impairment and determine the validity of these tests. Methods: We conducted systematic searches in electronic databases, including Google search, Google Play Store, and iPhone Operating System App Store, using the search terms 'Online OR Internet-based AND Memory OR Brain OR Dementia OR mild cognitive impairment OR MCI AND Test OR Screen OR Check.' Results: We identified 3,057 tools, of which 25 were included in the review. Most tools meeting the inclusion criteria assessed multiple cognitive domains. The most frequently assessed domains were memory, attention, and executive function. We then conducted an electronic survey with the developers of the tools to identify data relating to development and validation of each tool. If no response to the survey was received, Google (to identify gray literature), Google Scholar, and Medical Literature Analysis and Retrieval System Online were searched using key terms '[name of developer, if available]' AND '[name of the tool]' to identify any additional data. Only 7 tools had any information concerning psychometric quality, and only 1 tool reported data on performance norms, reliability, validity, sensitivity, and specificity for the detection of cognitive impairment. Conclusions: The number of cognitive self-assessment electronic health tools for cognitive impairment is increasing, but most are of uncertain quality. There is a need for well-validated tools and guidance for users concerning which tools provide reliable information about possible cognitive impairment that could warrant further investigation.

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[1] Charalambous AP, Pye A, Yeung WK et al Tools for App- and Web-Based Self-Testing of Cognitive Impairment: Systematic Search and Evaluation. *J Med Internet Res*. 2020;221.:e14551. Published 2020 Jan 17. doi:10.2196/14551

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Nagaraj, Megha Kondli et al (2020) [Systematic Review]
Internet/smartphone-based applications for the treatment of tinnitus: a systematic review[2]

Introduction: Most of the individuals suffering from tinnitus report of negative effects on their lives to the extent that clinical intervention is necessary. Although traditional tinnitus management has proven to be effective in treating tinnitus, there are a few drawbacks. The major drawback is the lack of professionals for the treatment of tinnitus, especially in remote areas. Considering the growing usage of the Internet as a platform for availing treatment, there is a requirement for the development of applications in the health care sector. Recent search related to tinnitus treatment revealed that more than 200 applications are available online in the most popular platforms such as Android and iOS. However, most of the applications for the treatment of tinnitus lack validation, and thus, there is a need for research on this ground. Method: Five studies evaluating the efficacy of Internet/app delivered tinnitus treatments were identified. The treatment forms included were Tinnitus E-program, Mobile serious game, Tinnitus web-based sound therapy, and Tailor-made notch music therapy delivered through a smart phone. Results: Each study used a variety of standardized and validated questionnaires to measure the outcome of the treatment. The outcome measures were diverse, but both Internet/app-based and traditional methods such as Tinnitus Retraining Therapy, Cognitive Behavioral Therapy, and Acceptance and Commitment Therapy had similar improvements in terms of tinnitus distress and quality of life. Conclusion: It can be construed that the development of tinnitus treatment applications and web-based platforms will have a significant impact on the normal life of individuals with tinnitus.

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[2] Nagaraj MK, Prabhu P. Internet/smartphone-based applications for the treatment of tinnitus: a systematic review. *Eur Arch Otorhinolaryngol.* 2020;2773.:649- 657. doi:10.1007/s00405-019-05743-8

Nunn, Terry B et al (2019) [Systematic Review] A systematic review of the impact of adjusting input dynamic range (IDR), electrical threshold (T) level and rate of stimulation on speech perception ability in cochlear implant users[3]

Objective: To systematically review the evidence of how adjustments of the electrical threshold (T) level, input dynamic range (IDR) and electrical stimulation rate impact on speech perception for cochlear implant (CI) users. Design: Systematic review. Study sample: A search of two electronic data sources yielded 32 studies, which met the inclusion criteria. A quality assessment and two evidence-based practice (EBP) review rating schemes were used to grade studies. Results: Due to the heterogeneity of speech perception measures, CI device type and study design, comparisons were made by structured review. Conclusion: The quality of studies was found to be moderate to poor. Increasing T levels above behavioural threshold, or as a proportion of electrical dynamic range (EDR), has been demonstrated to improve perception of monosyllables in quiet and sentences in both quiet and in noise. Specific IIDR and IDR setting may improve perception of monosyllables in quiet and sentences in noise. However, no recommendation could be determined for setting rate of stimulation as speech perception varied significantly across rates examined. To optimise speech perception, a bespoke approach to parameter setting providing an individualised CI fitting is recommended; however, detail of how to optimise settings and the interactions between parameters is as yet unknown.

Sorgini, Francesca et al (2019) [Systematic Review] Haptic-assistive technologies for audition and vision sensory disabilities[4]

Purpose: The aim of this review is to analyze haptic sensory substitution technologies for deaf, blind and deaf-blind individuals. Method: The literature search has been performed in Scopus, PubMed and Google Scholar databases using selected keywords, analyzing studies from 1960s to present. Search on databases for scientific publications has been accompanied by web search for commercial devices. Results have been classified by sensory disability and functionality, and analyzed by assistive technology. Complementary analyses have also been carried out on websites of public international agencies, such as the World Health

[3] Nunn TB, Jiang D, Green T, Boyle PJ, Vickers DA. A systematic review of the impact of adjusting input dynamic range (IDR), electrical threshold (T) level and rate of stimulation on speech perception ability in cochlear implant users. *Int J Audiol.* 2019;586.:317- 325. doi:10.1080/14992027.2018.1564844

[4] Sorgini F, Caliò R, Carrozza MC, Oddo CM. Haptic-assistive technologies for audition and vision sensory disabilities. *Disabil Rehabil Assist Technol.* 2018;134.:394- 421. doi:10.1080/17483107.2017.1385100

Organization (WHO), and of associations representing sensory disabled persons. Results: The reviewed literature provides evidences that sensory substitution aids are able to mitigate in part the deficits in language learning, communication and navigation for deaf, blind and deaf-blind individuals, and that the tactile sense can be a means of communication to provide some kind of information to sensory disabled individuals. Conclusions: A lack of acceptance emerged from the discussion of capabilities and limitations of haptic assistive technologies. Future researches shall go towards miniaturized, custom-designed and low-cost haptic interfaces and integration with personal devices such as smartphones for a major diffusion of sensory aids among disabled. Implications for rehabilitation Systematic review of state of the art of haptic assistive technologies for vision and audition sensory disabilities. Sensory substitution systems for visual and hearing disabilities have a central role in the transmission of information for patients with sensory impairments, enabling users to interact with the not disabled community in daily activities. Visual and auditory inputs are converted in haptic feedback via different actuation technologies. The information is presented in the form of static or dynamic stimulation of the skin. Their effectiveness and ease of use make haptic sensory substitution systems suitable for patients with different levels of disabilities. They constitute a cheaper and less invasive alternative to implantable partial sensory restitution systems. Future researches are oriented towards the optimization of the stimulation parameters together with the development of miniaturized, custom-designed and low-cost aids operating in synergy in networks, aiming to increase patients' acceptability of these technologies.

Beukes, Eldré W et al (2018) [Systematic Review] Internet-based interventions for adults with hearing loss, tinnitus and vestibular disorders: a protocol for a systematic review[5]
Background: Internet-based interventions are emerging as an alternative way of delivering accessible healthcare for various conditions including hearing and balance disorders. A comprehensive review regarding the evidence-base of Internet-based interventions for auditory-related conditions is required to determine the existing evidence of their efficacy and effectiveness. The objective of the current protocol is to provide the methodology for a systematic review regarding the effects of Internet-

[5] Beukes EW, Manchaiah V, Baguley DM, Allen PM, Andersson G. Internet-based interventions for adults with hearing loss, tinnitus and vestibular disorders: a protocol for a systematic review. *Syst Rev.* 2018;71.:205. Published 2018 Nov 23. doi:10.1186/s13643-018-0880-9

based interventions for adults with hearing loss, tinnitus and vestibular disorders. Method: This protocol was developed according to the Preferred Reporting Items for Systematic reviews and Meta-analyses for Protocols (PRISMA-P) 2015 guidelines. Electronic database searches will include EBSCOhost, PubMed and Cochrane Central Register performed by two researchers. This will be complemented by searching other resources such as the reference lists for included studies to identify studies meeting the eligibility for inclusion with regard to study designs, participants, interventions, comparators and outcomes. The Cochrane risk of bias tool (RoB 2) for randomised trials will be used for the bias assessments in the included studies. Criteria for conducting meta-analyses were defined. Discussion: The result of this systematic review will be of value to establish the effects of Internet-based interventions for hearing loss, tinnitus and vestibular disorders. This will be of importance to guide future planning of auditory intervention research and clinical services by healthcare providers, researchers, consumers and stakeholders.

Tao, Karina FM et al (2018) [Systematic Review] [Teleaudiology Services for Rehabilitation With Hearing Aids in Adults: A Systematic Review](#)[6]
Purpose: This review examined 1. the current evidence from studies on teleaudiology applications for rehabilitation of adults with hearing impairment with hearing aids; and 2. whether it is sufficient to support the translation into routine clinical practice. Method: A search strategy and eligibility criteria were utilized to include articles specifically related to hearing aid fitting and follow-up procedures that are involved in consultations for the rehabilitation of adults, where the service was provided by the clinician by teleaudiology. A search using key words and Medical Subject Headings (MeSH) was conducted on the main electronic databases that index health-related studies. The included studies were assessed using validated evaluation tools for methodological quality, level of evidence, and grade recommendations for application into practice. Results: Fourteen studies were identified as being within the scope of this review. The evaluation tools showed that none of these studies demonstrated either a strong methodological quality or high level of evidence. Analysis of evidence identified 19 activities, which were classified into service outcomes categories of feasibility, barriers, efficiency, quality, and effectiveness. Recommendations could be made regarding the feasibility, barriers and

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efficiency of teleaudiology for the rehabilitation of hearing loss with hearing aids. Conclusion: This review provides up-to-date evidence for teleaudiology hearing aid services in new and experienced hearing aid users in different practice settings. Findings direct future research priorities to strengthen evidence-based practice. There is a need for further studies of many aspects of teleaudiology services for rehabilitation with hearing aids to support their implementation into clinical practice.

Bush, Matthew L et al (2016) [Systematic Review] The Role of Telemedicine in Auditory Rehabilitation: A Systematic Review[7]
Objective: The purpose of this study was to assess the feasibility and effectiveness of live telemedicine applications in hearing amplification and cochlear implantation. Data sources and study selection: A systematic search was performed in PubMed, MEDLINE, PsychINFO, CINALH, and Web of Science to identify peer-reviewed research. Inclusion criteria were titles containing words from the search terms: 1 audiology, otolaryngology, and hearing impairment; 2 rehabilitative methods; and 3 telemedicine. Exclusion criteria were: 1 non-English articles; and 2 non-original research. Data extraction and synthesis: Twelve eligible studies were identified. The studies employed a prospective design in nine of the articles and retrospective case series in three. The use of telemedicine for the provision of cochlear implant services was examined in eight of the articles and with hearing aids in four of the articles. The types of services include intraoperative cochlear implant telemetry; implant programming and assessment of electrode-specific measures and speech recognition after implantation. Hearing aid programming and remote gain assessments were also reported. Many studies assess patient and provider satisfaction along with encounter time comparison. The studies occurred from 2009 to 2014 and took place in seven countries. Conclusions: This review examined the feasibility of remote telemedicine connection to provide in auditory rehabilitation services through hearing aids and cochlear implants. There are significant concerns regarding Internet bandwidth limitations for remote clinics. There is a paucity of research examining reimbursement and cost-effectiveness for services. Further prospective research investigating cost-effectiveness and bandwidth limitations is warranted to assess long-term sustainability of remote audiological rehabilitative service delivery.

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[7] Bush ML, Thompson R, Irungu C, Ayugi J. The Role of Telemedicine in Auditory Rehabilitation: A Systematic Review. *Otol Neurotol.* 2016;37(10):1466-1474. doi:10.1097/MAO.0000000000001236

Miscellaneous

Cheng, Yen-Fu et al (2020) [Pilot Study] Increased risk of tinnitus following a trigeminal neuralgia diagnosis: a one-year follow-up study[8]
Background: Tinnitus due to hyperactivity across neuronal ensembles along the auditory pathway is reported. We hypothesized that trigeminal neuralgia patients may subsequently suffer from tinnitus. Using nationwide, population-based data and a retrospective cohort study design, we investigated the risk of tinnitus within 1 year following trigeminal neuralgia. Methods: We used the Taiwan National Health Insurance Research Dataset, a claims database, to identify all patients diagnosed with trigeminal neuralgia from January 2001 to December 2014, 12,587 patients. From the remaining patients, we identified 12,587 comparison patients without trigeminal neuralgia by propensity score matching, using sex, age, monthly income, geographic region, residential urbanization level, and tinnitus-relevant comorbidities [hyperlipidemia, diabetes, coronary heart disease, hypertension, cervical spondylosis, temporomandibular joint disorders and injury to head and neck and index year]. All study patients (n = 25,174) were tracked for a one-year period to identify those with a subsequent diagnosis of tinnitus over 1-year follow-up. Results: Among total 25,174 sample patients, the incidence of tinnitus was 18.21 per 100 person-years (95% CI = 17.66 ~ 18.77), the rate being 23.57 (95% CI = 22.68 ~ 24.49) among patients with trigeminal neuralgia and 13.17 (95% CI = 12.53 ~ 13.84) among comparison patients. Furthermore, the adjusted Cox proportional hazard ratio for tinnitus in the trigeminal neuralgia group was 1.68 (95% CI = 1.58 ~ 1.80) relative to the comparison cohort. Conclusions: We found a significantly increased risk of tinnitus within 1 year of trigeminal neuralgia diagnosis compared to those without the diagnosis. Further studies in other countries and ethnicities are needed to explore the relationship between trigeminal neuralgia and subsequent tinnitus.

[8] Cheng YF, Xirasagar S, Yang TH et al Increased risk of tinnitus following a trigeminal neuralgia diagnosis: a one-year follow-up study. *J Headache Pain*. 2020;211.:46. Published 2020 May 6. doi:10.1186/s10194-020-01121-6

Cho, Young Sang et al (2020) [Pilot Study] Automated measurement of hydrops ratio from MRI in patients with Ménière's disease using CNN-based segmentation[9]

Ménière's Disease (MD) is difficult to diagnose and evaluate objectively over the course of treatment. Recently, several studies have reported MD diagnoses by MRI-based endolymphatic hydrops (EH) analysis. However, this method is time-consuming and complicated. Therefore, a fast, objective, and accurate evaluation tool is necessary. The purpose of this study was to develop an algorithm that can accurately analyze EH on intravenous gadolinium-enhanced inner-ear MRI using artificial intelligence with deep learning. In this study, we developed a convolutional neural network (CNN)-based deep-learning model named INHEARIT (INner ear Hydrops Estimation via ARtificial InTelligence) for the automatic segmentation of the cochlea and vestibule, and calculation of the EH ratio in the segmented region. Measurement of the EH ratio was performed manually by a neuro-otologist and neuro-radiologist and by estimation with the INHEARIT model and were highly consistent [intraclass correlation coefficient = 0.971]. This is the first study to demonstrate that automated EH ratio measurements are possible, which is important in the current clinical context where the usefulness of IV-Gd inner-ear MRI for MD diagnosis is increasing.

Corona, Ana Paula et al (2020) [Evaluation Study] Validity of hearing screening using hearTest smartphone-based audiometry: performance evaluation of different response modes[10]

Objective: To investigate the validity of hearing screening with hearTest smartphone-based audiometry and to specify test duration addressing the two response modes and hearing loss criteria. Design: A diagnostic accuracy study comparing hearing screening with conventional audiometry. Study sample: Three hundred and forty individuals, aged between 5-92 years. Results: Of the 340 participants, 301 undertook all test procedures; 273 adults and 28 children. Sensitivity and specificity were >90% for hearTest hearing screening to identify disabling hearing loss for both response modes with adults and children. We found similar sensitivity in identifying any level of hearing loss for both response modes in children, with specificity >80%,

[9] Cho YS, Cho K, Park CJ et al Automated measurement of hydrops ratio from MRI in patients with Ménière's disease using CNN-based segmentation. *Sci Rep*. 2020;101.:7003. Published 2020 Apr 24. doi:10.1038/s41598-020-63887-8

[10] Corona AP, Ferrite S, Bright T, Polack S. Validity of hearing screening using hearTest smartphone-based audiometry: performance evaluation of different response modes [published online ahead of print, 2020 Mar 5]. *Int J Audiol*. 2020;1- 8. doi:10.1080/14992027.2020.1731767

and for the self-test mode in adults. Low specificity was observed when identifying any level of hearing loss in adults using the test-operator mode. In adults, there was a significant difference between test duration for the test-operator and self-test modes. Conclusion: Hearing screening using hearTest smartphone-based audiometry is accurate for the identification of both disabling hearing loss and any level of hearing loss in adults and children in the self-test response mode. The test-operator mode is also an option for children; however, it does not provide good accuracy in identifying mild level of hearing loss in adults.

Cottrell, Elizabeth et al (2020) [Evaluation Study] Telescopic otology referrals: Evaluation of feasibility and acceptability[11]

Objective: A remote telemedical otology referral and advice service was introduced to interested general practices. General practitioners (GPs) were given a new device, "endoscope-i" that combines an optimized smartphone high definition video app with an otoendoscope. They were specifically trained to examine and capture images of patients' eardrums, which were sent electronically with a summary of clinical information and an in-app hearing testing, if required, for specialist advice to two ear, nose, and throat (ENT) consultants. We describe the findings from an evaluation of the first 6 months of this service to establish the feasibility and acceptability of an otology telemedical referral and advice service. Methods: The new service was advertised to GP practices in Northern Staffordshire. All interested GPs were provided with training and equipment to deliver the remote referral service. Data were collected from GPs at baseline, informal feedback in response to referral outcomes and end of service feedback. Referral data were collected routinely during the service delivery. Results: Fifteen GP leads from 15 practices received training and equipment. One quickly lost the equipment. Of the remaining 14 practices, eight sent a total of 53 remote referrals using this technology over 6 months. The most common reason for referral was an uncertainty of what could be seen in or around the eardrum. The primary barrier for implementation was lack of wireless Internet connections within practices. GPs reported that they used this technology to share examination findings with patients. Conclusions: GPs were positive about the technology, from initial engagement with training and after advice were given. Some GPs expanded the role of the technology to a consultation aid. Referral volume was manageable. Commissioners should consider

[11] Cottrell E, George A, Coulson C, Chambers R. Telescopic otology referrals: Evaluation of feasibility and acceptability. *Laryngoscope Investig Otolaryngol.* 2020;52.:221- 227. Published 2020 Mar 3. doi:10.1002/lio2.367

tariffs structures for such services; empirical cost-effectiveness and workload-impact evaluation would inform this.

Fletcher, Mark D et al (2020) [Evaluation Study] Electro-Haptic Enhancement of Spatial Hearing in Cochlear Implant Users[12]

Cochlear implants (CIs) have enabled hundreds of thousands of profoundly hearing-impaired people to perceive sounds by electrically stimulating the auditory nerve. However, CI users are often very poor at locating sounds, which leads to impaired sound segregation and threat detection. We provided missing spatial hearing cues through haptic stimulation to augment the electrical CI signal. We found that this electro-haptic stimulation dramatically improved sound localisation. Furthermore, participants were able to effectively integrate spatial information transmitted through these two senses, performing better with combined audio and haptic stimulation than with either alone. Our haptic signal was presented to the wrists and could readily be delivered by a low-cost wearable device. This approach could provide a non-invasive means of improving outcomes for the vast majority of CI users who have only one implant, without the expense and risk of a second implantation.

Geronazzo, Michele et al (2020) [Pilot Study] Superhuman Hearing - Virtual Prototyping of Artificial Hearing: a Case Study on Interactions and Acoustic Beamforming[13]

Directivity and gain in microphone array systems for hearing aids or hearable devices allow users to acoustically enhance the information of a source of interest. This source is usually positioned directly in front. This feature is called acoustic beamforming. The current study aimed to improve users' interactions with beamforming via a virtual prototyping approach in immersive virtual environments (VEs). Eighteen participants took part in experimental sessions composed of a calibration procedure and a selective auditory attention voice-pairing task. Eight concurrent speakers were placed in an anechoic environment in two virtual reality (VR) scenarios. The scenarios were a purely virtual scenario and a realistic 360° audio-visual recording. Participants were asked to find an individual optimal parameterization for three different virtual beamformers: 1. head-guided, 2.

[12] Fletcher MD, Cunningham RO, Mills SR. Electro-Haptic Enhancement of Spatial Hearing in Cochlear Implant Users. *Sci Rep*. 2020;101.:1621. Published 2020 Jan 31. doi:10.1038/s41598-020-58503-8

[13] Geronazzo M, Vieira LS, Nilsson NC, Udesen J, Serafin S. Superhuman Hearing - Virtual Prototyping of Artificial Hearing: a Case Study on Interactions and Acoustic Beamforming. *IEEE Trans Vis Comput Graph*. 2020;265.:1912-1922. doi:10.1109/TVCG.2020.2973059

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eye gaze-guided, and 3. a novel interaction technique called dualbeamformer, where head-guided is combined with an additional hand-guided beamformer. None of the participants were able to complete the task without a virtual beamformer ▯ ie in normal hearing condition ▯ due to the high complexity introduced by the experimental design. However, participants were able to correctly pair all speakers using all three proposed interaction metaphors. Providing superhuman hearing abilities in the form of a dual acoustic beamformer guided by head and hand movements resulted in statistically significant improvements in terms of pairing time, suggesting the task-relevance of interacting with multiple points of interests.

Kıroğlu, Mete et al (2020) [Pilot Study] [The Role of Mobile Phone Camera Recordings in the Diagnosis of Meniere's Disease and Pathophysiological Implications](#)[14]

Objectives: This study aimed to understand if videos of the patients' nystagmus recorded by themselves during the attacks can help in the diagnosis of Meniere's disease (MD). Materials and Methods: Sixty patients age range 32-78 years who had vestibular attacks and hearing complaints admitted to Çukurova University Hospital Otolaryngology Department and a private office between September 2013 and January 2017 were included in this randomized clinical trial study. Two groups with 30 patients each were formed. The first group was asked to send eye-videos recorded during the attack, while the patients in the second group were followed with conventional methods. Twenty-six patients in the first group were able to send satisfactory eye movement videos; four patients were excluded due to repeated recording faults. Twenty-seven patients in the second group could be followed; three patients were lost to follow-up. The number of attacks and time needed to diagnose both groups were compared. Results: The video group could be diagnosed in a shorter period compared to the control group. The diagnosis was made within two attacks [38 days] in the video group and within four attacks [92 days] in the control group. Conclusion: This study shows that cell phone camera recordings of nystagmus of the patients are very helpful to diagnose MD. These recordings can also be used as an adjunct to understand the pathophysiology of the disease.

[14] Kıroğlu M, Dağkıran M. The Role of Mobile Phone Camera Recordings in the Diagnosis of Meniere's Disease and Pathophysiological Implications. *J Int Adv Otol.* 2020;161.:18-23. doi:10.5152/iao.2019.6605

Luria, Alexander L et al (2020) [Feasibility Study] Cochlear Implant Mapping Through Telemedicine-A Feasibility Study[15]

Objective: Access to postoperative aural rehabilitation limits cochlear implant (CI) penetration to the candidate population. The purpose of this study was to evaluate the effectiveness of remote CI programming and aural rehabilitation via telehealth. Study design and setting: Retrospective study of one cochlear implant center. Patients and intervention: Patients undergoing cochlear implantation from 2015 to 2018 undergoing remote programming as part of routine audiologic follow up. Main outcome measures: AzBio scores, impedances, comfort and threshold levels, and responses to the International Outcome Inventory for Hearing Aids questionnaire modified for CIs (IOI-CI). Results: A total of 22 CIs in 20 patients were included during the study period. Threshold, comfort, and impedance levels were readily obtained via telehealth and were not significantly different between telehealth and live sessions. AzBio scores and warble tone pure tone averages were also similar and acceptable in both session modalities. Based on IOI-CI scores, patients were very satisfied with their hearing outcomes. Conclusions: Using telemedicine, reliable measurements were readily obtained and hearing outcomes after remote programming were comparable to those expected after in-person programming sessions. Patients were overall satisfied with their remote programming sessions. Telehealth is a cost-effective and safe way to deliver post-CI audiologic care, particularly to patients with limited mobility or those in remote locations.

Meeuws, Matthias et al (2020) [Feasibility Study] Cochlear implant telemedicine: Remote fitting based on psychoacoustic self-tests and artificial intelligence[16]

Objective: This study aims to assess the feasibility of autonomous cochlear implant (CI) fitting by adult CI recipients based on psychoacoustic self-testing and artificial intelligence (AI). Design: A feasibility study was performed on six adult CI recipients implanted with a Nucleus device. Two weeks after processor activation in the clinic, a 'self-fitting' session was organized in a supervised simulated home environment. The CI recipient performed pure tone audiometry and spectral discrimination tests as self-tests. The AI application FOX analysed the results and recommended a new

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[15] Luryi AL, Tower JI, Preston J, Burkland A, Trueheart CE, Hildrew DM. Cochlear Implant Mapping Through Telemedicine-A Feasibility Study. *Otol Neurotol.* 2020;413.:e330- e333. doi:10.1097/MAO.0000000000002551

[16] Meeuws M, Pascoal D, Janssens de Varebeke S, De Ceulaer G, Govaerts PJ. Cochlear implant telemedicine: Remote fitting based on psychoacoustic self-tests and artificial intelligence [published online ahead of print, 2020 May 13]. *Cochlear Implants Int.* 2020;1- 9.

map. The participants filled out a questionnaire and were tested again after 2 months of take-home experience. Results: Four out of six patients performed the self-tests without any help from the audiologist and four were fitted by FOX without any manual intervention. All patients were comfortable with the concept of self-testing and automated fitting. Patients acknowledged that at this stage the remote supervision of an audiologist remains essential. Conclusions: The study showed that audiological self-assessment and remote CI fitting with AI under the supervision of an audiologist is feasible, at least in a number of CI recipients. Currently, there are still some technical and regulatory challenges to be addressed before this can become routine practice.

Ratanjee-Vanmali, Husmita et al (2020) [Evaluation Study] Patient Uptake, Experience, and Satisfaction Using Web-Based and Face-to-Face Hearing Health Services: Process Evaluation Study[17]
Background: Globally, access to hearing health care is a growing concern with 900 million people estimated to suffer from disabling hearing loss by 2050. Hearing loss is one of the most common chronic health conditions, yet access to hearing health care is limited. Incorporating web-based (voice calling, messaging, or emailing) service delivery into current treatment pathways could improve access and allow for better scalability of services. Current electronic health studies in audiology have focused on technical feasibility, sensitivity, and specificity of diagnostic hearing testing and not on patient satisfaction, experiences, and sustainable models along the entire patient journey. Objective: This study aimed to investigate a hybrid [web-based and face-to-face] hearing health service in terms of uptake, experience, and satisfaction in adult patients with hearing loss. Methods: A nonprofit hearing research clinic using online and face-to-face services was implemented in Durban, South Africa, using online recruitment from the clinic's Facebook page and Google AdWords, which directed persons to an online web-based hearing screening test. web-based and face-to-face care pathways included assessment, treatment, and rehabilitation. To evaluate the service, an online survey comprising: 1. a validated satisfaction measurement tool [Short Assessment of Patient Satisfaction]; 2. a process evaluation of all the 5 steps completed; and 3. personal preferences of communication methods used vs methods preferred was conducted, which

[17] Ratanjee-Vanmali H, Swanepoel W, Laplante-Lévesque A. Patient Uptake, Experience, and Satisfaction Using Web-Based and Face-to-Face Hearing Health Services: Process Evaluation Study. *J Med Internet Res*. 2020;223.:e15875. Published 2020 Mar 20. doi:10.2196/15875

was sent to 46 patients who used clinic services. Results: Of the patients invited, 67% (31/46) completed the survey with mean age 66 years, (SD 16). Almost all patients, 92% (30/31) reported that the online screening test assisted them in seeking hearing health care. Approximately 60% (18/31) of the patients accessed the online hearing screening test from an Android device. Patients stayed in contact with the audiologist mostly through WhatsApp instant messaging (27/31, 87%), and most patients (25/31, 81%) preferred to use this method of communication. The patients continuing with hearing health care were significantly older and had significantly poorer speech recognition abilities compared with the patients who discontinued seeking hearing health care. A statistically significant positive result (p=.007) was found between age and the number of appointments per patient. Around 61% (19/31) of patients previously completed diagnostic testing at other practices, with 95% (18/19) rating the services at the hybrid clinic as better. The net promoter score was 87, indicating that patients were highly likely to recommend the hybrid clinic to friends and family. Conclusions: This study applied web-based and face-to-face components into a hybrid clinic and measured an overall positive experience with high patient satisfaction through a process evaluation. The findings support the potential of a hybrid clinic with synchronous and asynchronous modes of communication to be a scalable hearing health care model, addressing the needs of adults with hearing loss globally.

Saunders, Gabrielle H et al (2020) [Recommendation] Application of Big Data to Support Evidence-Based Public Health Policy Decision-Making for Hearing[18]

Ideally, public health policies are formulated from scientific data; however, policy-specific data are often unavailable. Big data can generate ecologically-valid, high-quality scientific evidence, and therefore has the potential to change how public health policies are formulated. Here, we discuss the use of big data for developing evidence-based hearing health policies, using data collected and analyzed with a research prototype of a data repository known as EVOTION [EVidence-based management of hearing impairments: public health pOlicy-making based on fusing big data analytics and simulation], to illustrate our points. Data in the repository consist of audiometric clinical data, prospective real-world data collected

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from hearing aids and an app, and responses to questionnaires collected for research purposes. To date, we have used the platform and a synthetic dataset to model the estimated risk of noise-induced hearing loss and have shown novel evidence of ways in which external factors influence hearing aid usage patterns. We contend that this research prototype data repository illustrates the value of using big data for policy-making by providing high-quality evidence that could be used to formulate and evaluate the impact of hearing health care policies.

Sun, Zhuoyi et al (2020) [Pilot Study] A Supervised Speech Enhancement Method for Smartphone-Based Binaural Hearing Aids[19]

It is essential but quite challenging to alleviate speech information loss and distortion while developing the speech processing algorithms in hearing aids. Recently, many speech enhancement methods based on deep learning are proven effective. However, most of the algorithms fail to achieve real-time processing, which is significant for hearing aids, especially for a smartphone-centered binaural hearing aid system. A supervised speech enhancement method based on an RNN structure is proposed to address the real-time problem. The problem is explored as a resource-constrained speech intelligibility improvement problem with the target of improving speech intelligibility at low SNR situations. Both the objective and subjective experimental results, using the standard evaluation metrics and the experiments on volunteers, respectively, have verified the superiority of the proposed method.

Wesarg, Thomas et al (2020) [Evaluation Study] Application of Digital Remote Wireless Microphone Technology in Single-Sided Deaf Cochlear Implant Recipients[20]

Background: Previous research showed benefits of remote wireless technology in bilaterally moderate- to-severe hearing-impaired participants provided with hearing aid(s), cochlear implant(s) (CIs), or bimodal devices as well as in single-sided deaf (SSD) cochlear implant recipients (with CI from Cochlear™) and normal-hearing (NH) participants. Purpose: To evaluate the effect of the digital remote wireless microphone system, Roger™, on speech recognition at different levels of multisource noise in SSD CI recipients using

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[19] Sun Z, Li Y, Jiang H, Chen F, Xie X, Wang Z. A Supervised Speech Enhancement Method for Smartphone-Based Binaural Hearing Aids [published online ahead of print, 2020 Apr 20]. *IEEE Trans Biomed Circuits Syst*. 2020;10.1109/TBCAS.2020.2988121. doi:10.1109/TBCAS.2020.2988121

[20] Wesarg T, Stelzig Y, Hilgert-Becker D et al Application of Digital Remote Wireless Microphone Technology in Single-Sided Deaf Cochlear Implant Recipients. *J Am Acad Audiol*. 2020;314.:246-256. doi:10.3766/jaaa.18060

MED-EL CI sound processor OPUS 2. Outcomes were assessed as a function of the listening condition (NH only, NH + CI, NH + CIRog, NHRog + CI, and NHRog + CIRog), Roger™ receiver type (Roger™ Focus for NH; Roger™ Xand Roger™ MyLink for CI) and accessory mixing ratio. Study sample: Eleven adult, SSD participants aided with CI from MED-EL. Data collection and analysis: Speech recognition in noise was assessed in two no-Roger™ conditions, one Roger™ X condition, and two Roger™ MyLink conditions. For the Roger™ X and no-Roger™ conditions, speech recognition was tested at 60.3 dB(A) with the Oldenburg Sentence Test in classroom noise at levels of 55, 65, and 75 dB(A). For the two Roger™ MyLink conditions, speech recognition at 60.3 dB(A) was measured at a noise level of 75 dB(A). Roger™ X was assessed with an accessory mixing ratio of 1:1 (summation of unattenuated microphone and audio accessory input). For Roger™ MyLink, two accessory mixing ratios were investigated, MT (1:1, summation of unattenuated microphone and telecoil input) and T with maximum attenuation of microphone input. Results: Speech recognition at higher noise levels (65 and 75 dB(A)) improved significantly with Roger™ in both unilateral use conditions (NH + CIRog and NHRog + CI) as well as bilateral use condition (NHRog + CIRog). Both the bilateral application of Roger™ and the unilateral Roger™ application on the NH ear outperformed the Roger™ application on CI alone. There was no statistically significant effect of type of CI Roger™ receiver (Roger™ X or Roger™ MyLink) and the accessory mixing ratio (MT or T) on speech recognition. Conclusions: Speech recognition for distant speakers in multisource noise improved significantly with the application of Roger™ in SSD CI recipients. Both the unilateral Roger™ application on the NH ear or the CI as well as the bilateral Roger™ application can be recommended.

▸ **Contents**

CHAPTER 3
Telemedicine and Cancer Care

Systematic Reviews

Magalhaes, B et al (2020) [Systematic Review] The use of mobile applications for managing care processes during chemotherapy treatments: a systematic review[1]
The aim of this study was to gather scientific evidence about the efficacy of the use of mobile apps during chemotherapy treatments. A systematic review of quantitative studies was performed. Based on the available research, mobile apps are likely to be a useful and acceptable tool to monitor interventions and complications. In addition, mobile apps can help in the self-management of treatment-related complications. Importantly, these apps need to bridge the academic context and clinical practice, by evaluating the impact of the use of mobile apps in patients. The concept of prescribing apps is being addressed to ensure that apps work and have fair privacy and data security policies that address safety requirements.

Abahussin, AA et al (2019) [Systematic Review] PROMs for pain in adult cancer patients: a systematic review of measurement properties[2]
The objective of this study is to systematically review measurement properties of patient-reported outcome measures (PROMs) used for adult cancer patients to measure pain and, as a secondary goal, to investigate the evidence of validated mobile health (mHealth) applications used to measure pain. Abahussin et al conclude that better quality validation studies of PROMs for cancer pain are needed to explore the full range of measurement properties. Utilising mHealth applications to measure pain in cancer patients is an innovative approach worthy of further investigation.

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[1] Magalhães B, Fernandes C, Santos C, Martínez-Galiano JM. The Use of Mobile Applications for Managing Care Processes During Chemotherapy Treatments: A Systematic Review [published online ahead of print, 2020 May 6]. *Cancer Nurs*. 2020;10.1097/NCC.0000000000000823. doi:10.1097/NCC.0000000000000823

[2] Abahussin AA, West RM, Wong DC, Ziegler LE. PROMs for Pain in Adult Cancer Patients: A Systematic Review of Measurement Properties. *Pain Pract*. 2019;191.:93- 117. doi:10.1111/papr.12711

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Bártolo, A et al (2019) [Systematic Review] Effectiveness of psycho-educational interventions with telecommunication technologies on emotional distress and quality of life of adult cancer patients: a systematic review[3]

The purpose of this study was to provide a comprehensive review of psycho-educational interventions using telecommunication technologies developed for adult cancer patients, assessing their effectiveness in reducing emotional distress and improving quality of life. Bártolo et al found the efficacy of interventions using distance approaches in the cancer setting is still not well-established. Further research should be conducted through well-designed studies with more interactive features that minimize the lack of face-to-face interaction. Programs using telecommunications technologies may reduce disparities in service delivery within this setting, minimizing geographic and socio-economic barriers to engagement in the interventions. With the current technological development, it is possible to perform more interactive interventions that stimulate therapist-patient interactions. However, available protocols in this field still employ basic resources: eg websites, email, and videos. Young adult cancer patients are exposed to additional requirements related to fertility and parenthood. New intervention approaches should consider their informational needs.

Hernandez Silva, E et al (2019) [Systematic Review] The effectiveness of mHealth for self-management in improving pain, psychological distress, fatigue, and sleep in cancer survivors: a systematic review[4]

The authors aim to assess the effectiveness of mHealth applications for self-management in improving pain, psychological distress, fatigue, or sleep outcomes in adult cancer survivors. Experimental quantitative studies evaluating apps aiming to support self-management for adult cancer survivors and reporting pain, psychological distress, fatigue, or sleep outcomes were included. There is emerging evidence that mHealth interventions that support self-management can improve pain and fatigue

[3] Bártolo A, Pacheco E, Rodrigues F, Pereira A, Monteiro S, Santos IM. Effectiveness of psycho-educational interventions with telecommunication technologies on emotional distress and quality of life of adult cancer patients: a systematic review. *Disabil Rehabil.* 2019;418.:870- 878. doi:10.1080/09638288.2017.1411534

[4] Hernandez Silva E, Lawler S, Langbecker D. The effectiveness of mHealth for self-management in improving pain, psychological distress, fatigue, and sleep in cancer survivors: a systematic review. *J Cancer Surviv.* 2019;131.:97- 107. doi:10.1007/s11764-018-0730-8

outcomes in cancer survivors, and some promise for psychological distress and sleep outcomes. Further development and investigation of mHealth is needed, incorporating targeted, evidence-based models of care into app design. mHealth interventions can improve outcomes for cancer survivors and have significant potential to benefit this growing population due to their reach.

Jongerius, C et al (2019) [Systematic Review] Research-tested mobile apps for breast cancer care: systematic review[5]
The main objective of this review was to provide an overview of the available research-tested interventions using mHealth apps and their impact on breast cancer care. The results indicate consistent and promising findings of interventions using mHealth apps that target care management in breast cancer. Among the categories of mHealth apps focusing on survivorship, mHealth-based interventions showed a positive effect by promoting weight loss, improving the quality of life, and decreasing stress. There is conflicting and less conclusive data on the effect of mHealth apps on psychological dimensions. The authors advocate further investigation to confirm and strengthen these findings. No consistent evidence for the impact of interventions using mHealth apps in breast cancer prevention and early detection was identified due to the limited number of studies identified by the search. Future research should continue to explore the impact of mHealth apps on breast cancer care to build on these initial recommendations.

Vergani, L et al (2019) [Systematic Review] Training cognitive functions using mobile apps in breast cancer patients: systematic review[6]
This systematic review gives an overview of the state-of-the-art mobile apps aimed at training cognitive functions to better understand whether these apps could be useful tools to counteract cognitive impairment in breast cancer patients. The authors systematically searched all the full-text articles from both PubMed and Embase. Their results highlight the lack of empirical evidence on the efficacy of currently available apps to train cognitive function. Cognitive domains are not well defined across studies. It is noteworthy that no apps are specifically developed for cancer patients, and their applicability to breast cancer should not be taken for granted.

[5] Jongerius C, Russo S, Mazzocco K, Pravettoni G. Research-Tested Mobile Apps for Breast Cancer Care: Systematic Review. *JMIR Mhealth Uhealth*. 2019;72.:e10930. Published 2019 Feb 11. doi:10.2196/10930
[6] Vergani L, Marton G, Pizzoli SFM, Monzani D, Mazzocco K, Pravettoni G. Training Cognitive Functions Using Mobile Apps in Breast Cancer Patients: Systematic Review. *JMIR Mhealth Uhealth*. 2019;73.:e10855. Published 2019 Mar 19. doi:10.2196/10855

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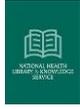
Future studies should test the feasibility, usability, and effectiveness of available cognitive training apps in women with breast cancer. Due to the complexity and multidimensionality of cognitive difficulties in this cancer population, it may be useful to design, develop, and implement an ad hoc app targeting cognitive impairment in breast cancer patients.

Han, CJ et al (2018) [Systematic Review] Interventions using social media for cancer prevention and management: a systematic review[7]
Han et al aim to systematically review intervention studies using social media for cancer care. A systematic search, using seven electronic databases was conducted to identify surveys and interventions using contemporary social media tools with a focus on cancer. Based on their findings, the authors conclude that social media tools have the potential to be effective in delivering interventions for cancer prevention and management. However, there was a dearth of studies with rigorous study methodologies to test social media effects on various cancer-related clinical outcomes. Social media use in cancer care will facilitate improved communication and support among patients, caregivers, and clinicians and, ultimately, improved patient care. Clinicians need to carefully harness social media to enhance patient care and clinical outcomes.

Moradian, S et al (2018) [Systematic Review] Effectiveness of Internet-based interventions in managing chemotherapy-related symptoms in patients with cancer: a systematic literature review[8]
The aims of this review were to: 1. examine the effectiveness of Internet-based interventions on cancer chemotherapy-related physical symptoms [severity and/or distress] and health-related quality of life outcomes; and 2. identify the design elements and processes for implementing these interventions in oncology practices. Despite the evidence in support of using the Internet as a worthwhile tool for effective patient engagement and self-management of chemotherapy-related symptoms outside clinic visits, methodological limitations in the evidence base require further well-planned and quality research.

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[7] Han CJ, Lee YJ, Demiris G. Interventions Using Social Media for Cancer Prevention and Management: A Systematic Review. *Cancer Nurs*. 2018;416.:E19- E31. doi:10.1097/NCC.0000000000000534

[8] Moradian S, Voelker N, Brown C, Liu G, Howell D. Effectiveness of Internet-based interventions in managing chemotherapy-related symptoms in patients with cancer: a systematic literature review. *Support Care Cancer*. 2018;262.:361- 374. doi:10.1007/s00520-017-3900-8

Chen, YY et al (2018) [Meta-Analysis] Effect of telehealth intervention on breast cancer patients' quality of life and psychological outcomes: A meta-analysis[9]

Telehealth intervention has been proposed as an innovative intervention approach to breast cancer patients, but there are still conflicting results in the literature about its effect. PubMed, EMBASE, CENTRAL and China National Knowledge Infrastructure were searched from inception to October 2016 for randomized controlled trials which assessed the effect of telehealth intervention versus usual care in breast cancer patients. Telehealth intervention is superior to usual care in breast cancer patients for improved quality of life, higher self-efficacy and less depression, distress, and perceived stress. However, these results should be recognized cautiously due to between-study heterogeneity, indicating that further well-designed RCTs are warranted.

Cox, A et al (2017) [Systematic Review] Cancer survivors' experience with telehealth: a systematic review and thematic synthesis[10]

The objective of this study was to systematically identify, appraise, and synthesize qualitative research evidence on the experiences of adult cancer survivors participating in telehealth interventions, to characterize the patient experience of telehealth interventions for this group. Across the included papers, three analytical themes emerged, each with three descriptive subthemes: 1. influence of telehealth on the disrupted lives of cancer survivors [convenience, independence, and burden]; 2. personalized care across physical distance [time, space, and the human factor]; and 3. remote reassurance-a safety net of health care professional connection [active connection, passive connection, and slipping through the net]. Telehealth interventions represent a convenient approach, which can potentially minimize treatment burden and disruption to cancer survivors' lives. Telehealth interventions can facilitate an experience of personalized care and reassurance for those living with and beyond cancer; however, it is important to consider individual factors when tailoring interventions to ensure engagement promotes benefit rather than burden. Telehealth interventions can provide cancer survivors with independence and reassurance. Future telehealth interventions need to be developed

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[9] Chen YY, Guan BS, Li ZK, Li XY. Effect of telehealth intervention on breast cancer patients' quality of life and psychological outcomes: A meta-analysis. *J Telemed Telecare*. 2018;243.:157- 167. doi:10.1177/1357633X16686777

[10] Cox A, Lucas G, Marcu A et al Cancer Survivors' Experience With Telehealth: A Systematic Review and Thematic Synthesis. *J Med Internet Res*. 2017;191.:e11. Published 2017 Jan 9. doi:10.2196/jmir.6575

iteratively in collaboration with a broad range of cancer survivors to maximize engagement and benefit.

Roberts, AL et al (2017) [Systematic Review and Meta-Analysis] Digital health behaviour change interventions targeting physical activity and diet in cancer survivors: a systematic review and meta-analysis[11]

Digital behaviour change interventions (DBCIs) have the potential to reach large numbers of cancer survivors. Roberts et al conducted a systematic review and meta-analyses of relevant studies identified by a search of Medline, EMBASE, PubMed and CINAHL. Studies which assessed a DBCI with measures of physical activity (PA), diet and/or sedentary behaviour were included. DBCIs may improve PA and BMI among cancer survivors, and there is mixed evidence for diet. The number of included studies is small, and risk of bias and heterogeneity was high. Future research should address these limitations with large, high-quality RCTs, with objective measures of PA and sedentary time. Digital technologies offer a promising approach to encourage health behaviour change among cancer survivors.

Randomised Controlled Trials

Greer, JA et al (2020) [Randomised Controlled Trial] Randomized trial of a smartphone mobile app to improve symptoms and adherence to oral therapy for cancer[12]

The authors conducted a randomized trial to test the use of a smartphone mobile app to improve symptoms and adherence to oral cancer therapy. From February 18, 2015, through December 31, 2016, 181 patients with diverse cancers who were prescribed oral therapy were randomized to receive either the smartphone mobile app or standard care. The mobile app included a medication plan with reminders, a symptom-reporting module, and patient education. Primary outcomes were adherence (per electronic pill caps), symptom burden (per MD Anderson Symptom Inventory), and quality of life (per the Functional Assessment of Cancer Therapy-General). Participants

[11] Roberts AL, Fisher A, Smith L, Heinrich M, Potts HWW. Digital health behaviour change interventions targeting physical activity and diet in cancer survivors: a systematic review and meta-analysis. *J Cancer Surviv.* 2017;116.:704- 719. doi:10.1007/s11764-017-0632-1
[12] Greer JA, Jacobs JM, Pensak N et al Randomized Trial of a Smartphone Mobile App to Improve Symptoms and Adherence to Oral Therapy for Cancer. *J Natl Compr Canc Netw.* 2020;182.:133- 141. doi:10.6004/jnccn.2019.7354

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also completed self-report measures of medication adherence, anxiety and depression symptoms, social support, quality of care, and healthcare utilization. Although the mobile app may not improve outcomes for all patients prescribed oral cancer therapy, the intervention may be beneficial for those with certain risk factors, such as difficulties with adherence or anxiety.

Handa, S et al (2020) [Randomised Controlled Trial] Effectiveness of a smartphone application as a support tool for patients undergoing breast cancer chemotherapy: a randomized controlled trial[13]

The effectiveness of a smartphone application as a support tool for patients undergoing breast cancer chemotherapy was tested in a randomized clinical trial, with 102 patients assigned to an app-using or a control group. Hospital-related anxiety, health literacy, and side effects were recorded. Sharing patients' reports through a smartphone app might optimize chemotherapy and deliver suitable support. Of the 102 patients, 95 completed the present study. No significant improvement was seen in anxiety, depression, or health literacy at the end of treatment between the BPSS and no-BPSS app groups. Overall, 1868 side effects were reported. When the patients' records were compared with the medical staff records, the analysis revealed that the medical staff had underestimated some grade 3 symptoms. The BPSS app is a feasible tool for patients with breast cancer and might be useful as a support tool for information sharing between patients and medical staff in an effort to optimize chemotherapy and deliver suitable patient care and support.

Zhou, K et al (2020) [Randomised Controlled Trial] Benefits of a WeChat-based multimodal nursing program on early rehabilitation in postoperative women with breast cancer: A clinical randomized controlled trial[14]

This study aimed to evaluate the benefits of a WeChat-based multimodal nursing program on early rehabilitation in postoperative women with breast cancer. The researchers recruited patients with breast cancer and randomly allocated them to the intervention and control groups. The former was

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[13] Handa S, Okuyama H, Yamamoto H, Nakamura S, Kato Y. Effectiveness of a Smartphone Application as a Support Tool for Patients Undergoing Breast Cancer Chemotherapy: A Randomized Controlled Trial [published online ahead of print, 2020 Feb 26]. *Clin Breast Cancer*. 2020;S1526-8209(20)30020-3. doi:10.1016/j.clbc.2020.01.004

[14] Zhou K, Wang W, Zhao W et al Benefits of a WeChat-based multimodal nursing program on early rehabilitation in postoperative women with breast cancer: A clinical randomized controlled trial [published online ahead of print, 2020 Mar 7]. *Int J Nurs Stud*. 2020;106:103565. doi:10.1016/j.ijnurstu.2020.103565

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subjected to the WeChat-based multimodal nursing program plus routine nursing care for 6 months, whereas the latter received only routine nursing care. They found a significant improvement in the health-related quality of life of postoperative women with breast cancer who used the WeChat-based multimodal nursing program during early rehabilitation. This demonstrated that the program is an effective intervention for postoperative rehabilitation in such patients. Findings of the study will provide evidence for eHealth services in clinical and transitional nursing care.

Ariza-Garcia, A et al (2019) [Randomised Controlled Trial] A web-based exercise system (e-CuidateChemo) to counter the side effects of chemotherapy in patients with breast cancer: randomized controlled trial[15]

This study aimed to evaluate the effectiveness of a web-based exercise program e-CuidateChemo to mitigate the side effects of chemotherapy on the physical being, anthropometric aspects, and body composition. A total of 68 patients diagnosed with breast cancer, who were undergoing chemotherapy, were enrolled. The patients were categorized into two groups: e-CuidateChemo (n=34) and controls (n=34). The e-CuidateChemo group participated in an adapted 8-week tailored exercise program through a web-based system. A blinded, trained researcher assessed functional capacity, strength, anthropometric parameters, and body composition. The intervention effects were tested using analysis of covariance and Cohen d tests. This paper showed that a web-based exercise program was effective in reversing the detriment in functional capacity and strength due to chemotherapy.

Kelleher, SA et al (2019) [Randomised Controlled Trial] A behavioral cancer pain intervention: A randomized noninferiority trial comparing in-person with videoconference delivery[16]

This study compared videoconference-delivered mobile health pain coping skills training (mPCST) to in-person pain coping skills training (PCST-traditional). This was a randomized, non-inferiority trial with cancer patients. Participants were randomly assigned to four, 45-minute sessions of mPCST

[15] Ariza-Garcia A, Lozano-Lozano M, Galiano-Castillo N, Postigo-Martin P, Arroyo-Morales M, Cantarero-Villanueva I. A Web-Based Exercise System (e-CuidateChemo) to Counter the Side Effects of Chemotherapy in Patients With Breast Cancer: Randomized Controlled Trial. *J Med Internet Res*. 2019;217.:e14418. Published 2019 Jul 24. doi:10.2196/14418

[16] Kelleher SA, Winger JG, Dorfman CS et al A behavioral cancer pain intervention: A randomized noninferiority trial comparing in-person with videoconference delivery [published correction appears in Psychooncology. 2020 Jan;291.:237]. *Psycho-oncology*. 2019;288.:1671-1678. doi:10.1002/pon.5141

or PCST-traditional. Session content focused on evidence-based cognitive and behavioural pain management skills. Assessments were completed at baseline, post-treatment, and 3-month post-treatment and included measures of primary intervention outcomes [ie pain severity and pain interference] and secondary intervention outcomes [ie physical symptoms, psychological distress, physical well-being, and self-efficacy]. The authors conclude that mPCST is highly accessible and noninferior to PCST-traditional.

Kubo, A et al (2019) [Randomised Controlled Trial] A randomized controlled trial of mHealth mindfulness intervention for cancer patients and informal cancer caregivers: a feasibility study within an integrated health care delivery system[17]

The purpose of this research was to assess feasibility and preliminary efficacy of a mobile/online-based (mHealth) mindfulness intervention for cancer patients and their caregivers to reduce distress and improve quality of life (QoL). Two-arm randomized controlled trial within Kaiser Permanente Northern California targeting cancer patients who received chemotherapy and their informal caregivers. The intervention group received a commercially available mindfulness program for 8 weeks. The wait-list control group received usual care. Kubo et al assessed feasibility using retention and adherence rates and obtained participant-reported data on distress, QoL, sleep, mindfulness, and posttraumatic growth before and immediately after the intervention. The authors conclude that results from fully powered efficacy trials would inform the potential for clinicians to use this scalable intervention to help improve QoL of those affected by cancer and their caregivers.

Van Blarigan, EL et al (2019) [Randomised Controlled Trial] Self-monitoring and reminder text messages to increase physical activity in colorectal cancer survivors (Smart Pace): a pilot randomized controlled trial[18]

Van Blarigan et al conducted a 2-arm non-blinded pilot randomised controlled trial. Participants were randomised 1:1 to receive the intervention with print educational materials or print educational materials alone. They

[17] Kubo A, Kurtovich E, McGinnis M et al A Randomized Controlled Trial of mHealth Mindfulness Intervention for Cancer Patients and Informal Cancer Caregivers: A Feasibility Study Within an Integrated Health Care Delivery System. *Integr Cancer Ther.* 2019;18:1534735419850634. doi:10.1177/1534735419850634

[18] Van Blarigan EL, Chan H, Van Loon K et al Self-monitoring and reminder text messages to increase physical activity in colorectal cancer survivors (Smart Pace): a pilot randomized controlled trial. *BMC Cancer.* 2019;191.:218. Published 2019 Mar 11. doi:10.1186/s12885-019-5427-5

explored the impact of the intervention versus usual care on physical activity using ActiGraph GT3X+ accelerometers pre-/post-intervention. They screened 406 individuals and randomised 42 to intervention (n = 21) or control (n = 21) groups. During the 12-week study, the intervention arm wore their Fitbits a median of 74 days [88% of days in study period, interquartile range: 23-83 days] and responded to a median of 34 out of 46 text messages that asked for a reply [interquartile range: 13-38 text messages]. Among the 16 intervention participants who completed the feedback survey, the majority (88%) reported that the intervention motivated them to exercise and that they were satisfied with their experience. No statistically significant difference in change in moderate-to-vigorous physical activity was found from baseline to 12 weeks between arms. A 12-week physical activity intervention with a Fitbit and text messages was feasible and acceptable among colorectal cancer patients after curative treatment. Larger studies are needed to determine whether the intervention increases physical activity.

Wall, LR et al (2019) [Randomised Controlled Trial] Economic analysis of a three-arm RCT exploring the delivery of intensive, prophylactic swallowing therapy to patients with head and neck cancer during (chemo) radiotherapy[19]

Research advocates for the use of intensive, prophylactic swallowing therapy to help reduce the severity of dysphagia in patients receiving (chemo) radiotherapy (CRT) for head/neck cancer (HNC). Unfortunately, the intensity of this therapy, coupled with growing patient numbers and limited clinical resources, provides challenges to many international cancer facilities. Telepractice has been proposed as a potential method to provide patients with greater support in home-practice, whilst minimising burden to the health service. This study investigated the clinical and patient-attributable costs of delivering an intensive, prophylactic swallowing therapy protocol via a new telepractice application SwallowIT as compared to clinician-directed FTF therapy and independent patient self-directed therapy. SwallowIT provided a cost-efficient model of care when compared to the clinician-directed model. The SwallowIT model also proved more cost-effective than the patient-directed model, yielding clinically significantly superior QoL at the end of (C)RT, for comparable costs. Overall, when

[19] Wall LR, Kularatna S, Ward EC et al Economic Analysis of a Three-Arm RCT Exploring the Delivery of Intensive, Prophylactic Swallowing Therapy to Patients with Head and Neck Cancer During (Chemo)Radiotherapy. *Dysphagia*. 2019;345.:627- 639. doi:10.1007/s00455-018-9960-1

compared to the alternate methods of service-delivery, SwallowIT provided a financially viable and cost-effective method for the delivery of intensive, prophylactic swallowing therapy to patients with HNC during (C)RT.

Yang, J et al (2019) [Randomised Controlled Trial] Development and testing of a mobile app for pain management among cancer patients discharged from hospital treatment: randomized controlled trial[20]
The aim was to design, construct, and test the Pain Guard app in patients managing cancer pain, evaluate the total remission rate of pain and the improvement in quality of life (QoL) to improve pain management for cancer pain patients, and assess patient acceptance of the app. This randomised controlled double-arm study involved 58 patients with cancer pain symptoms. Participants were randomly assigned to a group receiving care through the Pain Guard app or to a control group who received only traditional pharmaceutical care. The system's usability, feasibility, app compliance, and satisfaction were also assessed. The primary outcome was remission rate of pain, and secondary outcomes were medication adherence, improvements in QoL, frequency of breakthrough cancer pain (BTcP), incidence of adverse reactions, and satisfaction of patients. Pain Guard was effective for the management of pain in discharged patients with cancer pain, and its operability was effective and easily accepted by patients.

Graetz, I et al (2018) [Randomised Controlled Trial] Use of a web-based app to improve breast cancer symptom management and adherence for aromatase inhibitors: a randomized controlled feasibility trial[21]
Graetz et al conducted a pilot randomized controlled trial to test the use of a web-based application (app) designed with and without weekly reminders for patients to report real-time symptoms and AI use outside of clinic visits with built-in alerts to patients' oncology providers. Their goal was to improve symptom burden and medication adherence. Forty-four women with early-stage breast cancer and a new AI prescription were randomized to either an App+Reminder [weekly reminders to use app] or an App [no reminders] group. Pre- and post-assessment data were collected from all participants. Weekly reminders to use a web-based app to report AI adherence and

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[20] Yang J, Weng L, Chen Z et al Development and Testing of a Mobile App for Pain Management Among Cancer Patients Discharged From Hospital Treatment: Randomized Controlled Trial. *JMIR Mhealth Uhealth*. 2019;75.:e12542. Published 2019 May 29. doi:10.2196/12542

[21] Graetz I, McKillop CN, Stepanski E, Vidal GA, Anderson JN, Schwartzberg LS. Use of a web-based app to improve breast cancer symptom management and adherence for aromatase inhibitors: a randomized controlled feasibility trial. *J Cancer Surviv*. 2018;124.:431- 440. doi:10.1007/s11764-018-0682-z

treatment-related symptoms demonstrated feasibility and improved short-term AI adherence, which may reduce symptom burden for women with breast cancer and a new AI prescription. If short-term gains in adherence persist, this low-cost intervention could improve survival outcomes for women with breast cancer. A larger, long-term study should examine if AI adherence and symptom burden improvements persist for a 5-year treatment period.

Kim, HJ et al (2018) [Randomised Controlled Trial] A mobile game for patients with breast cancer for chemotherapy self-management and quality-of-life improvement: randomized controlled trial[22]
The objective of this study was to evaluate if patient education using a mobile game may increase drug compliance, decrease physical side effects of chemotherapy, and improve psychological status in breast cancer patients. A total of 76 patients with metastatic breast cancer who were planned to receive cytotoxic chemotherapy were enrolled in this trial. Study participants were randomly assigned to a mobile game play group or a conventional education group. The patients were unblinded and followed prospectively for three weeks. Outcome measures included time spent for education, compliance to medication, physical side effects, and psychological side effects including quality of life (QoL). Results from the study suggest the feasibility and potentiality of the use of smartphone mobile games for patients with breast cancer receiving chemotherapy. Education using a mobile game led to better patient education, improved drug compliance, decreased side effects, and better QoL compared with conventional education. Mobile games can be used as easy, fun, and effective measures for patient education and have the potential to improve treatment outcomes.

Ormel, HL et al (2018) [Randomised Controlled Trial] Self-monitoring physical activity with a smartphone application in cancer patients: a randomized feasibility study (SMART-trial)[23]
This study aimed to examine whether using RunKeeper to increase self-reported PA is feasible in cancer patients and to evaluate patients' opinion

[22] Kim HJ, Kim SM, Shin H, Jang JS, Kim YI, Han DH. A Mobile Game for Patients With Breast Cancer for Chemotherapy Self-Management and Quality-of-Life Improvement: Randomized Controlled Trial. *J Med Internet Res*. 2018;20(10):e273. Published 2018 Oct 29. doi:10.2196/jmir.9559

[23] Ormel HL, van der Schoot GGF, Westerink NL, Sluiter WJ, Gietema JA, Walenkamp AME. Self-monitoring physical activity with a smartphone application in cancer patients: a randomized feasibility study (SMART-trial). *Support Care Cancer*. 2018;26(11):3915-3923. doi:10.1007/s00520-018-4263-5

about using RunKeeper in a 12-week programme. Self-monitoring PA with RunKeeper was safe and feasible in cancer patients. Adult patients (n = 32), diagnosed with cancer, were randomised between usual care (n = 16) or a 12-week intervention with instructions to self-monitor PA with RunKeeper (n = 16). Changes in PA were determined with the Physical Activity Scale for the Elderly (PASE) at baseline (T0), 6 weeks (T1), and 12 weeks (T2). Usability and patients' experiences were tested at T2 with the System Usability Scale (SUS) and a semi-structured interview. The RunKeeper use resulted in an increase in PA after 6 weeks. Ormel et al conclude that RunKeeper usability was rated good and can be used to study PA in cancer patients.

Petzel, SV et al (2018) [Randomised Controlled Trial] Effects of web-based instruction and patient preferences on patient-reported outcomes and learning for women with advanced ovarian cancer: A randomized controlled trial[24]

A randomised controlled trial was conducted of a web-based intervention to improve advanced care planning in women with ovarian cancer. A secondary analysis of 35 randomized women focused on changes in distress and knowledge about ovarian cancer through distress monitoring and information tailored to patients' cognitive coping style. Pre-/postresults indicated the Intervention group demonstrated lower distress (p = 0.06); blunting was associated with lower depression (p = 0.04); knowledge in both groups was unchanged. Women in the Intervention vs. Control group reported their family was less likely to be upset by cancer information (p = 0.0004). This intervention reduced distress while incorporating patient preferences.

Bray, VJ et al (2017) [Randomised Controlled Trial] Evaluation of a web-based cognitive rehabilitation program in cancer survivors reporting cognitive symptoms after chemotherapy[25]

Bray et al evaluated a cognitive rehabilitation program (Insight) and compared it with standard care in cancer survivors self-reporting cognitive symptoms. They recruited adult cancer survivors with a primary malignancy

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[24] Petzel SV, Isaksson Vogel R, Cragg J et al Effects of web-based instruction and patient preferences on patient-reported outcomes and learning for women with advanced ovarian cancer: A randomized controlled trial. *J Psychosoc Oncol.* 2018;364.:503- 519. doi:10.1080/07347332.2018.1457125

[25] Bray VJ, Dhillon HM, Bell ML et al Evaluation of a Web-Based Cognitive Rehabilitation Program in Cancer Survivors Reporting Cognitive Symptoms After Chemotherapy. *J Clin Oncol.* 2017;352.:217- 225. doi:10.1200/JCO.2016.67.8201

excluding central nervous system malignancies who had completed three or more cycles of adjuvant chemotherapy in the previous 6 to 60 months and reported persistent cognitive symptoms. All participants received a 30-minute telephone consultation and were then randomly assigned to the 15-week, home-based intervention or to standard care. The intervention, Insight, led to improvements in cognitive symptoms compared with standard care. To the authors' knowledge, this is the first large randomized controlled trial showing an improvement in self-reported cognitive function in cancer survivors, indicating that this intervention is a feasible treatment.

Mooney, KH et al (2017) [Randomised Controlled Trial] [Automated home monitoring and management of patient-reported symptoms during chemotherapy: results of the symptom care at home RCT](26)
In a randomised controlled trial, the efficacy of an automated symptom management system was tested to determine if it reduced chemotherapy-related symptoms. Prospectively, 358 patients beginning chemotherapy were randomized to the Symptom Care at Home (SCH) intervention (n = 180) or enhanced usual care (UC) (n = 178). Participants called the automated monitoring system daily reporting severity of 11 symptoms. SCH participants received automated self-management coaching and nurse practitioner (NP) telephone follow-up for poorly controlled symptoms. NPs used a guideline-based decision support system. Primary endpoints were symptom severity across all symptoms, and the number of severe, moderate, mild, and no symptom days. A secondary endpoint was individual symptom severity. All individual symptoms, except diarrhoea, were significantly lower for SCH participants ($P < 0.05$). Symptom Care at Home dramatically improved symptom outcomes. These results demonstrate that symptoms can be improved through automated home monitoring and follow-up to intensify care for poorly controlled symptoms.

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[26] Mooney KH, Beck SL, Wong B et al Automated home monitoring and management of patient-reported symptoms during chemotherapy: results of the symptom care at home RCT. *Cancer Med.* 2017;63.:537– 546. doi:10.1002/cam4.1002

Zhu, J et al (2017) [Randomised Controlled Trial] A mobile application of breast cancer e-support program versus routine care in the treatment of Chinese women with breast cancer undergoing chemotherapy: study protocol for a randomized controlled trial[27]

Breast Cancer e-Support is a mobile application program that provides patients with individually tailored information and a support group of peers and health care professionals. Breast Cancer e-Support aims to promote women's self-efficacy, social support and symptom management, thus improving their quality of life and psychological well-being. This is the first study of its kind in China to evaluate the use of a mobile application intervention with a rigorous research design and theoretical framework. This study will contribute to evidence regarding the effectiveness of a theory-based mobile application to support women with breast cancer undergoing chemotherapy. The results should provide a better understanding of the role of self-efficacy and social support in reducing symptom distress and of the credibility of using a theoretical framework to develop Internet-based interventions. The results will provide evidence to support the implementation of an innovative and easily accessible intervention that enhances health outcomes.

Basch, E et al (2016) [Randomised Controlled Trial] Symptom monitoring with patient-reported outcomes during routine cancer treatment: a randomized controlled trial[28]

There is growing interest to enhance symptom monitoring during routine cancer care using patient-reported outcomes, but evidence of impact on clinical outcomes is limited. The authors randomly assigned patients receiving routine outpatient chemotherapy for advanced solid tumours to report 12 common symptoms via tablet computers or to receive usual care consisting of symptom monitoring at the discretion of clinicians. Those with home computers received weekly e-mail prompts to report between visits. Treating physicians received symptom printouts at visits, and nurses received e-mail alerts when participants reported severe or worsening symptoms. The primary outcome was change in health-related quality of life at 6 months compared with baseline, measured by the EuroQol EQ-5D Index.

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[27] Zhu J, Ebert L, Liu X, Chan SW. A mobile application of breast cancer e-support program versus routine Care in the treatment of Chinese women with breast cancer undergoing chemotherapy: study protocol for a randomized controlled trial. *BMC Cancer*. 2017;171.:291. Published 2017 Apr 26. doi:10.1186/s12885-017-3276-7

[28] Basch E, Deal AM, Kris MG et al Symptom Monitoring With Patient-Reported Outcomes During Routine Cancer Treatment: A Randomized Controlled Trial [published correction appears in J Clin Oncol. 2016 Jun 20;34(18):2198] [published correction appears in J Clin Oncol. 2019 Feb 20;376.:528]. *J Clin Oncol*. 2016;346.:557- 565. doi:10.1200/JCO.2015.63.0830

Secondary endpoints included emergency room visits, hospitalizations, and survival. Benefits were greater for participants lacking prior computer experience. Most patients receiving intervention (63%) reported severe symptoms during the study. Nurses frequently initiated clinical actions in response to e-mail alerts. Clinical benefits were associated with symptom self-reporting during cancer care.

Egbring, M et al (2016) [Randomised Controlled Trial] A mobile app to stabilize daily functional activity of breast cancer patients in collaboration with the physician: a randomized controlled clinical trial[29]
The aim of the study was to evaluate the effects of a mobile app on patient-reported daily functional activity in a supervised and unsupervised setting. The researchers conducted a randomized controlled study of 139 breast cancer patients undergoing chemotherapy. Participants were randomly assigned to a control group, an unsupervised group that used a mobile app to record data, or a supervised group that used the app and reviewed data with a physician. The mobile app was associated with stabilized daily functional activity when used under collaborative review. App-using participants could more frequently report adverse events, and those under supervision made fewer and more precise entries than unsupervised participants. Our findings suggest that patient well-being and awareness of chemotherapy adverse effects can be improved by using a mobile app in collaboration with the treating physician.

Foley, NM et al (2016) [Randomised Controlled Trial] PATI: Patient accessed tailored information: A pilot study to evaluate the effect on preoperative breast cancer patients of information delivered via a mobile application[30]
The aim of this project was to evaluate the effects of a mobile information application on anxiety levels of patients undergoing surgery for breast cancer. An application was developed for use with Apple iPad containing information on basic breast cancer biology, different treatments used and surgical techniques. Anxiety and depression in breast cancer patients is both multifactorial and significant, with anxiety levels directly correlating with

[29] Egbring M, Far E, Roos M et al A Mobile App to Stabilize Daily Functional Activity of Breast Cancer Patients in Collaboration With the Physician: A Randomized Controlled Clinical Trial. *J Med Internet Res*. 2016;18(9):e238. Published 2016 Sep 6. doi:10.2196/jmir.6414

[30] Foley NM, O'Connell EP, Lehane EA et al PATI: Patient accessed tailored information: A pilot study to evaluate the effect on preoperative breast cancer patients of information delivered via a mobile application. *Breast*. 2016;30:54–58. doi:10.1016/j.breast.2016.08.012

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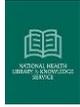
reduced quality of life. Intuitively, information should improve anxiety levels; however, Foley et al have demonstrated that surgical patients with less information reported significantly lower anxiety. They advise the thorough testing and auditing of information initiatives before deployment.

Kim, KK et al (2016) [Randomised Controlled Trial] A personal health network for chemotherapy care coordination: evaluation of usability among patients[31]

This study evaluates the usability of the "personal health network" (PHN), a novel solution leveraging social networking and mobile technologies, among individuals undergoing chemotherapy and receiving care coordination. Early results from interviews of 12 participants in a randomized pragmatic trial suggest that they feel more connected to the healthcare team using the PHN, find value in access to the patient education library, and are better equipped to organise the many activities that occur during chemotherapy. Improvements are needed in navigation, connectivity, and integration with electronic health records. Findings contribute to improvements in the PHN, and inform a roadmap for potentially greater impact in technology-enabled cancer care coordination.

Schwenk, M et al (2016) [Randomised Controlled Trial] Interactive sensor-based balance training in older cancer patients with chemotherapy-induced peripheral neuropathy: A randomized controlled trial[32]

This pilot study investigated the effect of an interactive motor adaptation balance training program based on wearable sensors for improving balance in older cancer patients with CIPN. Twenty-two patients (age: 70.3 +/- 8.7 years) with objectively confirmed CIPN were randomised to either an intervention or a control group. The intervention group received interactive game-based balance training including repetitive weight shifting and virtual obstacle crossing tasks. Wearable sensors provided real-time visual/auditory feedback from the lower limb trajectory and allowed the perception of motor errors during each motor action. The control group received no exercise intervention and continued their normal activity. This proof-of-concept study demonstrates that older cancer patients with CIPN can significantly improve their postural balance with specifically tailored,

[31] Kim KK, Bell JF, Bold R et al A Personal Health Network for Chemotherapy Care Coordination: Evaluation of Usability Among Patients. *Stud Health Technol Inform*. 2016;225:232-236.

[32] Schwenk M, Grewal GS, Holloway D, Muchna A, Garland L, Najafi B. Interactive Sensor-Based Balance Training in Older Cancer Patients with Chemotherapy-Induced Peripheral Neuropathy: A Randomized Controlled Trial. *Gerontology*. 2016;625.:553-563. doi:10.1159/000442253

sensor-based exercise training. The training approach has potential as a therapy for improving CIPN-related postural control deficits. However, future studies comparing the proposed technology-based training with traditional balance training are required to evaluate the benefit of the interactive joint movement feedback.

Siekkinen, M et al (2015) [Randomised Controlled Trial] Psychosocial outcomes of e-feedback of radiotherapy for breast cancer patients: a randomized controlled trial[33]

This study aims to test the effectiveness on psychosocial outcomes of electronic feedback knowledge of radiotherapy intervention [e-Re-Know] for breast cancer patients. A randomised controlled trial in one university hospital in Finland was carried out. Breast cancer patients (n = 126) in the radiotherapy (RT) department were randomly assigned into two groups: intervention (the e-Re-Know and standard education) and control group (standard education). The e-Re-Know intervention consisted of e-feedback after response to the knowledge test delivered by e-mail. Instruments were completed before commencing first RT (M1), after concluding last RT (M2) and 3 months after last RT (M3). The main outcomes were anxiety and QOL. Compared with the control group, the patients in the intervention group reported a marginally significant improvement in anxiety and significant improvement in QOL over time. The e-Re-Know seems to have positive effects on psychosocial outcomes for breast cancer patients. They might gain additional value from the e-Re-Know over a longer time period. Further research needs to focus more on development of e-feedback in patient education.

Spoelstra, SL et al (2015) [Randomised Controlled Trial] A randomized controlled trial of the feasibility and preliminary efficacy of a texting intervention on medication adherence in adults prescribed oral anti-cancer agents: study protocol[34]

The aim of this study was to report a study protocol that examines feasibility, preliminary efficacy and satisfaction of a text message intervention on the outcome of medication adherence in adult patients prescribed oral anti-cancer agents. Research indicates patients miss nearly

[33] Siekkinen M, Pyrhönen S, Ryhänen A, Vahlberg T, Leino-Kilpi H. Psychosocial outcomes of e-feedback of radiotherapy for breast cancer patients: a randomized controlled trial. *Psycho-oncology.* 2015;245.:515- 522. doi:10.1002/pon.3684

[34] Spoelstra SL, Given CW, Sikorskii A et al A randomized controlled trial of the feasibility and preliminary efficacy of a texting intervention on medication adherence in adults prescribed oral anti-cancer agents: study protocol. *J Adv Nurs.* 2015;71(12):2965- 2976. doi:10.1111/jan.12714
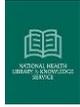
one-third of the prescribed oral anti-cancer agent dosages. Text message interventions have been shown to improve medication adherence in chronic conditions other than cancer. Standardised text message intervention protocol and detailed study procedures have been developed in this study to improve medication adherence.

Wang, P et al (2015) [Randomised Controlled Trial] Effect of remote Internet follow-up on postradiotherapy compliance among patients with esophageal cancer: a randomized controlled study[35]
The aim of this study was to explore the effects of using remote Internet follow-up on post-radiotherapy compliance with medical advice provided to patients with oesophageal cancer. A total of 128 patients with oesophageal squamous cell cancer treated with radiotherapy were randomly assigned to either an observation group or a control group. The control group received routine outpatient follow-up, whereas the observation group received additional remote Internet follow-up for six months after discharge from the hospital. The treatment effects and compliance were investigated using a questionnaire. At three months and six months after discharge, patients in the observation group had sought significantly more consultations and undergone more periodic re-examinations than patients in the control group. Furthermore, both the disease-free survival rate and the symptom reduction rate were significantly higher in the observation group compared with the control group. Wang et al conclude that remote Internet follow-up is an easy and fast method for improving post-radiotherapy compliance with medical instructions and promoting normalisation among patients with oesophageal cancer.

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[35] Wang P, Yang L, Hua Z. Effect of Remote Internet Follow-Up on Postradiotherapy Compliance Among Patients with Esophageal Cancer: A Randomized Controlled Study. *Telemed J E Health*. 2015;21(11):923-929. doi:10.1089/tmj.2014.0237

Miscellaneous

Coats, V et al (2020) [Pilot Study] Feasibility of an eight-week telerehabilitation intervention for patients with unresectable thoracic neoplasia receiving chemotherapy: A pilot study[36]

The aim of this study was to investigate the feasibility, adherence and satisfaction of a home-based telerehabilitation program [TELERP] with real-time physiological parameters acquisition in patients with unresectable thoracic neoplasia receiving chemotherapy and to explore its effects on patients' functional capacity. Five patients receiving chemotherapy followed an 8-week TELERP using real-time monitoring combined with interactive exercises. The TELERP included supervised and unsupervised exercise sessions. The feasibility of the TELERP, adverse outcomes and adherence were analysed. Six-minute walking test (6MWT) and timed stair test (TST) were done to assess functional capacity. These results support the feasibility of a TELERP and suggest that such intervention may contribute to maintain or improve functional capacity for patients with thoracic neoplasia receiving chemotherapy.

Potdar, R et al (2020) [Cross-Sectional Study] Access to Internet, smartphone usage, and acceptability of mobile health technology among cancer patients[37]

The use of mobile health (mHealth) technologies to augment patient care enables providers to communicate remotely with patients enhancing the quality of care and patient engagement. Few studies evaluated predictive factors of its acceptance and subsequent implementation, especially in medically underserved populations. A cross-sectional study of 151 cancer patients was conducted at an academic medical centre in the USA. A trained interviewer performed structured interviews regarding the barriers and facilitators of patients' current and desired use of mHealth technology for healthcare services. The study suggests that factors such as age,

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[36] Coats V, etal. Feasibility of an eight-week telerehabilitation intervention for patients with unresectable thoracic neoplasia receiving chemotherapy: A pilot study, *Canadian Journal of Respiratory, Critical Care, and Sleep Medicine*. 2020:41.:14–24, doi: 10.1080/24745332.2019.1575703. [Accessed 18 May 2020].

[37] Potdar R, Thomas A, DiMeglio M et al Access to Internet, smartphone usage, and acceptability of mobile health technology among cancer patients [published online ahead of print, 2020 Mar 12]. *Support Care Cancer*. 2020;10.1007/s00520-020-05393-1. doi:10.1007/s00520-020-05393-1

educational achievement, and access to Internet are significant predictors of acceptability of a mHealth application among cancer patients. Healthcare organisations should consider these factors when launching patient engagement platforms.

Osborn, J et al (2020) [Review] Do mHealth applications improve clinical outcomes of patients with cancer? A critical appraisal of the peer-reviewed literature[38]

The impact of usage of cancer-related mobile health (mHealth) applications on patient-related outcomes requires investigation. A critical appraisal of the literature was performed for the following question: In patients with cancer have mHealth applications been compared with usual care to examine impact on commonly used clinical outcomes? Smartphone applications or Internet portals collected data on symptoms or patient activity. Several studies showed statistically significant differences in patient-reported outcomes when symptom monitoring using mobile health application was compared to usual care. Change in mobility was the only outcome that was related directly to toxicity. Only limited data on mortality, cancer-related morbidity including complications of care, health-economic outcomes or long-term outcomes were reported. Studies on mHealth applications might improve aspects of symptom control in patients with cancer, but there is currently little evidence for impact on other outcomes. This requires future research in interventional studies.

Shalowitz, DI et al (2020) [Review] Telemedicine and gynecologic cancer care[39]

Patients with gynaecologic cancers experience better outcomes when treated by specialists and institutions with experience in their diseases. Unfortunately, high-volume centres tend to be located in densely populated regions, leaving many women with geographic barriers to care. Remote management through telemedicine offers the possibility of decreasing these disparities by extending the reach of specialty expertise and minimizing travel burdens. Telemedicine can assist in diagnosis, treatment planning, preoperative and postoperative follow-up, administration of chemotherapy, provision of palliative care, and surveillance. Telemedical infrastructure

[38] Osborn J, Ajakaiye A, Cooksley T, Subbe CP. Do mHealth applications improve clinical outcomes of patients with cancer? A critical appraisal of the peer-reviewed literature. *Support Care Cancer*. 2020;283.:1469-1479. doi:10.1007/s00520-019-04945-4

[39] Shalowitz DI, Smith AG, Bell MC, Gibb RK. Teleoncology for gynecologic cancers. *Gynecol Oncol.* 2015;1391.:172-177. doi:10.1016/j.ygyno.2015.06.042

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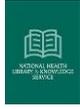
requires careful consideration of the needs of relevant stakeholders including patients, caregivers, referring clinicians, specialists, and health system administrators.

Al-Shamsi, HO et al (2020) [Review. Article in Press] A practical approach to the management of cancer patients during the novel coronavirus disease 2019 (COVID-19) pandemic: an international collaborative group [40]
In this review, the potential challenges associated with managing cancer patients during the COVID-19 infection pandemic will be addressed, with suggestions of some practical approaches. The main management strategies for treating cancer patients during the COVID-19 epidemic include clear communication and education about hand hygiene, infection control measures, high-risk exposure, and the signs and symptoms of COVID-19. Consideration of risk and benefit for active intervention in the cancer population must be individualized. Postponing elective surgery or adjuvant chemotherapy for cancer patients with low risk of progression should be considered on a case-by-case basis. Minimising outpatient visits can help to mitigate exposure and possible further transmission. Telemedicine may be used to support patients to minimize number of visits and risk of exposure.

Dorfman, CS et al (2019) [Clinical Trial] Development and pilot testing of an mHealth behavioral cancer pain protocol for medically underserved communities [41]
The purpose of this study was to refine and test a mobile-health behavioural cancer pain coping skills training protocol for women with breast cancer and pain from medically underserved areas. Three focus groups (Phase 1) were used to refine the initial protocol. A single-arm pilot trial (Phase 2) was conducted to assess feasibility, acceptability, and changes in outcomes. The intervention was delivered at a community-based clinic via videoconferencing technology. Participants were women with breast cancer and pain in medically underserved areas. Major themes from focus groups were used to refine the intervention. The refined intervention demonstrated feasibility and acceptability. Participants reported significant improvement in pain severity, pain interference, and self-efficacy for pain management. The intervention is feasible, acceptable, and likely to lead to improvement in

[40] Al-Shamsi HO, Alhazzani W, Alhuraiji A et al A Practical Approach to the Management of Cancer Patients During the Novel Coronavirus Disease 2019 (COVID-19) Pandemic: An International Collaborative Group [published online ahead of print, 2020 Apr 3]. *Oncologist*. 2020;10.1634/theoncologist.2020-0213. doi:10.1634/theoncologist.2020-0213

[41] Dorfman CS, Kelleher SA, Winger JG et al Development and pilot testing of an mHealth behavioral cancer pain protocol for medically underserved communities. *J Psychosoc Oncol*. 2019;373.:335- 349. doi:10.1080/07347332.2018.1479327

pain-related outcomes for breast cancer patients in medically underserved areas. Implications for Psychosocial Oncology Practice Breast cancer patients being treated in medically underserved areas have a dearth of exposure to behavioural interventions that may improve their ability to manage pain. Dorfman et al conclude that evidence from this single-arm pilot trial suggests their mobile-health behavioural cancer pain coping skills training protocol is acceptable and feasible in this vulnerable population. Appropriately adapted mobile-health technologies may provide an avenue to reach underserved patients and implement behavioural interventions to improve pain management.

Ohri, N et al (2019) [Clinical Trial] Daily step counts: a new prognostic factor in locally advanced non-small cell lung cancer?[42]
Ohri et al explore the prognostic value of baseline step count data captured using wearable devices for patients treated with definitive chemoradiation therapy for locally advanced non-small cell lung cancer (NSCLC). Patients with locally advanced NSCLC wore a commercial fitness tracker during a course of definitive, concurrent chemoradiation therapy as part of a clinical trial. Baseline activity level measured using wearable devices may help identify patients with NSCLC who are fit for concurrent chemoradiation therapy and can predict clinical outcomes in this setting.

Terstriep, SA et al (2019) [Conference Abstract] Use of remote symptom monitoring with breast cancer survivors using patient reported outcome measures through Epic Mychart[43]
This pilot study of breast cancer survivors assessed utilisation and satisfaction of proactive PRO symptom and adherence monitoring through an EHR patient portal (EPIC MyChart). Eighty breast cancer survivors who had completed surgery, chemotherapy, and/or radiation and received a survivorship care plan were randomised 1:1 either to usual care or PRO monitoring. The PRO group received questions from the NIH PROMIS toolkit through EPIC MyChart monthly between visits for 6 months. The triage nurse received an EPIC Inbasket alert if the survivor reported moderate to severe symptoms, had not taken their medication or reported they wanted to speak

[42] Ohri N, Halmos B, Bodner WR et al Daily Step Counts: A New Prognostic Factor in Locally Advanced Non-Small Cell Lung Cancer?. *Int J Radiat Oncol Biol Phys*. 2019;1054.:745-751. doi:10.1016/j.ijrobp.2019.07.055

[43] Shelby A et al Use of remote symptom monitoring with breast cancer survivors using patient reported outcome measures through Epic Mychart. *Journal of Clinical Oncology* 2019; 37:27_suppl, 208-208. doi: 10.1200/JCO.2019.37.27_suppl.208. [Accessed 19 May 2020].

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to a nurse. Participants in the control group were assessed for sadness, anxiety and satisfaction with provider communication at their usual follow visits. Remote electronic monitoring of symptoms and adherence through the EHR bet was feasible with high completion rates, improved satisfaction, and did not increase anxiety in breast cancer survivors. Follow up work is assessing PRO monitoring to improve efficiency of following cancer survivors, and implementation of survivorship care plans.

Bae, WK et al (2018) [Clinical Trial] Feasibility and accessibility of electronic patient-reported outcome measures using a smartphone during routine chemotherapy: a pilot study[44]
Bae et al evaluated the feasibility and accessibility of electronic patient-reported outcomes (PRO) measures using a smartphone (PRO-SMART) for cancer patients receiving routine chemotherapy. The proposed PRO-SMART application obtains daily personal health record (PHR) data from cancer patients via a smartphone. An analysis report of cumulative PHR data is provided to the clinician in a format suitable for upload to electronic medical records. Cancer outpatients who had received at least two cycles of chemotherapy, and who were scheduled for two more cycles were enrolled. This study suggests that the proposed PRO-SMART is feasible and accessible for assessment of symptomatic adverse events in cancer patients receiving chemotherapy for a prospective randomised trial.

Cheong, IY et al (2018) [Clinical Trial] Efficacy of mobile health care application and wearable device in improvement of physical performance in colorectal cancer patients undergoing chemotherapy[45]
The aim of this study was to evaluate the efficacy and feasibility of comprehensive mobile health care using a tailored rehabilitation program for colorectal cancer patients undergoing active chemotherapy. A total of 102 colorectal cancer patients undergoing chemotherapy underwent 12 weeks of smartphone aftercare through provision of a mobile application and wearable device that included a rehabilitation exercise program and information on their disease and treatment. The grip strength test, 30-second chair stand test, 2-minute walk test, amount of physical activity,

[44] Bae WK, Kwon J, Lee HW et al Feasibility and accessibility of electronic patient-reported outcome measures using a smartphone during routine chemotherapy: a pilot study. *Support Care Cancer*. 2018;26(11):3721-3728. doi:10.1007/s00520-018-4232-z
[45] Cheong IY, An SY, Cha WC et al Efficacy of Mobile Health Care Application and Wearable Device in Improvement of Physical Performance in Colorectal Cancer Patients Undergoing Chemotherapy. *Clin Colorectal Cancer*. 2018;172.:e353-e362. doi:10.1016/j.clcc.2018.02.002

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quality of life and nutritional status were assessed and measured at baseline, at mid-intervention, and at completion of the intervention. The rehabilitation exercise intensity was adjusted by the test results at every assessment and through real-time communication between the patients and clinicians. A tailored rehabilitation exercise programme provided through a comprehensive mobile health care application was effective in improving patients' physical capacity and treatment-related symptoms even during active chemotherapy.

Hardcastle, SJ et al (2018) [Clinical Trial] Acceptability and utility of, and preference for wearable activity trackers amongst non-metropolitan cancer survivors[46]

The study purpose was to investigate the acceptability and utility of, and preference for, wearable activity trackers (WATs) amongst cancer survivors living in regional and remote areas of Western Australia. Twenty participants were recruited to test two to three trackers from five available models: Fitbit Alta, Garmin Vivofit 2, Garmin Vivosmart, Polar loop 2 and Polar A300. Participants wore each device for two weeks, followed by a one-week washout period between devices. Interviews were conducted with participants to explore user perceptions and experiences. Interview transcripts were analysed using thematic analysis. Four main themes emerged: 1. consciousness raising; 2. prompts and feedback; 3. accuracy and registry of activities; and, 4. WAT preferences and features. WATs were acceptable and useful to cancer survivors. WATs increased self-awareness of physical activity, provided real time feedback in relation to step goals, and reinforced progress and efforts towards goals. The aesthetics of the WATs were deemed crucial in determining preference and likelihood of use. Future interventions may do well to have two different WATs available for participants to choose from, according to activity preferences, aesthetic preferences, and display size.

Devine, KA et al (2018) [Narrative Review] Digital health interventions for adolescent and young adult cancer survivors[47]

This narrative review describes the evidence regarding digital health interventions targeting adolescent and young adult (AYA) cancer survivors.

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[46] Hardcastle SJ, Galliott M, Lynch BM et al Acceptability and utility of, and preference for wearable activity trackers amongst non-metropolitan cancer survivors. *PLoS One*. 2018;13(12):e0210039. Published 2018 Dec 31. doi:10.1371/journal.pone.0210039

[47] Devine KA, Viola AS, Coups EJ, Wu YP. Digital Health Interventions for Adolescent and Young Adult Cancer Survivors. *JCO Clin Cancer Inform*. 2018;2:1-15. doi:10.1200/CCI.17.00138

Devine et al reviewed the published literature for studies involving Internet, mHealth, social media, telehealth, and other digital interventions for AYA survivors. They highlight selected studies to illustrate the state of the research in this unique patient population. Interventions have used various digital modalities to improve health behaviours, enhance emotional well-being, track and intervene on cancer-related symptoms, and improve survivorship care delivery. The majority of studies have demonstrated feasibility and acceptability of digital health interventions for AYA survivors, but few efficacy studies have been conducted. Digital health interventions are promising to address unmet psychosocial and health information needs of AYA survivors. Researchers should use rigorous development and evaluation methods to demonstrate the efficacy of these approaches to improve health outcomes for AYA survivors.

Cannon, C (2018) [Review] Telehealth, mobile applications, and wearable devices are expanding cancer care beyond walls[48]
The objective is to review telehealth solutions, mobile applications, and wearable devices that are currently impacting patients, caregivers, and providers who work in the oncology setting. A literature search was conducted using the terms (Telehealth, Mobile Health, mHealth, Wearable Devices) + (Oncology, Cancer Care). Cannon concludes there are many current applications of telehealth and mobile health in the oncology setting. Nurses who care for patients with cancer should be aware of the pervasiveness and impact of telehealth and mobile health to this unique population.

Fallahzadeh, R et al (2018) [Review] Digital health for geriatric oncology[49]
In this review, the authors describe state-of-the-art digital health solutions for geriatric oncology and explore the potential application of emerging remote health-monitoring technologies in the context of cancer care. They also discuss the benefits and motivations behind adopting technology for symptom monitoring of older adults with cancer. They provide an overview of common symptoms and of the digital solutions-designed remote symptom assessment. They describe state-of-the-art systems for this purpose and highlight the limitations and challenges for the full-scale

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[48] Cannon C. Telehealth, Mobile Applications, and Wearable Devices are Expanding Cancer Care Beyond Walls. *Semin Oncol Nurs*. 2018;342.:118-125. doi:10.1016/j.soncn.2018.03.002

[49] Fallahzadeh R, Rokni SA, Ghasemzadeh H, Soto-Perez-de-Celis E, Shahrokni A. Digital Health for Geriatric Oncology. *JCO Clin Cancer Inform*. 2018;2:1-12. doi:10.1200/CCI.17.00133

adoption of such solutions in geriatric oncology. They conclude that perhaps the clearest path to future large-scale use of remote digital health technologies in cancer research is designing and conducting collaborative studies involving computer scientists, oncologists, and patient advocates.

Gabrys, L et al (2017) [Clinical Trial] Real-time visual activity feedback for physical activity improvement in breast and colon cancer patients[50]

The study aims to evaluate the effects and feasibility of a biofeedback device for physical activity (PA) improvement in breast and colon cancer patients. Daily PA of 19 cancer patients was measured by accelerometry (ActiGraph, GT1 M). Additionally, patients wore a motion sensor with real-time visual activity feedback (ActiSmile). Counts per minutes (cpm) and moderate to vigorous physical activity (MVPA) were calculated and patients' activity data were compared to PA of 20 age-matched healthy controls. Baseline PA of patients was lower compared to controls. Following visual real-time feedback cancer patients increased cpm by 21% (p = .002) and MVPA by 9% (p = .007) compared to baseline measurement. PA levels in cancer patients obtained with visual feedback became almost equal compared to age-matched healthy controls: cpm (301; IQR 170 vs. 299; IQR 111), MVPA (36; IQR 23 vs. 41; IQR 25 min/day). Activity biofeedback seems to be feasible to induce changes in patients' PA behaviour.

Ream, M et al (2017) [Conference Abstract] Patient engagement with a smartphone mobile app for adherence to oral chemotherapy[51]

Ream et al developed a smartphone mobile app consisting of medication reminders, symptom reporting, clinician communication, and educational resources for improving adherence and symptom management. They sought to identify potential correlates of app usage. From December 2014 to August 2016, 181 patients with diverse malignancies prescribed oral chemotherapy enrolled in the randomised trial. Medication adherence was monitored using electronic pill caps (MEMScaps). Fostering patient engagement with the app may also serve to buffer difficulties in patient-clinician communication about care.

[50] Gabrys L, Sperzel S, Bernhoerster M, Banzer W, Vogt L. Real-time visual activity feedback for physical activity improvement in breast and colon cancer patients. *Res Sports Med*. 2017;251.:1-10. doi:10.1080/15438627.2016.1258639
[51] Ream, M et al Patient engagement with a smartphone mobile app for adherence to oral chemotherapy. *Journal of Clinical Oncology*. 201735 (31 Supplement 1): 243. http://dx.doi.org/10.1200/JCO.2017.35.31_suppl.243. [Accessed 19 May 2020].

Maguire, R et al (2017) [Protocol] The eSMART study protocol: a randomised controlled trial to evaluate electronic symptom management using the advanced symptom management system (ASyMS) remote technology for patients with cancer[52]

While some evidence exists that real-time remote symptom monitoring devices can decrease morbidity and prevent unplanned admissions in oncology patients, overall, these studies have significant methodological weaknesses. The electronic Symptom Management using the Advanced Symptom Management System (ASyMS) Remote Technology (eSMART) study is designed to specifically address these weaknesses with an appropriately powered, repeated-measures, parallel-group stratified randomised controlled trial of oncology patients. A total of 1,108 patients scheduled to commence first-line chemotherapy (CTX) for breast, colorectal or haematological cancer will be recruited from multiple sites across five European countries. Patients will be randomised (1:1) to the ASyMS intervention [intervention group] or to standard care currently available at each site [control group]. Patients in the control and intervention groups will complete a demographic and clinical questionnaire, as well as a set of valid and reliable electronic patient-reported outcome measures at enrolment, after each of their CTX cycles up to a maximum of six cycles, and at 3, 6, 9 and 12 months after completion of their sixth cycle of CTX. Outcomes that will be assessed include symptom burden [primary outcome], quality of life, supportive care needs, anxiety, self-care self-efficacy, work limitations and cost effectiveness and, from a health professional perspective, changes in clinical practice.

Shen, J et al (2017) [Review] Telehealth in older adults with cancer in the United States: the emerging use of wearable sensors[53]

As the aging and cancer populations in the world continue to increase, the need for complements to traditional geriatric assessments and the logical incorporation of fast and reliable telehealth tools have become interlinked. In the United States, studies examining the use of telehealth for chronic disease management have shown promising results in small groups. The implementation of health technology on a broader scale requires older adults to both accept and adapt such innovation into routine medical care.

[52] Maguire R, Fox PA, McCann L et al The eSMART study protocol: a randomised controlled trial to evaluate electronic symptom management using the advanced symptom management system (ASyMS) remote technology for patients with cancer. *BMJ Open*. 2017;75.:e015016. Published 2017 Jun 6. doi:10.1136/bmjopen-2016-015016

[53] Shen J, Naeim A. Telehealth in older adults with cancer in the United States: The emerging use of wearable sensors. *J Geriatr Oncol*. 2017;86.:437- 442. doi:10.1016/j.jgo.2017.08.008

Though the commercial and recreational use of new technology has increased in older individuals, the transition into creating a smart and connected home that can interface with both patients and healthcare professionals is in its early phases. Current limitations include an inherent digital divide, as well as concerns regarding privacy, data volume, rapid change, cost and reimbursement. The emergence of low-cost, high-fidelity wearable sensors with a spectrum of clinical utility may be the key to increased use and adaptation by older adults. An opportunity to utilise wearable sensors for objective and real-time assessment of older patients with cancer for baseline functional status and treatment toxicity may be on the horizon.

Burhenn, PS et al (2015) [Review] Using tools and technology to promote education and adherence to oral agents for cancer[54]

The researchers reviewed electronic devices, as well as traditional methods such as calendars and pillboxes, that can assist patients in remembering to take the medication they are administering at home. A literature search was compiled and websites were searched for patient education tools, reminder tools, and smartphone applications. The project was part of the Oncology Nursing Society Putting Evidence into Practice effort on oral adherence. Burhenn et al conclude that education alone is insufficient to promote adherence to oral medication regimens. Multicomponent interventions have demonstrated improved adherence, and tools and technology directed at improving adherence to oral agents can be used. The researchers found multiple reminder aids to assist patients in adhering to an oral regimen. They are highlighted in this article.

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[54] Burhenn PS, Smudde J. Using tools and technology to promote education and adherence to oral agents for cancer. *Clin J Oncol Nurs*. 2015;19(3 Suppl):53–59. doi:10.1188/15.S1.CJON.53-59

CHAPTER 4
Telemedicine and Chronic Kidney Disease

Systematic Reviews

Jeddi, Fateme R et al (2019) [Systematic Review] Features and Effects of Information Technology-Based Interventions to Improve Self-Management in Chronic Kidney Disease Patients: a Systematic Review of the Literature[1]

Slowing down the progression of chronic kidney disease (CKD) and its adverse health outcomes requires the patient's self-management and attention to treatment recommendations. Information technology (IT)-based interventions are increasingly being used to support self-management in patients with chronic diseases such as CKD. We conducted a systematic review of randomized controlled trials (RCTs) to assess the features and effects of IT-based interventions on self-management outcomes of CKD patients. A comprehensive search was conducted in Medline, Scopus, and the Cochrane Library to identify relevant papers that were published until May 2016. RCT Studies that assessed at least one automated IT tool in patients with CKD stages 1 to 5, and reported at least one self-management outcome were included. Studies were appraised for quality using the Cochrane Risk of Bias assessment tool. Out of 12,215 papers retrieved, eight study met the inclusion criteria. Interventions were delivered via smartphones/personal digital assistants (PDAs) (3 studies), wearable devices (3 studies), computerized systems (1 study), and multiple component (1 study). The studies assessed 15 outcomes, including eight clinical outcomes and seven process of care outcomes. In 12 (80%) of the 15 outcomes, the studies had revealed the effects of the interventions as statistically significant positive. These positive effects were observed in 75% of the clinical outcomes and 86% of the process of care outcomes. The evidence indicates the potential of IT-based interventions (ie

smartphones/PDAs, wearable devices, and computerized systems) in self-management outcomes (clinical and process of care outcomes) of CKD patients.

Luo, Li et al (2019) [Systematic Review] Telehealth for the management of blood pressure in patients with chronic kidney disease: A systematic review[2]

Background: Most patients with chronic kidney disease (CKD) fail to achieve blood pressure (BP) management as recommended. Meanwhile, the effects of promising intervention and telehealth on BP control in CKD patients remain unclear. We aimed to evaluate the efficacy of telehealth for BP in CKD non-dialysis patients. Methods: Databases including MEDLINE, EMBASE, CENTRAL, CNKI, Wanfang, VIP and CBM were systematically searched for randomised controlled trials or quasi-randomised controlled trials on telehealth for BP control of CKD3-5 non-dialysis patients. We analysed systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), serum creatinine, and estimated glomerular filtration rate (eGFR) with a fixed-effects model. Results: Three studies, with total 680 subjects, were included in our systematic review and two were included for meta-analysis. Pooled estimates showed decreased SBP (pooled mean difference (MD), -5.10; 95% confidence interval (CI), -11.34, 1.14; $p > 0.05$, $p = 0.11$), increased DBP (pooled MD, 0.45; 95% CI, -4.24, 5.13; $p > 0.05$, $p = 0.85$), decreased serum creatinine (pooled MD, -0.38; 95% CI, -0.83, 0.07; $p > 0.05$, $p = 0.10$) and maintained eGFR (pooled MD, 4.72; 95% CI, -1.85, 11.29; $p > 0.05$, $p = 0.16$) in the telehealth group. There was no significant difference from the control group. MAP (MD, 0.6; 95% CI, -6.61, 7.81; $p > 0.05$, $p = 0.87$) and BP control rate ($p > 0.05$, $p = 0.8$), respectively, shown in two studies also demonstrated no statistical significance in the telehealth group. Conclusions: There was no statistically significant evidence to support the superiority of telehealth for BP management in CKD patients. This suggests further studies with improved study design and optimised intervention are needed in the future.

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[2] Luo L, Ye M, Tan J et al Telehealth for the management of blood pressure in patients with chronic kidney disease: A systematic review. *J Telemed Telecare*. 2019;252.:80- 92. doi:10.1177/1357633X17743276

Shen, Hongxia et al (2019) [Systematic Review] Electronic Health Self-Management Interventions for Patients With Chronic Kidney Disease: Systematic Review of Quantitative and Qualitative Evidence[3]

Background: Chronic kidney disease (CKD) poses a major challenge to public health. In CKD patients, adequate disease self-management has been shown to improve both proximal and distal outcomes. Currently, eHealth interventions are increasingly used to optimize patients' self-management skills. Objective: This study aimed to systematically review the existing evidence regarding the implementation and effectiveness of eHealth self-management interventions for patients with CKD. Methods: Following a search in 8 databases up to November 2017, quantitative and qualitative data on process and effect outcomes were extracted from relevant studies. Quality was appraised using the Crowe Critical Appraisal Tool; narrative synthesis was performed to analyze the data extracted. Results: Of the 3307 articles retrieved, 24, comprising 23 studies, were included in this review; of these, almost half were appraised to be of low to moderate quality. There was considerable heterogeneity in the types of interventions used and the outcomes measured. A total of 10 effect and 9 process outcome indicators were identified. The most frequently reported effect outcome indicators were specific laboratory tests and blood pressure (BP), whereas satisfaction was the most frequently reported process outcome indicator. Positive effects were found for proximal outcomes [eg BP control and medication adherence], and mixed effects were found for more distal outcomes [eg quality of life]. High feasibility, usability, and acceptability of and satisfaction with eHealth self-management interventions were reported. The determinant ability of health care professionals to monitor and, if necessary, anticipate on patient measurements online was mostly cited to influence patients' adherence to interventions. Conclusions: eHealth self-management interventions have the potential to improve disease management and health outcomes. To broaden the evidence base and facilitate intervention upscaling, more detailed descriptions and thorough analysis of the intervention components used are required. In addition, our review reveals that outcomes closely related to the scope and duration of the intervention implemented are most likely to be impacted. For instance, if a 4-week web-based training to optimize disease management skills is implemented, the outcome perceived control would more likely be affected than kidney

[3] Shen H, van der Kleij RMJJ, van der Boog PJM, Chang X, Chavannes NH. Electronic Health Self-Management Interventions for Patients With Chronic Kidney Disease: Systematic Review of Quantitative and Qualitative Evidence. *J Med Internet Res*. 2019;21(11):e12384. Published 2019 Nov 5. doi:10.2196/12384

function. Although this seems obvious, most studies evaluate only distal outcomes and thereby fail to capture intervention effects that might contribute to long-term health improvement. We advise future researchers to carefully consider their choice of outcomes based on their sensitivity for change. In this way, we ensure that relevant effects are captured and legitimate conclusions are drawn.

Stevenson, Jessica K et al (2019) [Cochrane Systematic Review] eHealth interventions for people with chronic kidney disease[4]

Background: Chronic kidney disease (CKD) is associated with high morbidity and death, which increases as CKD progresses to end-stage kidney disease (ESKD). There has been increasing interest in developing innovative, effective and cost-efficient methods to engage with patient populations and improve health behaviours and outcomes. Worldwide there has been a tremendous increase in the use of technologies, with increasing interest in using eHealth interventions to improve patient access to relevant health information, enhance the quality of healthcare and encourage the adoption of healthy behaviours.

Objectives: This review aims to evaluate the benefits and harms of using eHealth interventions to change health behaviours in people with CKD. Search methods: We searched the Cochrane Kidney and Transplant Register of Studies up to 14 January 2019 through contact with the Information Specialist using search terms relevant to this review. Studies in the Register are identified through searches of CENTRAL, MEDLINE, and EMBASE, conference proceedings, the International Clinical Trials Register (ICTRP) Search Portal and ClinicalTrials.gov. Selection criteria: Randomised controlled trials (RCTs) and quasi-RCTs using an eHealth intervention to promote behaviour change in people with CKD were included. There were no restrictions on outcomes, language or publication type. Data collection and analysis: Two authors independently assessed trial eligibility, extracted data and assessed the risk of bias. The certainty of the evidence was assessed using GRADE. Main results: We included 43 studies with 6617 participants that evaluated the impact of an eHealth intervention in people with CKD. Included studies were heterogeneous in terms of eHealth modalities employed, type of intervention, CKD population studied and outcomes assessed. The majority of studies were conducted in an adult population, with 16 studies (37%) conducted in those on dialysis, 11 studies (26%) in the

[4] Stevenson JK, Campbell ZC, Webster AC et al eHealth interventions for people with chronic kidney disease. *Cochrane Database Syst Rev.* 2019;88.:CD012379. Published 2019 Aug 6. doi:10.1002/14651858.CD012379.pub2

pre-dialysis population, 15 studies (35%) in transplant recipients and 1 study (2%) in transplant candidates. We identified six different eHealth modalities including: telehealth; mobile or tablet application; text or email messages; electronic monitors; websites; and video or DVD. Three studies used a combination of eHealth interventions. Interventions were categorised into six types: educational; reminder systems; self-monitoring; behavioural counselling; clinical decision-aid; and mixed intervention types. We identified 98 outcomes, which were categorised into nine domains: blood pressure (9 studies); biochemical parameters (6 studies); clinical end-points (16 studies); dietary intake (3 studies); quality of life (9 studies); medication adherence (10 studies); behaviour (7 studies); physical activity (1 study); and cost-effectiveness (7 studies). Only three outcomes could be meta-analysed as there was substantial heterogeneity with respect to study population and eHealth modalities utilised. There was found to be a reduction in interdialytic weight gain of 0.13kg (4 studies, 335 participants: MD -0.13, 95% CI -0.28 to 0.01; I2 = 0%) and a reduction in dietary sodium intake of 197 mg/day (2 studies, 181 participants: MD -197, 95% CI -540.7 to 146.8; I2 = 0%). Both dietary sodium and fluid management outcomes were graded as being of low evidence due to high or unclear risk of bias and indirectness [interdialytic weight gain] and high or unclear risk of bias and imprecision [dietary sodium intake]. Three studies reported death (2799 participants, 146 events), with 45 deaths/1000 cases compared to standard care of 61 deaths/1000 cases (RR 0.74, CI 0.53 to 1.03; P = 0.08). We are uncertain whether using eHealth interventions, in addition to usual care, impact on the number of deaths as the certainty of this evidence was graded as low due to high or unclear risk of bias, indirectness and imprecision. Authors' conclusions: eHealth interventions may improve the management of dietary sodium intake and fluid management. However, overall these data suggest that current evidence for the use of eHealth interventions in the CKD population is of low quality, with uncertain effects due to methodological limitations and heterogeneity of eHealth modalities and intervention types. Our review has highlighted the need for robust, high quality research that reports a core minimum data set to enable meaningful evaluation of the literature.

He, Ting et al (2017) [Systematic Review] Remote home management for chronic kidney disease: A systematic review[5]

Background: Remote home management is a new healthcare model that uses information technology to enhance patients' self-management of disease in a home setting. This study is designed to identify the effects of remote home management on patients with chronic kidney disease (CKD). Methods: A comprehensive search of PubMed, MEDLINE, Embase, and the Cochrane Central Register of Controlled Trials was performed in January 2015. The reference listings of the included articles in this review were also manually examined. Randomized controlled trials (RCTs) designed to evaluate the effects of remote home management on patients with CKD were included. Results: Eight trials were identified. The results of this study suggest that the quality of life (QOL) enabled by remote home management was higher than typical care in certain dimensions. However, the effects of remote home management on blood pressure (BP) remain inconclusive. The studies that assessed health service utilization demonstrated a significant decrease in hospital readmission, emergency room visits, and number of days in the hospital. Another favorable result of this study is that regardless of their gender, age or nationality, patients tend to comply with remote home management programs and the use of related technologies. Conclusions: The available data indicate that remote home management may be a novel and effective disease management strategy for improving CKD patients' QOL and influencing their attitudes and behaviors. And, relatively little is known about BP and cost-effectiveness, so future research should focus on these two aspects for the entire population of patients with CKD.

Thilly, Nathalie et al (2017) [Randomised Controlled Trial] Cost-effectiveness of Home Telemonitoring in Chronic Kidney Disease Patients at Different Stages by a Pragmatic Randomized Controlled Trial (eNephro): Rationale and Study Design[6]

Background: Home telemonitoring has developed considerably over recent years in chronic diseases in order to improve communication between healthcare professionals and patients and to promote early detection of deteriorating health status. In the nephrology setting, home telemonitoring has been evaluated in home dialysis patients but data are scarce concerning chronic kidney disease (CKD) patients before and after renal replacement therapy. The eNephro study is designed to assess the cost effectiveness, clinical/biological impact, and patient perception of a home telemonitoring for CKD patients. Our purpose is to present the rationale, design and organisational aspects of this study. Methods: eNephro is a pragmatic randomised controlled trial, comparing home telemonitoring versus usual care in three populations of CKD patients: stage 3B/4 (n = 320); stage 5D CKD on dialysis (n = 260); stage 5 T CKD treated with transplantation (n= 260). Five hospitals and three not-for-profit providers managing self-care dialysis situated in three administrative regions in France are participating. The trial began in December 2015, with a scheduled 12-month inclusion period and 12 months follow-up. Outcomes include clinical and biological data (eg blood pressure, haemoglobin) collected from patient records, perceived health status (eg health related quality of life) collected from self-administered questionnaires, and health expenditure data retrieved from the French health insurance database (SNIIRAM) using a probabilistic matching procedure. Discussion: The hypothesis is that home telemonitoring enables better control of clinical and biological parameters as well as improved perceived health status. This better control should limit emergency consultations and hospitalisations leading to decreased healthcare expenditure, compensating for the financial investment due to the telemedicine system. Trial registration: This study has been registered at

[6] Thilly N, Chanliau J, Frimat L et al Cost-effectiveness of home telemonitoring in chronic kidney disease patients at different stages by a pragmatic randomized controlled trial (eNephro): rationale and study design. *BMC Nephrol.* 2017;181.:126. Published 2017 Apr 5. doi:10.1186/s12882-017-0529-2

ClinicalTrials.gov under NCT02082093; date of registration: February 14, 2014.

Ishani, Areef et al (2017) [Randomised Controlled Trial] Telehealth by an Interprofessional Team in Patients With CKD: A Randomized Controlled Trial[7]

Background: Telehealth and interprofessional case management are newer strategies of care within chronic disease management. We investigated whether an interprofessional team using telehealth was a feasible care delivery strategy and whether this strategy could affect health outcomes in patients with chronic kidney disease (CKD). Study design: Randomized clinical trial. Setting and Participants: Minneapolis Veterans Affairs Health Care System (VAHCS), St. Cloud VAHCS, and affiliated clinics March 2012 to November 2013 in patients with CKD (estimated glomerular filtration rate < 60mL/min/1.73m2.).

Interventions: Patients were randomly assigned to receive an intervention (n=451) consisting of care by an interprofessional team (nephrologist, nurse practitioner, nurses, clinical pharmacy specialist, psychologist, social worker, and dietician) using a telehealth device (touch screen computer with peripherals) or to usual care (n=150). Outcomes: The primary end point was a composite of death, hospitalization, emergency department visits, or admission to skilled nursing facilities, compared to usual care. Results: Baseline characteristics of the overall study group: mean age, 75.1±8.1 (SD) years; men, 98.5%; white, 97.3%; and mean estimated glomerular filtration rate, 37±9mL/min/1.73m2. Telehealth and interprofessional care were successfully implemented with meaningful engagement with the care system. One year after randomization, 208 (46.2%) patients in the intervention group versus 70 (46.7%) in the usual-care group had the primary composite outcome (HR, 0.98; 95% CI, 0.75-1.29; P=0.9). There was no difference between groups for any component of the primary outcome: all-cause mortality (HR, 1.46; 95% CI, 0.42-5.11), hospitalization (HR, 1.15; 95% CI, 0.80-1.63), emergency department visits (HR, 0.92; 95% CI, 0.68-1.24), or nursing home admission (HR, 3.07; 95% CI, 0.71-13.24). Limitations: Older population, mostly men, potentially underpowered/wide CIs. Conclusions: Telehealth by an interprofessional team is a feasible care delivery strategy in

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[7] Ishani A, Christopher J, Palmer D et al Telehealth by an Interprofessional Team in Patients With CKD: A Randomized Controlled Trial. *Am J Kidney Dis*. 2016;681.:41- 49. doi:10.1053/j.ajkd.2016.01.018

patients with CKD. There was no statistically significant evidence of superiority of this intervention on health outcomes compared to usual care.

Miscellaneous

Hull, SA et al (2020) [Review] Do Virtual Renal Clinics Improve Access to Kidney Care? A Preliminary Impact Evaluation of a Virtual Clinic in East London[8]

Background: Early identification of people with CKD in primary care, particularly those with risk factors such as diabetes and hypertension, enables proactive management and referral to specialist services for progressive disease. The 2019 NHS Long Term Plan endorses the development of digitally-enabled services to replace the 'unsustainable' growth of the traditional out-patient model of care. Shared views of the complete health data available in the primary care electronic health record (EHR) can bridge the divide between primary and secondary care, and offers a practical solution to widen timely access to specialist advice. Methods: We describe an innovative community kidney service based in the renal department at Barts Health NHS Trust and four local clinical commissioning groups (CCGs) in east London. An impact evaluation of the changes in service delivery used quantitative data from the virtual CKD clinic and from the primary care electronic health records (EHR) of 166 participating practices. Survey and interview data from health professionals were used to explore changes to working practices. Results: Prior to the start of the service the general nephrology referral rate was 0.8/1000 GP registered population, this rose to 2.5/1000 registered patients by the second year of the service. The majority (> 80%) did not require a traditional outpatient appointment, but could be managed with written advice for the referring clinician. The wait for specialist advice fell from 64 to 6 days. General practitioners (GPs) had positive views of the service, valuing the rapid response to clinical questions and improved access for patients unable to travel to clinic. They also reported improved confidence in managing CKD, and high levels of patient satisfaction. Nephrologists valued seeing the entire primary care record but reported concerns about the volume of referrals and changes to working practices. Conclusions: Virtual specialist services using shared access to the

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[8] Hull SA, Rajabzadeh V, Thomas N et al Do virtual renal clinics improve access to kidney care? A preliminary impact evaluation of a virtual clinic in East London. *BMC Nephrol.* 2020;211.:10. Published 2020 Jan 10. doi:10.1186/s12882-020-1682-6

complete primary care EHR are feasible and can expand capacity to deliver timely advice. To use both specialist and generalist expertise efficiently these services require support from community interventions which engage primary care clinicians in a data driven programme of service improvement.

Yang, Feng-Jung et al (2020) [Quasi-Experimental Study] The Impact of a Social Networking Service-Enhanced Smart Care Model on Stage 5 Chronic Kidney Disease: Quasi-Experimental Study[9]
Background: Stage 5 chronic kidney disease (CKD) presents a high risk for dialysis initiation and for complications such as uremic encephalopathy, uremic symptoms, gastrointestinal bleeding, and infection. One of the most common barriers to health care for patients with stage 5 CKD is poor continuity of care due to unresolved communication gaps. Objective: Our aim was to establish a powerful care model that includes the use of a social networking service (SNS) to improve care quality for patients with CKD and safely delay dialysis initiation. Methods: We used a retrospective cohort of CKD patients aged 20-85 years who received care between 2007 and 2017 to evaluate the efficacy of incorporating an SNS into the health care system. In 2014, author Feng-Jung Yang, a nephrologist at the National Taiwan University Hospital Yunlin Branch, started to use an SNS app to connect with stage 5 CKD patients and their families. In cases of emergency, patients and families could quickly report any condition to FJY. Using this app, FJY helped facilitate productive interactions between these patients and the health care system. The intention was to safely delay the initiation of dialysis therapy. We divided patients into four groups: group 1 included patients at the study hospital during the 2007-2014 period who had contact only with nephrologists other than FJY; group 2 included patients who visited FJY during the 2007-2014 period before he began using the SNS app; group 3 included patients who visited nephrologists other than FJY during the 2014-2017 period and had no interactions using the SNS; and group 4 included patients who visited F-JY during the 2014-2017 period and interacted with him using the SNS app. Results: We recruited 209 patients with stage 5 CKD who had been enrolled in the study hospital's CKD program between 2007 and 2017. Each of the four groups initiated dialysis at different times. Before adjusting for baseline estimated glomerular filtration rate (eGFR), the G4 patients had a longer time to dialysis (mean 761.7 days, SD 616.2 days) than the other groups (G1: mean 403.6 days, SD 409.4 days, P=.011 for G4 vs G1; G2:

[9] Yang FJ, Hou YH, Chang RE. The Impact of a Social Networking Service-Enhanced Smart Care Model on Stage 5 Chronic Kidney Disease: Quasi-Experimental Study. *J Med Internet Res*. 2020;224.:e15565. Published 2020 Apr 14. doi:10.2196/15565

394.8 days, SD 318.8 days, P=.04; G3: 369.1 days, SD 330.8 days, P=.049). After adjusting for baseline eGFR, G4 had a longer duration for each eGFR drop (mean 84.8 days, SD 65.1 days) than the other groups (G1: mean 43.5 days, SD 45.4 days, P=.005; G2: mean 42.5 days, SD 26.5 days, P=.03; G3: mean 3.8.7 days, SD 33.5 days, P=.002). Conclusions: The use of an SNS app between patients with stage 5 CKD and their physicians can reduce the communication gap between them and create benefits such as prolonging time-to-dialysis initiation. The role of SNSs and associated care models should be further investigated in a larger population.

Clemens, K et al (2019) [Scoping Review] [Nonconventional diabetes-related care strategies for patients with chronic kidney disease: A scoping review of the literature](#)[10]

Background: Patients with diabetes and chronic kidney disease (CKD) are at high risk of diabetes-related complications. Diabetes care can support these individuals, but outpatient clinic appointments can be difficult to attend, given their already high burden of multimorbidity. Methods: We systematically searched the medical and grey literature for studies that evaluated the effect of nonconventional diabetes care strategies on diabetes-related outcomes in adults with stages 2-5 CKD or using dialysis. We included both randomized-controlled trials and observational studies. Study selection and data extraction were completed by two independent reviewers. Diabetes-related outcomes included glycemic, blood pressure, and lipid control, along with microvascular complications, macrovascular complications, and death.

Results: After screening 2,177 relevant citations, we identified 34 studies which met inclusion. The majority were observational studies. Studies were frequently small, single-centered, and excluded patients with more advanced CKD. Nonconventional diabetes care strategies included community-based care, unique self-management and education programs, nurse-led care clinics, dialysis-based diabetes programs, telemedicine, and interdisciplinary care clinics. Programs were most often developed by study investigators. Although there were limitations to several of the included studies, programs were described to have modest effects on physiologic outcomes, and in some cases, diabetes-related complications and death. Conclusions: Nonconventional diabetes-related care might be helpful to

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patients with CKD. Prior to developing and implementing programs, however, it will be important to study them more rigorously, understand their acceptability to patients, and evaluate their costs and feasibility in a real-world setting.

Doyle, N et al. (2019) [Intervention Study] The "Mikidney" smartphone app pilot study: Empowering patients with Chronic Kidney Disease[11]
Background: Successful management of chronic kidney disease (CKD) depends on patients' self-management efforts. Mobile health applications can empower patients with CKD to manage their own condition. We developed, with patient involvement, the MiKidney smartphone application. Aim: Evaluate the MiKidney app as an aid to empowering patients with CKD to become more engaged in the management of their condition. Design: Pilot single group pre- and post-test intervention study. Setting: Renal clinic of an urban University Hospital in Ireland. Patients: Aged over 18 years with CKD and able to use a smartphone. Sample size based on expression of interest and availability of free smartphones (n = 23); three patients withdrew prior to T3 data collection (n = 20). Measurements: Data were collected at T1 (baseline), T2 (week 6) and when exiting the study (T3, 12 weeks) on physical activity, body measurements and blood parameters. Information on app usage and patient satisfaction collected at T2 and T3. Results: There was significant improvement in the six-minute walking test (p = 0.02), total cholesterol (p = 0.023) and LDL cholesterol (p = 0.005) serum levels and a significant decrease in waist circumstance (p = 0.00) and body fat (p = 0.01) measurements. Eighteen participants found the MiKidney app easy to navigate. Conclusion: The MiKidney study highlights the viability and usability of the MiKidney app. It has the potential to empower and motivate patients to understand and self-manage their condition by providing them with the necessary information on renal diet and symptom management. Additionally, tools such as exercise tracker and reminder alerts are available on a readily accessible user-friendly platform. Conflict of interest: article added to this literature review by request of one of the authors.

Park, Sook H et al (2019) [Review] Recent Advances of Biosensors for Hypertension and Nephrology[12]

Purpose of review: Hypertension (HTN) and chronic kidney disease (CKD) are significant problems. With recent advances in technologies, biosensors have shown a great potential to provide better home monitoring in hypertension (HTN), medication compliance, diagnostic device for kidney disease, CKD/end-stage renal disease (ESRD) care, and post kidney transplant management. Recent findings: Multiple devices/biosensors have been developed related to HTN, kidney function including real-time glomerular filtration rate, CKD/end-stage renal disease, and transplant care. In recent advances in wearable biosensors, point of care monitoring system could provide more integrated care to the patients via telenephrology. Summary: This review focuses on the recent advances in biosensors which may be useful for HTN and nephrology. We will discuss future potential clinical implication of these biosensors.

Siddique, Abu Bakker et al (2019) [Scoping Review] Mobile Apps for the Care Management of Chronic Kidney and End-Stage Renal Diseases: Systematic Search in App Stores and Evaluation[13]

Background: Numerous free and low-cost mobile apps for the care management of kidney disease have become available in recent years. Although these appear to be promising tools, they have not been evaluated comparatively based on standard mobile app metrics; and thus, limited evidence is available regarding their efficacy. This study systematically cataloged and assessed mobile apps designed to assist medication compliance and nutrition tracking that are useful to the chronic kidney disease (CKD) and the end-stage renal disease (ESRD) patients who are on dialysis. Objective: The objective of this study was to comprehensively evaluate mobile apps used for medication compliance and nutrition tracking for possible use by CKD and ESRD patients. Methods: A systematic review framework was applied to the search, screening, and assessment of apps identified and downloaded from the iOS and Android app stores. We selected apps using 13 relevant search terms, narrowed down based on a set of inclusion and exclusion criteria, and then used the Mobile App Rating Scale

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[12] Park SH, Zhang Y, Rogers JA, Gallon L. Recent advances of biosensors for hypertension and nephrology. *Curr Oin Nephrol Hypertens*. 2019;284.:390- 396. doi:10.1097/MNH.0000000000000517

[13] Siddique AB, Krebs M, Alvarez S et al Mobile Apps for the Care Management of Chronic Kidney and End-Stage Renal Diseases: Systematic Search in App Stores and Evaluation. *JMIR Mhealth Uhealth*. 2019;7(9):e12604. Published 2019 Sep 4. doi:10.2196/12604

(MARS), a widely adopted app evaluation tool to assess the effectiveness of apps. The internal consistency and interrater reliability were tested using Cronbach alpha and interclass correlation coefficients (ICCs), respectively. Results: The MARS total score had excellent internal consistency (Cronbach alpha=.90) and a moderate level of interrater reliability (2-way mixed ICC 0.65). Overall, 11 out of the 12 reviewed apps met the minimum acceptable score of 3.0 in MARS rating. The 3 apps with the highest combined scores were My Kidneys, My Health Handbook (MARS=4.68); My Food Coach (MARS=4.48); and National Kidney Foundation Malaysia (MARS=4.20). The study identified general weaknesses in the existing apps: the apps fell short of accommodating advanced interactive features such as providing motivational feedback and promoting family member and caregiver participations in the app utilization. Conclusions: The MARS rating system performed well in the app evaluation. The 3 highest ranked apps scored consistently high across the 5 dimensions specified in MARS. These apps were developed in collaboration with reputable organizations and field experts, demonstrating the importance of expert guidance in developing medical apps.

Thomas, Nicola et al (2019) [Qualitative Analysis] Using Chronic Kidney Disease Trigger Tools for Safety and Learning: A Qualitative Evaluation in East London Primary Care[14]
Background: An innovative programme to improve identification and management of chronic kidney disease (CKD) in primary care was implemented across three clinical commissioning groups (CCGs) in 2016. This included a falling estimated glomerular filtration rate (eGFR) trigger tool built from data in the electronic health record (EHR). This tool notifies GP practices of falling eGFR values. By alerting clinicians to patients with possible CKD progression the tool invites clinical review, a referral option, and written reflection on management. Aim: To identify practitioner perceptions of trigger tool use from interviews, and compare these with reflections on clinical management recorded within the tools. Design and setting: A qualitative analysis set in 136 practices across East London during 2016-2018. Method: Eight semi-structured interviews with GPs and practice staff were recorded, and thematic analysis was undertaken using framework analysis. The reflective comments recorded in the trigger tools of 1921 cases

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[14] Thomas N, Rajabzadeh V, Hull S. Using chronic kidney disease trigger tools for safety and learning: a qualitative evaluation in East London primary care. *Br J Gen Pract.* 2019;69(687):e715- e723. Published 2019 Sep 26. doi:10.3399/bjgp19X705497

were categorised by age group, referral status, and by the drop in eGFR (>15 or >25 ml/min).

Results: Three themes emerged from the interviews: getting started; patient safety; and trigger tools for learning. Well-organised practices found the tool was readily embedded into workflow and expressed greater motivation for using it. The tool was seen to support patient safety, and was used for learning about CKD management, both individually and as a practice. Reflective comments from 1921 trigger tools were reviewed. These supported the theme of patient safety. The free-text data, stratified by age, challenged the expectation that younger cases, at higher risk of progressive CKD, would have higher referral rates. Conclusion: Building electronic trigger tools from the EHR can identify patients with a falling eGFR, prompting review of the eGFR trajectory and management plan. Interview and reflective data illustrated that practice use of the tool supports the patient safety agenda and encourages learning about CKD management.

Bonner, Ann et al (2018) [Cross-Sectional Study] Evaluating the prevalence and opportunity for technology use in chronic kidney disease patients: a cross-sectional study[15]

Background: Chronic kidney disease (CKD) is increasing worldwide and early education to improve adherence to self-management is a key strategy to slow CKD progression. The use of the Internet and mobile phone technologies (mHealth) to support patients is considered an effective tool in many other chronic disease populations. While a number of mHealth platforms for CKD exist, few studies have investigated if and how this population use technology to engage in self-management. Methods: Using a cross-sectional design across five health districts in Queensland (Australia), a 38-item self-report survey was distributed to adults with CKD attending outpatient clinics or dialysis units to measure current use and type of engagement with mHealth, perceived barriers to use, and opportunities to support CKD self-management. Odds ratio (OR) were calculated to identify associations between demographic characteristic and mHealth use. Results: Of the 708 participants surveyed, the majority had computer access (89.2%) and owned a mobile phone (83.5%). The most likely users of the Internet were those aged ≤ 60 years (OR: 7.35, 95% confidence interval: 4.25-12.75, p < 0.001), employed (OR: 7.67, 95% CI: 2.58-22.78, p < 0.001), from non-

[15] Bonner A, Gillespie K, Campbell KL et al Evaluating the prevalence and opportunity for technology use in chronic kidney disease patients: a cross-sectional study. *BMC Nephrol*. 2018;191.:28. Published 2018 Feb 2. doi:10.1186/s12882-018-0830-8

indigenous background (OR: 6.98, 95% CI: 3.50-13.93, p < 0.001), or having completed higher levels of education (OR: 3.69, CI: 2.38-5.73, p < 0.001). Those using a mobile phone for complex communication were also younger (OR: 6.01, 95% CI: 3.55-10.19, p < 0.001), more educated (OR: 1.99, 95% CI: 1.29-3.18, p < 0.01), or from non-indigenous background (OR: 3.22, 95% CI: 1.58-6.55, p < 0.001). Overall, less than 25% were aware of websites to obtain information about renal healthcare. The mHealth technologies most preferred for communication with their renal healthcare teams were by telephone (56.5%), Internet (50%), email (48.3%) and text messages (46%). Conclusion: In the CKD cohort, younger patients are more likely than older patients to use mHealth intensively and interactively although all patients' technology literacy ought to be thoroughly assessed by renal teams before implementing in practice. Further research testing mHealth interventions to improve self-management in a range of patient cohorts is warranted. Ethics approval and consent to participate: Prior to undertaking the study, ethical approval was obtained for each study site via the Metro South Human Research Ethics Committee (HREC/15/QPAH/19), and also from the Queensland University of Technology (1500000370). Participants were advised that the questionnaire was anonymous and that completing the questionnaire would indicate consent.

Lunney, Meaghan et al (2018) [Review] Impact of Telehealth Interventions on Processes and Quality of Care for Patients With ESRD[16] Caring for patients with end-stage renal disease (ESRD) requiring dialysis is intensive and expensive. Telehealth may improve the access and efficiency of ESRD care. For this perspective, we systematically reviewed studies that examined the effectiveness of telehealth versus or in addition to usual care for ESRD management. 10 studies were identified, including 7 randomized trials and 3 cohort studies. Study populations, modes of delivery including telephone, telemetry, or videoconferencing, and the outcomes evaluated varied substantially between studies. Two studies examined telehealth interventions versus standard ESRD care and demonstrated mixed results on processes of care, no differences in laboratory surrogate markers of ESRD care, and reduced or similar rates of hospitalization. Eight studies evaluated the addition of telehealth to usual care and demonstrated no significant improvements in processes of care or surrogate laboratory

[16] Lunney M, Lee R, Tang K et al Impact of Telehealth Interventions on Processes and Quality of Care for Patients With ESRD. *Am J Kidney Dis.* 2018;724.:592- 600. doi:10.1053/j.ajkd.2018.02.353

measures, variable impacts on hospitalization rates, and mixed impacts on some domains of quality of life, including improvement in mental health. Although potential benefits of telehealth in ESRD care have been reported, optimal designs for delivery and elements of care that may be improved through telehealth remain uncertain.

Salani, M et al (2018) [Review] Innovations in Wearable and Implantable Artificial Kidneys[17]

More than 2 million people worldwide receive treatment for end-stage renal disease (ESRD). Current modalities of renal replacement therapy include in-center hemodialysis, peritoneal dialysis, home hemodialysis, and kidney transplantation. Patient survival has gradually increased during the past 2 decades and efforts continue to improve mortality and quality of life for patients with ESRD. Developments in sorbent technology, nanotechnology, and cell culture techniques provide promise for new innovations in ESRD management. New modalities currently in testing include wearable (WAKs) and implantable artificial kidneys (IAKs). The automated WAK (AWAK) and WAK are devices that have undergone small trials in humans. Additional study is needed before regulatory approval, coverage decisions, and widespread clinical implementation. The IAK is a biohybrid combining artificial filters and living cells currently in preclinical testing. These portable devices reduce the need for large quantities of water and continuous electrical supply. This could lower some barriers to home dialysis, making self-care renal replacement therapy more accessible and desirable. If widely successful, these devices could reduce the need to build and staff dialysis facilities, thus lowering health care costs associated with dialysis. The potential advantages and shortcomings of the AWAK, WAK, and IAK are described here.

Rosner, Mitchell H et al (2017) [Review] Perspectives From the Kidney Health Initiative on Advancing Technologies to Facilitate Remote Monitoring of Patient Self-Care in RRT[18]

Telehealth and remote monitoring of a patient's health status has become more commonplace in the last decade and has been applied to conditions such as heart failure, diabetes mellitus, hypertension, and chronic

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[17] Salani M, Roy S, Fissell WH 4th. Innovations in Wearable and Implantable Artificial Kidneys. *Am J Kidney Dis*. 2018;725.:745-751. doi:10.1053/j.ajkd.2018.06.005

[18] Rosner MH, Lew SQ, Conway P et al Perspectives from the Kidney Health Initiative on Advancing Technologies to Facilitate Remote Monitoring of Patient Self-Care in RRT. *Clin J Am Soc Nephrol*. 2017;12(11):1900- 1909. doi:10.2215/CJN.12781216

obstructive pulmonary disease. Conversely, uptake of these technologies to help engender and support home RRTs has lagged. Although studies have looked at the role of telehealth in RRT, they are small and single-centered, and both outcome and cost-effectiveness data are needed to inform future decision making. Furthermore, alignment of payer and government regulations with telehealth procedures is needed along with a better understanding of the viewpoints of the various stakeholders in this process: patients, caregivers, clinicians, payers, dialysis organizations, and government regulators. Despite these barriers, telehealth has great potential to increase the acceptance of home dialysis, and improve outcomes and patient satisfaction while potentially decreasing costs. The Kidney Health Initiative convened a multidisciplinary workgroup to examine the current state of telehealth use in home RRTs as well as outline potential benefits and drawbacks, impediments to implementation, and key unanswered questions.

Solomon, Richard et al (2017) [Review] Real-time Measurement of Glomerular Filtration Rate[19]
Purpose: Measurement of glomerular filtration rate is an essential tool for determining the health or dysfunction of the kidney. The glomerular filtration rate is a dynamic function that can change almost instantaneously in response to stressors. Despite its central role in nephrology, there are no techniques available to the clinician for monitoring glomerular filtration rate in real time. Recent advances in technology to measure fluorescent compounds through the skin are providing a new approach for real-time monitoring of glomerular filtration rate. This review frames these technologies within how such measurements might be used in clinical medicine. Recent Findings: Fluorescent molecules that act as ideal filtration markers are now available. Using transdermal sensors, the plasma disappearance rate of these exogenous markers can be measured rather than their steady state concentration. This eliminates the delay inherent in using an endogenous marker of filtration and permits continuous monitoring of GFR. Summary: These new technologies provide enhanced opportunities for diagnosis of kidney dysfunction and therapeutic monitoring. Accurate assessment of measured GFR will eliminate the erroneous diagnosis of chronic kidney disease (CKD) from many patients. Assessment of renal reserve will provide a new risk factor for progression of CKD. Real-time

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[19] Solomon R, Goldstein S. Real-time measurement of glomerular filtration rate. *Curr Opin Crit Care*. 2017;236.:470- 474. doi:10.1097/MCC.0000000000000456

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monitoring of GFR in critically ill patients will allow for earlier diagnosis of acute kidney injury and a dynamic metric to guide therapeutics. These are but a few of the many opportunities that this new technology will provide in both the clinical and research arenas.

Tuot, Delphine S et al (2017) [Review] Telehealth Applications to Enhance CKD Knowledge and Awareness Among Patients and Providers[20]
CKD affects 13% of the US adult population, causes excess mortality, and is associated with significant sociodemographic disparities. Optimal CKD management slows progression of disease and reduces cardiovascular-related outcomes. Resources for patients and primary care providers, major stakeholders in preventive CKD care, are critically needed to enhance understanding of the disease and to optimize CKD health, particularly because of the asymptomatic nature of kidney disease. Telehealth is defined as the use of electronic communication and telecommunications technology to support long-distance clinical health care, patient and professional health-related education, and public health and health administration. It provides new opportunities to enhance awareness and understanding among these important stakeholders. This review will examine the role of telehealth within existing educational theories, identify telehealth applications that can enhance CKD knowledge and behavior change among patients and primary care providers, and examine the advantages and disadvantages of telehealth vs usual modalities for education.

Weiner, Shoshana et al (2017) [Review] Telemedicine to Promote Patient Safety: Use of Phone-Based Interactive Voice-Response System to Reduce Adverse Safety Events in Pre-dialysis CKD[21]
CKD patients have several features conferring on them a high risk of adverse safety events, which are defined as incidents with unintended harm related to processes of care or medications. These characteristics include impaired kidney function, polypharmacy, and frequent health system encounters. The consequences of such events in CKD can include new or prolonged hospitalization, accelerated kidney function loss, acute kidney injury, ESRD, and death. Health information technology administered via telemedicine presents opportunities for CKD patients to remotely communicate safety-related findings to providers for the purpose of improving their care.

[20] Tuot DS, Boulware LE. Telehealth Applications to Enhance CKD Knowledge and Awareness Among Patients and Providers. *Adv Chronic Kidney Dis.* 2017;241.:39- 45. doi:10.1053/j.ackd.2016.11.017
[21] Weiner S, Fink JC. Telemedicine to Promote Patient Safety: Use of Phone-Based Interactive Voice-Response System to Reduce Adverse Safety Events in Pre-dialysis CKD. *Adv Chronic Kidney Dis.* 2017;241.:31- 38. doi:10.1053/j.ackd.2016.12.004
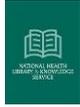
However, many CKD patients have limitations that hinder their use of telemedicine and access to the broad capabilities of health information technology. In this review, we summarize previous assessments of the pre-dialysis CKD populations' proficiency in using telemedicine modalities and describe the use of interactive voice-response system to gauge the safety phenotype of the CKD patient. We discuss the potential for expanded interactive voice-response system use in CKD to address the safety threats inherent to this population.

Ong, Stephanie W et al (2016) [Proof-of-Principle Study] Integrating a Smartphone-Based Self-Management System into Usual Care of Advanced CKD[22]

Background and Objectives: Patient self-management has been shown to improve health outcomes. We developed a smartphone-based system to boost self-care by patients with CKD and integrated its use into usual CKD care. We determined its acceptability and examined changes in several clinical parameters. Design, Setting, Participants, and Measurements: We recruited patients with stage 4 or 5 CKD attending outpatient renal clinics who responded to a general information newsletter about this 6-month proof-of-principle study. The smartphone application targeted four behavioral elements: monitoring BP, medication management, symptom assessment, and tracking laboratory results. Prebuilt customizable algorithms provided real-time personalized patient feedback and alerts to providers when predefined treatment thresholds were crossed or critical changes occurred. Those who died or started RRT within the first 2 months were replaced. Only participants followed for 6 months after recruitment were included in assessing changes in clinical measures. Results: In total, 47 patients (26 men; mean age =59 years old; 33% were ≥65 years old) were enrolled; 60% had never used a smartphone. User adherence was high [>80% performed ≥80% of recommended assessments] and sustained. The mean reductions in home BP readings between baseline and exit were statistically significant (systolic BP, -3.4 mmHg; 95% confidence interval, -5.0 to -1.8 and diastolic BP, -2.1 mmHg; 95% confidence interval, -2.9 to -1.2); 27% with normal clinic BP readings had newly identified masked hypertension. One hundred twenty-seven medication discrepancies were identified; 59% were medication errors that required an intervention to prevent harm. In exit interviews, patients indicated feeling more confident and in control of their

[22] Ong SW, Jassal SV, Miller JA et al Integrating a Smartphone-Based Self-Management System into Usual Care of Advanced CKD. *Clin J Am Soc Nephrol.* 2016;116.:1054- 1062. doi:10.2215/CJN.10681015

condition; clinicians perceived patients to be better informed and more engaged. Conclusions: Integrating a smartphone-based self-management system into usual care of patients with advanced CKD proved feasible and acceptable, and it appeared to be clinically useful. The results provide strong rationale for a randomized, controlled trial.

CHAPTER 5
Telemedicine and Chronic Obstructive Pulmonary Disease

Systematic Reviews

Hong and Lee (2019) [Systematic Review and Meta-Analysis]
Effectiveness of Tele-Monitoring by Patient Severity and Intervention Type in Chronic Obstructive Pulmonary Disease Patients: A Systematic Review and Meta-Analysis[1]

Background: Chronic obstructive pulmonary disease is a major burden on healthcare systems worldwide. Tele-monitoring has recently been used for management of chronic obstructive pulmonary disease patients.

Objectives: We analyzed the effect of tele-monitoring on chronic obstructive pulmonary disease patients and performed subgroup analysis by patient severity and intervention type.

Design: Systematic review.

Data Source: Electronic databases including Ovid-Medline, Ovid-Embase, and the Cochrane Library.

Review Methods: We conducted a meta-analysis of randomized controlled trials published up to April 2017. Three databases were searched, two investigators independently extracted data and assessed study quality using risk of bias.

Results: Out of 1,185 studies, 27 articles were identified to be relevant for this study. The included studies were divided by intervention: 15 studies used tele-monitoring only, 4 studies used integrated tele-monitoring [pure control], and 8 studies used integrated tele-monitoring [not pure control]. We also divided the studies by patient severity: 16 studies included severely ill patients, 8 studies included moderately ill patients, and 3 studies did not discuss the severity of the patients' illness. Meta-analysis showed that tele-monitoring reduced the emergency room visits (risk ratio 0.63, 95%

[1] Hong Y, Lee SH. Effectiveness of tele-monitoring by patient severity and intervention type in chronic obstructive pulmonary disease patients: A systematic review and meta-analysis. *Int J Nurs Stud.* 2019;92:1-15. doi:10.1016/j.ijnurstu.2018.12.006

confidence interval 0.55-0.72) and hospitalizations (risk ratio 0.88, 95% confidence interval 0.80-0.97). The subgroup analysis of patient severity showed that tele-monitoring more effectively reduced emergency room visits in patients with severe vs. moderate disease (risk ratio 0.48, 95% confidence interval 0.31-0.74; risk ratio 1.28, 95% confidence interval 0.61-2.69, retrospectively) and hospitalizations (risk ratio 0.92, 95% confidence interval 0.82-1.02; risk ratio 1.24, 95% confidence interval 0.57-2.70, retrospectively). The mental health quality of life score (mean difference 3.06, 95% confidence interval 2.15-3.98) showed more improved quality of life than the physical health quality of life score (mean difference -0.11, 95% confidence interval -0.83-0.61).

Conclusions: Tele-monitoring reduced rates of emergency room visits and hospitalizations and improved the mental health quality of life score. Integrated tele-monitoring including the delivery of coping skills or education by online methods including pulmonary rehabilitation is recommended to produce significant improvement. This application of integrated tele-monitoring ⬜ the delivery of education, exercise and other interventions in addition to tele-monitoring ⬜ is more useful for patients with severe chronic obstructive pulmonary disease than those with moderate disease. Tele-monitoring might be a useful application of information and communication technologies, if the intervention includes the appropriate intervention components for eligible patients. Further studies such as large size randomized controlled trials with sub-group by patient severity and intervention type is needed to confirm these finding.

Baroi et al (2018) [Systematic Review] Advances in Remote Respiratory Assessments for People With Chronic Obstructive Pulmonary Disease: A Systematic Review[2]

Background: Chronic obstructive pulmonary disease (COPD) is a leading cause of mortality. Advances in remote technologies and telemedicine provide new ways to monitor respiratory function and improve chronic disease management. However, telemedicine does not always include remote respiratory assessments, and the current state of knowledge for people with COPD has not been evaluated.

Objective: Systematically review the use of remote respiratory assessments in people with COPD, including the following questions: What devices have

been used? Can acute exacerbations of chronic obstructive pulmonary disease (AECOPD) be predicted by using remote devices? Do remote respiratory assessments improve health-related outcomes?

Materials and Methods: The review protocol was registered (PROSPERO 2016:CRD42016049333). MEDLINE, EMBASE, and COMPENDEX databases were searched for studies that included remote respiratory assessments in people with COPD. A narrative synthesis was then conducted by two reviewers according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results: Fifteen studies met the inclusion criteria. Forced expiratory volume assessed daily by using a spirometer was the most common modality. Other measurements included resting respiratory rate, respiratory sounds, and end-tidal carbon dioxide level. Remote assessments had high user satisfaction. Benefits included early detection of AECOPD, improved health-related outcomes, and the ability to replace hospital care with a virtual ward.

Conclusion: Remote respiratory assessments are feasible and when combined with sufficient organizational backup can improve health-related outcomes in some but not all cohorts. Future research should focus on the early detection, intervention, and rehabilitation for AECOPD in high-risk people who have limited access to best care and investigate continuous as well as intermittent monitoring.

Buekers et al (2018) [Systematic Review] [Oxygen Saturation Measurements in Telemonitoring of Patients With COPD: A Systematic Review](#)[3]

Telemonitoring applications are expected to become a key component in future healthcare. Despite the frequent use of SpO2 measurements in telemonitoring of patients with chronic obstructive pulmonary disease (COPD), no profound overview is available about these measurements. Areas covered: A systematic search identified 71 articles that performed SpO2 measurements in COPD telemonitoring. The results indicate that long-term follow-up of COPD patients using daily SpO2 spot checks is practically feasible. Very few studies specified protocols for performing these measurements. In many studies, deviating SpO2 values were used to raise alerts that led to immediate action from healthcare professionals. However, little information was available about the exact implementation and performance of these alerts. Therefore, no firm conclusions can be drawn

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[3] Buekers J, De Boever P, Vaes AW, et al. Oxygen saturation measurements in telemonitoring of patients with COPD: a systematic review. *Expert Rev Respir Med.* 2018;12(2):113-123. doi:10.1080/17476348.2018.1417842

about the real value of SpO2 measurements. Future research could optimize performance of alerts using individualized, time-dependent thresholds or predictive algorithms to account for individual differences and SpO2 baseline changes. Additionally, the value of performing continuous measurements should be examined. Expert commentary: Standardization of the measurements, data science techniques and advancing technology can still boost performance of telemonitoring applications. All these opportunities should be thoroughly explored to assess the real value of SpO2 in COPD telemonitoring.

Yang et al (2018) [Systematic Review and Meta-Analysis] Mobile Health Applications in Self-Management of Patients With Chronic Obstructive Pulmonary Disease: A Systematic Review and Meta-Analysis of Their Efficacy[4]

Background: Mobile health applications are increasingly used in patients with Chronic Obstructive Pulmonary Disease (COPD) to improve their self-management, nonetheless, without firm evidence of their efficacy. This meta-analysis was aimed to assess the efficacy of mobile health applications in supporting self-management as an intervention to reduce hospital admission rates and average days of hospitalization, etc. Methods: PubMed, Web of Science, Cochrane Library, and Embase were searched for relevant articles published before November 14, 2017. A total of 6 reports with randomized controlled trials were finally included in this meta-analysis. Results: Patients using mobile phone applications may have a lower risk for hospital admissions than those in the usual care group (risk ratio (RR) = 0.73, 95% CI [0.52, 1.04]). However, there was no significant difference in reducing the average days of hospitalization.

Conclusion: Self-management with mobile phone applications could reduce hospital admissions of patients with COPD.

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[4] Yang F, Wang Y, Yang C, Hu H, Xiong Z. Mobile health applications in self-management of patients with chronic obstructive pulmonary disease: a systematic review and meta-analysis of their efficacy. *BMC Pulm Med.* 2018;18(1):147. Published 2018 Sep 4. doi:10.1186/s12890-018-0671-z

Hanlon et al (2017) [Systematic Review] Telehealth Interventions to Support Self-Management of Long-Term Conditions: A Systematic Metareview of Diabetes, Heart Failure, Asthma, Chronic Obstructive Pulmonary Disease, and Cancer[5]

Background: Self-management support is one mechanism by which telehealth interventions have been proposed to facilitate management of long-term conditions.

Objective: The objectives of this metareview were to: 1. assess the impact of telehealth interventions to support self-management on disease control and health care utilization; and 2. identify components of telehealth support and their impact on disease control and the process of self-management. Our goal was to synthesise evidence for telehealth-supported self-management of diabetes, heart failure, asthma, chronic obstructive pulmonary disease (COPD) and cancer to identify components of effective self-management support.

Methods: We performed a metareview [a systematic review of systematic reviews] of randomized controlled trials of telehealth interventions to support self-management in 6 exemplar long-term conditions. We searched 7 databases for reviews published from January 2000 to May 2016 and screened identified studies against eligibility criteria. We weighted reviews by quality, size, and relevance. We then combined our results in a narrative synthesis and using harvest plots.

Results: We included 53 systematic reviews, comprising 232 unique RCTs. Reviews concerned diabetes (type 1: n=6; type 2, n=11; mixed, n=19), heart failure (n=9), asthma (n=8), COPD (n=8), and cancer (n=3). Findings varied between and within disease areas. The highest-weighted reviews showed that blood glucose telemonitoring with feedback and some educational and lifestyle interventions improved glycemic control in type 2, but not type 1, diabetes, and that telemonitoring and telephone interventions reduced mortality and hospital admissions in heart failure, but these findings were not consistent in all reviews. Results for the other conditions were mixed, although no reviews showed evidence of harm. Analysis of the mediating role of self-management, and of components of successful interventions, was limited and inconclusive. More intensive and multifaceted interventions were associated with greater improvements in diabetes, heart failure, and asthma.

[5] Hanlon P, Daines L, Campbell C, McKinstry B, Weller D, Pinnock H. Telehealth Interventions to Support Self-Management of Long-Term Conditions: A Systematic Metareview of Diabetes, Heart Failure, Asthma, Chronic Obstructive Pulmonary Disease, and Cancer. *J Med Internet Res*. 2017;19(5):e172. Published 2017 May 17. doi:10.2196/jmir.6688

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Conclusions: While telehealth-mediated self-management was not consistently superior to usual care, none of the reviews reported any negative effects, suggesting that telehealth is a safe option for delivery of self-management support, particularly in conditions such as heart failure and type 2 diabetes, where the evidence base is more developed. Larger-scale trials of telehealth-supported self-management, based on explicit self-management theory, are needed before the extent to which telehealth technologies may be harnessed to support self-management can be established.

Alwashmi et al (2016) [Systematic Review and Meta-Analysis] [The Effect of Smartphone Interventions on Patients With Chronic Obstructive Pulmonary Disease Exacerbations: A Systematic Review and Meta-Analysis](#)[6]

Background: The prevalence and mortality rates of chronic obstructive pulmonary disease (COPD) are increasing worldwide. Therefore, COPD remains a major public health problem. There is a growing interest in the use of smartphone technology for health promotion and disease management interventions. However, the effectiveness of smartphones in reducing the number of patients having a COPD exacerbation is poorly understood.

Objective: To summarize and quantify the association between smartphone interventions and COPD exacerbations through a comprehensive systematic review and meta-analysis.

Methods: A comprehensive search strategy was conducted across relevant databases from inception to October 2015. We included studies that assessed the use of smartphone interventions in the reduction of COPD exacerbations compared with usual care. Full-text studies were excluded if the investigators did not use a smartphone device or did not report on COPD exacerbations. Observational studies, abstracts, and reviews were also excluded. Two reviewers extracted the data and conducted a risk of bias assessment using the US Preventive Services Task Force quality rating criteria. A random effects model was used to meta-analyze the results from included studies. Pooled odds ratios were used to measure the effectiveness of smartphone interventions on COPD exacerbations. Heterogeneity was also measured.

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[6] Alwashmi M, Hawboldt J, Davis E, Marra C, Gamble JM, Abu Ashour W. The Effect of Smartphone Interventions on Patients With Chronic Obstructive Pulmonary Disease Exacerbations: A Systematic Review and Meta-Analysis. *JMIR Mhealth Uhealth*. 2016;4(3):e105. Published 2016 Sep 1. doi:10.2196/mhealth.5921

Results: Of the 245 unique citations screened, 6 studies were included in the qualitative synthesis. Studies were relatively small with less than 100 participants in each study (range 30 to 99) and follow-up ranged from 4-9 months. The mean age was 70.5 years (SD 5.6) and 74% (281/380) were male. The studies varied in terms of country, type of smartphone intervention, frequency of data collection from the participants, and the feedback strategy. Three studies were included in the meta-analysis. The overall assessment of potential bias of the studies that were included in the meta-analysis was good for one study and fair for 2 studies. The pooled random effects odds ratio of patients having an exacerbation was 0.20 in patients using a smartphone intervention (95% CI 0.07-0.62), a reduction of 80% for smartphone interventions compared with usual care. However, there was moderate heterogeneity across the included studies.

Conclusion: Although current literature on the role of smartphones in reducing COPD exacerbations is limited, findings from our review suggest that smartphones are useful in reducing the number of patients having a COPD exacerbation. Nevertheless, using smartphones require synergistic strategies to achieve the desired outcome. These results should be interpreted with caution due to the heterogeneity among the studies. Researchers should focus on conducting rigorous studies with adequately powered sample sizes to determine the validity and clinical utility of smartphone interventions in the management of COPD.

Brunton et al (2015) [Systematic Review and Meta-Analysis] The Contradictions of Telehealth User Experience in Chronic Obstructive Pulmonary Disease (COPD): A Qualitative Meta-Synthesis[7]

Objective: As the global burden of chronic disease rises, policy makers are showing a strong interest in adopting telehealth technologies for use in long term condition management, including COPD. However, there remain barriers to its implementation and sustained use. To date, there has been limited qualitative investigation into how users ꞏ both patients/carers and staff ꞏ perceive and experience the technology. We aimed to systematically review and synthesise the findings from qualitative studies that investigated user perspectives and experiences of telehealth in COPD management, in order to identify factors which may impact on uptake.

Method: Systematic review and meta-synthesis of published qualitative studies of user experience of telehealth technologies for the management of

[7] Brunton L, Bower P, Sanders C. The Contradictions of Telehealth User Experience in Chronic Obstructive Pulmonary Disease (COPD): A Qualitative Meta-Synthesis. *PLoS One.* 2015;10(10):e0139561. Published 2015 Oct 14. doi:10.1371/journal.pone.0139561

Chronic Obstructive Pulmonary Disease. ASSIA, CINAHL, Embase, Medline, PsychInfo and Web of Knowledge databases were searched up to October 2014. Reference lists of included studies and reference lists of key papers were also searched. Quality appraisal was guided by an adapted version of the CASP qualitative appraisal tool.

Findings: 705 references were identified and 10 papers, relating to 7 studies were included in the review. Most authors of included studies had identified both positive and negative experiences of telehealth use in the management of COPD. Through a line of argument synthesis we were able to derive new insights from the data to identify three overarching themes that have the ability to either impede or promote positive user experience of telehealth in COPD: the influence on moral dilemmas of help-seeking [enables dependency or self-care]; transforming interactions [increases risk or reassurance]; and reconfiguration of work practices [causes burden or empowerment].

Conclusion: Findings from this meta-synthesis have implications for the future design and implementation of telehealth services. Future research needs to include potential users at an earlier stage of telehealth/service development.

Lundell et al (2015) [Systematic Review and Meta-Analysis]
Telehealthcare in COPD: A Systematic Review and Meta-Analysis on Physical Outcomes and Dyspnea[8]

Background: Only a minority of patients with chronic obstructive pulmonary disease (COPD) have access to pulmonary rehabilitation (PR). Home-based solutions such as telehealthcare, have been used in efforts to make PR more available. The aim of this systematic review was to investigate the effects of telehealthcare on physical activity level, physical capacity and dyspnea in patients with COPD, and to describe the interventions used.

Methods: Randomized controlled trials were identified through database searches, reference lists and included authors. Articles were reviewed based on eligibility criteria by three authors. Risk of bias was assessed by two authors. Standardized mean differences (SMD) or mean differences (MD) with 95% CI were calculated. Forest plots were used to present data visually.

Results: Nine studies [982 patients] were included. For physical activity level, there was a significant effect favoring telehealthcare (MD, 64.7 min; 95% CI, 54.4-74.9). No difference between groups was found for physical capacity

[8] Lundell S, Holmner Å, Rehn B, Nyberg A, Wadell K. Telehealthcare in COPD: a systematic review and meta-analysis on physical outcomes and dyspnea. *Respir Med.* 2015;109(1):11-26. doi:10.1016/j.rmed.2014.10.008

(MD, -1.3 m; 95% CI, -8.1-5.5) and dyspnea (SMD, 0.088; 95% CI, -0.056-0.233). Telehealthcare was promoted through phone calls, websites or mobile phones, often combined with education and/or exercise training. Comparators were ordinary care, exercise training and/or education. Conclusions: The use of telehealthcare may lead to improvements in physical activity level, although the results should be interpreted with caution given the heterogeneity in studies. This is an important area of research and further studies of the effect of telehealthcare for patients with COPD would be beneficial.

Pedone and Lelli (2015) [Systematic Review] Systematic Review of Telemonitoring in COPD: An Update[9]

Telemedicine may support individual care plans in people with chronic obstructive pulmonary disease (COPD), potentially improving the clinical outcomes. To-date there is no clear evidence of benefit of telemedicine in this patients. The aim of this study is to provide an update on the effectiveness of telemedicine in reducing adverse clinical outcomes. We searched the Pubmed database for articles published between January 2005 and December 2014. We included only randomized controlled trials exclusively focused on patients with COPD and with a telemedicine intervention arm. Evaluated outcomes were number of exacerbations, ER visits, COPD hospitalizations, length of stay and death. We eventually included 12 randomized controlled trials. Most of them had a small sample size and was of poor quality, with a wide heterogeneity in the parameters and technologies used. Most studies reported a positive effect of telemonitoring on hospitalization for any cause, with risk reductions between 10% and 63%; however only three studies reached statistical significance. The same trend was observed for COPD-related hospital admission and ER visits. No significative effects of telemedicine was evidenced in reducing length of hospital stay, improving quality of life and reducing deaths. In conclusion, our study confirms that the available evidence on the effectiveness of telemedicine in COPD does not allow to draw definite conclusions; most evidence suggests a positive effect of telemonitoring on hospital admissions and ER visits. More trials with adequate sample size and with adequate consideration of background clinical services are needed to definitively establish its effectiveness.

[9] Pedone C, Lelli D. Systematic review of telemonitoring in COPD: an update. *Pneumonol Alergol Pol.* 2015;83(6):476-484. doi:10.5603/PiAP.2015.0077

Duiverman et al (2020) [Randomised Controlled Trial] Home Initiation of Chronic Non-Invasive Ventilation in COPD Patients With Chronic Hypercapnic Respiratory Failure: A Randomised Controlled Trial[10]

Introduction: Chronic non-invasive ventilation (NIV) has become evidence-based care for stable hypercapnic COPD patients. While the number of patients increases, home initiation of NIV would greatly alleviate the healthcare burden. We hypothesise that home initiation of NIV with the use of telemedicine in stable hypercapnic COPD is non-inferior to in-hospital NIV initiation.

Methods: Sixty-seven stable hypercapnic COPD patients were randomised to initiation of NIV in the hospital or at home using telemedicine. Primary outcome was daytime arterial carbon dioxide pressure ($PaCO_2$) reduction after 6 months NIV, with a non-inferiority margin of 0.4 kPa. Secondary outcomes were health-related quality of life (HRQoL) and costs.

Results: Home NIV initiation was non-inferior to in-hospital initiation (adjusted mean difference in $PaCO_2$ change home vs in-hospital: 0.04 kPa (95% CI -0.31 to 0.38 kPa), with both groups showing a $PaCO_2$ reduction at 6 months compared with baseline (home: from 7.3±0.9 to 6.4±0.8 kPa (p<0.001) and in-hospital: from 7.4±1.0 to 6.4±0.6 kPa (p<0.001)). In both groups, HRQoL improved without a difference in change between groups (Clinical COPD Questionnaire total score-adjusted mean difference 0.0 (95% CI -0.4 to 0.5)). Furthermore, home NIV initiation was significantly cheaper (home: median €3768 (IQR €3546-€4163) vs in-hospital: median €8537 (IQR €7540-€9175); p<0.001).

Discussion: This is the first study showing that home initiation of chronic NIV in stable hypercapnic COPD patients, with the use of telemedicine, is non-inferior to in-hospital initiation, safe and reduces costs by over 50%.

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[10] Duiverman ML, Vonk JM, Bladder G, et al. Home initiation of chronic non-invasive ventilation in COPD patients with chronic hypercapnic respiratory failure: a randomised controlled trial. *Thorax*. 2020;75(3):244-252. doi:10.1136/thoraxjnl-2019-213303

Galdiz et al (2020) [Randomised Controlled Trial] Telerehabilitation Programme as a Maintenance Strategy for COPD Patients: A 12-Month Randomized Clinical Trial[11]

Background: There is uncertainty regarding efficacy of telehealth-based approaches in COPD patients for sustaining benefits achieved with intensive pulmonary rehabilitation (PR).

Research Question: To determine whether a maintenance pulmonary telerehabilitation (TelePR) programme, after intensive initial PR, is superior to usual care in sustaining over time benefits achieved by intensive PR.

Study Design and Methods: A multicentre open-label pragmatic parallel-group randomized clinical trial was conducted. Two groups were created at completion of an 8-week intensive outpatient hospital PR programme. Intervention group (IG) patients were given appropriate training equipment and instructed to perform three weekly training sessions and send performance data through an app to a web-based platform. Patients in the control group (CG) were advised to exercise regularly [usual care].

Results: Ninety-four patients (46 IG, 48 CG) were randomized. The analysis of covariance showed non-significant improvements in 6-min walk distance [19.9m (95% CI -4.1/+43.8)] and Chronic Respiratory Disease Questionnaire - Emotion score [0.4 points (0-0.8)] in the IG. Secondary linear mixed models showed improvements in the IG in Short Form-36 mental component summary [9.7, (4.0-15.4)] and Chronic Respiratory Disease Questionnaire - Emotion [0.5, (0.2-0.9)] scores, but there was no association between compliance and outcomes. Acute exacerbations were associated with a marginally significant decrease in 6-minute walk distance of 15.8m (-32.3/0.8) in linear models.

Conclusions: The TelePR maintenance strategy was both feasible and safe but failed to show superiority over usual care, despite improvements in some HRQoL domains. Acute exacerbations may have an important negative influence on long-term physical function.

[11] Galdiz JB, Gómez A, Rodriguez D, et al. Telerehabilitation Programme as a Maintenance Strategy for COPD Patients: A 12-Month Randomized Clinical Trial [published online ahead of print, 2020 May 18]. *Arch Bronconeumol.* 2020;S0300-2896(20)30116-2. doi:10.1016/j.arbres.2020.03.034

Jiang et al (2020) [Randomised Controlled Trial] Evaluating an Intervention Program Using WeChat for Patients With Chronic Obstructive Pulmonary Disease: Randomized Controlled Trial[12]

Background: The application of telemedicine in home pulmonary rehabilitation interventions for the management of patients with chronic obstructive pulmonary disease (COPD) has achieved promising results.

Objective: This study aimed to develop a WeChat official account (Pulmonary Internet Explorer Rehabilitation [PeR]) based on social media. It further evaluated the effect of PeR on the quality of life, symptoms, and exercise self-efficacy of patients with COPD.

Methods: The functional modules of PeR were developed by a multidisciplinary team according to the electronic health-enhanced chronic care model (eCCM) components. A total of 106 patients were randomly selected (53 in the PeR group and 53 in the outpatient face-to-face group [FtF]). Pulmonary rehabilitation intervention was conducted for 3 months, and the outcome was observed for 3 months. The primary outcome was patient quality of life measured with the COPD assessment test (CAT). The secondary outcomes were evaluated using the modified Medical Research Council scale (mMRC), exercise self-regulatory efficacy scale (Ex-SRES), and St George's Respiratory Questionnaire (SGRQ).

Results: The intention-to-treat analysis was used in the study. A total of 94 participants completed the 6-month pulmonary rehabilitation program. No statistically significant differences were observed in CAT ($F_{1,3}=7.78$, P=.001), Ex-SRES ($F_{1,3}=21.91$, P<.001), and mMRC scores ($F_{1,3}=29.64$, P<.001) between the two groups with the variation in time tendency. The Ex-SRES score had a significant effect on the CAT score (P=.03). The partial regression coefficient of Ex-SRES to CAT was 0.81, and Exp (B) was 2.24.

Conclusions: The telemedicine technology was effective using the eCCM combined with a behavioral intervention strategy centering on self-efficacy. Pulmonary rehabilitation at home through PeR and FtF could improve the sense of self-efficacy and quality of life and alleviate symptoms in patients with COPD.

[12] Jiang Y, Liu F, Guo J, et al. Evaluating an Intervention Program Using WeChat for Patients With Chronic Obstructive Pulmonary Disease: Randomized Controlled Trial. *J Med Internet Res*. 2020;22(4):e17089. Published 2020 Apr 21. doi:10.2196/17089

Jimenez-Reguera et al (2020) [Randomised Controlled Trial]
Development And Preliminary Evaluation Of The Effects Of An mHealth Web-based Platform (HappyAir™) on Adherence To a Maintenance Program After Pulmonary Rehabilitation In COPD Patients: Randomized Controlled Trial[13]

Background: Pulmonary rehabilitation (PR) is one of the main interventions to reduce the use of health resources, and it promotes a reduction in chronic obstructive pulmonary disease (COPD) costs. mHealth systems in COPD aim to improve adherence to maintenance programs after PR by promoting the change in attitude and behavior necessary for patient involvement in the management of the disease.

Objective: This study aimed to assess the effects of an integrated care plan based on an mHealth web-based platform [HappyAir™] on adherence to a 1-year maintenance program applied after PR in COPD patients.

Methods: COPD patients from three hospitals were randomized to a control group (CG) or an intervention group [HappyAir™ group [HG]]. Patients from both groups received an 8-week program of PR and educational sessions about their illness. After completion of the process, only the HG performed an integrated care plan for 10 months, supervised by an mHealth system and therapeutic educator. The CG only underwent the scheduled check-ups. Adherence to the program was rated using the CAP FISIO questionnaire. Other variables analyzed were adherence to physical activity (Morisky-Green Test), quality of life (CAT, SGRQ and EuroQOL-5D), exercise capacity (6MWT) and lung function.

Results: In total, 44 patients were recruited and randomized in the CG (n=24) and HG (n=20). Eight patients dropped out for different reasons. The CAP FISIO questionnaire results showed an improvement in adherence during follow-up period for the HG, which was statistically different compared to the CG at 12 months (56.1±4 vs 44±13.6; P=.004) after PR.

Conclusions: mHealth systems designed for COPD patients improve adherence to maintenance programs, as long as they are accompanied by disease awareness and patient involvement in management.

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[13] Jiménez-Reguera B, Maroto López E, Fitch S, et al. Development And Preliminary Evaluation Of The Effects Of An mHealth Web-based Platform (HappyAir™) on Adherence To a Maintenance Program After Pulmonary Rehabilitation In COPD Patients: Randomized Controlled Trial [published online ahead of print, 2020 Jun 3]. *JMIR Mhealth Uhealth*. 2020;10.2196/18465. doi:10.2196/18465

Sink et al (2020) [Randomised Controlled Trial] **Effectiveness of a Novel, Automated Telephone Intervention on Time to Hospitalisation in Patients With COPD: A Randomised Controlled Trial**[14]

Introduction: Owing to its capacity to perform remote assessments, telemedicine is rising as a new force in chronic obstructive pulmonary disease (COPD) management. We conducted an eight month randomised-controlled-trial to study the effect of an automated telemedicine intervention on patients' time-to-hospitalisation.

Methods: A total of 168 patients with a diagnosis of COPD in the past 24 months were enrolled to receive the intervention at a primary care clinic. The treatment group received daily phone messages from an automated system asking them to report if they were breathing better than, worse than, or the same as the day prior. Patients reported their breathing status by responding to the text message or call. If a patient reported breathing worse, an alert was sent directly to that patient's provider within the clinic. The control group received the same daily phone messages as the treatment group. However, no proactive breathing alerts were ever generated to the provider for these subjects. The primary outcome was the subjects' time-to-first-COPD-related hospitalisation following the start of messages.

Results: The treatment group's time-to-hospitalisation was significantly different than the control group's with a hazard ratio of 2.36 (95% confidence interval 1.02–5.45, p = 0.0443). The number needed-to-treat ratio was 8.62. Subject engagement consistently ranged between 60% and 75%. The treatment group received both proactive monitoring and follow-up care from the providers.

Discussion: Active monitoring with provider feedback enables the detection of exacerbation events early enough for subjects to avoid admissions. The use of non-smartphone interventions reduces barriers to care presented by more complicated and expensive technologies. This intervention represents a simple, innovative, and inexpensive tool for improved COPD management.

[14] Sink E, Patel K, Groenendyk J, et al. Effectiveness of a novel, automated telephone intervention on time to hospitalisation in patients with COPD: A randomised controlled trial. *J Telemed Telecare*. 2020;26(3):132-139. doi:10.1177/1357633X18800211

Boer et al (2019) [Randomised Controlled Trial] A Smart Mobile Health Tool Versus a Paper Action Plan to Support Self-Management of Chronic Obstructive Pulmonary Disease Exacerbations: Randomized Controlled Trial[15]

Background: Many patients with chronic obstructive pulmonary disease (COPD) suffer from exacerbations, a worsening of their respiratory symptoms that warrants medical treatment. Exacerbations are often poorly recognized or managed by patients, leading to increased disease burden and health care costs.

Objective: This study aimed to examine the effects of a smart mobile health (mHealth) tool that supports COPD patients in the self-management of exacerbations by providing predictions of early exacerbation onset and timely treatment advice without the interference of health care professionals.

Methods: In a multicenter, 2-arm randomized controlled trial with 12-months follow-up, patients with COPD used the smart mHealth tool [intervention group] or a paper action plan [control group] when they experienced worsening of respiratory symptoms. For our primary outcome exacerbation-free time, expressed as weeks without exacerbation, we used an automated telephone questionnaire system to measure weekly respiratory symptoms and treatment actions. Secondary outcomes were health status, self-efficacy, self-management behavior, health care utilization, and usability. For our analyses, we used negative binomial regression, multilevel logistic regression, and generalized estimating equation regression models.

Results: Of the 87 patients with COPD recruited from primary and secondary care centers, 43 were randomized to the intervention group. We found no statistically significant differences between the intervention group and the control group in exacerbation-free weeks (mean 30.6, SD 13.3 vs mean 28.0, SD 14.8 weeks, respectively; rate ratio 1.21; 95% CI 0.77-1.91) or in health status, self-efficacy, self-management behavior, and health care utilization. Patients using the mHealth tool valued it as a more supportive tool than patients using the paper action plan. Patients considered the usability of the mHealth tool as good.

Conclusions: This study did not show beneficial effects of a smart mHealth tool on exacerbation-free time, health status, self-efficacy, self-

[15] Boer L, Bischoff E, van der Heijden M, et al. A Smart Mobile Health Tool Versus a Paper Action Plan to Support Self-Management of Chronic Obstructive Pulmonary Disease Exacerbations: Randomized Controlled Trial. *JMIR Mhealth Uhealth*. 2019;7(10):e14408. Published 2019 Oct 9. doi:10.2196/14408

management behavior, and health care utilization in patients with COPD compared with the use of a paper action plan. Participants were positive about the supportive function and the usability of the mHealth tool. mHealth may be a valuable alternative for COPD patients who prefer a digital tool instead of a paper action plan.

Ancochea et al (2018) [Randomised Controlled Trial] Efficacy and Costs of Telehealth for the Management of COPD: The PROMETE II Trial[16]

Chronic obstructive pulmonary disease (COPD) is a significant and largely underdiagnosed cause of morbidity and mortality worldwide. More long-term survivors with advanced disease have led to an ageing COPD population profile with an increased level of acute exacerbations, hospitalisations and polymorbidity.

Attention has been placed on identifying and validating innovative COPD care models, such as telehealth, particularly for high-cost patients with severe COPD and/or frequent acute exacerbations. Early intervention during an exacerbation has been shown to reduce severity, duration and hospitalisation rates, and may lead to a slower decline in lung function and reduced clinical or social care costs.

Remote patient monitoring is often a key element of new care programmes as it permits the regular collection of physiological and symptomatic data from patients at home, which can be used to promptly identify exacerbations and initiate treatment.

Previously, the PROMETE I study confirmed the practicality of a telehealth intervention for severe COPD patients, and produced directional cost and clinical benefit data. As a development and refinement of this study, the larger and longer PROMETE II project was designed. The primary objective was to reduce the number of COPD exacerbations leading to emergency department visits/hospital admissions with telehealth.

Broadbent et al (2018) [Randomised Controlled Trial] Using Robots at Home to Support Patients With Chronic Obstructive Pulmonary Disease: Pilot Randomized Controlled Trial[17]

Background: Socially assistive robots are being developed for patients to help manage chronic health conditions such as chronic obstructive

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[16] Ancochea J, García-Río F, Vázquez-Espinosa E, et al. Efficacy and costs of telehealth for the management of COPD: the PROMETE II trial. *Eur Respir J.* 2018;51(5):1800354. Published 2018 May 30. doi:10.1183/13993003.00354-2018

[17] Broadbent E, Garrett J, Jepsen N, et al. Using Robots at Home to Support Patients With Chronic Obstructive Pulmonary Disease: Pilot Randomized Controlled Trial. *J Med Internet Res.* 2018;20(2):e45. Published 2018 Feb 13. doi:10.2196/jmir.8640

pulmonary disease (COPD). Adherence to medication and availability of rehabilitation are suboptimal in this patient group, which increases the risk of hospitalization.

Objective: This pilot study aimed to investigate the effectiveness of a robot delivering telehealth care to increase adherence to medication and home rehabilitation, improve quality of life, and reduce hospital readmission compared with a standard care control group.

Methods: At discharge from hospital for a COPD admission, 60 patients were randomized to receive a robot at home for 4 months or to a control group. Number of hospitalization days for respiratory admissions over the 4-month study period was the primary outcome. Medication adherence, frequency of rehabilitation exercise, and quality of life were also assessed. Implementation interviews as well as benefit-cost analysis were conducted.

Results: Intention-to-treat and per protocol analyses showed no significant differences in the number of respiratory-related hospitalizations between groups. The intervention group was more adherent to their long-acting inhalers (mean number of prescribed puffs taken per day=48.5%) than the control group (mean 29.5%, P=.03, d=0.68) assessed via electronic recording. Self-reported adherence was also higher in the intervention group after controlling for covariates (P=.04). The intervention group increased their rehabilitation exercise frequency compared with the control group (mean difference -4.53, 95% CI -7.16 to -1.92). There were no significant differences in quality of life. Of the 25 patients who had the robot, 19 had favorable attitudes.

Conclusions: This pilot study suggests that a homecare robot can improve adherence to medication and increase exercise. Further research is needed with a larger sample size to further investigate effects on hospitalizations after improvements are made to the robots. The robots could be especially useful for patients struggling with adherence.

Kwon et al (2018) [Randomised Controlled Trial] An mHealth Management Platform for Patients With Chronic Obstructive Pulmonary Disease (Efil Breath): Randomized Controlled Trial[18]

Background: Chronic obstructive pulmonary disease (COPD) is one of the major morbidities in public health, and the use of mHealth technology for rehabilitation of patients with COPD can help increase physical activity and ameliorate respiratory symptoms.

Objective: This study aimed to develop a comprehensive rehabilitation management platform to improve physical activity and quality of life in patients with COPD.

Methods: The study comprised the following 2 stages: 1. a pilot stage in which a prototype app was developed; and 2. a fully-fledged platform development stage in which 2 apps and 1 COPD patient monitoring website were developed. We conducted a randomized clinical trial to investigate the efficacy of the apps developed in the second stage of the study. In addition, two 12-week exercise regimens [fixed and fixed-interactive] were tested for the trial. The clinical parameters of the respiratory function and patient global assessment (PGA) of the app were obtained and analyzed. Notably, Android was the chosen operating system for apps.

Results: We developed 2 COPD rehabilitation apps and 1 patient monitoring website. For the clinical trial, 85 patients were randomized into the following 3 groups: 57 were allocated to the 2 intervention groups and 28 to the control group. After 6 weeks, the COPD assessment test scores were significantly reduced in the fixed group (P=.01), and signs of improvement were witnessed in the fixed-interactive group. In addition, the PGA score was moderate or high in all aspects of the user experience of the apps in both intervention groups.

Conclusions: A well-designed mobile rehabilitation app for monitoring and managing patients with COPD can supplement or replace traditional center-based rehabilitation programs and achieve improved patient health outcomes.

[18] Kwon H, Lee S, Jung EJ, et al. An mHealth Management Platform for Patients with Chronic Obstructive Pulmonary Disease (efil breath): Randomized Controlled Trial. *JMIR Mhealth Uhealth*. 2018;6(8):e10502. Published 2018 Aug 24. doi:10.2196/10502

Soriano et al (2018) [Randomised Controlled Trial] A Multicentre, Randomized Controlled Trial of Telehealth for the Management of COPD[19]

Background: Evidence is needed to determine the role of telehealth (TH) in COPD management.

Methods: PROMETE II was a multicentre, randomized, 12-month trial. Severe COPD patients in stable condition were randomized to a specific monitoring protocol with TH or routine clinical practice (RCP). The primary objective was to reduce the number of COPD exacerbations leading to ER visits/hospital admissions between groups.

Results: Overall, 237 COPD patients were screened, and 229 (96.6%) were randomized to TH (n = 115) or RCP (n = 114), with age of 71 ± 8 years and 80% were men. Overall, 169 completed the full follow-up period. There were no statistical differences at one year between groups in the proportion of participants who had a COPD exacerbation (60% in TH vs. 53.5% in RCP; p = 0.321). There was, however, a marked but non-significant trend towards a shorter duration of hospitalization and days in ICU in the TH group (18.9 ± 16.0 and 6.0 ± 4.6 days) compared to the RCP group (22.4 ± 19.5 and 13.3 ± 11.1 days). The number of all-cause deaths was comparable between groups (12 in TH vs. 13 in RCP) as was total resource utilization cost (7912€ in TH vs. 8918€ in RCP). Telehealth was evaluated highly positively by patients and doctors.

Conclusions: Remote patient management did not reduce COPD-related ER visits or hospital admissions compared to RCP within 12 months.

Tupper et al (2018) [Randomised Controlled Trial] Effect of Tele-Health Care on Quality of Life in Patients With Severe COPD: A Randomized Clinical Trial[20]

Background and Objective: Telemonitoring (TM) of patients with COPD has gained much interest, but studies have produced conflicting results. We aimed to investigate the effect of TM with the option of video consultations on quality of life (QoL) in patients with severe COPD.

Patients and Methods: COPD patients at high risk of exacerbations were eligible for the 6-month study and a total of 281 patients were equally randomized to either TM (n=141) or usual care (n=140). TM comprised

[19] Soriano JB, García-Río F, Vázquez-Espinosa E, et al. A multicentre, randomized controlled trial of telehealth for the management of COPD. *Respir Med*. 2018;144:74-81. doi:10.1016/j.rmed.2018.10.008

[20] Tupper OD, Gregersen TL, Ringbaek T, et al. Effect of tele-health care on quality of life in patients with severe COPD: a randomized clinical trial. *Int J Chron Obstruct Pulmon Dis*. 2018;13:2657-2662. Published 2018 Aug 29. doi:10.2147/COPD.S164121

recording of symptoms, oxygen saturation, spirometry, and video consultations. Algorithms generated alerts if readings breached thresholds. Both groups filled in a health-related QoL questionnaire (15D©) and the COPD Assessment Test (CAT) at baseline and at 6 months. Within-group differences were analyzed by paired *t*-test.

Results: Most of the enrolled patients had severe COPD: 86% with Global Initiative for Chronic Obstructive Lung Disease stage 3 or 4 and 45% with admission for COPD within the last year, respectively. No difference in drop-out rate and mortality was found between the groups, and likewise there was no difference in 15D or CAT at baseline. At 6 months, a significant improvement of 0.016 in 15D score (p=0.03; minimal clinically important difference 0.015) was observed in the TM group compared to baseline, while there was no improvement in the control group -0.003 (p=0.68). After stratifying 15D score at baseline to <0.75 or ≥0.75, respectively, there was a significant difference in the <0.75 TM group of 0.037 (p=0.001), which is a substantial improvement. No statistically significant changes were found in CAT score.

Conclusion: Compared to the nonintervention group, TM as an add-on to usual care over a 6-month period improved QoL, as assessed by the 15D questionnaire, in patients with severe COPD, whereas no difference between groups was observed in CAT score.

Walker et al (2018) [Randomised Controlled Trial] Telemonitoring in Chronic Obstructive Pulmonary Disease (CHROMED). A Randomized Clinical Trial[21]

Rationale: Early detection of chronic obstructive pulmonary disease (COPD) exacerbations using telemonitoring of physiological variables might reduce the frequency of hospitalization.

Objectives: To evaluate the efficacy of home monitoring of lung mechanics by the forced oscillation technique and cardiac parameters in older patients with COPD and comorbidities.

Methods: This multicenter, randomized clinical trial recruited 312 patients with Global Initiative for Chronic Obstructive Lung Disease grades II to IV COPD (median age, 71 yr [interquartile range, 66-76 yr]; 49.6% grade II, 50.4% grades III-IV), with a history of exacerbation in the previous year and at least one nonpulmonary comorbidity. Patients were randomized to usual care (n =

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[21] Walker PP, Pompilio PP, Zanaboni P, et al. Telemonitoring in Chronic Obstructive Pulmonary Disease (CHROMED). A Randomized Clinical Trial. *Am J Respir Crit Care Med.* 2018;198(5):620-628. doi:10.1164/rccm.201712-2404OC

158) or telemonitoring (n = 154) and followed for 9 months. All telemonitoring patients self-assessed lung mechanics daily, and in a subgroup with congestive heart failure (n = 37) cardiac parameters were also monitored. An algorithm identified deterioration, triggering a telephone contact to determine appropriate interventions.

Measurements and Main Results: Primary outcomes were time to first hospitalization (TTFH) and change in the EuroQoL EQ-5D utility index score. Secondary outcomes included: rate of antibiotic/corticosteroid prescription; hospitalization; the COPD Assessment Tool, Patient Health Questionnaire-9, and Minnesota Living with Heart Failure questionnaire scores; quality-adjusted life years; and healthcare costs. Telemonitoring did not affect TTFH, EQ-5D utility index score, antibiotic prescriptions, hospitalization rate, or questionnaire scores. In an exploratory analysis, telemedicine was associated with fewer repeat hospitalizations (-54%; P = 0.017).

Conclusions: In older patients with COPD and comorbidities, remote monitoring of lung function by forced oscillation technique and cardiac parameters did not change TTFH and EQ-5D.

Bourne et al (2017) [Randomised Controlled Trial] Online Versus Face-To-Face Pulmonary Rehabilitation for Patients With Chronic Obstructive Pulmonary Disease: Randomised Controlled Trial[22]

Objective: To obtain evidence whether the online pulmonary rehabilitation(PR) programme 'my-PR' is non-inferior to a conventional face-to-face PR in improving physical performance and symptom scores in patients with COPD.

Design: A two-arm parallel single-blind, randomised controlled trial.

Setting: The online arm carried out pulmonary rehabilitation in their own homes and the face to face arm in a local rehabilitation facility.

Participants: 90 patients with a diagnosis of chronic obstructive pulmonary disease (COPD), modified Medical Research Council score of 2 or greater referred for pulmonary rehabilitation (PR), randomised in a 2:1 ratio to online (n=64) or face-to-face PR (n=26). Participants unable to use an internet-enabled device at home were excluded.

Main Outcome Measures: Coprimary outcomes were 6 min walk distance test and the COPD assessment test (CAT) score at completion of the programme.

[22] Bourne S, DeVos R, North M, et al. Online versus face-to-face pulmonary rehabilitation for patients with chronic obstructive pulmonary disease: randomised controlled trial. *BMJ Open*. 2017;7(7):e014580. Published 2017 Jul 17. doi:10.1136/bmjopen-2016-014580

Interventions: A 6-week PR programme organised either as group sessions in a local rehabilitation facility, or online PR via log in and access to 'myPR'. Results: The adjusted mean difference for the 6 min walk test (6MWT) between groups for the intention-to-treat (ITT) population was 23.8 m with the lower 95% CI well above the non-inferiority threshold of -40.5 m at -4.5 m with an upper 95% CI of +52.2 m. This result was consistent in the per-protocol (PP) population with a mean adjusted difference of 15 m (-13.7 to 43.8). The CAT score difference in the ITT was -1.0 in favour of the online intervention with the upper 95% CI well below the non-inferiority threshold of 1.8 at 0.86 and the lower 95% CI of -2.9. The PP analysis was consistent with the ITT.

Conclusion: PR is an evidenced-based and guideline-mandated intervention for patients with COPD with functional limitation. A 6-week programme of online-supported PR was non-inferior to a conventional model delivered in face-to-face sessions in terms of effects on 6MWT distance, and symptom scores and was safe and well tolerated.

Chaplin et al (2017) [Randomised Controlled Trial] Interactive Web-Based Pulmonary Rehabilitation Programme: A Randomised Controlled Feasibility Trial[23]

Objectives: The aim of this study was to determine if an interactive web-based pulmonary rehabilitation (PR) programme is a feasible alternative to conventional PR.

Design: Randomised controlled feasibility trial.

Setting: Participants with a diagnosis of chronic obstructive pulmonary disease were recruited from PR assessments, primary care and community rehabilitation programmes. Patients randomised to conventional rehabilitation started the programme according to the standard care at their referred site on the next available date.

Participants: 103 patients were recruited to the study and randomised: 52 to conventional rehabilitation (mean (±SD) age 66 (±8) years, Medical Research Council (MRC) 3 (IQR2-4)); 51 to the web arm (mean (±SD) age 66 (±10) years, MRC 3 (IQR2-4)). Participants had to be willing to participate in either arm of the trial, have internet access and be web literate.

Interventions: Patients randomised to the web-based programme worked through the website, exercising and recording their progress as well as

[23] Chaplin E, Hewitt S, Apps L, et al. Interactive web-based pulmonary rehabilitation programme: a randomised controlled feasibility trial. *BMJ Open*. 2017;7(3):e013682. Published 2017 Mar 31. doi:10.1136/bmjopen-2016-013682

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reading educational material. Conventional PR consisted of twice weekly, 2 hourly sessions, an hour for exercise training and an hour for education. Outcome Measures: Recruitment rates, eligibility, patient preference and dropout and completion rates for both programmes were collected. Standard outcomes for a PR assessment including measures of exercise capacity and quality of life questionnaires were also evaluated.

Results: A statistically significant improvement (p≤0.01) was observed within each group in the endurance shuttle walk test (WEB: mean change 189±211.1; PR classes: mean change 184.5±247.4 s) and Chronic Respiratory disease Questionnaire-Dyspnoea (CRQ-D; WEB: mean change 0.7±1.2; PR classes: mean change 0.8±1.0). However, there were no significant differences between the groups in any outcome. Dropout rates were higher in the web-based programme (57% vs 23%).

Conclusions: An interactive web-based PR programme is feasible and acceptable when compared with conventional PR. Future trials maybe around choice-based PR programmes for select patients enabling stratification of patient care.

Farmer et al (2017) [Randomised Controlled Trial] Self-Management Support Using a Digital Health System Compared With Usual Care for Chronic Obstructive Pulmonary Disease: Randomized Controlled Trial[24]

Background: We conducted a randomized controlled trial of a digital health system supporting clinical care through monitoring and self-management support in community-based patients with moderate to very severe chronic obstructive pulmonary disease (COPD).

Objective: The aim of this study was to determine the efficacy of a fully automated Internet-linked, tablet computer-based system of monitoring and self-management support (EDGE' sElf-management anD support proGrammE) in improving quality of life and clinical outcomes.

Methods: We compared daily use of EDGE with usual care for 12 months. The primary outcome was COPD-specific health status measured with the St George's Respiratory Questionnaire for COPD (SGRQ-C).

Results: A total of 166 patients were randomized: 110 EDGE vs. 56 usual care. All patients were included in an intention to treat analysis. The estimated difference in SGRQ-C at 12 months was -1.7 with a 95% CI of -6.6 to 3.2 (p=.49). The relative risk of hospital admission for EDGE was 0.83 (0.56–1.24,

[24] Farmer A, Williams V, Velardo C, et al. Self-Management Support Using a Digital Health System Compared With Usual Care for Chronic Obstructive Pulmonary Disease: Randomized Controlled Trial. *J Med Internet Res*. 2017;19(5):e144. Published 2017 May 3. doi:10.2196/jmir.7116

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p=.37) compared with usual care. Generic health status (EQ-5D, EuroQol 5-Dimension Questionnaire) between the groups differed significantly with better health status for the EDGE group (0.076, 95% CI 0.008-0.14, P=.03). The median number of visits to general practitioners for EDGE versus usual care were 4 versus 5.5 (p=.06) and to practice nurses were 1.5 versus 2.5 (p=.03), respectively.

Conclusions: The EDGE clinical trial does not provide evidence for an effect on COPD-specific health status in comparison with usual care, despite uptake of the intervention. However, there appears to be an overall benefit in generic health status; and the effect sizes for improved depression score, reductions in hospital admissions, and general practice visits warrants further evaluation and could make an important contribution to supporting people with COPD.

Rixon et al (2017) [Randomised Controlled Trial] A RCT of Telehealth for COPD Patient's Quality of Life: The Whole System Demonstrator Evaluation[25]

Introduction and Objectives: Despite some concerns that the introduction of telehealth (TH) may lead to reductions in quality of life (QoL), lower mood and increased anxiety in response to using assistive technologies to reduce health care utilisation and manage long term conditions, this research focuses on the extent to which providing people with tools to monitor their condition can improve QoL.

Methods: The Chronic Obstructive Pulmonary Disease (COPD) cohort of the Whole Systems Demonstrator Trial is a pragmatic General Practitioner (GP) clustered randomised controlled trial (RCT) evaluating TH in the UK from three regions in England. All patients at a participating GP practice were deemed eligible for inclusion in the study if they were diagnosed with COPD.

Results: 447 participants completed baseline and either a short [4 months] or long term [12 months] follow-up. There was a trend of improved QoL and mood in the TH group at longer-term follow-up, but not short term follow-up. Emotional functioning (g = 0.280 95%CI, 0.051-0.510) and mastery reached (g = 2.979 95%CI, 0-0.46) significance at P < 0.05 [all Hedges g <0.3].

Conclusions: TH showed minimal benefit to QoL in COPD patients who were not preselected to be at increased risk of acute exacerbations. Benefits were more likely in disease specific measures at longer term follow-up. TH is a

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[25] Rixon L, Hirani SP, Cartwright M, et al. A RCT of telehealth for COPD patient's quality of life: the whole system demonstrator evaluation. *Clin Respir J.* 2017;11(4):459-469. doi:10.1111/crj.12359

complex intervention and should be embedded in a service that is evidenced based. Outcome measures must be sensitive enough to detect changes in the target population for the specific intervention.

Shah et al (2017) [Randomised Controlled Trial] Exacerbations in Chronic Obstructive Pulmonary Disease: Identification and Prediction Using a Digital Health System[26]

Background: Chronic obstructive pulmonary disease (COPD) is a progressive, chronic respiratory disease with a significant socioeconomic burden. Exacerbations, the sudden and sustained worsening of symptoms, can lead to hospitalization and reduce quality of life. Major limitations of previous telemonitoring interventions for COPD include low compliance, lack of consensus on what constitutes an exacerbation, limited numbers of patients, and short monitoring periods. We developed a telemonitoring system based on a digital health platform that was used to collect data from the 1-year EDGE [Self-Management and Support Programme] COPD clinical trial aiming at daily monitoring in a heterogeneous group of patients with moderate to severe COPD.

Objective: The objectives of the study were as follows: first, to develop a systematic and reproducible approach to exacerbation identification and to track the progression of patient condition during remote monitoring; and second, to develop a robust algorithm able to predict COPD exacerbation, based on vital signs acquired from a pulse oximeter.

Methods: We used data from 110 patients, with a combined monitoring period of more than 35,000 days. We propose a finite-state machine-based approach for modeling COPD exacerbation to gain a deeper insight into COPD patient condition during home monitoring to take account of the time course of symptoms. A robust algorithm based on short-period trend analysis and logistic regression using vital signs derived from a pulse oximeter is also developed to predict exacerbations.

Results: On the basis of 27,260 sessions recorded during the clinical trial with average usage of 5.3 times per week for 12 months, there were 361 exacerbation events. There was considerable variation in the length of exacerbation events, with a mean length of 8.8 days. The mean value of oxygen saturation was lower, and both the pulse rate and respiratory rate were higher before an impending exacerbation episode, compared with stable periods. On the basis of the classifier developed in this work,

[26] Shah SA, Velardo C, Farmer A, Tarassenko L. Exacerbations in Chronic Obstructive Pulmonary Disease: Identification and Prediction Using a Digital Health System. *J Med Internet Res*. 2017;19(3):e69. Published 2017 Mar 7. doi:10.2196/jmir.7207

prediction of COPD exacerbation episodes with 60%-80% sensitivity will result in 68%-36% specificity.

Conclusions: All 3 vital signs acquired from a pulse oximeter ▢ pulse rate, oxygen saturation, and respiratory rate ▢ are predictive of COPD exacerbation events, with oxygen saturation being the most predictive, followed by respiratory rate and pulse rate. Combination of these vital signs with a robust algorithm based on machine learning leads to further improvement in positive predictive accuracy.

Tsai et al (2017) [Randomised Controlled Trial] Home-based Telerehabilitation via Real-Time Videoconferencing Improves Endurance Exercise Capacity in Patients With COPD: The Randomized Controlled TeleR Study[27]

Background and Objective: Telerehabilitation has the potential to increase access to pulmonary rehabilitation (PR) for patients with COPD who have difficulty accessing centre-based PR due to poor mobility, lack of transport and cost of travel. We aimed to determine the effect of supervised, home-based, real-time videoconferencing telerehabilitation on exercise capacity, self-efficacy, health-related quality of life (HRQoL) and physical activity in patients with COPD compared with usual care without exercise training.

Methods: Patients with COPD were randomized to either a supervised home-based telerehabilitation group (TG) that received exercise training three times a week for 8 weeks or a control group (CG) that received usual care without exercise training. Outcomes were measured at baseline and following the intervention.

Results: Thirty-six out of 37 participants (mean ± SD age = 74 ± 8 years, forced expiratory volume in 1 s (FEV_1) = 64 ± 21% predicted) completed the study. Compared with the CG, the TG showed a statistically significant increase in endurance shuttle walk test time (mean difference = 340 s (95% CI: 153-526, P < 0.001)), an increase in self-efficacy (mean difference = 8 points (95% CI: 2-14, P < 0.007)), a trend towards a statistically significant increase in the Chronic Respiratory Disease Questionnaire total score (mean difference = 8 points (95% CI: -1 to 16, P = 0.07)) and no difference in physical activity (mean difference = 475 steps per day (95% CI: -200 to 1151, P = 0.16)).

[27] Tsai LL, McNamara RJ, Moddel C, Alison JA, McKenzie DK, McKeough ZJ. Home-based telerehabilitation via real-time videoconferencing improves endurance exercise capacity in patients with COPD: The randomized controlled TeleR Study. *Respirology*. 2017;22(4):699-707. doi:10.1111/resp.12966

Conclusion: This study showed that telerehabilitation improved endurance exercise capacity and self-efficacy in patients with COPD when compared with usual care.

Vasilopoulou et al (2017) [Randomised Controlled Trial] Home-based Maintenance Tele-Rehabilitation Reduces the Risk for Acute Exacerbations of COPD, Hospitalisations and Emergency Department Visits[28]

Pulmonary rehabilitation (PR) remains grossly underutilised by suitable patients worldwide. We investigated whether home-based maintenance tele-rehabilitation will be as effective as hospital-based maintenance rehabilitation and superior to usual care in reducing the risk for acute chronic obstructive pulmonary disease (COPD) exacerbations, hospitalisations and emergency department (ED) visits. Following completion of an initial 2-month PR programme this prospective, randomised controlled trial between December 2013 and July 2015 compared 12 months of home-based maintenance tele-rehabilitation (n=47) with 12 months of hospital-based, outpatient, maintenance rehabilitation (n=50) and also to 12 months of usual care treatment (n=50) without initial PR. In a multivariate analysis during the 12-month follow-up, both home-based tele-rehabilitation and hospital-based PR remained independent predictors of a lower risk for 1) acute COPD exacerbation (incidence rate ratio (IRR) 0.517, 95% CI 0.389-0.687, and IRR 0.635, 95% CI 0.473-0.853), respectively, and 2) hospitalisations for acute COPD exacerbation (IRR 0.189, 95% CI 0.100-0.358, and IRR 0.375, 95% CI 0.207-0.681), respectively. However, only home-based maintenance tele-rehabilitation and not hospital-based, outpatient, maintenance PR was an independent predictor of ED visits (IRR 0.116, 95% CI 0.072-0.185). Home-based maintenance tele-rehabilitation is equally effective as hospital-based, outpatient, maintenance PR in reducing the risk for acute COPD exacerbation and hospitalisations. In addition, it encounters a lower risk for ED visits, thereby constituting a potentially effective alternative strategy to hospital-based, outpatient, maintenance PR.

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[28] Vasilopoulou M, Papaioannou AI, Kaltsakas G, et al. Home-based maintenance tele-rehabilitation reduces the risk for acute exacerbations of COPD, hospitalisations and emergency department visits. *Eur Respir J.* 2017;49(5):1602129. Published 2017 May 25. doi:10.1183/13993003.02129-2016

Velardo et al (2017) [Randomised Controlled Trial] Digital Health System for Personalised COPD Long-Term Management[29]

Background: Recent telehealth studies have demonstrated minor impact on patients affected by long-term conditions. The use of technology does not guarantee the compliance required for sustained collection of high-quality symptom and physiological data. Remote monitoring alone is not sufficient for successful disease management. A patient-centred design approach is needed in order to allow the personalisation of interventions and encourage the completion of daily self-management tasks.

Methods: A digital health system was designed to support patients suffering from chronic obstructive pulmonary disease in self-managing their condition. The system includes a mobile application running on a consumer tablet personal computer and a secure backend server accessible to the health professionals in charge of patient management. The patient daily routine included the completion of an adaptive, electronic symptom diary on the tablet, and the measurement of oxygen saturation via a wireless pulse oximeter.

Results: The design of the system was based on a patient-centred design approach, informed by patient workshops. One hundred and ten patients in the intervention arm of a randomised controlled trial were subsequently given the tablet computer and pulse oximeter for a 12-month period. Patients were encouraged, but not mandated, to use the digital health system daily. The average used was 6.0 times a week by all those who participated in the full trial. Three months after enrolment, patients were able to complete their symptom diary and oxygen saturation measurement in less than 1 m 40s [96% of symptom diaries]. Custom algorithms, based on the self-monitoring data collected during the first 50 days of use, were developed to personalise alert thresholds.

Conclusions: Strategies and tools aimed at refining a digital health intervention require iterative use to enable convergence on an optimal, usable design. Continuous improvement allowed feedback from users to have an immediate impact on the design of the system such as collection of quality data resulting in high compliance with self-monitoring over a prolonged period of time. Health professionals were prompted by prioritisation algorithms to review patient data, which led to their regular use of the remote monitoring website throughout the trial.

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[29] Velardo C, Shah SA, Gibson O, et al. Digital health system for personalised COPD long-term management. *BMC Med Inform Decis Mak.* 2017;17(1):19. Published 2017 Feb 20. doi:10.1186/s12911-017-0414-8

Cameron-Tucker et al (2016) [Randomised Controlled Trial] A Randomized Controlled Trial of Telephone-Mentoring With Home-Based Walking Preceding Rehabilitation in COPD[30]

Purpose: With the limited reach of pulmonary rehabilitation (PR) and low levels of daily physical activity in chronic obstructive pulmonary disease (COPD), a need exists to increase daily exercise. This study evaluated telephone health-mentoring targeting home-based walking [tele-rehabilitation] compared to usual waiting time [usual care] followed by group PR.

Patients and Methods: People with COPD were randomized to tele-rehab [intervention] or usual care [controls]. Tele-rehab delivered by trained nurse health-mentors supported participants' home-based walking over 8-12 weeks. PR, delivered to both groups simultaneously, included 8 weeks of once-weekly education and self-management skills, with separate supervised exercise. Data were collected at three time-points: baseline (TP1), before (TP2), and after (TP3) pulmonary rehabilitation. The primary outcome was change in physical capacity measured by 6-minute walk distance (6MWD) with two tests performed at each time-point. Secondary outcomes included changes in self-reported home-based walking, health-related quality of life, and health behaviors.

Results: Of 65 recruits, 25 withdrew before completing PR. Forty attended a median of 6 (4) education sessions. Seventeen attended supervised exercise (5±2 sessions). Between TP1 and TP2, there was a statistically significant increase in the median 6MWD of 12 (39.1) m in controls, but no change in the tele-rehab group. There were no significant changes in 6MWD between other time-points or groups, or significant change in any secondary outcomes. Participants attending supervised exercise showed a nonsignificant improvement in 6MWD, 12.3 (71) m, while others showed no change, 0 (33) m. The mean 6MWD was significantly greater, but not clinically meaningful, for the second test compared to the first at all time-points.

Conclusion: Telephone-mentoring for home-based walking demonstrated no benefit to exercise capacity. Two 6-minute walking tests at each time-

[30] Cameron-Tucker HL, Wood-Baker R, Joseph L, Walters JA, Schüz N, Walters EH. A randomized controlled trial of telephone-mentoring with home-based walking preceding rehabilitation in COPD. *Int J Chron Obstruct Pulmon Dis*. 2016;11:1991-2000. Published 2016 Aug 25. doi:10.2147/COPD.S109820

point may not be necessary. Supervised exercise seems essential in PR. The challenge of incorporating exercise into daily life in COPD is substantial.

Chatwin et al (2016) [Randomised Controlled Trial] Randomised Crossover Trial of Telemonitoring in Chronic Respiratory Patients (TeleCRAFT Trial)[31]

Design: Randomised crossover trial with 6 months of standard best practice clinical care [control group] and 6 months with the addition of telemonitoring.

Participants: 68 patients with chronic lung disease (38 with COPD; 30 with chronic respiratory failure due to other causes), who had a hospital admission for an exacerbation within 6 months of randomisation and either used long-term oxygen therapy or had an arterial oxygen saturation (SpO2) of <90% on air during the previous admission. Individuals received telemonitoring via broadband link to a hospital-based care team.

Outcome Measures: Primary outcome measure was time to first hospital admission for an acute exacerbation. Secondary outcome measures were hospital admissions, general practitioner consultations and home visits by nurses, quality of life measured by EuroQol-5D and hospital anxiety and depression (HAD) scale, and self-efficacy score (Stanford).

Results: Median (IQR) number of days to first admission showed no difference between the two groups—77 (114) telemonitoring, 77.5 (61) control (p=0.189). Hospital admission rate at 6 months increased (0.63 telemonitoring vs 0.32 control p=0.026). Home visits increased during telemonitoring; GP consultations were unchanged. Self-efficacy fell, while HAD depression score improved marginally during telemonitoring.

Conclusions: Telemonitoring added to standard care did not alter time to next acute hospital admission, increased hospital admissions and home visits overall, and did not improve quality of life in chronic respiratory patients

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[31] Chatwin M, Hawkins G, Panicchia L, et al. Randomised crossover trial of telemonitoring in chronic respiratory patients (TeleCRAFT trial). *Thorax*. 2016;71(4):305-311. doi:10.1136/thoraxjnl-2015-207045

Cordova et al (2016) [Randomised Controlled Trial] A Telemedicine-Based Intervention Reduces the Frequency and Severity of COPD Exacerbation Symptoms: A Randomized Controlled Trial[32]

Background: Patients with chronic obstructive pulmonary disease (COPD) may not recognize worsening symptoms that require intensification of therapy. They may also be reluctant to contact a healthcare provider for minor worsening of symptoms. A telemedicine application for daily symptom reporting may reduce these barriers and improve patient outcomes.

Materials and Methods: Patients hospitalized for a COPD exacerbation within the past year or using supplemental O2 were approached for participation. Patients received optimal COPD care and were given a telecommunication device for symptom reporting. Initial symptom scores were obtained while patients were in their usual state of health. Patients were randomly assigned to an intervention group or a control group [usual medical care]. The control group patients were instructed to seek medical care if their condition worsened. The intervention group symptom scores were assessed by a computer algorithm and compared with initial values. Scores 1 or more points above the initial score generated an alert, and patients were reviewed by a nurse and referred to a physician who prescribed treatment.

Results: Eighty-six patients were screened; 79 met entry criteria and were randomized (intervention group, n=39; control group, n=40). Twelve patients submitted five or fewer symptom reports and were excluded from the analysis. Daily peak flow and dyspnea scores improved only in the intervention group. There were no differences in hospitalization and mortality rates between groups. No serious adverse events were reported.

Conclusions: A telemedicine-based symptom reporting program facilitated early treatment of symptoms and improved lung function and functional status.

Franke et al (2016) [Randomised Controlled Trial] Telemonitoring of Home Exercise Cycle Training in Patients With COPD[33]

Background: Regular physical activity is associated with reduced mortality in patients with chronic obstructive pulmonary disease (COPD). Interventions

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[32] Cordova FC, Ciccolella D, Grabianowski C, et al. A Telemedicine-Based Intervention Reduces the Frequency and Severity of COPD Exacerbation Symptoms: A Randomized, Controlled Trial. *Telemed J E Health*. 2016;22(2):114–122. doi:10.1089/tmj.2015.0035

[33] Franke KJ, Domanski U, Schroeder M, et al. Telemonitoring of home exercise cycle training in patients with COPD. *Int J Chron Obstruct Pulmon Dis*. 2016;11:2821-2829. Published 2016 Nov 11. doi:10.2147/COPD.S114181

to reduce time spent in sedentary behavior could improve outcomes. The primary purpose was to investigate the impact of telemonitoring with supportive phone calls on daily exercise times with newly established home exercise bicycle training. The secondary aim was to examine the potential improvement in health-related quality of life and physical activity compared to baseline.

Methods: This prospective crossover-randomized study was performed over 6 months in stable COPD patients. The intervention phase [domiciliary training with supporting telephone calls] and the control phase [training without phone calls] were randomly assigned to the first or the last 3 months. In the intervention phase, patients were called once a week if they did not achieve a real-time monitored daily cycle time of 20 minutes. Secondary aims were evaluated at baseline and after 3 and 6 months. Health-related quality of life was measured by the COPD Assessment Test (CAT), physical activity by the Godin Leisure Time Exercise Questionnaire (GLTEQ).

Results: Of the 53 included patients, 44 patients completed the study (forced expiratory volume in 1 second 47.5%±15.8% predicted). In the intervention phase, daily exercise time was significantly higher compared to the control phase (24.2±9.4 versus 19.6±10.3 minutes). Compared to baseline (17.6±6.1), the CAT-score improved in the intervention phase to 15.3±7.6 and in the control phase to 15.7±7.3 units. The GLTEQ-score increased from 12.2±12.1 points to 36.3±16.3 and 33.7±17.3.

Conclusion: Telemonitoring is a simple method to enhance home exercise training and physical activity, improving health-related quality of life.

Ho et al (2016) [Randomised Controlled Trial] [Effectiveness of Telemonitoring in Patients With Chronic Obstructive Pulmonary Disease in Taiwan-A Randomized Controlled Trial](#)[34]

Chronic obstructive pulmonary disease (COPD) is the leading cause of death worldwide, and poses a substantial economic and social burden. Telemonitoring has been proposed as a solution to this growing problem, but its impact on patient outcome is equivocal. This randomized controlled trial aimed to investigate effectiveness of telemonitoring in improving COPD patient outcome. In total, 106 subjects were randomly assigned to the

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[34] Ho TW, Huang CT, Chiu HC, et al. Effectiveness of Telemonitoring in Patients with Chronic Obstructive Pulmonary Disease in Taiwan-A Randomized Controlled Trial. *Sci Rep.* 2016;6:23797. Published 2016 Mar 31. doi:10.1038/srep23797

telemonitoring (n = 53) or usual care (n = 53) group. During the two months following discharge, telemonitoring group patients had to report their symptoms daily using an electronic diary. The primary outcome measure was time to first re-admission for COPD exacerbation within six months of discharge. During the follow-up period, time to first re-admission for COPD exacerbation was significantly increased in the telemonitoring group than in the usual care group (p = 0.026). Telemonitoring was also associated with a reduced number of all-cause re-admissions (0.23 vs. 0.68/patient; p = 0.002) and emergency room visits (0.36 vs. 0.91/patient; p = 0.006). In conclusion, telemonitoring intervention was associated with improved outcomes among COPD patients admitted for exacerbation in a country characterized by a small territory and high accessibility to medical services. The findings are encouraging and add further support to implementation of telemonitoring as part of COPD care.

Ritchie et al (2016) [Randomised Controlled Trial] The E-Coach Technology-Assisted Care Transition System: A Pragmatic Randomized Trial[35]

Care transitions from the hospital to home remain a vulnerable time for many patients, especially for those with heart failure (CHF) and chronic obstructive pulmonary disease (COPD). Despite regular use in chronic disease management, it remains unclear how technology can best support patients during their transition from the hospital. We sought to evaluate the impact of a technology-supported care transition support program on hospitalizations, days out of the community and mortality. Using a pragmatic randomized trial, we enrolled patients (511 enrolled, 478 analyzed) hospitalized with CHF/COPD to E-Coach, an intervention with condition-specific customization and in-hospital and post-discharge support by a care transition nurse (CTN), interactive voice response post-discharge calls, and CTN follow-up versus usual post-discharge care (UC). The primary outcome was 30-day rehospitalization. Secondary outcomes included 1. rehospitalization and death; and 2. days in the hospital and out of the community. E-Coach and UC groups were similar at baseline except for gender imbalance (p = 0.02). After adjustment for gender, our primary outcome, 30-day rehospitalization rates did not differ between the E-Coach and UC groups (15.0 vs. 16.3 %, adjusted hazard ratio [95 % confidence

[35] Ritchie CS, Houston TK, Richman JS, et al. The E-Coach technology-assisted care transition system: a pragmatic randomized trial. *Transl Behav Med.* 2016;6(3):428-437. doi:10.1007/s13142-016-0422-8

interval]: 0.94 [0.60, 1.49]). However, in the COPD subgroup, E-Coach was associated with significantly fewer days in the hospital (0.5 vs. 1.6, p = 0.03). E-Coach, an IVR-augmented care transition intervention did not reduce rehospitalization. The positive impact on our secondary outcome (days in hospital) among COPD patients, but not in CHF, may suggest that E-Coach may be more beneficial among patients with COPD.

Talboom-Kamp et al (2016) [Randomised Controlled Trial] e-Vita: Design of an Innovative Approach to COPD Disease Management in Primary Care Through eHealth Application[36]

Background: COPD is a highly complex disease to manage as patients show great variation in symptoms and limitations in daily life. In the last decade self-management support of COPD has been introduced as an effective method to improve quality and efficiency of care, and to reduce healthcare costs. Despite the urge to change the organisation of health care and the potential of eHealth to support this, large-scale implementation in daily practice remains behind, especially in the Netherlands.

Methods: We designed a multilevel study, called e-Vita, to investigate different organisational implementation methods of a self-management web portal to support and empower patients with COPD in three different primary care settings. Using a parallel cohort design, the clinical effects of the web portal will be assessed using an interrupted times series (ITS) study design and measured according to changes in health status with the Clinical COPD Questionnaire (CCQ). The different implementations and net benefits of self-management through eHealth on clinical outcomes will be evaluated from human, organisational, and technical perspectives.

Discussion: To our knowledge this is the first study to combine different study designs that enable simultaneous investigation of clinical effects, as well as effects of different organisational implementation methods whilst controlling for confounding effects of the organisational characteristics. We hypothesize that an implementation with higher levels of personal assistance, and integrated in an existing care program will result in increased use of and satisfaction with the platform, thereby increasing health status and diminishing exacerbation and hospitalisation.

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[36] Talboom-Kamp EP, Verdijk NA, Blom CM, et al. e-Vita: design of an innovative approach to COPD disease management in primary care through eHealth application. *BMC Pulm Med*. 2016;16(1):121. Published 2016 Aug 16. doi:10.1186/s12890-016-0282-5

Vianello et al (2016) [Randomised Controlled Trial] Home Telemonitoring for Patients With Acute Exacerbation of Chronic Obstructive Pulmonary Disease: A Randomized Controlled Trial[37]

Background: Although a number of studies have suggested that the use of Telemonitoring (TM) in patients with Chronic Obstructive Pulmonary Disease (COPD) can be useful and efficacious, its real utility in detecting Acute Exacerbation (AE) signaling the need for prompt treatment is not entirely clear. The current study aimed to investigate the benefits of a TM system in managing AE in advanced-stage COPD patients to improve their Health-Related Quality of Life (HRQL) and to reduce utilization of healthcare services.

Methods: A 12-month Randomised Controlled Trial (RCT) was conducted in the Veneto region of Italy. Adult patients diagnosed with Class III-IV COPD in accordance with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) classification were recruited and provided a TM system to alert the clinical staff via a trained operator whenever variations in respiratory parameters fell beyond the individual's normal range. The study's primary endpoint was HRQL, measured by the Italian version of the two Short Form 36-item Health Survey (SF36v2). Its secondary endpoints were: scores on the Hospital Anxiety and Depression Scale (HADS); the number and duration of hospitalizations; the number of readmissions; the number of appointments with a pulmonary specialist; the number of visits to the emergency department; and the number of deaths.

Results: Three hundred thirty-four patients were enrolled and randomized into two groups for a 1-year period. At its conclusion, changes in the SF36 Physical and Mental Component Summary scores did not significantly differ between the TM and control groups [(-2.07 (8.98) vs -1.91 (7.75); p = 0.889 and -1.08 (11.30) vs -1.92 (10.92); p = 0.5754, respectively]. Variations in HADS were not significantly different between the two groups [0.85 (3.68) vs 0.62 (3.6); p = 0.65 and 0.50 (4.3) vs 0.72 (4.5); p = 0.71]. The hospitalization rate for AECOPD and/or for any cause was not significantly different in the two groups [IRR = 0.89 (95% CI 0.79-1,04); p = 0.16 and IRR = 0.91 (95% CI 0,75 - 1.04); p = 0.16, respectively]. The readmission rate for AECOPD and/or any cause was, however, significantly lower in the TM group with respect to the

[37] Vianello A, Fusello M, Gubian L, et al. Home telemonitoring for patients with acute exacerbation of chronic obstructive pulmonary disease: a randomized controlled trial. *BMC Pulm Med*. 2016;16(1):157. Published 2016 Nov 22. doi:10.1186/s12890-016-0321-2

control one [IRR = 0.43 (95% CI 0.19-0.98); p = 0.01 and 0.46 (95% CI 0.24-0.89); p = 0.01, respectively].

Conclusion: Study results showed that in areas where medical services are well established, TM does not significantly improve HRQL in patients with COPD who develop AE. Although not effective in reducing hospitalizations, TM can nevertheless facilitate continuity of care during hospital-to-home transition by reducing the need for early readmission.

Vitacca et al (2016) [Randomised Controlled Trial] Is There Any Additional Effect of Tele-Assistance on Long-Term Care Programmes in Hypercapnic COPD Patients? A Retrospective Study[38]

The evidence for tele-assistance (TA) in hypercapnic chronic obstructive pulmonary disease (COPD) patients on long-term oxygen therapy (LTOT) is scarce. The aim of this study was to evaluate the effects of addition of long-term TA to LTOT with or without non-invasive ventilation (NIV) in these patients. Retrospective analysis of a previous randomised study of patients on LTOT. According to the care programme patients were divided into Group 1: LTOT; Group 2: LTOT + NIV; Group 3: LTOT + TA and Group 4: LTOT + NIV+TA. Primary Outcomes: Time to first exacerbation and hospitalisation during 12 months of long-term care. Risk of exacerbation was statistically different among groups (p = 0.0002). TA addition to NIV significantly reduced exacerbation risk when compared with that to all groups. Hospitalisation risk was statistically different among groups (p = 0.049). Addition of TA to LTOT but not to NIV significantly reduced hospitalisation risk when compared to Group 1 (p = 0.013). Risk of mortality did not differ among groups (p = 0.074). In chronically hypercapnic COPD patients on LTOT, 1. TA alone and with greater efficacy when combined with NIV may reduce the frequency of exacerbations and 2. TA added to LTOT, but not to NIV, may reduce the frequency of hospitalisations.

[38] Vitacca M, Paneroni M, Grossetti F, Ambrosino N. Is There Any Additional Effect of Tele-Assistance on Long-Term Care Programmes in Hypercapnic COPD Patients? A Retrospective Study. *COPD*. 2016;13(5):576-582. doi:10.3109/15412555.2016.1147542

Vorrink et al (2016) [Randomised Controlled Trial] Efficacy of an mHealth Intervention to Stimulate Physical Activity in COPD Patients After Pulmonary Rehabilitation[39]

Physical inactivity in patients with chronic obstructive pulmonary disease (COPD) is associated with poor health status and increased disease burden. The present study aims to test the efficacy of a previously developed mobile (m)Health intervention to improve or maintain physical activity in patients with COPD after pulmonary rehabilitation. A randomised controlled trial was performed in 32 physiotherapy practices in the Netherlands. COPD patients were randomised into intervention or usual care groups. The intervention consisted of a smartphone application for the patients and a monitoring website for the physiotherapists. Measurements were performed at 0, 3, 6 and 12 months. Physical activity, functional exercise capacity, lung function, health-related quality of life and body mass index were assessed.157 patients started the study and 121 completed it. There were no significant positive effects of the intervention on physical activity (at 0 months: intervention 5824±3418 steps per weekday, usual care 5717±2870 steps per weekday; at 12 months: intervention 4819±2526 steps per weekday, usual care 4950±2634 steps per weekday; p=0.811) or on the secondary end-points. There was a significant decrease over time in physical activity (p<0.001), lung function (p<0.001) and mastery (p=0.017), but not in functional exercise capacity (p=0.585). Although functional exercise capacity did not deteriorate, our mHealth intervention did not improve or maintain physical activity in patients with COPD after a period of pulmonary rehabilitation.

Zanaboni et al (2016) [Randomised Controlled Trial] Long-term Integrated Telerehabilitation of COPD Patients: A Multicentre Randomised Controlled Trial (iTrain)[40]

Background: Pulmonary rehabilitation (PR) is an effective intervention for the management of people with chronic obstructive pulmonary disease (COPD). However, available resources are often limited, and many patients bear with poor availability of programmes. Sustaining PR benefits and regular exercise over the long term is difficult without any exercise maintenance strategy. In contrast to traditional centre-based PR programmes, telerehabilitation may

[39] Vorrink SN, Kort HS, Troosters T, Zanen P, Lammers JJ. Efficacy of an mHealth intervention to stimulate physical activity in COPD patients after pulmonary rehabilitation. *Eur Respir J.* 2016;48(4):1019-1029. doi:10.1183/13993003.00083-2016

[40] Zanaboni P, Dinesen B, Hjalmarsen A, et al. Long-term integrated telerehabilitation of COPD Patients: a multicentre randomised controlled trial (iTrain). *BMC Pulm Med.* 2016;16(1):126. Published 2016 Aug 22. doi:10.1186/s12890-016-0288-z

promote more effective integration of exercise routines into daily life over the longer term and broaden its applicability and availability. A few studies showed promising results for telerehabilitation, but mostly with short-term interventions. The aim of this study is to compare long-term telerehabilitation with unsupervised exercise training at home and with standard care.

Methods: An international multicentre randomised controlled trial conducted across sites in three countries will recruit 120 patients with COPD. Participants will be randomly assigned to telerehabilitation, treadmill and control, and followed up for 2 years. The telerehabilitation intervention consists of individualised exercise training at home on a treadmill, telemonitoring by a physiotherapist via videoconferencing using a tablet computer, and self-management via a customised website. Patients in the treadmill arm are provided with a treadmill only to perform unsupervised exercise training at home. Patients in the control arm are offered standard care. The primary outcome is the combined number of hospitalisations and emergency department presentations. Secondary outcomes include changes in health status, quality of life, anxiety and depression, self-efficacy, subjective impression of change, physical performance, level of physical activity, and personal experiences in telerehabilitation.

Discussion: This trial will provide evidence on whether long-term telerehabilitation represents a cost-effective strategy for the follow-up of patients with COPD. The delivery of telerehabilitation services will also broaden the availability of PR and maintenance strategies, especially to those living in remote areas and with no access to centre-based exercise programmes.

Dyrvig et al (2015) [Cohort Study] A Cohort Study Following Up on a Randomised Controlled Trial of a Telemedicine Application in COPD Patients[41]

Introduction: The studies that constitute the knowledge base of evidence based medicine represent only 5%-50% of patients seen in routine clinical practice. Therefore, whether the available evidence applies to the implementation of a particular service often remains unclear. Chronic obstructive pulmonary disease (COPD) is no exception.

Methods: In this article, the effects of implementing a telemedicine intervention for COPD patients were analysed using data collected before,

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[41] Dyrvig AK, Gerke O, Kidholm K, Vondeling H. A cohort study following up on a randomised controlled trial of a telemedicine application in COPD patients. *J Telemed Telecare*. 2015;21(7):377-384. doi:10.1177/1357633X15572202

during, and after a randomised controlled trial (RCT).More specifically, regression techniques using robust variance estimators were used to analyse whether the use of telemedicine, patient age, and gender could explain the risk of readmission, length of hospital admission, and death during a five-year observation period.

Results: Increased risk of readmission was significantly related to both use of telemedicine and increased age in three sub-periods of the study, whereas women showed a more pronounced risk of readmission than men only during and after the RCT period. The number of days admitted to hospital was higher for patients using telemedicine and being of older age. Risk of death during the observation period was decreased for patients using telemedicine and for female patients and increased for elderly patients. No interaction between intervention and time period was observed.Statistically significant relationships were identified between use of telemedicine and risk of readmission, days admitted to hospital, and death.

Discussion: Research on effect modification in telemedicine is essential in designing future implementation of interventions as it cannot be taken for granted that effectiveness follows from efficacy.

Jakobsen et al (2015) [Randomised Controlled Trial] Home-based Telehealth Hospitalization for Exacerbation of Chronic Obstructive Pulmonary Disease: Findings From The Virtual Hospital Trial[42]

Background: Telehealth interventions for patients with chronic obstructive pulmonary disease (COPD) have focused primarily on stable outpatients. Telehealth designed to handle the acute exacerbation that normally requires hospitalization could also be of interest. The aim of this study was to compare the effect of home-based telehealth hospitalization with conventional hospitalization for exacerbation in severe COPD.

Materials and Methods: A two-center, noninferiority, randomized, controlled effectiveness trial was conducted between June 2010 and December 2011. Patients with severe COPD admitted because of exacerbation were randomized 1:1 either to home-based telehealth hospitalization or to continue standard treatment and care at the hospital. The primary outcome was treatment failure defined as re-admission due to exacerbation in COPD within 30 days after initial discharge. The noninferiority margin was set at 20% of the control group's risk of re-admission. Secondary outcomes were

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mortality, need for manual or mechanical ventilation or noninvasive ventilation, length of hospitalization, physiological parameters, health-related quality of life, user satisfaction, healthcare costs, and adverse events.

Results: In total, 57 patients were randomized: 29 participants in the telehealth group and 28 participants in the control group. Testing the incidence of re-admission within 30 days after discharge could not confirm noninferiority (lower 95% confidence limit, -24.8%; p=0.35). Results were also nonsignificant at 90 days (lower 95% CL, -16.2%; p=0.33) and 180 days (lower 95% CL, -16.6%; p =0.33) after discharge. Superiority testing on secondary outcomes showed nonsignificant differences between groups. Healthcare costs have not yet been evaluated.

Conclusions: Whether home-based telehealth hospitalization is noninferior to conventional hospitalization requires further investigation. The results indicate that a subgroup of patients with severe COPD can be treated for acute exacerbation at home using telehealth, without the physical presence of health professionals and with a proper organizational back-up.

McDowell et al (2015) [Randomised Controlled Trial] A Randomised Clinical Trial of the Effectiveness of Home-Based Health Care With Telemonitoring in Patients With COPD[43]

We studied the effect of telemonitoring in addition to usual care compared to usual care alone in patients with chronic obstructive pulmonary disease (COPD). A total of 110 patients with moderate to severe COPD were recruited from a specialist respiratory service in Northern Ireland. Patients had at least two of: emergency department admissions, hospital admissions or emergency general practitioner contacts in the 12 months before the study. Exclusion criteria were patients who had any respiratory disorder other than COPD, or were cognitively unable to learn the process of monitoring. Patients were randomised to receive six months of home telemonitoring with usual care, or six months of usual care. The primary outcome measure was disease-specific quality of life, as measured by the St George's Respiratory Questionnaire for COPD patients (SGRQ-C). Of 100 patients completing the study, 48 patients were randomised to telemonitoring and 52 patients were randomised to the control group. The SGRQ-C scores improved significantly in the intervention group compared to usual care (P = 0.001). The HADS anxiety score was significantly higher in the telehealth group compared to

[43] McDowell JE, McClean S, FitzGibbon F, Tate S. A randomised clinical trial of the effectiveness of home-based health care with telemonitoring in patients with COPD. *J Telemed Telecare*. 2015;21(2):80-87. doi:10.1177/1357633X14566575

the usual care group (P = 0.01). There were significantly more contacts with the Community Respiratory Team in the telemonitoring group compared to the control group (P = 0.029). There were no significant between group differences in EQ-5D scores, HADS depression scores, GP activity, emergency department visits, hospital admissions or exacerbations. The total cost to the health service of the intervention over the 6-month study period was £2039, giving an estimated ICER of £203,900. In selected patients with COPD, telemonitoring was effective in improving health-related quality of life and anxiety, but was not a cost-effective intervention.

Ringbaek et al (2015) [Randomised Controlled Trial] Effect of Tele Health Care on Exacerbations and Hospital Admissions in Patients With Chronic Obstructive Pulmonary Disease: A Randomized Clinical Trial[44]
Background and Objective: Tele monitoring (TM) of patients with chronic obstructive pulmonary disease (COPD) has gained much interest, but studies have produced conflicting results. Our aim was to investigate the effect of TM with the option of video consultations on exacerbations and hospital admissions in patients with severe COPD.
Materials and Methods: Patients with severe COPD at high risk of exacerbations were eligible for the study. Of 560 eligible patients identified, 279 (50%) declined to participate. The remaining patients were equally randomized to either TM (n=141) or usual care (n=140) for the 6-month study period. TM comprised recording of symptoms, saturation, spirometry, and weekly video consultations. Algorithms generated alerts if readings breached thresholds. Both groups received standard care. The primary outcome was number of hospital admissions for exacerbation of COPD during the study period.
Results: Most of the enrolled patients had severe COPD [forced expiratory volume in 1 second <50%pred in 86% and ≥hospital admission for COPD in the year prior to enrollment in 45%, respectively, of the patients]. No difference in drop-out rate and mortality was found between the groups. With regard to the primary outcome, no significant difference was found in hospital admissions for COPD between the groups (P=0.74), and likewise, no difference was found in time to first admission or all-cause hospital admissions. Compared with the control group, TM group patients had more moderate exacerbations (ie treated with antibiotics/corticosteroid, but not

[44] Ringbæk T, Green A, Laursen LC, Frausing E, Brøndum E, Ulrik CS. Effect of tele health care on exacerbations and hospital admissions in patients with chronic obstructive pulmonary disease: a randomized clinical trial. *Int J Chron Obstruct Pulmon Dis*. 2015;10:1801-1808. Published 2015 Sep 3. doi:10.2147/COPD.S85596

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requiring hospital admission; P<0.001), whereas the control group had more visits to outpatient clinics (P<0.001).

Conclusion: Our study of patients with severe COPD showed that TM including video consultations as add-on to standard care did not reduce hospital admissions for exacerbated COPD, but TM may be an alternative to visits at respiratory outpatient clinics. Further studies are needed to establish the optimal role of TM in the management of severe COPD.

Miscellaneous

Bentley et al (2020) [Feasibility Study] The Use of a Smartphone App and an Activity Tracker to Promote Physical Activity in the Management of Chronic Obstructive Pulmonary Disease: Randomized Controlled Feasibility Study[45]

Background: Chronic obstructive pulmonary disease (COPD) is highly prevalent and significantly affects the daily functioning of patients. Self-management strategies, including increasing physical activity, can help people with COPD have better health and a better quality of life. Digital mobile health techniques have the potential to aid the delivery of self-management interventions for COPD. We developed an mHealth intervention (Self-Management supported by Assistive, Rehabilitative, and Telehealth technologies-COPD [SMART-COPD]), delivered via a smartphone app and an activity tracker, to help people with COPD maintain (or increase) physical activity after undertaking pulmonary rehabilitation (PR).

Objective: This study aimed to determine the feasibility and acceptability of using the SMART-COPD intervention for the self-management of physical activity and to explore the feasibility of conducting a future randomized controlled trial (RCT) to investigate its effectiveness.

Methods: We conducted a randomized feasibility study. A total of 30 participants with COPD were randomly allocated to receive the SMART-COPD intervention (n=19) or control (n=11). Participants used SMART-COPD throughout PR and for 8 weeks afterward (ie, maintenance) to set physical activity goals and monitor their progress. Questionnaire-based and physical activity-based outcome measures were taken at baseline, the end of PR, and

[45] Bentley CL, Powell L, Potter S, et al. The Use of a Smartphone App and an Activity Tracker to Promote Physical Activity in the Management of Chronic Obstructive Pulmonary Disease: Randomized Controlled Feasibility Study. *JMIR Mhealth Uhealth*. 2020;8(6):e16203. Published 2020 Jun 3. doi:10.2196/16203

the end of maintenance. Participants, and health care professionals involved in PR delivery, were interviewed about their experiences with the technology. Results: Overall, 47% (14/30) of participants withdrew from the study. Difficulty in using the technology was a common reason for withdrawal. Participants who completed the study had better baseline health and more prior experience with digital technology, compared with participants who withdrew. Participants who completed the study were generally positive about the technology and found it easy to use. Some participants felt their health had benefitted from using the technology and that it assisted them in achieving physical activity goals. Activity tracking and self-reporting were both found to be problematic as outcome measures of physical activity for this study. There was dissatisfaction among some control group members regarding their allocation.

Conclusions: mHealth shows promise in helping people with COPD self-manage their physical activity levels. mHealth interventions for COPD self-management may be more acceptable to people with prior experience of using digital technology and may be more beneficial if used at an earlier stage of COPD. Simplicity and usability were more important for engagement with the SMART-COPD intervention than personalization; therefore, the intervention should be simplified for future use. Future evaluation will require consideration of individual factors and their effect on mHealth efficacy and use; within-subject comparison of step count values; and an opportunity for control group participants to use the intervention if an RCT were to be carried out. Sample size calculations for a future evaluation would need to consider the high dropout rates.

Holmner et al (2020) [Longitudinal Study] How Stable Is Lung Function in Patients With Stable Chronic Obstructive Pulmonary Disease When Monitored Using a Telehealth System? A Longitudinal and Home-Based Study[46]

Background: Many telehealth systems have been designed to identify signs of exacerbations in patients with chronic obstructive pulmonary disease (COPD), but few previous studies have reported the nature of recorded lung function data and what variations to expect in this group of individuals. The aim of the study was to evaluate the nature of individual diurnal, day-to-day

[46] Holmner Å, Öhberg F, Wiklund U, Bergmann E, Blomberg A, Wadell K. How stable is lung function in patients with stable chronic obstructive pulmonary disease when monitored using a telehealth system? A longitudinal and home-based study. *BMC Med Inform Decis Mak*. 2020;20(1):87. Published 2020 May 12. doi:10.1186/s12911-020-1103-6

and long-term variation in important prognostic markers of COPD exacerbations by employing a telehealth system developed in-house. Methods: Eight women and five men with COPD performed measurements (spirometry, pulse oximetry and the COPD assessment test (CAT)) three times per week for 4-6 months using the telehealth system. Short-term and long-term individual variations were assessed using the relative density and weekly means respectively. Quality of the spirometry measurements (forced expiratory volume in one second (FEV_1) and inspiratory capacity (IC)) was assessed employing the criteria of American Thoracic Society (ATS)/European Respiratory Society (ERS) guidelines.

Results: Close to 1100 measurements of both FEV_1 and IC were performed during a total of 240 patient weeks. The two standard deviation ranges for intra-individual short-term variation were approximately ±210 mL and ± 350 mL for FEV_1 and IC respectively. In long-term, spirometry values increased and decreased without notable changes in symptoms as reported by CAT, although it was unusual with a decrease of more than 50 mL per measurement of FEV_1 between three consecutive measurement days. No exacerbation occurred. There was a moderate to strong positive correlation between FEV_1 and IC, but weak or absent correlation with the other prognostic markers in the majority of the participants.

Conclusions: Although FEV_1 and IC varied within a noticeable range, no corresponding change in symptoms occurred. Therefore, this study reveals important and, to our knowledge, previously not reported information about short and long-term variability in prognostic markers in stable patients with COPD. The present data are of significance when defining criteria for detecting exacerbations using telehealth strategies.

Rodriquez Hermosa et al (2020) [Cohort Study] Compliance and Utility of a Smartphone App for the Detection of Exacerbations in Patients With Chronic Obstructive Pulmonary Disease: Cohort Study[47]
Background: In recent years, mobile health (mHealth)-related apps have been developed to help manage chronic diseases. Apps may allow patients with a chronic disease characterized by exacerbations, such as chronic obstructive pulmonary disease (COPD), to track and even suspect disease exacerbations, thereby facilitating self-management and prompt

[47] Rodriguez Hermosa JL, Fuster Gomila A, Puente Maestu L, et al. Compliance and Utility of a Smartphone App for the Detection of Exacerbations in Patients With Chronic Obstructive Pulmonary Disease: Cohort Study. *JMIR Mhealth Uhealth*. 2020;8(3):e15699. Published 2020 Mar 19. doi:10.2196/15699

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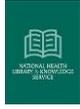
intervention. Nevertheless, there is insufficient evidence regarding patient compliance in the daily use of mHealth apps for chronic disease monitoring.

Objective: This study aimed to provide further evidence in support of prospectively recording daily symptoms as a useful strategy to detect COPD exacerbations through the smartphone app, Prevexair. It also aimed to analyze daily compliance and the frequency and characteristics of acute exacerbations of COPD recorded using Prevexair.

Methods: This is a multicenter cohort study with prospective case recruitment including 116 patients with COPD who had a documented history of frequent exacerbations and were monitored over the course of 6 months. At recruitment, the Prevexair app was installed on their smartphones, and patients were instructed on how to use the app. The information recorded in the app included symptom changes, use of medication, and use of health care resources. The patients received messages on healthy lifestyle behaviors and a record of their cumulative symptoms in the app. There was no regular contact with the research team and no mentoring process. An exacerbation was considered reported if medical attention was sought and considered unreported if it was not reported to a health care professional.

Results: Overall, compliance with daily records in the app was 66.6% (120/180), with a duration compliance of 78.8%, which was similar across disease severity, age, and comorbidity variables. However, patients who were active smokers, with greater dyspnea and a diagnosis of depression and obesity had lower compliance (P<.05). During the study, the patients experienced a total of 262 exacerbations according to daily records in the app, 99 (37.8%) of which were reported exacerbations and 163 (62.2%) were unreported exacerbations. None of the subject-related variables were found to be significantly associated with reporting. The duration of the event and number of symptoms present during the first day were strongly associated with reporting. Despite substantial variations in the COPD Assessment Test (CAT), there was improvement only among patients with no exacerbation and those with reported exacerbations. Nevertheless, CAT scores deteriorated among patients with unreported exacerbations.

Conclusions: The daily use of the Prevexair app is feasible and acceptable for patients with COPD who are motivated in their self-care because of frequent exacerbations of their disease. Monitoring through the Prevexair app showed great potential for the implementation of self-care plans and offered a better diagnosis of their chronic condition.

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Sheridan et al (2020) [Evaluation] "A Breath of Fresh Air" for Tackling Chronic Disease in Ireland? An Evaluation of a Self-Management Support Service for People With Chronic Respiratory Diseases[48]

Objective: To describe the impact of a nurse-led telephone self-management support (SMS) service for people with asthma and COPD in Ireland.

Methods: A cross-sectional survey of all (442) SMS users, July 2016 to May 2017, described user demographics, self-reported experience, process and outcome. Population utilisation was estimated and compared across groups. Factors associated with key outcomes were identified.

Results: The response rate was 162 (36.7%). Utilisation varied across population groups. Reported satisfaction was high, and 56.0% of users without a written action plan reported developing one. Most users reported positive cognitive and affective outcomes indicating effective patient activation. Information pack receipt was independently associated with better outcomes (odds ratio = 11.4 (95% CI, 2.0, 216.6), p < 0.05).

Conclusion: A nurse-led telephone SMS intervention positively impacted self-management for people with asthma and COPD in Ireland.

Practice implications: Roll-out of SMS should include staff training to promote positive service user experience and should include routine monitoring and evaluation to assure equitable reach and quality of key evidence-based care processes.

Al Rajeh et al (2019) [Survey] Use, Utility and Methods of Telehealth for Patients With COPD in England and Wales: A Healthcare Provider Survey[49]

Introduction: Although the effectiveness of domiciliary monitoring (telehealth) to improve outcomes in chronic obstructive pulmonary disease (COPD) is controversial, it is being used in the National Health Service (NHS).

Aim: To explore the use of teleheath for COPD across England and Wales, to assess the perceptions of clinicians employing telehealth in COPD and to summarise the techniques that have been used by healthcare providers to personalise alarm limits for patients with COPD enrolled in telehealth programmes.

[48] Sheridan A, Jennings A, Keane S, Power A, Kavanagh P. "A breath of fresh air" for tackling chronic disease in Ireland? An evaluation of a self-management support service for people with chronic respiratory diseases. *Ir J Med Sci*. 2020;189(2):551-556. doi:10.1007/s11845-019-02081-w

[49] Al Rajeh A, Steiner MC, Aldabayan Y, et al. Use, utility and methods of telehealth for patients with COPD in England and Wales: a healthcare provider survey. *BMJ Open Respir Res*. 2019;6(1):e000345. Published 2019 Feb 18. doi:10.1136/bmjresp-2018-000345

Methods: A cross-sectional survey consisting of 14 questions was sent to 230 COPD community services in England and Wales. Questions were designed to cover five aspects of telehealth in COPD: purpose of use, equipment type, clinician perceptions, variables monitored and personalisation of alarm limits.

Results: 65 participants completed the survey from 52 different NHS Trusts. 46% of Trusts had used telehealth for COPD, and currently, 31% still provided telehealth services to patients with COPD. Telehealth is most commonly used for baseline monitoring and to allow early detection of exacerbations, with 54% believing it to be effective. The three most commonly monitored variables were oxygen saturation, heart rate and breathlessness. A variety of methods were used to set alarm limits with the majority of respondents believing that at least 40% of alarms were false.

Conclusion: Around one-third of responded community COPD services are using telehealth, believing it to be effective without robust evidence, with a variety of variables monitored, a variety of hardware and varying techniques to set alarm limits with high false alarm frequencies.

Alharbey and Chatterjee (2019) [Design Study] An mHealth Assistive System "MyLung" to Empower Patients With Chronic Obstructive Pulmonary Disease: Design Science Research[50]

Background: Chronic obstructive pulmonary disease (COPD) comprises a group of progressive diseases that deteriorate lung functions. When patients cannot breathe, nothing else in their lives matter. Breathlessness has negative implications on patients' lives, which leads to physical and psychological limitations. Moreover, the lack of relevant and updated information about the causes and consequences of the disease can exacerbate the problems of health literacy, information accessibility, and medical adherence.

Objective: The objective of this study is to design an innovative mobile health (mHealth) app system called MyLung that provides complete solutions in order to increase self-awareness and promote better self-care management. This system, an information technology artifact, includes three novel integrative modules: education, risk reduction, and monitoring.

Methods: The utility and effectiveness of the assistive mobile-based technology were evaluated using a mixed-methods approach. The study combined quantitative and qualitative research methods to thoroughly

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[50] Alharbey R, Chatterjee S. An mHealth Assistive System "MyLung" to Empower Patients with Chronic Obstructive Pulmonary Disease: Design Science Research. *JMIR Form Res*. 2019;3(1):e12489. Published 2019 Mar 19. doi:10.2196/12489

understand how the assistive mobile-based technology can influence patients' behavioral intention to change their lifestyle. Thirty patients were categorized into two groups [intervention group and control group]. Results: The results from the quantitative analysis led to four follow-up interviews in the qualitative study. The results of the quantitative study provided significant evidence to show that the design of MyLung leads to a change in the awareness level, self-efficacy, and behavioral intention for patients with COPD. The t tests revealed a significant difference before and after using the mobile-based app with regard to the awareness level (mean 3.28 vs 4.56; t_{10}=6.062; P<.001), self-efficacy (mean 3.11 vs 5.56; t_{10}=2.96; P=.01), and behavioral intention (mean 2.91 vs 4.55; t_{10}=3.212; P=.009). Independent sample t tests revealed significant differences between the intervention group and the control group in terms of the awareness level (mean 4.56 vs 3.31; t_{19}=4.80; P<.001) and self-efficacy (mean 5.56 vs 3.66; t_{19}=2.8; P<.01). Integration of findings from quantitative and qualitative studies reveled the impact of the design in a comprehensive manner. These inferences are referred to as meta-inferences in this study.

Conclusions: We designed an innovative assistive mobile-based technology to empower patients with COPD, which helped increase awareness and engage patients in self-care management activities. The assistive technology aims to inform patients about the risk factors of COPD and to improve access to relevant information. Meta-inferences that emerge from the research outputs contribute to research into chronic management information systems by helping us gain a more complete understanding of the potential impacts of this proposed mobile-based design on patients with chronic disease.

Bowler et al (2019) [Observational Study] Real-world Use of Rescue Inhaler Sensors, Electronic Symptom Questionnaires and Physical Activity Monitors in COPD[51]

Background: Chronic obstructive pulmonary disease (COPD) is a heterogeneous disease characterised by airflow obstruction and other morbidities such as respiratory symptoms, reduced physical activity and frequent bronchodilator use. Recent advances in personal digital monitoring devices can permit continuous collection of these data in COPD patients, but the relationships among them are not well understood.

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[51] Bowler R, Allinder M, Jacobson S, et al. Real-world use of rescue inhaler sensors, electronic symptom questionnaires and physical activity monitors in COPD. *BMJ Open Respir Res*. 2019;6(1):e000350. Published 2019 Feb 18. doi:10.1136/bmjresp-2018-000350

Methods: 184 individuals from a single centre of the COPDGene cohort agreed to participate in this 3-week observational study. Each participant used a smartphone to complete a daily symptom diary [EXAcerbations of Chronic pulmonary disease Tool, EXACT], wore a wrist-worn accelerometer to record continuously physical activity and completed the Clinical Visit PROactive Physical Activity in COPD questionnaire. 58 users of metered dose inhalers for rescue were provided with an inhaler sensor, which time stamped each inhaler actuation.

Results: Rescue inhaler use was strongly correlated with E-RS:COPD score, while step counts were correlated with neither rescue use nor E-RS:COPD score. Frequent, unpatterned inhaler use pattern was associated with worse respiratory symptoms and less physical activity compared with frequent inhaler use with a regular daily pattern. There was a strong week-by-week correlation among measurements, suggesting that 1 week of monitoring is sufficient to characterise stable patients with COPD.

Discussion: The study highlights the interaction and relevance of personal real-time monitoring of respiratory symptoms, physical activity and rescue medication in patients with COPD. Additionally, visual displays of longitudinal data may be helpful for disease management to help drive conversations between patients and caregivers and for risk-based monitoring in clinical trials.

Buekers et al (2019) [Observational Study] Wearable Finger Pulse Oximetry for Continuous Oxygen Saturation Measurements During Daily Home Routines of Patients With Chronic Obstructive Pulmonary Disease (COPD) Over One Week: Observational Study[52]

Background: Chronic obstructive pulmonary disease (COPD) patients can suffer from low blood oxygen concentrations. Peripheral blood oxygen saturation (SpO2), as assessed by pulse oximetry, is commonly measured during the day using a spot check, or continuously during one or two nights to estimate nocturnal desaturation. Sampling at this frequency may overlook natural fluctuations in SpO2.

Objective: This study used wearable finger pulse oximeters to continuously measure SpO2 during daily home routines of COPD patients and assess natural SpO2 fluctuations.

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[52] Buekers J, Theunis J, De Boever P, et al. Wearable Finger Pulse Oximetry for Continuous Oxygen Saturation Measurements During Daily Home Routines of Patients With Chronic Obstructive Pulmonary Disease (COPD) Over One Week: Observational Study. *JMIR Mhealth Uhealth*. 2019;7(6):e12866. Published 2019 Jun 6. doi:10.2196/12866

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Methods: A total of 20 COPD patients wore a WristOx2 pulse oximeter for 1 week to collect continuous SpO2 measurements. A SenseWear Armband simultaneously collected actigraphy measurements to provide contextual information. SpO2 time series were preprocessed and data quality was assessed afterward. Mean SpO2, SpO2 SD, and cumulative time spent with SpO2 below 90% (CT90) were calculated for every day, day in rest, and night to assess SpO2 fluctuations.

Results: A high percentage of valid SpO2 data (daytime: 93.27%; nocturnal: 99.31%) could be obtained during a 7-day monitoring period, except during moderate-to-vigorous physical activity (MVPA) (67.86%). Mean nocturnal SpO2 (89.9%, SD 3.4) was lower than mean daytime SpO2 in rest (92.1%, SD 2.9; P<.001). On average, SpO2 in rest ranged over 10.8% (SD 4.4) within one day. Highly varying CT90 values between different nights led to 50% (10/20) of the included patients changing categories between desaturator and nondesaturator over the course of 1 week.

Conclusions: Continuous SpO2 measurements with wearable finger pulse oximeters identified significant SpO2 fluctuations between and within multiple days and nights of patients with COPD. Continuous SpO2 measurements during daily home routines of patients with COPD generally had high amounts of valid data, except for motion artifacts during MVPA. The identified fluctuations can have implications for telemonitoring applications that are based on daily SpO2 spot checks. CT90 values can vary greatly from night to night in patients with a nocturnal mean SpO2 around 90%, indicating that these patients cannot be consistently categorized as desaturators or nondesaturators. We recommend using wearable sensors for continuous SpO2 measurements over longer time periods to determine the clinical relevance of the identified SpO2 fluctuations.

Chan et al (2019) [Evaluation Study] A Smartphone Oximeter With a Fingertip Probe for Use During Exercise Training: Usability, Validity and Reliability in Individuals With Chronic Lung Disease and Healthy Controls[53]

Background and aim: Telehealth is a strategy to expand the reach of pulmonary rehabilitation (PR). Smartphones can monitor and transmit oxygen saturation (SpO2) and heart rate (HR) data to ensure patient safety during home-based or other exercise. The purpose of this study was to

[53] Chan C, Inskip JA, Kirkham AR, et al. A smartphone oximeter with a fingertip probe for use during exercise training: usability, validity and reliability in individuals with chronic lung disease and healthy controls. *Physiotherapy*. 2019;105(3):297-306. doi:10.1016/j.physio.2018.07.015

evaluate the usability, validity and reliability of a Kenek O2 pulse oximeter and custom prototype smartphone application [smartphone oximeter] during rest and exercise in healthy participants and those with chronic lung disease.

Methods: Fifteen individuals with chronic lung disease and 15 healthy controls were recruited. SpO2 and HR were evaluated at rest and during cycling and walking. SpO2 was valid if the mean bias was within +±2%, the level of agreement (LoA) was within ±4%; HR was valid if the mean bias was within ±5 beats per min (bpm), LoA was within ±10bpm. Usability was assessed with a questionnaire and direct observation.

Results: The smartphone oximeter was deemed easy to use. At rest, SpO2 measures were valid in both groups (bias <2%, lower bound LoA -2 to 3%). During exercise, SpO2 measurement did not meet validity and reliability thresholds in the patients with chronic lung disease, but was accurate for the healthy controls. HR recording during exercise or rest was not valid (LoA>10bpm) in either group.

Conclusions: The smartphone oximeter did not record HR or SpO2 accurately in patients with chronic lung disease during exercise, although SpO2 was valid at rest. During exercise, patients with chronic lung disease should pause to ensure greatest accuracy of SpO2 and HR measurement.

Chung et al (2019) [Design Study] Remote Pulmonary Function Test Monitoring in Cloud Platform via Smartphone Built-in Microphone[54]

With an aging population that continues to grow, health care technology plays an increasingly active role, especially for chronic disease management. In the health care market, cloud platform technology is becoming popular, as both patients and physicians demand cost efficiency, easy access to information, and security. Especially for asthma and chronic obstructive pulmonary disease (COPD) patients, it is recommended that pulmonary function test (PFT) be performed on a daily basis. However, it is difficult for patients to frequently visit a hospital to perform the PFT. In this study, we present an application and cloud platform for remote PFT monitoring that can be directly measured by smartphone microphone with no external devices. In addition, we adopted the IBM Watson Internet-of-Things (IoT) platform for PFT monitoring, using a smartphone's built-in microphone with a high-resolution time-frequency representation. We successfully

[54] Chung H, Jeong C, Luhach AK, Nam Y, Lee J. Remote Pulmonary Function Test Monitoring in Cloud Platform via Smartphone Built-in Microphone. *Evol Bioinform Online*. 2019;15:1176934319888904. Published 2019 Nov 15. doi:10.1177/1176934319888904

demonstrated real-time PFT monitoring using the cloud platform. The PFT parameters of FEV1/FVC (%) could be remotely monitored when a subject performed the PFT test. As a pilot study, we tested 13 healthy subjects, and found that the absolute error mean was 4.12 and the standard deviation was 3.45 on all 13 subjects. With the developed applications on the cloud platform, patients can freely measure the PFT parameters without restriction on time and space, and a physician can monitor the patients' status in real time. We hope that the PFT monitoring platform will work as a means for early detection and treatment of patients with pulmonary diseases, especially those having asthma and COPD.

Ding et al (2019) [Review] Digital Health for COPD Care: The Current State of Play[55]

Chronic obstructive pulmonary disease (COPD) imposes a huge burden to our healthcare systems and societies. To alleviate the burden, digital health–"the use of digital technologies for health"-has been recognized as a potential solution for improving COPD care at scale. The aim of this review is to provide an overview of digital health interventions in COPD care. We accordingly reviewed recent and emerging evidence on digital transformation approaches for COPD care focusing on: 1. self-management; 2. in-hospital care; 3. post-discharge care; 4. hospital-at-home; 5. ambient environment; and 6. public health surveillance. The emerging approaches included digital-technology-enabled homecare programs, electronic records, big data analytics, and environment-monitoring applications. The digital health approaches of telemonitoring, telehealth and mHealth support the self-management, post-discharge care, and hospital-at-home strategy, with prospective effects on reducing acute COPD exacerbations and hospitalizations. Electronic records and classification tools have been implemented; and their effectiveness needs to be further evaluated in future studies. Air pollution concentrations in the ambient environment are associated with declined lung functions and increased risks for hospitalization and mortality. In all the digital transformation approaches, clinical evidence on reducing mortality, the ultimate goal of digital health intervention, is often inconsistent or insufficient. Digital health transformation provides great opportunities for clinical innovations and discovery of new intervention strategies. Further research remains needed

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[55] Ding H, Fatehi F, Maiorana A, Bashi N, Hu W, Edwards I. Digital health for COPD care: the current state of play. *J Thorac Dis*. 2019;11(Suppl 17):S2210-S2220. doi:10.21037/jtd.2019.10.17

for achieving reliable improvements in clinical outcomes and cost-benefits in future studies.

Farias et al (2019) [Observation Study] Innovating the Treatment of COPD Exacerbations: A Phone Interactive Telesystem to Increase COPD Action Plan Adherence[56]

Introduction: Self-management interventions with Written Action Plans and case management support have been shown to improve outcomes in patients with chronic obstructive pulmonary disease (COPD). Novel telehealth technologies may improve self-management interventions. The objectives of this study were to determine whether the use of an interactive phone telesystem increases Action Plan adherence, improves exacerbation recovery and reduces healthcare use in a real-life practice of a COPD clinic.

Methods: Initially, 40 patients were followed by a COPD telesystem for 1 year. Detailed data from patients' behaviours during exacerbations was recorded. The telesystem use was then extended to 256 patients from a real-life COPD clinic. Healthcare utilisation for the year before and after telesystem enrolment was then assessed through hospital administrative databases.

Results: Thirty-three of the 40 patients completed the initial 1-year study. Eighty-one exacerbations were reported in the 1-year follow-up. Action Plan adherence was observed for 72% of the exacerbations and those who were adherent had a significantly faster exacerbation recovery time. The large-scale implementation of the telesystem resulted in a significant decrease in the proportion of patients with ≥1 respiratory-related emergency room (ER) visits (120 before vs 110 after enrolment, p<0.001) and with ≥1 COPD-related hospitalisations (75 before vs 65 after enrolment, p<0.001).

Discussion: COPD Written Action Plan adherence was further enhanced with the use of telehealth technologies in a specialised clinic with experience in COPD self-management. Patients followed by the telesystem recovered faster from exacerbations and had a further decrease in COPD-related ER visits and hospitalisations.

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[56] Farias R, Sedeno M, Beaucage D, et al. Innovating the treatment of COPD exacerbations: a phone interactive telesystem to increase COPD Action Plan adherence. *BMJ Open Respir Res.* 2019;6(1):e000379. Published 2019 Apr 9. doi:10.1136/bmjresp-2018-000379

Fung et al (2019) [Feasibility Study] Design and Benchmark Testing for Open Architecture Reconfigurable Mobile Spirometer and Exhaled Breath Monitor With GPS and Data Telemetry[57]

Portable and wearable medical instruments are poised to play an increasingly important role in health monitoring. Mobile spirometers are available commercially, and are used to monitor patients with advanced lung disease. However, these commercial monitors have a fixed product architecture determined by the manufacturer, and researchers cannot easily experiment with new configurations or add additional novel sensors over time. Spirometry combined with exhaled breath metabolite monitoring has the potential to transform healthcare and improve clinical management strategies. This research provides an updated design and benchmark testing for a flexible, portable, open access architecture to measure lung function, using common Arduino/Android microcontroller technologies. To demonstrate the feasibility and the proof-of-concept of this easily-adaptable platform technology, we had 43 subjects (healthy, and those with lung diseases) perform three spirometry maneuvers using our reconfigurable device and an office-based commercial spirometer. We found that our system compared favorably with the traditional spirometer, with high accuracy and agreement for forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC), and gas measurements were feasible. This provides an adaptable/reconfigurable open access personalized medicine platform for researchers and patients, and new chemical sensors and other modular instrumentation can extend the flexibility of the device in the future.

Gaveikaite et al (2019) [Mapping Study] A Systematic Map and In-Depth Review of European Telehealth Interventions Efficacy for Chronic Obstructive Pulmonary Disease[58]

Background: Evidence to support the implementation of telehealth (TH) interventions in the management of chronic obstructive pulmonary disease (COPD) varies throughout Europe. Despite more than ten years of TH research in COPD management, it is still not possible to define which TH interventions are beneficial to which patient group. Therefore, informing

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[57] Fung AG, Tan LD, Duong TN, et al. Design and Benchmark Testing for Open Architecture Reconfigurable Mobile Spirometer and Exhaled Breath Monitor with GPS and Data Telemetry. *Diagnostics (Basel)*. 2019;9(3):100. Published 2019 Aug 21. doi:10.3390/diagnostics9030100

[58] Gaveikaite V, Grundstrom C, Winter S, Chouvarda I, Maglaveras N, Priori R. A systematic map and in-depth review of European telehealth interventions efficacy for chronic obstructive pulmonary disease. *Respir Med*. 2019;158:78-88. doi:10.1016/j.rmed.2019.09.005

policymakers on TH implementation is complicated. We aimed to examine the provision and efficacy of TH for COPD management to guide future decision-making.

Methods: A mapping study of twelve systematic reviews of TH interventions for COPD management was conducted. This was followed by an in-depth review of fourteen clinical trials performed in Europe extracted from the systematic reviews. Efficacy outcomes for COPD management were synthesized.

Results: The mapping study revealed that systematic reviews with a meta-analysis often report positive clinical outcomes. Despite this, we identified a lack of pragmatic trial design affecting the synthesis of reported outcomes. The in-depth review visualized outcomes for three TH categories, which revealed a plethora of heterogeneous outcomes. Suggestions for reporting within these three outcomes are synthesized as targets for future empirical research reporting.

Conclusion: The present study indicates the need for more standardized and updated systematic reviews. Policymakers should advocate for improved TH trial designs, focusing on the entire intervention's adoption process evaluation. One of the policymakers' priorities should be the harmonization of the outcome sets, which would be considered suitable for deciding about subsequent reimbursement. We propose possible outcome sets in three TH categories which could be used for discussion with stakeholders.

Guber et al (2019) [Observation Study] Wrist-Sensor Pulse Oximeter Enables Prolonged Patient Monitoring in Chronic Lung Diseases[59]

Pulse oximetry is an important diagnostic tool in monitoring and treating both in-patients and ambulatory patients. Modern pulse oximeters exploit different body sites: eg fingertip, forehead or earlobe). All those are bulky and uncomfortable, resulting in low patient compliance. Therefore, we evaluated the accuracy and precision of a wrist-sensor pulse oximeter [Oxitone-1000, Oxitone Medical] vs. the traditional fingertip device. Fifteen healthy volunteers and 23 patients were recruited. The patient group included chronic obstructive pulmonary disease (COPD) (N = 8), asthma (N = 6), sarcoidosis (N = 5) and others. Basic demographic data, skin tone type, smoking status and medical history were recorded. Blood oxygen level (SpO2) and pulse-rate values were determined by a non-invasive pulse oximeter [Reference, a conventional FDA-cleared fingertip pulse oximeter]

[59] Guber A, Epstein Shochet G, Kohn S, Shitrit D. Wrist-Sensor Pulse Oximeter Enables Prolonged Patient Monitoring in Chronic Lung Diseases. *J Med Syst*. 2019;43(7):230. Published 2019 Jun 14. doi:10.1007/s10916-019-1317-2

and by Oxitone-1000. All tests were performed in singleton and in a blinded fashion. The measurements were done in sitting and standing positions, as well as after a 6-min walk test. The mean age was 60.4 ± 9.83 years, 55% were male. No significant differences were observed between the wrist-sensor and the traditional fingertip pulse oximeters in all tested parameters. Mean SpO2 was 96.45% vs. 97.18% and the mean pulse was 74.64 vs. 74.6 bpm (Oxitone-1000 vs. Reference, respectively, p < 0.0001). Precision rate was 2.28472% and the accuracy was met. The Oxitone-1000 is both accurate and precise for SpO2 and pulse measurements during daily activities of pulmonary patients, and is not inferior to standard devices for spot checking or short period examinations. Its wrist-sensor design is comfortable and provides the advantage of extended use.

Knox et al (2019) [Feasibility Study] Safety, Feasibility, and Effectiveness of Virtual Pulmonary Rehabilitation in the Real World[60]

Purpose: To assess the feasibility, safety, and effectiveness of a VIrtual PulmonAry Rehabilitation (VIPAR) program in a real-world setting.

Patients and methods: Twenty-one patients with stable chronic lung disease at a spoke site received (VIPAR) through live video conferencing with a hub where 24 patients were receiving 14 sessions of standard, outpatient, multi-disciplinary pulmonary rehabilitation (PR) in a hospital. We studied three such consecutive PR programs with 6-10 patients at each site. The hub had a senior physiotherapist, occupational therapist, exercise assistant, and guest lecturer, and the spoke usually had only an exercise instructor and nurse present. Uptake, adverse events (AEs), and early clinical changes were compared within and between groups. Travel distances were estimated using zip codes.

Results: Mean attendance was 11.0 sessions in the hub and 10.5 sessions in the spoke (P=0.65). There was a single (mild) AE (hypoglycemia) in all three hub programs and no AEs in the three spoke programs. Mean COPD Assessment Test scores improved from 25.3 to 21.5 in the hub (P<0.001, 95% CI 2.43-5.17) and from 23.4 to 18.8 (P<0.001, 2.23-7.02) in the spoke group, with no difference between the groups (P=0.51, -3.35-1.70). Mean incremental shuttle walk test scores improved from 142 to 208 m (P<0.001, 75-199) in the hub and from 179 to 316 minutes in the spoke (P<0.001, 39.3-92.4), with a greater improvement in the spoke (P=0.025, 9.31-133). Twenty-

[60] Knox L, Dunning M, Davies CA, et al. Safety, feasibility, and effectiveness of virtual pulmonary rehabilitation in the real world. *Int J Chron Obstruct Pulmon Dis.* 2019;14:775-780. Published 2019 Apr 8. doi:10.2147/COPD.S193827

one patients saved a total of 8,609.8 miles over the three programs by having the PR in their local spoke, rather than traveling to the usual nearest (hospital) hub.

Conclusion: Video-conferencing, which links a local site to a standard PR program is feasible, safe, and demonstrates at least equivalent short-term clinical gains. Throughput can be increased, with less staffing ratios and significantly less traveling.

Locke et al (2019) [Retrospective Chart Review] Using Video Telehealth to Facilitate Inhaler Training in Rural Patients With Obstructive Lung Disease[61]

Background: Proper inhaler technique is important for effective drug delivery and symptom control in chronic obstructive pulmonary disease (COPD) and asthma, yet not all patients receive inhaler instructions.

Introduction: Using a retrospective chart review of participants in a video telehealth inhaler training program, the study compared inhaler technique within and between monthly telehealth visits and reports associated with patient satisfaction.

Materials and methods: Seventy-four (N = 74) rural patients prescribed ≥1 inhaler participated in three to four pharmacist telehealth inhaler training sessions using teach-to-goal methodology. Within and between visit inhaler technique scores are compared, with descriptive statistics of pre- and postprogram survey results including program satisfaction and computer technical issues. Healthcare utilization is compared between pre- and post-training periods.

Results: Sixty-nine (93%) patients completed all three to four video telehealth inhaler training sessions. During the initial visit, patients demonstrated improvement in inhaler technique for metered dose inhalers (albuterol, budesonide/formoterol), dry powder inhalers (formoterol, mometasone, tiotropium), and soft mist inhalers (ipratropium/albuterol) ($p < 0.01$ for all). Improved inhaler technique was sustained at 2 months ($p < 0.01$). Ninety-four percent of participants were satisfied with the program. Although technical issues were common, occurring among 63% of attempted visits, most of these visits (87%) could be completed. There was no significant difference in emergency department visits and hospitalizations pre- and post-training.

[61] Locke ER, Thomas RM, Woo DM, et al. Using Video Telehealth to Facilitate Inhaler Training in Rural Patients with Obstructive Lung Disease. *Telemed J E Health*. 2019;25(3):230-236. doi:10.1089/tmj.2017.0330

Discussion: This study demonstrated high patient acceptance of video telehealth training and objective improvement in inhaler technique. Conclusions: Video telehealth inhaler training using the teach-to-goal methodology is a promising program that improved inhaler technique and access to inhaler teaching for rural patients with COPD or asthma.

Lyth et al (2019) [Observational Study] Can a Telemonitoring System Lead to Decreased Hospitalization in Elderly Patients?[62]
Introduction: Expanding populations of elderly patients with chronic obstructive pulmonary disease (COPD) or heart failure (HF) require more healthcare. A four-year telehealth intervention - the Health Diary system based on digital pen technology - was implemented. We hypothesized that study patients with advanced COPD or HF would have lower rates of hospitalization when using the Health Diary. The aim was to investigate the effects of the intervention on healthcare costs and the number of hospitalizations, as well as other care required in COPD and HF patients. Methods: Patients were introduced to the telemonitoring system which was supervised by a specialized hospital-based home care (HBHC) unit. Staff associated with this unit were responsible for the healthcare provided. The study included patients with COPD or HF, aged ≥ 65 years who were frequently hospitalized due to exacerbations - at least two inpatient episodes within the last 12 months. Observed number of hospitalizations and total healthcare costs were compared with the expected values, which were calculated using the generalized estimating equations (GEE) method. Results: A total of 36 COPD and 58 HF patients with advanced stages of disease were included. The number of hospitalizations was significantly reduced for both HF and COPD patients participating in telemonitoring. Accordingly, hospitalization costs were significantly reduced for both groups, but the total healthcare cost was not significantly different from the expected costs. Conclusion: A telemonitoring system, the Health Diary, combined with a specialized HBHC unit significantly decreases the need for hospital care in elderly patients with advanced HF or COPD without increasing total healthcare costs.

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[62] Lyth J, Lind L, Persson HL, Wiréhn AB. Can a telemonitoring system lead to decreased hospitalization in elderly patients? [published online ahead of print, 2019 Jul 10]. *J Telemed Telecare*. 2019;1357633X19858178. doi:10.1177/1357633X19858178

Pericleous and van Staa (2019) [Review] [The Use of Wearable Technology to Monitor Physical Activity in Patients With COPD: A Literature Review](#)[63]

Background: Physical activity is an important predictor for survival in patients with COPD. Wearable technology, such as pedometer or accelerometer, may offer an opportunity to quantify physical activity and evaluate related health benefits in these patients.

Objectives: To assess the performance of wearable technology in monitoring and improving physical activity in COPD patients from published studies.

Methods: Literature search of Medline, Cochrane, Dare, Embase and PubMed databases was made to find relevant articles that used wearable technology to monitor physical activity in COPD patients.

Results: We identified 13 studies that used wearable technology, a pedometer or an accelerator, to monitor physical activity in COPD patients. Of these, six studies were randomized controlled trials (RCTs) which used the monitors as part of the intervention. Two studies reported the same outcomes and comparable units. They had measured the difference that the intervention makes on the number of steps taken daily by the patients. The results were highly heterogeneous with I^2=92%. The random-effects model gave an effect outcome on the number of steps taken daily of 1,821.01 [-282.71; 3,924.74] in favor of the wearable technology. Four of the 13 studies have reported technical issues with the use of the wearable technology, including high signal-to-noise ratio, memory storage problems and inaccuracy of counts. While other studies did not mention any technical issues, it is not clear whether these did not experience them or chose not to report them.

Conclusions: Our literature search has shown that data on the use of wearable technology to monitor physical activity in COPD patients are limited by the small number of studies and their heterogeneous study design. Further research and better-designed RCTs are needed to provide reliable results before physical activity monitors can be implemented routinely for COPD patients.

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[63] Pericleous P, van Staa TP. The use of wearable technology to monitor physical activity in patients with COPD: a literature review. *Int J Chron Obstruct Pulmon Dis*. 2019;14:1317-1322. Published 2019 Jun 19. doi:10.2147/COPD.S193037

Rutkowski et al (2019) [Evaluation] Effect of Virtual Reality-Based Rehabilitation on Physical Fitness in Patients With Chronic Obstructive Pulmonary Disease[64]

The aim of the study was to evaluate the effects of rehabilitation in patients with chronic obstructive pulmonary disease (COPD) using the Kinect system during stationary rehabilitation. The study included 68 patients with COPD (35 men, 33 women, mean age 61.3 ± 3.7). The subjects were randomly assigned to one of the two experimental groups described below. Group I included 34 patients - non-participants in Kinect training. Group II included 34 patients - participants in Kinect training. In all patients before and after rehabilitation physical fitness was assessed using the Senior Fitness Test (SFT). The Xbox 360 and Kinect motion sensor were used to carry out virtual reality training. In group I, statistically significant improvements in SFT performance were observed. Patients in group II also showed statistically significant improvement in physical fitness in all attempts of the SFT. Virtual rehabilitation training in patients with COPD seems to be a practical and beneficial intervention capable of enhancing mobility and physical fitness.

Soler et al (2019) [Review] Validation of Respiratory Rate Measurements From Remote Monitoring Device in COPD Patients[65]

With healthcare objectives and budget constraint, remote monitoring of chronic obstructive pulmonary disease (COPD) patients is an important challenge in most European countries. Recent works have shown that it is possible to predict COPD exacerbation based on monitoring of simple parameters, such as the respiratory rate (RR) of the patient in spontaneous ventilation or under non-invasive ventilation. Until now, these devices do not allow a daily automatic data remote transmission,[4] or it is restricted to patients under mechanical ventilation. TeleOx® (SRETT, Boulogne-Billancourt, France), the first oxygen flow rate remote monitoring device, also allows a RR measurement by associating a pressure sensor and a fluidic oscillator flow sensor. A median RR is output every 5 minutes based on time interval between two consecutive respiratory cycles. In this study, we compared the corresponding RR measurements between TeleOx® and the reference polygraph (Nox-T3®, Nox Medical Inc. Reykjavik, Iceland) from

[64] Rutkowski S, Rutkowska A, Jastrzębski D, Racheniuk H, Pawełczyk W, Szczegielniak J. Effect of Virtual Reality-Based Rehabilitation on Physical Fitness in Patients with Chronic Obstructive Pulmonary Disease. *J Hum Kinet.* 2019;69:149-157. Published 2019 Oct 18. doi:10.2478/hukin-2019-0022

[65] Soler J, Alves Pegoraro J, Le XL, et al. Validation of respiratory rate measurements from remote monitoring device in COPD patients. *Respir Med Res.* 2019;76:1-3. doi:10.1016/j.resmer.2019.05.002

COPD patients under nasal oxygen therapy with flow rates between 0.5 and 5.0 litres per minute. Patients without mechanical ventilation and without any other respiratory pathology were eligible to the study if they would undergo a ventilatory polygraph record for other reasons.

Clarke et al (2018) [Evaluation] Evaluation of the National Health Service (NHS) Direct Pilot Telehealth Program: Cost-Effectiveness Analysis[66]

Objective: To evaluate the cost-effectiveness of a pilot telehealth program applied to a wide population of patients with chronic obstructive pulmonary disease (COPD).

Design: Vital signs data were transmitted from the home of the patient on a daily basis using a patient monitoring system for review by community nurse to assist decisions on management.

Setting: Community services for patients diagnosed with COPD.

Participants: Two Primary Care Trusts (PCTs) enrolled 321 patients diagnosed with COPD into the telehealth program. Two hundred twenty-seven (n = 227) patients having a complete baseline record of at least 88 days of continuous remote monitoring and meeting all inclusion criteria were included in the statistical analysis.

Intervention: Remote monitoring.

Methods: Resource and cost data associated with patient events (inpatient hospitalization, accident and emergency, and home visits) 12 months before, immediately before and during monitoring, equipment, start-up, and administration were collected and compared to determine cost-effectiveness of the program.

Main outcome measures: Cost-effectiveness of program, impact on resource usage, and patterns of change in resource usage.

Results: Cost-effectiveness was determined for the two PCTs and the two periods before monitoring to provide four separate estimates. Cost-effectiveness had high variance both between the PCTs and between the comparison periods ranging from a saving of £140,800 ($176,000) to an increase of £9,600 ($12,000). The average saving was £1,023 ($1,280) per patient per year. The largest impact was on length of stay with a fall in the average length of inpatient care in PCT1 from 11.5 days in the period 12 months before monitoring to 6.5 days during monitoring, and similarly in PCT2 from 7.5 to 5.2 days.

[66] Clarke M, Fursse J, Brown-Connolly NE, Sharma U, Jones R. Evaluation of the National Health Service (NHS) Direct Pilot Telehealth Program: Cost-Effectiveness Analysis. *Telemed J E Health*. 2018;24(1):67-76. doi:10.1089/tmj.2016.0280

Conclusion: There was a wide discrepancy in the results from the two PCTs. This places doubt on outcomes and may indicate also why the literature on cost-effectiveness remains inconclusive. The wide variance on savings and the uncertainty of monitoring cost do not allow a definitive conclusion on the cost-effectiveness as an outcome of this study. It might well be that the average saving was £1,023 ($1,280) per patient per year, but the variance is too great to allow this to be statistically significant. Each locality-based clinical service provides a service to achieve the same clinical goal, but it does so in significantly different ways. The introduction of remote monitoring has a profound effect on team learning and clinical practice and thus distorts the cost-effectiveness evaluation of the use of the technology. Cost-effectiveness studies will continue to struggle to provide a definitive answer because outcome measurements are too dependent on factors other than the technology.

Miron Rubio et al (2018) [Review] [Telemonitoring and Home Hospitalization in Patients With Chronic Obstructive Pulmonary Disease: Study TELEPOC](#)[67]

Background: Chronic obstructive pulmonary disease (COPD) is a major consumer of healthcare resources, with most costs related to disease exacerbations. Telemonitoring of patients with COPD may help to reduce the number of exacerbations and/or the related costs. On the other hand, home hospitalization is a cost-saving alternative to inpatient hospitalization associated with increased comfort for patients. The results are reported regarding using telemonitoring and home hospitalization for the management of patients with COPD.

Methods: Twenty-eight patients monitored their health parameters at home for six months. A nurse remotely revised the collected parameters and followed the patients as programmed. A home care unit was dispatched to the patients' home if an alarm signal was detected. The outcomes were compared to historical data from the same patients.

Results: The number of COPD exacerbations during the study period did not reduce but the number of hospital admissions decreased by 60% and the number of emergency room visits by 38%. On average, costs related to utilization of healthcare resources were reduced by €1,860.80 per patient per year.

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[67] Mirón Rubio M, Ceballos Fernández R, Parras Pastor I, et al. Telemonitoring and home hospitalization in patients with chronic obstructive pulmonary disease: study TELEPOC. *Expert Rev Respir Med.* 2018;12(4):335-343. doi:10.1080/17476348.2018.1442214

Conclusions: Telemonitoring of patients with COPD combined with home hospitalization may allow for a reduction in healthcare costs, although its usefulness in preventing exacerbations is still unclear.

Milkowska-Dymanowska (2018) [Pilot Study] A Pilot Study of Daily Telemonitoring to Predict Acute Exacerbation in Chronic Obstructive Pulmonary Disease[68]

Background: Exacerbations of COPD (ECOPD) are important events in the course of COPD and they accelerate the rate of decline of lung function, and exacerbations requiring hospitalization are associated with significant mortality. Therefore, developing approaches of prevention and early treatment of ECOPDs are of special clinical interests. One of such approaches is telecare, including home telemonitoring.

Material and methods: Daily telemonitoring of HR, BP, SpO2 and spirometry was performed. Variables were compared using the bootstrap-boosted inference tests: the paired t-test or Wilcoxon signed rank test, depending on data normality, and categorical variables were compared using exact McNemar's test.

Results: Nineteen patients were included to the study. We observed significant decrease in SpO2 7 days preceding ECOPD (P = 0.007; Pbootstrap-boosted = 0.005) and increase in number of events of day-to-day decrease in oxygen saturation >4% in the period of 7 days preceding ECOPD versus reference period (P = 0.02).

Conclusions: Oxygen saturation telemonitoring would be successfully used in predicting ECOPD. Recording of day-to-day decrease in oxygen saturation >4% as alarming events would be effective approach which would be easily implemented in telemonitoring devices, however this outcome should be further validated in larger size samples.

O'Hoski et al (2018) [Review] Use of telemedicine in the assessment of patients referred for pulmonary rehabilitation[69]

Rationale: Due to the high global prevalence and economic burden of COPD, there is growing interest in new approaches to reduce the time from referral

[68] Miłkowska-Dymanowska J, Białas AJ, Obrębski W, Górski P, Piotrowski WJ. A pilot study of daily telemonitoring to predict acute exacerbation in chronic obstructive pulmonary disease. *Int J Med Inform*. 2018;116:46-51. doi:10.1016/j.ijmedinf.2018.04.013

[69] O'Hoski, S, Butler, S, Dubois-Webster, J, Brooks, D Goldstein, R Use of telemedicine in the assessment of patients referred for pulmonary rehabilitation, *Canadian Journal of Respiratory, Critical Care, and Sleep Medicine*. 2018; 2(1) 4-8, DOI: 10.1080/24745332.2017.1391055

to assessment for rehabilitation, especially among those in remote communities.

Objectives: To describe the structure of a pilot teleconsultation (TC) service for people referred for inpatient pulmonary rehabilitation (PR) and the characteristics of patients seen over four years.

Methods: Patient and clinic visit information since inception of the TC service in 2012 was retrieved from the electronic record of the respiratory medicine service at West Park Healthcare Centre. Descriptive statistics were calculated for patient characteristics and TC data.

Main results: From January 2012 to December 2015, 112 patients were booked for TC with the majority (n = 90, 80%) attending at least once. Of the 90 attendees, 78 (86%) were seen for assessment for inpatient PR and 61 of them (78%) were subsequently enrolled. Of these 78 patients, the majority (n = 61, 78%) had chronic obstructive pulmonary disease (COPD) as their primary lung condition and they resided in 46 locations across Ontario as well as in Newfoundland, Alberta and New Brunswick. The patients located in Ontario were saved a total of 70,070 km in travel which translates to a travel-only cost savings of $28,028.

Conclusions: TC is an alternative to in-person visits for the assessment of patients referred for PR. It results in meaningful cost savings and increased convenience for the patient and will assist clinicians in identifying those for whom PR would be a valuable intervention.

Siddiqui and Morshed (2018) [Review] Severity Classification of Chronic Obstructive Pulmonary Disease and Asthma With Heart Rate and SpO2 Sensors[70]

Asthma and Chronic Obstructive Pulmonary Disease are chronic and long-term lung diseases. Disease monitoring with minimal sensors with high efficacy can make the disease control simple and practical for patients. We propose a model for the severity assessment of the diseases through wearables and compatible with mobile health applications, using only heart rate and SpO2 from pulse oximeter sensor. Patient data were obtained from the MIMIC- III Waveform Database Matched Subset. The dataset consists of 158 subjects. Both heart rate and SpO2 signal of patients are analyzed via the proposed algorithm to classify the severity of the diseases. Strategically, a rule-based threshold approach in real time evaluation is considered for the categorization scheme. Furthermore, a method is proposed to assess

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[70] Siddiqui T, Morshed BI. Severity Classification of Chronic Obstructive Pulmonary Disease and Asthma with Heart Rate and SpO2 Sensors. *Conf Proc IEEE Eng Med Biol Soc*. 2018;2018:2929-2932. doi:10.1109/EMBC.2018.8512927
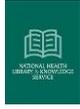
severity as an Event of Interest (EOI) from the computed metrics in retrospective. This type of autonomous system for real-time evaluation of patient's condition has the potential to improve individual health through continual monitoring and self- management, as well as improve the health status of the overall Smart and Connected Community (SCC).

Sumino et al (2018) [Feasibility Study] Use of a Remote Inhaler Monitoring Device to Measure Change in Inhaler Use With Chronic Obstructive Pulmonary Disease Exacerbations[71]

Background: Remote inhaler monitoring is an emerging technology that enables the healthcare team to monitor the time and location of a patient's inhaler use. We assessed the feasibility of remote inhaler monitoring for chronic obstructive pulmonary disease (COPD) patients and the pattern of albuterol inhaler use associated with COPD exacerbations.

Methods: Thirty-five participants with COPD used an electronic inhaler sensor for 12 weeks which recorded the date and time of each albuterol actuation. Self-reported COPD exacerbations and healthcare utilization were assessed monthly. We used generalized estimating equations with a logit link to compare the odds of an exacerbation day to a nonexacerbation day by the frequency of daily albuterol use.

Results: Average daily albuterol use on nonexacerbation days varied greatly between patients, ranging from 1.5 to 17.5 puffs. There were 48 exacerbation events observed in 29 participants during the study period, of which 16 were moderate-to-severe exacerbations. During the moderate-to-severe exacerbation days, the median value in average daily albuterol use increased by 14.1% (interquartile range: 2.7%-56.9%) compared to average nonexacerbation days. A 100% increase in inhaler use was associated with increased odds of a moderate-to severe exacerbation (odds ratio 1.54; 95% CI: 1.21-1.97). Approximately 74% of participants reported satisfaction with the sensor.

Conclusions: The electronic inhaler sensor was well received in older patients with COPD over a 12-week period. Increased albuterol use captured by the device was associated with self-reported episodes of moderate-to-severe exacerbations.

[71] Sumino K, Locke ER, Magzamen S, et al. Use of a Remote Inhaler Monitoring Device to Measure Change in Inhaler Use with Chronic Obstructive Pulmonary Disease Exacerbations. *J Aerosol Med Pulm Drug Deliv*. 2018;31(3):191-198. doi:10.1089/jamp.2017.1383

Tomasic et al (2018) [Review] [Continuous Remote Monitoring of COPD Patients-Justification and Explanation of the Requirements and a Survey of the Available Technologies](#)[72]

Remote patient monitoring should reduce mortality rates, improve care, and reduce costs. We present an overview of the available technologies for the remote monitoring of chronic obstructive pulmonary disease (COPD) patients, together with the most important medical information regarding COPD in a language that is adapted for engineers. Our aim is to bridge the gap between the technical and medical worlds and to facilitate and motivate future research in the field. We also present a justification, motivation, and explanation of how to monitor the most important parameters for COPD patients, together with pointers for the challenges that remain. Additionally, we propose and justify the importance of electrocardiograms (ECGs) and the arterial carbon dioxide partial pressure (PaCO2) as two crucial physiological parameters that have not been used so far to any great extent in the monitoring of COPD patients. We cover four possibilities for the remote monitoring of COPD patients: continuous monitoring during normal daily activities for the prediction and early detection of exacerbations and life-threatening events, monitoring during the home treatment of mild exacerbations, monitoring oxygen therapy applications, and monitoring exercise. We also present and discuss the current approaches to decision support at remote locations and list the normal and pathological values/ranges for all the relevant physiological parameters. The paper concludes with our insights into the future developments and remaining challenges for improvements to continuous remote monitoring systems.

Wu et al (2018) [Feasibility Study] [Feasibility of Using a Smartwatch to Intensively Monitor Patients With Chronic Obstructive Pulmonary Disease: Prospective Cohort Study](#)[73]

Background: Acute exacerbations of chronic obstructive pulmonary disease (COPD) are associated with accelerated decline in lung function, diminished quality of life, and higher mortality. Proactively monitoring patients for early signs of an exacerbation and treating them early could prevent these outcomes. The emergence of affordable wearable technology allows for

[72] Tomasic I, Tomasic N, Trobec R, Krpan M, Kelava T. Continuous remote monitoring of COPD patients-justification and explanation of the requirements and a survey of the available technologies. *Med Biol Eng Comput*. 2018;56(4):547-569. doi:10.1007/s11517-018-1798-z

[73] Wu R, Liaqat D, de Lara E, et al. Feasibility of Using a Smartwatch to Intensively Monitor Patients With Chronic Obstructive Pulmonary Disease: Prospective Cohort Study. *JMIR Mhealth Uhealth*. 2018;6(6):e10046. Published 2018 Jun 14. doi:10.2196/10046

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nearly continuous monitoring of heart rate and physical activity as well as recording of audio which can detect features such as coughing. These signals may be able to be used with predictive analytics to detect early exacerbations. Prior to full development, however, it is important to determine the feasibility of using wearable devices such as smartwatches to intensively monitor patients with COPD.

Objective: We conducted a feasibility study to determine if patients with COPD would wear and maintain a smartwatch consistently and whether they would reliably collect and transmit sensor data.

Methods: Patients with COPD were recruited from 3 hospitals and were provided with a smartwatch that recorded audio, heart rate, and accelerations. They were asked to wear and charge it daily for 90 days. They were also asked to complete a daily symptom diary. At the end of the study period, participants were asked what would motivate them to regularly use a wearable for monitoring of their COPD.

Results: Of 28 patients enrolled, 16 participants completed the full 90 days. The average age of participants was 68.5 years, and 36% (10/28) were women. Survey, heart rate, and activity data were available for an average of 64.5, 65.1, and 60.2 days respectively. Technical issues caused heart rate and activity data to be unavailable for approximately 13 and 17 days, respectively. Feedback provided by participants indicated that they wanted to actively engage with the smartwatch and receive feedback about their activity, heart rate, and how to better manage their COPD.

Conclusions: Some patients with COPD will wear and maintain smartwatches that passively monitor audio, heart rate, and physical activity, and wearables were able to reliably capture near-continuous patient data. Further work is necessary to increase acceptability and improve the patient experience.

Crooks et al (2017) [Observational Study] Continuous Cough Monitoring Using Ambient Sound Recording During Convalescence From a COPD Exacerbation[74]

Purpose: Cough is common in chronic obstructive pulmonary disease (COPD) and is associated with frequent exacerbations and increased mortality. Cough increases during acute exacerbations (AE-COPD), representing a possible metric of clinical deterioration. Conventional cough monitors accurately report cough counts over short time periods. We describe a novel

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[74] Crooks MG, den Brinker A, Hayman Y, et al. Continuous Cough Monitoring Using Ambient Sound Recording During Convalescence from a COPD Exacerbation. *Lung*. 2017;195(3):289-294. doi:10.1007/s00408-017-9996-2

monitoring system which we used to record cough continuously for up to 45 days during AE-COPD convalescence.

Methods: This is a longitudinal, observational study of cough monitoring in AE-COPD patients discharged from a single teaching hospital. Ambient sound was recorded from two sites in the domestic environment and analysed using novel cough classifier software. For comparison, the validated hybrid HACC/LCM cough monitoring system was used on days 1, 5, 20 and 45. Patients were asked to record symptoms daily using diaries.

Results: Cough monitoring data were available for 16 subjects with a total of 568 monitored days. Daily cough count fell significantly from mean ± SEM 272.7 ± 54.5 on day 1 to 110.9 ± 26.3 on day 9 ($p < 0.01$) before plateauing. The absolute cough count detected by the continuous monitoring system was significantly lower than detected by the hybrid HACC/LCM system but normalised counts strongly correlated ($r = 0.88$, $p < 0.01$) demonstrating an ability to detect trends. Objective cough count and subjective cough scores modestly correlated ($r = 0.46$).

Conclusions: Cough frequency declines significantly following AE-COPD and the reducing trend can be detected using continuous ambient sound recording and novel cough classifier software. Objective measurement of cough frequency has the potential to enhance our ability to monitor the clinical state in patients with COPD.

Kargiannakis et al (2017) [Review] Does Telehealth Monitoring Identify Exacerbations of Chronic Obstructive Pulmonary Disease and Reduce Hospitalisations? An Analysis of System Data[75]

Background: The increasing prevalence and associated cost of treating chronic obstructive pulmonary disease (COPD) is unsustainable. Health care organizations are focusing on ways to support self-management and prevent hospital admissions, including telehealth-monitoring services capturing physiological and health status data. This paper reports on data captured during a pilot randomized controlled trial of telehealth-supported care within a community-based service for patients discharged from hospital following an exacerbation of their COPD.

Objective: The aim was to undertake the first analysis of system data to determine whether telehealth monitoring can identify an exacerbation of

[75] Kargiannakis M, Fitzsimmons DA, Bentley CL, Mountain GA. Does Telehealth Monitoring Identify Exacerbations of Chronic Obstructive Pulmonary Disease and Reduce Hospitalisations? An Analysis of System Data. *JMIR Med Inform*. 2017;5(1):e8. Published 2017 Mar 22. doi:10.2196/medinform.6359
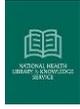
COPD, providing clinicians with an opportunity to intervene with timely treatment and prevent hospital readmission.

Methods: A total of 23 participants received a telehealth-supported intervention. This paper reports on the analysis of data from a telehealth monitoring system that captured data from two sources: 1. data uploaded both manually and using Bluetooth peripheral devices by the 23 participants; and 2. clinical records entered as nursing notes by the clinicians. Rules embedded in the telehealth monitoring system triggered system alerts to be reviewed by remote clinicians who determined whether clinical intervention was required. We also analyzed data on the frequency and length of hospital admissions, frequency of hospital Accident and Emergency visits that did not lead to hospital admission, and frequency and type of community health care service contacts-other than the COPD discharge service-for all participants for the duration of the intervention and 6 months postintervention.

Results: Patients generated 512 alerts, 451 of which occurred during the first 42 days that all participants used the equipment. Patients generated fewer alerts over time with typically seven alerts per day within the first 10 days and four alerts per day thereafter. They also had three times more days without alerts than with alerts. Alerts were most commonly triggered by reports of being more tired, having difficulty with self-care, and blood pressure being out of range. During the 8-week intervention, and for 6-month follow-up, eight of the 23 patients were hospitalized. Hospital readmission rates (2/23, 9%) in the first 28 days of service were lower than the 20% UK norm.

Conclusions: It seems that the clinical team can identify exacerbations based on both an increase in alerts and the types of system-generated alerts as evidenced by their efforts to provided treatment interventions. There was some indication that telehealth monitoring potentially delayed hospitalizations until after patients had been discharged from the service. We suggest that telehealth-supported care can fulfill an important role in enabling patients with COPD to better manage their condition and remain out of hospital, but adequate resourcing and timely response to alerts is a critical factor in supporting patients to remain at home.

Merone et al (2017) [Report] [A Decision Support System for Tele-Monitoring COPD-Related Worrisome Events](#)[76]

Chronic Obstructive Pulmonary Disease (COPD) is a preventable, treatable, and slowly progressive disease, whose course is aggravated by a periodic worsening of symptoms and lung function lasting for several days. The development of home telemonitoring systems has made possible to collect symptoms and physiological data in electronic records, boosting the development of decision support systems (DSSs). Current DSSs work with physiological measurements collected by means of several measuring and communication devices as well as with symptoms gathered by questionnaires submitted to COPD subjects. However, this contrasts with the advices provided by the World Health Organization and the Global initiative for chronic Obstructive Lung Disease that recommend to avoid invasive or complex daily measurements. ReportFor these reasons this manuscript presents a DSS detecting the onset of worrisome events in COPD subjects. It uses the hearth rate and the oxygen saturation, which can be collected via a pulse oximeter. The DSS consists in a binary finite state machine, whose training stage allows a subject specific personalization of the predictive model, triggering warnings, and alarms as the health status evolves over time. The experiments on data collected from 22 COPD patients tele-monitored at home for six months show that the system recognition performance is better than the one achieved by medical experts. Furthermore, the support offered by the system in the decision-making process allows to increase the agreement between the specialists, largely impacting the recognition of the worrisome events.

Rubio et al (2017) [Observational Study] [Home Monitoring of Breathing Rate in People With Chronic Obstructive Pulmonary Disease: Observational Study of Feasibility, Acceptability, and Change After Exacerbation](#)[77]

Telehealth programs to promote early identification and timely self-management of acute exacerbations of chronic obstructive pulmonary diseases (AECOPDs) have yielded disappointing results, in part, because parameters monitored [symptoms, pulse oximetry, and spirometry] are weak predictors of exacerbations.

[76] Merone M, Pedone C, Capasso G, Incalzi RA, Soda P. A Decision Support System for Tele-Monitoring COPD-Related Worrisome Events. *IEEE J Biomed Health Inform*. 2017;21(2):296-302. doi:10.1109/JBHI.2017.2654682

[77] Rubio N, Parker RA, Drost EM, et al. Home monitoring of breathing rate in people with chronic obstructive pulmonary disease: observational study of feasibility, acceptability, and change after exacerbation. *Int J Chron Obstruct Pulmon Dis*. 2017;12:1221-1231. Published 2017 Apr 20. doi:10.2147/COPD.S120706

Purpose: Breathing rate (BR) rises during AECOPD and may be a promising predictor. Devices suitable for home use to measure BR have recently become available, but their accuracy, acceptability, and ability to detect changes in people with COPD is not known.

Patients and methods: We compared five BR monitors, which used different monitoring technologies, with a gold standard [Oxycon Mobile®; CareFusion®, a subsidiary of Becton Dickinson, San Diego, CA, USA]. The monitors were validated in 21 stable COPD patients during a 57-min "activities of daily living protocol" in a laboratory setting. The two best performing monitors were then tested in a 14-day trial in a home setting in 23 stable COPD patients to determine patient acceptability and reliability of signal. Acceptability was explored in qualitative interviews. The better performing monitor was then given to 18 patients recruited during an AECOPD who wore the monitor to observe BR during the recovery phase of an AECOPD.

Results: While two monitors demonstrated acceptable accuracy compared with the gold standard, some participants found them intrusive particularly when ill with an exacerbation, limiting their potential utility in acute situations. A reduction in resting BR during the recovery from an AECOPD was observed in some, but not in all participants and there was considerable day-to-day individual variation.

Conclusion: Resting BR shows some promise in identifying exacerbations; however, further prospective study to assess this is required.

Talboom-Kamp et al (2017) [Cohort Study] The Effect of Integration of Self-Management Web Platforms on Health Status in Chronic Obstructive Pulmonary Disease Management in Primary Care (e-Vita Study): Interrupted Time Series Design[78]

Background: Worldwide nearly 3 million people die from chronic obstructive pulmonary disease (COPD) every year. Integrated disease management (IDM) improves quality of life for COPD patients and can reduce hospitalization. Self-management of COPD through eHealth is an effective method to improve IDM and clinical outcomes.

Objectives: The objective of this implementation study was to investigate the effect of 3 chronic obstructive pulmonary disease eHealth programs applied in primary care on health status. The e-Vita COPD study compares different levels of integration of Web-based self-management platforms in IDM in 3

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[78] Talboom-Kamp EP, Verdijk NA, Kasteleyn MJ, et al. The Effect of Integration of Self-Management Web Platforms on Health Status in Chronic Obstructive Pulmonary Disease Management in Primary Care (e-Vita Study): Interrupted Time Series Design. *J Med Internet Res.* 2017;19(8):e291. Published 2017 Aug 16. doi:10.2196/jmir.8262

primary care settings. Patient health status is examined using the Clinical COPD Questionnaire (CCQ).

Methods: The parallel cohort design includes 3 levels of integration in IDM [groups 1, 2, 3] and randomization of 2 levels of personal assistance for patients [group A, high assistance, group B, low assistance]. Interrupted time series (ITS) design was used to collect CCQ data at multiple time points before and after intervention, and multilevel linear regression modeling was used to analyze CCQ data.

Results: Of the 702 invited patients, 215 (30.6%) registered to a platform. Of these, 82 participated in group 1 (high integration IDM), 36 in group 1A (high assistance), and 46 in group 1B (low assistance); 96 participated in group 2 (medium integration IDM), 44 in group 2A (high assistance) and 52 in group 2B (low assistance); also, 37 participated in group 3 (no integration IDM). In the total group, no significant difference was found in change in CCQ trend (P=.334) before (-0.47% per month) and after the intervention (-0.084% per month). Also, no significant difference was found in CCQ changes before versus after the intervention between the groups with high versus low personal assistance. In all subgroups, there was no significant change in the CCQ trend before and after the intervention (group 1A, P=.237; 1B, P=.991; 2A, P=.120; 2B, P=.166; 3, P=.945).

Conclusions: The e-Vita eHealth-supported COPD programs had no beneficial impact on the health status of COPD patients. Also, no differences were found between the patient groups receiving different levels of personal assistance.

Thomas et al (2017) [Pilot Study] Inhaler Training Delivered by Internet-Based Home Videoconferencing Improves Technique and Quality of Life[79]

Background: COPD is common, and inhaled medications can reduce the risk of exacerbations. Incorrect inhaler use is also common and may lead to worse symptoms and increased exacerbations. We examined whether inhaler training could be delivered using Internet-based home videoconferencing and its effect on inhaler technique, self-efficacy, quality of life, and adherence.

Methods: In this pre-post pilot study, participants with COPD had 3 monthly Internet-based home videoconference visits with a pharmacist who provided inhaler training using teach-to-goal methodology. Participants

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[79] Thomas RM, Locke ER, Woo DM, et al. Inhaler Training Delivered by Internet-Based Home Videoconferencing Improves Technique and Quality of Life. *Respir Care*. 2017;62(11):1412-1422. doi:10.4187/respcare.05445

completed mailed questionnaires to ascertain COPD severity, self-efficacy, health literacy, quality of life, adherence, and satisfaction with the intervention.

Results: A total of 41 participants completed at least one, and 38 completed all 3 home videoconference visits. During each visit, technique improved for all inhalers, with significant improvements for the albuterol metered-dose inhaler, budesonide/formoterol metered-dose inhaler, and tiotropium dry powder inhaler. Improved technique was sustained for nearly all inhalers at 1 and 2 months. Quality of life measured with the Chronic Respiratory Questionnaire improved following the training: dyspnea (+0.3 points, P = .01), fatigue (+0.6 points, P < .001), emotional function (+0.5 points, P = .001), and mastery (+0.7 points, P < .001). Coping skills measured with the Seattle Obstructive Lung Disease Questionnaire improved (+9.9 points, P = .003). Participants reported increased confidence in inhaler use; for example, mean self-efficacy for using albuterol increased 3 points (P < .001). Inhaler adherence improved significantly after the intervention from 1.6 at the initial visit to 1.1 at month 2 (P = .045). The pharmacist reported technical issues in 64% of visits.

Conclusions: Inhaler training using teach-to-goal methodology delivered by home videoconference is a promising means to provide training to patients with COPD that can improve technique, quality of life, self-efficacy, and adherence.

Tillis et al (2017) [Feasibilty Study] Implementation of Activity Sensor Equipment in the Homes of Chronic Obstructive Pulmonary Disease Patients[80]

Introduction: Telemedicine care models for managing advanced chronic obstructive pulmonary disease (COPD) may benefit from the addition of motion sensing, spirometry, and tablet-based symptom diary tracking. Methods: We conducted a feasibility study of telemedicine in the home setting using multiple activity sensor monitoring equipment. Deployment and monitoring were supported by home health nurses with technical advice from the equipment makers as needed. Data analytics for motion sensing was provided by the research sponsor, but was not used for care decisions. On study intake, a health risk assessment, Quality of Life (SF-36) survey, and the St. George Respiratory Questionnaire were administered to assess

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[80] Tillis W, Bond WF, Svendsen J, Guither S. Implementation of Activity Sensor Equipment in the Homes of Chronic Obstructive Pulmonary Disease Patients. *Telemed J E Health*. 2017;23(11):920-929. doi:10.1089/tmj.2016.0201

patients' self-perception of quality of life, activities of daily life function, and difficulty living with COPD.

Results: Twenty-eight patients were enrolled and data were gathered for a minimum of 6 months and maximum of 9 months. The researchers demonstrated that augmentation of traditional telemedicine methods with motion sensing, spirometry, and symptom diaries appears feasible. The technical, process, logistics barriers, and solutions required for system deployment are described. The researchers demonstrated that augmentation of traditional telemedicine methods with motion sensing, spirometry, and symptom diaries appears feasible.

Conclusions: Further exploration will be needed to determine the value of this information in preventing outcomes relevant to patients.

Zanaboni et al (2017) [Pilot Study] Long-term Exercise Maintenance in COPD via Telerehabilitation: A Two-Year Pilot Study[81]

Introduction: Pulmonary rehabilitation (PR) is an integral part of the management of chronic obstructive pulmonary disease (COPD). However, many patients do not access or complete PR, and long-term exercise maintenance has been difficult to achieve after PR. This study aimed to investigate feasibility, long-term exercise maintenance, clinical effects, quality of life and use of hospital resources of a telerehabilitation intervention. Methods: Ten patients with COPD were offered a two-year follow-up via telerehabilitation after attending PR. The intervention consisted of home exercise, telemonitoring and self-management via a webpage combined with weekly videoconferencing sessions. Equipment included a treadmill, a pulse oximeter and a tablet. Data collected at baseline, one year and two years were six-minute walking distance (6MWD), COPD assessment test (CAT), EuroQol 5 dimensions (EQ-5D), hospitalisations and outpatient visits.

Results: No dropout occurred. Physical performance, lung capacity, health status and quality of life were all maintained at two years. At one year, 6MWD improved by a mean of 40 metres from baseline, CAT decreased by four points and EQ visual analogue scale (EQ VAS) improved by 15.6 points.

Discussion: Long-term exercise maintenance in COPD via telerehabilitation is feasible. Results are encouraging and suggest that telerehabilitation can prevent deterioration and improve physical performance, health status and quality of life.

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[81] Zanaboni P, Hoaas H, Aarøen Lien L, Hjalmarsen A, Wootton R. Long-term exercise maintenance in COPD via telerehabilitation: a two-year pilot study. *J Telemed Telecare*. 2017;23(1):74–82. doi:10.1177/1357633X15625545

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Esteban et al (2016) [Observational Study] Outcomes of a Telemonitoring-Based Program (telEPOC) in Frequently Hospitalized COPD Patients[82]

Background: The increasing prevalence of chronic diseases requires changes in health care delivery. In COPD, telemedicine appears to be a useful tool. Our objective was to evaluate the efficacy (in improving health care-resource use and clinical outcomes) of a telemonitoring-based program (telEPOC) in COPD patients with frequent hospitalizations.

Materials and methods: We conducted a nonrandomized observational study in an intervention cohort of 119 patients (Galdakao-Usansolo Hospital) and a control cohort of 78 patients (Cruces Hospital), followed up for 2 years. The inclusion criteria were two or more hospital admissions in the previous year or three or more admissions in the previous 2 years. The intervention group received telemonitoring plus education and controls usual care.

Results: Most participants were men (13% women), and the sample had a mean age of 70 years, forced expiratory volume in 1 second of 45%, Charlson comorbidity index score of 3.5, and BODE (body mass index, airflow obstruction, dyspnea, and exercise capacity) index score of 4.1. In multivariate analysis, the intervention was independently related to lower rates of hospital admission (odds ratio [OR] 0.38, 95% confidence interval [CI] 0.27-0.54; $P<0.0001$), emergency department attendance (OR 0.56, 95% CI 0.35-0.92; $P<0.02$), and 30-day readmission (OR 0.46, 95% CI 0.29-0.74; $P<0.001$), as well as cumulative length of stay (OR 0.58, 95% CI 0.46-0.73; $P<0.0001$). The intervention was independently related to changes in several clinical variables during the 2-year follow-up.

Conclusion: An intervention including telemonitoring and education was able to reduce the health care-resource use and stabilize the clinical condition of frequently admitted COPD patients.

Hamad et al (2016) [Observational Study] The Value of Telehealth in the Early Detection of Chronic Obstructive Pulmonary Disease Exacerbations: A Prospective Observational Study[83]

We aim to establish the value of telemonitoring in the early detection of chronic obstructive pulmonary disease exacerbations. We followed up patients undergoing chronic obstructive pulmonary disease telemonitoring

[82] Esteban C, Moraza J, Iriberri M, et al. Outcomes of a telemonitoring-based program (telEPOC) in frequently hospitalized COPD patients. *Int J Chron Obstruct Pulmon Dis*. 2016;11:2919-2930. Published 2016 Nov 24. doi:10.2147/COPD.S115350
[83] Hamad GA, Crooks M, Morice AH. The value of telehealth in the early detection of chronic obstructive pulmonary disease exacerbations: A prospective observational study. *Health Informatics J*. 2016;22(2):406-413. doi:10.1177/1460458214564434

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for 4 months. We studied changes in the telemonitored data in the week prior to admission or to community chronic obstructive pulmonary disease exacerbation. A total of 183 patients were studied. In all, 30 chronic obstructive pulmonary disease-related hospital admissions and 68 chronic obstructive pulmonary disease community exacerbations were recorded. Changes in telehealth parameters occurred in 80 per cent (24/30) of admissions and 82 per cent (56/68) of community exacerbations. Although changes in telehealth data occurred in the majority of exacerbations, most individual symptoms was present in less than half the exacerbations and almost 20 per cent of exacerbations were not preceded by any change in telemonitoring data. Cough created significantly more alerts by those treated in the community (p = 0.008), whereas a drop in oxygen saturation created significantly more alerts pre-hospitalisation (p = 0.049). We conclude that further work is required to develop methods of identifying impending chronic obstructive pulmonary disease exacerbations with greater sensitivity and specificity.

Huygens et al (2016) [Qualitative Study] Expectations and Needs of Patients With a Chronic Disease Toward Self-Management and eHealth for Self-Management Purposes[84]
Background: Self-management is considered as an essential component of chronic care by primary care professionals. eHealth is expected to play an important role in supporting patients in their self-management. For effective implementation of eHealth it is important to investigate patients' expectations and needs regarding self-management and eHealth. The objectives of this study are to investigate expectations and needs of people with a chronic condition regarding self-management and eHealth for self-management purposes, their willingness to use eHealth, and possible differences between patient groups regarding these topics.
Methods: Five focus groups with people with diabetes (n = 14), COPD (n = 9), and a cardiovascular condition (n = 7) were conducted in this qualitative research. Separate focus groups were organized based on patients' chronic condition. The following themes were discussed: 1. the impact of the chronic disease on patients' daily life; 2. their opinions and needs regarding self-management; and 3. their expectations and needs regarding, and willingness

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[84] Huygens MW, Vermeulen J, Swinkels IC, Friele RD, van Schayck OC, de Witte LP. Expectations and needs of patients with a chronic disease toward self-management and eHealth for self-management purposes. *BMC Health Serv Res*. 2016;16:232. Published 2016 Jul 8. doi:10.1186/s12913-016-1484-5

to use, eHealth for self-management purposes. A conventional content analysis approach was used for coding.

Results: Patient groups seem to differ in expectations and needs regarding self-management and eHealth for self-management purposes. People with diabetes reported most needs and benefits regarding self-management and were most willing to use eHealth, followed by the COPD group. People with a cardiovascular condition mentioned having fewer needs for self-management support, because their disease had little impact on their life. In all patient groups it was reported that the patient, not the care professional, should choose whether or not to use eHealth. Moreover, participants reported that eHealth should not replace, but complement personal care. Many participants reported expecting feelings of anxiety by doing measurement themselves and uncertainty about follow-up of deviant data of measurements. In addition, many participants worried about the implementation of eHealth being a consequence of budget cuts in care. Conclusion: This study suggests that aspects of eHealth, and the way in which it should be implemented, should be tailored to the patient. Patients' expected benefits of using eHealth to support self-management and their perceived controllability over their disease seem to play an important role in patients' willingness to use eHealth for self-management purposes.

McNamara et al (2016) [Prospective Study] Measurement of Daily Physical Activity Using the SenseWear Armband: Compliance, Comfort, Adverse Side Effects and Usability[85]

Little is known about the acceptability of wearing physical activity-monitoring devices. This study aimed to examine the compliance, comfort, incidence of adverse side effects, and usability when wearing the SenseWear Armband (SWA) for daily physical activity assessment. In a prospective study, 314 participants (252 people with COPD, 36 people with a dust-related respiratory disease and 26 healthy age-matched people) completed a purpose-designed questionnaire following a 7-day period of wearing the SWA. Compliance, comfort levels during the day and night, adverse side effects and ease of using the device were recorded. Non-compliance with wearing the SWA over 7 days was 8%. The main reasons for removing the device were adverse side effects and discomfort. The SWA comfort level during the day was rated by 11% of participants as uncomfortable/very uncomfortable, with higher levels of discomfort reported during the night

[85] McNamara RJ, Tsai LL, Wootton SL, et al. Measurement of daily physical activity using the SenseWear Armband: Compliance, comfort, adverse side effects and usability. *Chron Respir Dis*. 2016;13(2):144-154. doi:10.1177/1479972316631138

(16%). Nearly half of the participants (46%) experienced at least one adverse skin irritation side effect from wearing the SWA including itchiness, skin irritation and rashes, and/or bruising. Compliance with wearing the SWA for measurement of daily physical activity was found to be good, despite reports of discomfort and a high incidence of adverse side effects.

Fernandez-Granero et al (2015) [Pilot Study] Computerised Analysis of Telemonitored Respiratory Sounds for Predicting Acute Exacerbations of COPD[86]

Chronic obstructive pulmonary disease (COPD) is one of the commonest causes of death in the world and poses a substantial burden on healthcare systems and patients' quality of life. The largest component of the related healthcare costs is attributable to admissions due to acute exacerbation (AECOPD). The evidence that might support the effectiveness of the telemonitoring interventions in COPD is limited partially due to the lack of useful predictors for the early detection of AECOPD. Electronic stethoscopes and computerised analyses of respiratory sounds (CARS) techniques provide an opportunity for substantial improvement in the management of respiratory diseases. This exploratory study aimed to evaluate the feasibility of using: (a) a respiratory sensor embedded in a self-tailored housing for ageing users; (b) a telehealth framework; (c) CARS and (d) machine learning techniques for the remote early detection of the AECOPD. In a 6-month pilot study, 16 patients with COPD were equipped with a home base-station and a sensor to daily record their respiratory sounds. Principal component analysis (PCA) and a support vector machine (SVM) classifier was designed to predict AECOPD. 75.8% exacerbations were early detected with an average of 5 ± 1.9 days in advance at medical attention. The proposed method could provide support to patients, physicians and healthcare systems.

Mohktar et al (2015) [Review] Predicting the Risk of Exacerbation in Patients With Chronic Obstructive Pulmonary Disease Using Home Telehealth Measurement Data[87]

Background: The use of telehealth technologies to remotely monitor patients suffering chronic diseases may enable preemptive treatment of

[86] Fernandez-Granero MA, Sanchez-Morillo D, Leon-Jimenez A. Computerised Analysis of Telemonitored Respiratory Sounds for Predicting Acute Exacerbations of COPD. *Sensors (Basel)*. 2015;15(10):26978-26996. Published 2015 Oct 23. doi:10.3390/s151026978

[87] Mohktar MS, Redmond SJ, Antoniades NC, et al. Predicting the risk of exacerbation in patients with chronic obstructive pulmonary disease using home telehealth measurement data. *Artif Intell Med*. 2015;63(1):51-59. doi:10.1016/j.artmed.2014.12.003

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worsening health conditions before a significant deterioration in the subject's health status occurs, requiring hospital admission.

Objective: The objective of this study was to develop and validate a classification algorithm for the early identification of patients, with a background of chronic obstructive pulmonary disease (COPD), who appear to be at high risk of an imminent exacerbation event. The algorithm attempts to predict the patient's condition one day in advance, based on a comparison of their current physiological measurements against the distribution of their measurements over the previous month.

Method: The proposed algorithm, which uses a classification and regression tree (CART), has been validated using telehealth measurement data recorded from patients with moderate/severe COPD living at home. The data were collected from February 2007 to January 2008, using a telehealth home monitoring unit.

Results: The CART algorithm can classify home telehealth measurement data into either a low risk or high risk category with 71.8% accuracy, 80.4% specificity and 61.1% sensitivity. The algorithm was able to detect a 'high risk' condition one day prior to patients actually being observed as having a worsening in their COPD condition, as defined by symptom and medication records.

Conclusion: The CART analyses have shown that features extracted from three types of physiological measurements; forced expiratory volume in 1s (FEV1), arterial oxygen saturation (SPO2) and weight have the most predictive power in stratifying the patients condition. This CART algorithm for early detection could trigger the initiation of timely treatment, thereby potentially reducing exacerbation severity and recovery time and improving the patient's health. This study highlights the potential usefulness of automated analysis of home telehealth data in the early detection of exacerbation events among COPD patients.

Paneroni et al (2015) [Feasibility Study] Is Telerehabilitation a Safe and Viable Option for Patients With COPD? A Feasibility Study[88]
In patients with COPD non-naïve to rehabilitation we tested the feasibility, adherence and satisfaction of a home-based reinforcement telerehabilitation program (TRP). Outcomes were compared with a standard outpatient rehabilitation program (ORP). Then 18 TRP patients underwent 28

sessions of strength exercises (60 min) and cycle training (40 min) using a satellite platform provided telemonitoring, tele-prescription, video-assistance and phone-calls, patients were equipped with an oximeter, steps-counter, bicycle, remote control and interactive TV software. 18 matched ORP, retrospectively identified from our hospital ORP database, were used as controls. At baseline and end of program, the 6-min walking test (6MWT), Medical Research Council (MRC) scale and Saint George's Respiratory Questionnaire (SGRQ) were administered. In TRP only, we assessed platform use, incremental exercise, steps walked/day and patient satisfaction. TRP patients completed all sessions without side effects, used the remote control 1,394 ± 2,329 times being in the 84% of the cases satisfied with the service. In 22% of the cases patients found the technology unfriendly. Each health-professional performed 46 ± 65 actions, 14.6 ± 2.12 phone calls and 1 ± 1.67 videoconference sessions per patient. TRP patients increased physical activity (3,412 vs. 1,863 steps/day, p = 0.0002). Both programs produced significant (all, p < 0.01) gains in 6MWT [meters, TRP +34.22 ± 50.79; ORP +33.61 ± 39.25], dyspnea [TRP - 0.72 ± 0.89; ORP - 0.94 ± 0.53] and SGRQ [TRP - 6.9 ± 9.96, ORP - 9.9 ± 12.92] without between-group differences. In conclusion, TRP is feasible and well accepted by patients, although sometimes technology was perceived as difficult. It seems to improve walking capacity, dyspnea, quality of life and daily physical activity. Future RCTs will demonstrate cost-effectiveness.

Sanchez-Morillo et al (2015) [Pilot Study] Detecting COPD Exacerbations Early Using Daily Telemonitoring of Symptoms and K-Means Clustering: A Pilot Study[89]
COPD places an enormous burden on the healthcare systems and causes diminished health-related quality of life. The highest proportion of human and economic cost is associated with admissions for acute exacerbation of respiratory symptoms (AECOPD). Since prompt detection and treatment of exacerbations may improve outcomes, early detection of AECOPD is a critical issue. This pilot study was aimed to determine whether a mobile health system could enable early detection of AECOPD on a day-to-day basis. A novel electronic questionnaire for the early detection of COPD exacerbations was evaluated during a 6-months field trial in a group of 16 patients. Pattern recognition techniques were applied. A k-means clustering algorithm was

[89] Sanchez-Morillo D, Fernandez-Granero MA, Jiménez AL. Detecting COPD exacerbations early using daily telemonitoring of symptoms and k-means clustering: a pilot study. *Med Biol Eng Comput.* 2015;53(5):441-451. doi:10.1007/s11517-015-1252-4

trained and validated, and its accuracy in detecting AECOPD was assessed. Sensitivity and specificity were 74.6 and 89.7 %, respectively, and area under the receiver operating characteristic curve was 0.84. 31 out of 33 AECOPD were early identified with an average of 4.5 ± 2.1 days prior to the onset of the exacerbation that was considered the day of medical attendance. Based on the findings of this preliminary pilot study, the proposed electronic questionnaire and the applied methodology could help to early detect COPD exacerbations on a day-to-day basis and therefore could provide support to patients and physicians.

CHAPTER 6
Telemedicine and Cystic Fibrosis

Randomised Controlled Trials

Lechtzin, Noah et al (2017) [Randomised Controlled Trial] Home Monitoring of Patients With Cystic Fibrosis to Identify and Treat Acute Pulmonary Exacerbations. eICE Study Results[1]

Rationale: Individuals with cystic fibrosis (CF) experience frequent acute pulmonary exacerbations, which lead to decreased lung function and reduced quality of life. Objectives: The goal of this study was to determine if an intervention directed toward early detection of pulmonary exacerbations using home spirometry and symptom monitoring would result in slower decline in lung function than in control subjects. Methods: We conducted a multicenter, randomized trial at 14 CF centers with subjects at least 14 years old. The early intervention arm subjects measured home spirometry and symptoms electronically twice per week. Sites were notified if a participant met criteria for an exacerbation and contacted participants to determine if treatment for acute exacerbation was required. Participants in the usual care arm were seen every 3 months and were asked to contact the site if they were concerned about worsening pulmonary symptoms. Measurements and main results: The primary outcome was the 52-week change in FEV1. Secondary outcomes included time to first exacerbation and subsequent exacerbation, quality of life, and change in weight. A total of 267 patients were randomized, and the study arms were well matched at baseline. There was no significant difference between study arms in 52-week mean change in FEV1 slope (mean slope difference, 0.00 L, 95% confidence interval, -0.07 to 0.07; P = 0.99). The early intervention arm subjects detected exacerbations more frequently than usual care arm subjects (time to first exacerbation hazard ratio, 1.45; 95% confidence interval, 1.09 to 1.93; P = 0.01). Adverse

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[1] Lechtzin N, Mayer-Hamblett N, West NE et al Home Monitoring of Patients with Cystic Fibrosis to Identify and Treat Acute Pulmonary Exacerbations. eICE Study Results. Am J Respir Crit Care Med. 2017;196(9):1144-1151. doi:10.1164/rccm.201610-2172OC

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events were not significantly different between treatment arms. Conclusions: An intervention of home monitoring among patients with CF was able to detect more exacerbations than usual care, but this did not result in slower decline in lung function. Clinical trial registered with www.clinicaltrials.gov (NCT01104402) **SEE ALSO:**

Lechtzin, Noah et al (2013) [Randomised Controlled Trial] Rationale and Design of a Randomized Trial of Home Electronic Symptom and Lung Function Monitoring to Detect Cystic Fibrosis Pulmonary Exacerbations: The Early Intervention in Cystic Fibrosis Exacerbation (eICE) Trial[2]
Background: Acute pulmonary exacerbations are central events in the lives of individuals with cystic fibrosis (CF). Pulmonary exacerbations lead to impaired lung function, worse quality of life, and shorter survival. We hypothesized that aggressive early treatment of acute pulmonary exacerbation may improve clinical outcomes. Purpose: Describe the rationale of an ongoing trial designed to determine the efficacy of home monitoring of both lung function measurements and symptoms for early detection and subsequent early treatment of acute CF pulmonary exacerbations. Study Design: A randomized, non-blinded, multi-center trial in 320 individuals with CF aged 14 years and older. The study compares usual care to a twice a week assessment of home spirometry and CF respiratory symptoms using an electronic device with data transmission to the research personnel to identify and trigger early treatment of CF pulmonary exacerbation. Participants will be enrolled in the study for 12 months. The primary endpoint is change in FEV1 (L) from baseline to 12 months determined by a linear mixed effects model incorporating all quarterly FEV1 measurements. Secondary endpoints include time to first acute protocol-defined pulmonary exacerbation, number of acute pulmonary exacerbations, number of hospitalization days for acute pulmonary exacerbation, time from the end of acute pulmonary exacerbation to onset of subsequent pulmonary exacerbation, change in health related quality of life, change in treatment burden, change in CF respiratory symptoms, and adherence to the study protocol. Conclusions: This study is a first step in establishing alternative approaches to the care of CF pulmonary exacerbations. We hypothesize that early treatment of pulmonary exacerbations has the potential to slow lung

[2] Lechtzin N, West N, Allgood S et al Rationale and design of a randomized trial of home electronic symptom and lung function monitoring to detect cystic fibrosis pulmonary exacerbations: the early intervention in cystic fibrosis exacerbation (eICE) trial. *Contemp Clin Trials*. 2013;362.:460- 469. doi:10.1016/j.cct.2013.09.004

function decline, reduce respiratory symptoms and improve the quality of life for individuals with CF.

Murgia, F et al (2015) [Randomised Controlled Trial] **Telemedicine home program in patients with cystic fibrosis: Results after 10 years**[3]
Objectives: We studied the effect of telehomecare (THC) in a group of cystic fibrosis (CF) patients. Materials and Methods: Forced Expiratory Volume in the first second (FEV1) was monitored at home, with the aim of an early recognition of the relapses of pulmonary infections. FEV1 was monitored for 4.5 years, using THC as a tool, in addition to the standard therapeutic protocol. 16 CF patients were followed by doctors experts in the treatment of CF, over a period of 4.5 years. We compared a control group among patients seen in the past for an identical period, matching for number, age, sex, respiratory function, bacterial colonization, O2 dependency, and complications. 16 CF patients with similar characteristics of age, degree of pulmonary involvement, bacterial colonization and O2 dependency. We calculated the annual mean values of FEV1 in both groups. Results: Spirometry data showed a significant improvement in annual Fev1 mean values for the THC patients as compared to the control group. Discussion: The data are encouraging for a possible role of Telemedicine as a tool for domestic assistance of patients affected by chronic diseases, such as CF. However, reliable data on the long-term effectiveness of the use of THC in the treatment of CF patients is still lacking. The time has come to obtain reliable data through a multicenter collaboration study, also in order to standardize the international Telemedicine protocols.

Miscellaneous

Calthorpe, Rebecca Jane et al (2020) [Review] **Using Digital Technology for Home Monitoring, Adherence and Self-Management in Cystic Fibrosis: A State-Of-The-Art Review**[4]
Digital healthcare is a rapidly growing healthcare sector. Its importance has been recognised at both national and international level, with the WHO recently publishing its first global strategy for digital health. The use of

[3] Murgia F, Bianciardi F, Solvoll T et al Telemedicine Home Program in Patients with Cystic Fibrosis: Results after 10 Years. *Clin Ter.* 2015;1666.:e384– e388. doi:10.7417/T.2015.1905
[4] Calthorpe RJ, Smith S, Gathercole K, Smyth AR. Using digital technology for home monitoring, adherence and self-management in cystic fibrosis: a state-of-the-art review. *Thorax.* 2020;751.:72– 77. doi:10.1136/thoraxjnl-2019-213233
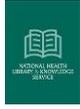
digital technology within cystic fibrosis (CF) has also increased. CF is a chronic, life-limiting condition, in which the treatment burden is high and treatment regimens are not static. Digital technologies present an opportunity to support the lives of people with CF. We included 59 articles and protocols in this state-of-the-art review, relating to 48 studies from 1999 until 2019. This provides a comprehensive overview of the expansion and evolution of the use of digital technology. Technology has been used with the aim of increasing accessibility to healthcare, earlier detection of pulmonary exacerbations and objective electronic adherence monitoring. It may also be used to promote adherence and self-management through education, treatment management Apps and social media. Competing interests: ARS has provided consultancy for Vertex and holds a current unrestricted research grant from Vertex. He has taken part in clinical trials sponsored by Vertex, Raptor and Insmed. He has given lectures at meetings sponsored by Teva and Vertex.

Compton, Martina et al (2020) [Feasibility Study] A Feasibility Study of Urgent Implementation of Cystic Fibrosis Multidisciplinary Telemedicine Clinic in the Face of COVID-19 Pandemic: Single-Center Experience[5] Introduction: The coronavirus 2019 (COVID-19) pandemic has become a major world health problem. All US states have advised their cystic fibrosis (CF) populations to socially isolate. Major health care payors such as Medicare and most private insurance companies have agreed to reimburse health care providers for telemedicine and telephone visits. Methods: The CF adult team at the University of Virginia (UVA) transitioned from face-to-face clinics to multidisciplinary telemedicine clinics by using WebEx®, a Health Insurance Portability and Accountability Act of 1996 (HIPAA) compliant platform. Interventions: Patients were contacted before scheduled visits and triaged into: 1. patients eligible for the multidisciplinary telemedicine clinic; 2. patients to be seen in clinic urgently due to acute needs; and 3. stable patients who can be rescheduled at a later time. Ineligible patients for the telemedicine clinic due to lack of access to technology were followed up via telephone. Results: A total of 63 patients were scheduled to be seen in the UVA clinic over 4 weeks, 10 clinic days. Of these patients, 20 (32%) rescheduled their appointment. In addition, 2 patients (3%) were seen in clinic for acute needs and 38 (60%) were seen by the multidisciplinary team

[5] Compton M, Soper M, Reilly B et al A Feasibility Study of Urgent Implementation of Cystic Fibrosis Multidisciplinary Telemedicine Clinic in the Face of COVID-19 Pandemic: Single-Center Experience [published online ahead of print, 2020 Apr 30]. *Telemed J E Health*. 2020;10.1089/tmj.2020.0091.

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through telemedicine. Conclusions: In the context of the COVID-19 pandemic, implementing a telemedicine clinic process that serves the needs of a multidisciplinary care team is paramount to preserving the CF care model. Through a systematic design and test process, a feasible and sustainable program was created that can be utilized by other multidisciplinary programs to adapt to their context.

Cuartero, Maria et al (2019) [Wearable Potentiometric Sensors for Medical Applications](6)

Wearable potentiometric sensors have received considerable attention owing to their great potential in a wide range of physiological and clinical applications, particularly involving ion detection in sweat. Despite the significant progress in the manner that potentiometric sensors are integrated in wearable devices, in terms of materials and fabrication approaches, there is yet plenty of room for improvement in the strategy adopted for the sample collection. Essentially, this involves a fluidic sampling cell for continuous sweat analysis during sport performance or sweat accumulation via iontophoresis induction for one-spot measurements in medical settings. Even though the majority of the reported papers from the last five years describe on-body tests of wearable potentiometric sensors while the individual is practicing a physical activity, the medical utilization of these devices has been demonstrated on very few occasions and only in the context of cystic fibrosis diagnosis. In this sense, it may be important to explore the implementation of wearable potentiometric sensors into the analysis of other biofluids, such as saliva, tears and urine, as herein discussed. While the fabrication and uses of wearable potentiometric sensors vary widely, there are many common issues related to the analytical characterization of such devices that must be consciously addressed, especially in terms of sensor calibration and the validation of on-body measurements. After the assessment of key wearable potentiometric sensors reported over the last five years, with particular attention paid to those for medical applications, the present review offers tentative guidance regarding the characterization of analytical performance as well as analytical and clinical validations, thereby aiming at generating debate in the scientific community to allow for the establishment of well-conceived protocols.

6 Cuartero M, Parrilla M, Crespo GA. Wearable Potentiometric Sensors for Medical Applications. *Sensors (Basel).* 2019;192.:363. Published 2019 Jan 17. doi:10.3390/s19020363
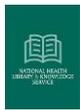
Gao, Wei et al (2019) [Flexible Electronics Toward Wearable Sensing](#)[7]

Wearable sensors play a crucial role in realizing personalized medicine, as they can continuously collect data from the human body to capture meaningful health status changes in time for preventive intervention. However, motion artifacts and mechanical mismatches between conventional rigid electronic materials and soft skin often lead to substantial sensor errors during epidermal measurement. Because of its unique properties such as high flexibility and conformability, flexible electronics enables a natural interaction between electronics and the human body. In this Account, we summarize our recent studies on the design of flexible electronic devices and systems for physical and chemical monitoring. Material innovation, sensor design, device fabrication, system integration, and human studies employed toward continuous and noninvasive wearable sensing are discussed. A flexible electronic device typically contains several key components, including the substrate, the active layer, and the interface layer. The inorganic-nanomaterials-based active layer prepared by a physical transfer or solution process is shown to have good physicochemical properties, electron/hole mobility, and mechanical strength. Flexible electronics based on the printed and transferred active materials has shown great promise for physical sensing. For example, integrating a nanowire transistor array for the active matrix and a conductive pressure-sensitive rubber enables tactile pressure mapping; tactile-pressure-sensitive e-skin and organic light-emitting diodes can be integrated for instantaneous pressure visualization. Such printed sensors have been applied as wearable patches to monitor skin temperature, electrocardiograms, and human activities. In addition, liquid metals could serve as an attractive candidate for flexible electronics because of their excellent conductivity, flexibility, and stretchability. Liquid-metal-enabled electronics based on liquid-liquid heterojunctions and embedded microchannels have been utilized to monitor a wide range of physiological parameters: eg pulse and temperature. Despite the rapid growth in wearable sensing technologies, there is an urgent need for the development of flexible devices that can capture molecular data from the human body to retrieve more insightful health information. We have developed a wearable and flexible sweat-sensing platform toward real-time multiplexed perspiration analysis. An integrated iontophoresis module on a wearable sweat sensor could enable autonomous and programmed sweat extraction. A microfluidics-based sensing system was demonstrated for

[7] Gao W, Ota H, Kiriya D, Takei K, Javey A. Flexible Electronics toward Wearable Sensing. *Acc Chem Res*. 2019;523.:523–533. doi:10.1021/acs.accounts.8b00500

sweat sampling, sensing, and sweat rate analysis. Roll-to-roll gravure printing allows for mass production of high-performance flexible chemical sensors at low cost. These wearable and flexible sweat sensors have shown great promise in dehydration monitoring, cystic fibrosis diagnosis, drug monitoring, and noninvasive glucose monitoring. Future work in this field should focus on designing robust wearable sensing systems to accurately collect data from the human body and on large-scale human studies to determine how the measured physical and chemical information relates to the individual's specific health conditions. Further research in these directions, along with the large sets of data collected via these wearable and flexible sensing technologies, will have a significant impact on future personalized healthcare.

Lee, Eun Kwang et al (2019) [Review] Skin-Mountable Biosensors and Therapeutics: A Review[8]
Miniaturization of electronic components and advances in flexible and stretchable materials have stimulated the development of wearable health care systems that can reflect and monitor personal health status by health care professionals. New skin-mountable devices that offer seamless contact onto the human skin, even under large deformations by natural motions of the wearer, provide a route for both high-fidelity monitoring and patient-controlled therapy. This article provides an overview of several important aspects of skin-mountable devices and their applications in many medical settings and clinical practices. We comprehensively describe various transdermal sensors and therapeutic systems that are capable of detecting physical, electrophysiological, and electrochemical responses and/or providing electrical and thermal therapies and drug delivery services, and we discuss the current challenges, opportunities, and future perspectives in the field. Finally, we present ways to protect the embedded electronic components of skin-mountable devices from the environment by use of mechanically soft packaging materials.

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[8] Lee EK, Kim MK, Lee CH. Skin-Mountable Biosensors and Therapeutics: A Review. *Annu Rev Biomed Eng*. 2019;21:299-323. doi:10.1146/annurev-bioeng-060418-052315

Martinez-Millana, Antonio et al (2019) [Mixed-Methods Study] The Potential of Self-Management mHealth for Pediatric Cystic Fibrosis: Mixed-Methods Study for Health Care and App Assessment[9]

Background: Remote care services and patient empowerment have boosted mobile health. A study of user needs related to mHealth for pediatric cystic fibrosis (PCF) identified the set of preferred features mobile apps should support; however, the potential use of PCF apps and their suitability to fit into PCF clinical management remains unexplored. Objective: We examine whether PCF holds potential for the implementation of mHealth care. Methods: The study is based on a literature review and qualitative analysis of content and was conducted in two parts: 1. we reviewed scientific and gray literature to explore how European countries manage PCF and conducted a qualitative study of 6 PCF units; and 2. we performed a systematic review of apps available in the myhealthapps.net repository searching for cystic fibrosis (CF) management and nutrition apps, which we analyzed for characteristics, business models, number of downloads, and usability. Results: European CF routine care guidelines are acknowledged in most European countries, and treatments are fully covered in almost all countries. The majority of teams in CF units are interdisciplinary. With respect to the systematic review of apps, we reviewed 12 apps for CF management and 9 for general nutrition management in the myhealthapps.net directory. All analyzed apps provided functionalities for recording aspects related to the disease and nutrition such as medication, meals, measurements, reminders, and educational material. None of the apps reviewed in this study supported pancreatic enzyme replacement therapy. CF apps proved to be less appealing and usable than nutrition apps (2.66 [SD 1.15] vs 4.01 [SD 0.90]; P<.001, z-value: -2.6). User needs detected in previous research are partially matched by current apps for CF management. Conclusions: The health care context for PCF is a unique opportunity for the adoption of mHealth. Well-established clinical guidelines, heterogeneous clinical teams, and coverage by national health care systems provide a suitable scenario for the use of mHealth solutions. However, available apps for CF self-management do not cover essential aspects such as nutrition and education. To increase the adoption of mHealth for CF self-management, new apps should include these features. International registered report identifier (irrid): RR2-10.1136/bmjopen-2016-014931.

[9] Martinez-Millana A, Zettl A, Floch J et al The Potential of Self-Management mHealth for Pediatric Cystic Fibrosis: Mixed-Methods Study for Health Care and App Assessment. *JMIR Mhealth Uhealth*. 2019;74.:e13362. Published 2019 Apr 18. doi:10.2196/13362

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Wood, Jamie et al (2019) [High Usability of a Smartphone Application for Reporting Symptoms in Adults With Cystic Fibrosis](#)[10]

Introduction: In cystic fibrosis, exacerbations impair lung function and health-related quality of life, increase healthcare costs and reduce survival. Delayed reporting of worsening symptoms can result in more severe exacerbations and worse clinical outcomes; therefore, there is a need for a novel approach to facilitate the early identification and treatment of exacerbations in this population. This study investigated the usability of a smartphone application to report symptoms in adults with cystic fibrosis, and the observer agreement in clinical decision-making between senior clinicians interpreting smartphone application responses. Methods: Adults with cystic fibrosis used the smartphone application weekly for four weeks. The application comprised 10 yes/no questions regarding respiratory symptoms and two regarding emotional well-being. Usability was measured with the System Usability Scale; observer agreement was tested by providing a cystic fibrosis physician and a nurse practitioner with 45 clinical scenarios. For each scenario the clinicians, who were blinded to each other's responses, were asked to indicate whether or not they would: 1. initiate telephone contact; and/or 2. request a clinic visit for the individual. Results: 10 participants (5 female), aged mean (SD) 33 (11) years, FEV1 49 (27)% predicted completed the study. The mean (SD) System Usability Scale score was 94 6.. There was perfect agreement between clinicians for initiating contact with the participant (κ = 1.0, p < 0.001), and near-perfect for requesting a clinic visit (κ = 0.86, p < 0.001). Discussion The use of a smartphone application for reporting symptoms in adults with cystic fibrosis has excellent usability and near-perfect agreement between senior clinicians when interpreting the application responses.

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[10] Wood J, Jenkins S, Putrino D et al High usability of a smartphone application for reporting symptoms in adults with cystic fibrosis. *J Telemed Telecare*. 2018;248.:547- 552. doi:10.1177/1357633X17723366

Calvo-Lerma, Joaquim et al (2017) Innovative approach for self-management and social welfare of children with cystic fibrosis in Europe: Development, validation and implementation of an mHealth tool (MyCyFAPP)[11]

Introduction: For the optimal management of children with cystic fibrosis, there are currently no efficient tools for the precise adjustment of pancreatic enzyme replacement therapy, either for advice on appropriate dietary intake or for achieving an optimal nutrition status. Therefore, we aim to develop a mobile application that ensures a successful nutritional therapy in children with cystic fibrosis. Methods and analysis: A multidisciplinary team of 12 partners coordinate their efforts in 9 work packages that cover the entire so-called 'from laboratory to market' approach by means of an original and innovative co-design process. A cohort of 200 patients with cystic fibrosis aged 1-17 years are enrolled. We will develop an innovative, clinically tested mobile health application for patients and health professionals involved in cystic fibrosis management. The mobile application integrates the research knowledge and innovative tools for maximising self-management with the aim of leading to a better nutritional status, quality of life and disease prognosis. Bringing together different and complementary areas of knowledge is fundamental for tackling complex challenges in disease treatment, such as optimal nutrition and pancreatic enzyme replacement therapy in cystic fibrosis. Patients are expected to benefit the most from the outcomes of this innovative project. Ethics and dissemination: The project is approved by the Ethics Committee of the coordinating organisation, Hospital Universitari La Fe (Ref: 2014/0484). Scientific findings will be disseminated via journals and conferences addressed to clinicians, food scientists, information and communications technology experts and patients. The specific dissemination working group within the project will address the wide audience communication through the website (http://www.mycyfapp.eu), the social networks and the newsletter.

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[11] Calvo-Lerma J, Martinez-Jimenez CP, Lázaro-Ramos JP et al Innovative approach for self-management and social welfare of children with cystic fibrosis in Europe: development, validation and implementation of an mHealth tool (MyCyFAPP). *BMJ Open*. 2017;73.:e014931. Published 2017 Mar 16. doi:10.1136/bmjopen-2016-014931

Emaminejad, Sam et al (2017) Autonomous Sweat Extraction and Analysis Applied to Cystic Fibrosis and Glucose Monitoring Using a Fully Integrated Wearable Platform[12]

Perspiration-based wearable biosensors facilitate continuous monitoring of individuals' health states with real-time and molecular-level insight. The inherent inaccessibility of sweat in sedentary individuals in large volume (≥10 μL) for on-demand and in situ analysis has limited our ability to capitalize on this noninvasive and rich source of information. A wearable and miniaturized iontophoresis interface is an excellent solution to overcome this barrier. The iontophoresis process involves delivery of stimulating agonists to the sweat glands with the aid of an electrical current. The challenge remains in devising an iontophoresis interface that can extract sufficient amount of sweat for robust sensing, without electrode corrosion and burning/causing discomfort in subjects. Here, we overcame this challenge through realizing an electrochemically enhanced iontophoresis interface, integrated in a wearable sweat analysis platform. This interface can be programmed to induce sweat with various secretion profiles for real-time analysis, a capability which can be exploited to advance our knowledge of the sweat gland physiology and the secretion process. To demonstrate the clinical value of our platform, human subject studies were performed in the context of the cystic fibrosis diagnosis and preliminary investigation of the blood/sweat glucose correlation. With our platform, we detected the elevated sweat electrolyte content of cystic fibrosis patients compared with that of healthy control subjects. Furthermore, our results indicate that oral glucose consumption in the fasting state is followed by increased glucose levels in both sweat and blood. Our solution opens the possibility for a broad range of noninvasive diagnostic and general population health monitoring applications.

Cox, Narelle S et al (2015) [Feasibility Study] Feasibility and acceptability of an Internet-Based program to promote physical activity in adults with cystic fibrosis[13]

Background: Lifelong physical activity is an important component of the therapeutic management of patients with cystic fibrosis (CF). Use of the Internet to monitor and encourage participation in physical activity has not

[12] Emaminejad S, Gao W, Wu E et al Autonomous sweat extraction and analysis applied to cystic fibrosis and glucose monitoring using a fully integrated wearable platform. *Proc Natl Acad Sci U S A*. 2017;114(18):4625- 4630. doi:10.1073/pnas.1701740114

[13] Cox NS, Alison JA, Button BM, Wilson JW, Holland AE. Feasibility and acceptability of an Internet-based program to promote physical activity in adults with cystic fibrosis. *Respir Care*. 2015;603.:422- 429. doi:10.4187/respcare.03165

been assessed in adults with CF. We aimed to establish the feasibility and acceptability of a specifically developed Internet-based program to monitor and encourage physical activity participation in adults with CF. Methods: Subjects were recruited at hospital discharge to trial an Internet-based physical activity program (ActivOnline) for 8 weeks, which incorporated fortnightly telephone consultation to support physical activity behavior change. Acceptability of the program was assessed by semistructured interview, as well as subject-rated system usability and perceived benefit using Likert scales. Feasibility was assessed by frequency of access of the online site and number of physical activity sessions recorded. Results: Ten subjects were recruited who rated system usability and perceived benefit favorably (median score usability of 89% [interquartile range of 84-95%]; median score of perceived benefit (maximum of 5) of 4 [interquartile range of 3-4.8]). During interviews, subjects described a positive reaction to receiving graphical representation of their activity participation; however, 80% would have preferred a more mobile interface such as an app. Subjects accessed ActivOnline on a mean ± SD of 13 ± 11 occasions over 8 weeks and recorded a mean of 35 (range of 15-57) physical activity sessions. Conclusions: Use of an Internet-based program to encourage participation in physical activity was both feasible and acceptable to adults with CF. Feasibility may be further improved with the ability to access the program through a mobile application.

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CHAPTER 7
Telemedicine and Dermatology

Systematic Reviews

Andrees et al (2020) [Systematic Review] **Live interactive teledermatology compared to in-person care - a systematic review**[1] Teledermatology is a rapidly developing field of dermatological care, giving the opportunity to deliver more efficient healthcare to patients in remote areas. Live interactive (LI) teledermatology uses videoconferencing and, hence, allows for direct communication. A current overview on effectiveness, costs, feasibility and accuracy of LI applications compared to standard care is missing. The present systematic review provides this overview on LI teledermatology. Two databases were searched until April 2019, followed by title, abstract and full-text screening. Additionally, reference lists of the detected eligible articles were screened for further eligible studies. Studies comparing LI applications with standard care were included. Data on study design, sample size, country, objectives, main findings and characteristics of LI applications were extracted. Results on time effectiveness, costs, accuracy and feasibility of LI applications were synthesized. Additionally, the quality of included studies was assessed. Twenty-three publications were included in the final analysis: seventeen case-control studies and six randomized controlled trials. Included studies were published between 1997 and 2017. Study quality differed across studies. The studies were carried out in eight different countries. Eleven studies focused on patient consultation, three on patient organization and nine on combined applications of the aforementioned. Nine studies investigated applications facilitating patient-provider interaction. Fourteen studies evaluated applications combining patient-provider and provider-provider interaction, meaning the patient sits next to one provider while using LI applications to interact with another provider. This review reveals that LI applications can be a time effective substitute of or supplement to standard dermatological care. Results demonstrated that LI and standard care are comparable with regard to

[1] Andrees V, Klein TM, Augustin M, Otten M. Live interactive teledermatology compared to in-person care - a systematic review. *J Eur Acad Dermatol Venereol.* 2020;34(4):733-745. doi:10.1111/jdv.16070
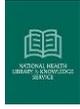
feasibility and accuracy. No clear tendencies can be reported with regard to costs. However, there is a lack of current comparative studies.

Freeman et al (2020) [Systematic Review] Algorithm based smartphone apps to assess risk of skin cancer in adults: systematic review of diagnostic accuracy studies[2]

Objective: To examine the validity and findings of studies that examine the accuracy of algorithm based smartphone applications ("apps") to assess risk of skin cancer in suspicious skin lesions.

Design: Systematic review of diagnostic accuracy studies.

Data sources: Cochrane Central Register of Controlled Trials, MEDLINE, Embase, CINAHL, CPCI, Zetoc, Science Citation Index, and online trial registers from database inception to 10 April, 2019.

Eligibility criteria for selecting studies: Studies of any design that evaluated algorithm based smartphone apps to assess images of skin lesions suspicious for skin cancer. Reference standards included histological diagnosis or follow-up, and expert recommendation for further investigation or intervention. Two authors independently extracted data and assessed validity using QUADAS-2. Estimates of sensitivity and specificity were reported for each app.

Results: Nine studies that evaluated six different identifiable smartphone apps were included. Six verified results by using histology or follow-up (n=725 lesions), and three verified results by using expert recommendations (n=407 lesions). Studies were small and of poor methodological quality, with selective recruitment, high rates of unevaluable images, and differential verification. Lesion selection and image acquisition were performed by clinicians rather than smartphone users. Two CE [Conformit Europenne] marked apps are available for download. No published peer reviewed study was found evaluating the TeleSkin skinScan app. SkinVision was evaluated in three studies (n=267, 66 malignant or premalignant lesions) and achieved a sensitivity of 80% (95% confidence interval 63% to 92%) and a specificity of 78% (67% to 87%) for the detection of malignant or premalignant lesions. Accuracy of the SkinVision app verified against expert recommendations was poor (three studies).

Conclusions: Current algorithm based smartphone apps cannot be relied on to detect all cases of melanoma or other skin cancers. Test performance is

[2] Freeman K, Dinnes J, Chuchu N, et al. Algorithm based smartphone apps to assess risk of skin cancer in adults: systematic review of diagnostic accuracy studies [published correction appears in BMJ. 2020 Feb 25;368:m645]. *BMJ*. 2020;368:m127. Published 2020 Feb 10. doi:10.1136/bmj.m127

likely to be poorer than reported here when used in clinically relevant populations and by the intended users of the apps. The current regulatory process for awarding the CE marking for algorithm based apps does not provide adequate protection to the public.

Pala et al (2020) [Systematic Review] [Teledermatology: idea, benefits and risks of modern age - a systematic review based on melanoma](#)[3]
Telemedicine may be described as a modern technology supporting health care at a distance. Dermatology, as a visually-dependent specialty, is particularly suited for this kind of the health care model. This has been proven in a number of recent studies, which emphasized feasibility and reliability of teledermatology. Many patients in the world still do not have access to appropriate dermatological care, while skin cancers morbidity is on an upward trend. Technological development has enabled clinicians to care for diverse patient populations in need of skin expertise without increasing their overhead costs. Teledermatology has been used for various purposes: health care workers can use this technology to provide clinical services to patients, to monitor patient health, to consult with other health care providers and to provide patients with access to educational resources. It seems that teledermatology might be the answer to numerous issues concerning diagnosing, screening and managing cancers as well as pigmented skin lesions.

Bruce et al (2018) [Systematic Review] [The use of teledermoscopy in the accurate identification of cancerous skin lesions in the adult population: A systematic review](#)[4]
Background: The use of teledermoscopy in the diagnostic management of pre-cancerous and cancerous skin lesions involves digital dermoscopic images transmitted over telecommunication networks via email or web applications. Teledermoscopy may improve the accuracy in clinical diagnoses of melanoma skin cancer if integrated into electronic medical records and made available to rural communities, potentially leading to decreased morbidity and mortality.
Objective and Method: The purpose of this paper is to present a systematic review of evidence on the use of teledermoscopy to improve the accuracy of skin lesion identification in adult populations. The PRISMA method guided

[3] Pala P, Bergler-Czop BS, Gwiżdż JM. Teledermatology: idea, benefits and risks of modern age - a systematic review based on melanoma. *Postepy Dermatol Alergol.* 2020;37(2):159-167. doi:10.5114/ada.2020.94834
[4] Bruce AF, Mallow JA, Theeke LA. The use of teledermoscopy in the accurate identification of cancerous skin lesions in the adult population: A systematic review. *J Telemed Telecare.* 2018;24(2):75-83. doi:10.1177/1357633X16686770

the development of this systematic review. A total of seven scholarly databases were searched for articles published between the years of 2000 and 2015. All studies were critically appraised using the Rosswurm and Larrabee critique worksheet, placed in a matrix for comparison evaluating internal and external validity and inspected for homogeneity of findings.

Results: Sixteen articles met inclusion criteria for this review. A majority of the studies were cross-sectional and non-experimental. Ten of the 16 focused on interobserver concordance and diagnostic agreement between teledermoscopy and another comparator. Instrumentation in conducting the studies showed inconsistency with reported results.

Discussion: Higher level evidence is needed to support clinical application of teledermoscopy for accuracy of diagnostic measurement in the treatment of pre-cancerous and cancerous skin lesions in adults. Future research is needed to develop a standardized, reliable and valid measurement tool for implementation in clinical practice.

Choi et a (2018) [Systematic Review] mHealth Approaches in Managing Skin Cancer: Systematic Review of Evidence-Based Research Using Integrative Mapping[5]

Background: mHealth, which encompasses mobile health technologies and interventions, is rapidly evolving in various medical specialties, and its impact is evident in oncology. In particular, mHealth has established itself as a prominent part of dermatology for cancer screening. Intensified research to seek its use and effectiveness in each phase of the skin cancer continuum is needed in this fast-growing field of teledermatology.

Objective: The purpose of this review was to describe current trends in research addressing the integration of mHealth and its contributions across the skin cancer continuum.

Methods: A systematic review framework was applied to the search using three electronic databases: PubMed, Web of Science, and Embase. We extensively reviewed appropriate studies regarding skin cancer and mobile technology published between 2007 and 2017. Studies of the role and impact of mobile technology in the prevention and management of skin cancer were included. We selected 18 studies adhering to the inclusion and exclusion criteria for analysis.

Results: Of the 18 studies, 5 (28%) evaluated prevention interventions, 6 (33%) assessed diagnostic accuracy, and 7 (39%) pertained to feasibility in

[5] Choi J, Cho Y, Woo H. mHealth Approaches in Managing Skin Cancer: Systematic Review of Evidence-Based Research Using Integrative Mapping. *JMIR Mhealth Uhealth*. 2018;6(8):e164. Published 2018 Aug 2. doi:10.2196/mhealth.8554
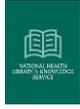
the context of mHealth approaches for skin cancer care. These studies portray the potential of mobile teledermatology in the prevention and management of skin cancer. However, not all phases of skin cancer involve mHealth, and not all have been addressed by research.

Conclusions: This review extends our knowledge not only on the contributions of mHealth technologies, but also on their integration in different phases of skin cancer care. To optimize the effectiveness of mHealth in dermatology, larger numbers of robust, evidence-based studies on teledermatology implementations, distributed evenly across the care continuum, should be conducted so that research can be expanded to systematic reviews.

Chuchu et al (2018) [Systematic Review] Smartphone applications for triaging adults with skin lesions that are suspicious for melanoma[6]

Background: Melanoma accounts for a small proportion of all skin cancer cases but is responsible for most skin cancer-related deaths. Early detection and treatment can improve survival. Smartphone applications are readily accessible and potentially offer an instant risk assessment of the likelihood of malignancy so that the right people seek further medical attention from a clinician for more detailed assessment of the lesion. There is, however, a risk that melanomas will be missed and treatment delayed if the application reassures the user that their lesion is low risk.

Objectives: To assess the diagnostic accuracy of smartphone applications to rule out cutaneous invasive melanoma and atypical intraepidermal melanocytic variants in adults with concerns about suspicious skin lesions.

Search methods: We undertook a comprehensive search of the following databases from inception to August 2016: Cochrane Central Register of Controlled Trials; MEDLINE; Embase; CINAHL; CPCI; Zetoc; Science Citation Index; US National Institutes of Health Ongoing Trials Register; NIHR Clinical Research Network Portfolio Database; and the World Health Organization International Clinical Trials Registry Platform. We studied reference lists and published systematic review articles.

Selection Criteria: Studies of any design evaluating smartphone applications intended for use by individuals in a community setting who have lesions that might be suspicious for melanoma or atypical intraepidermal melanocytic variants versus a reference standard of histological confirmation or clinical follow-up and expert opinion.

[6] Chuchu N, Takwoingi Y, Dinnes J, et al. Smartphone applications for triaging adults with skin lesions that are suspicious for melanoma. *Cochrane Database Syst Rev*. 2018;12(12):CD013192. Published 2018 Dec 4. doi:10.1002/14651858.CD013192
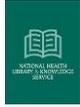
Data Collection and Analysis: Two review authors independently extracted all data using a standardised data extraction and quality assessment form based on QUADAS-2. Due to scarcity of data and poor quality of studies, we did not perform a meta-analysis for this review. For illustrative purposes, we plotted estimates of sensitivity and specificity on coupled forest plots for each application under consideration.

Main Results: This review reports on two cohorts of lesions published in two studies. Both studies were at high risk of bias from selective participant recruitment and high rates of non-evaluable images. Concerns about applicability of findings were high due to inclusion only of lesions already selected for excision in a dermatology clinic setting, and image acquisition by clinicians rather than by smartphone app users.We report data for five mobile phone applications and 332 suspicious skin lesions with 86 melanomas across the two studies. Across the four artificial intelligence-based applications that classified lesion images as melanomas [one application] or as high risk or problematic lesions [three applications] using a pre-programmed algorithm, sensitivities ranged from 7% (95% CI 2% to 16%) to 73% (95% CI 52% to 88%) and specificities from 37% (95% CI 29% to 46%) to 94% (95% CI 87% to 97%). The single application using store-and-forward review of lesion images by a dermatologist had a sensitivity of 98% (95% CI 90% to 100%) and specificity of 30% (95% CI 22% to 40%).The number of test failures ☐ lesion images analysed by the applications but classed as unevaluable and excluded by the study authors ☐ ranged from 3 to 31 (or 2% to 18% of lesions analysed). The store-and-forward application had one of the highest rates of test failure (15%). At least one melanoma was classed as unevaluable in three of the four application evaluations.

Authors' Conclusions: Smartphone applications using artificial intelligence-based analysis have not yet demonstrated sufficient promise in terms of accuracy, and they are associated with a high likelihood of missing melanomas. Applications based on store-and-forward images could have a potential role in the timely presentation of people with potentially malignant lesions by facilitating active self-management health practices and early engagement of those with suspicious skin lesions; however, they may incur a significant increase in resource and workload. In respect of the paucity of evidence and low methodological quality of existing studies, it is not possible to draw any implications for practice. Nevertheless, this is a rapidly advancing field, and new and better applications with robust reporting of studies could change these conclusions substantially.

Chuchu et al (2018) [Systematic Review] Teledermatology for diagnosing skin cancer in adults[7]

Background: Early accurate detection of all skin cancer types is essential to guide appropriate management and to improve morbidity and survival. Melanoma and squamous cell carcinoma (SCC) are high-risk skin cancers which have the potential to metastasise and ultimately lead to death, whereas basal cell carcinoma (BCC) is usually localised with potential to infiltrate and damage surrounding tissue. Anxiety around missing early curable cases needs to be balanced against inappropriate referral and unnecessary excision of benign lesions. Teledermatology provides a way for generalist clinicians to access the opinion of a specialist dermatologist for skin lesions that they consider to be suspicious without referring the patients through the normal referral pathway. Teledermatology consultations can be 'store-and-forward' with electronic digital images of a lesion sent to a dermatologist for review at a later time, or can be live and interactive consultations using videoconferencing to connect the patient, referrer and dermatologist in real time.

Objectives: To determine the diagnostic accuracy of teledermatology for the detection of any skin cancer ⬚ melanoma, BCC or cutaneous squamous cell carcinoma (cSCC) ⬚ in adults, and to compare its accuracy with that of in-person diagnosis.

Search methods: We undertook a comprehensive search of the following databases from inception up to August 2016: Cochrane Central Register of Controlled Trials, MEDLINE, Embase, CINAHL, CPCI, Zetoc, Science Citation Index, US National Institutes of Health Ongoing Trials Register, NIHR Clinical Research Network Portfolio Database and the World Health Organization International Clinical Trials Registry Platform. We studied reference lists and published systematic review articles.

Selection criteria: Studies evaluating skin cancer diagnosis for teledermatology alone, or in comparison with face-to-face diagnosis by a specialist clinician, compared with a reference standard of histological confirmation or clinical follow-up and expert opinion. We also included studies evaluating the referral accuracy of teledermatology compared with a reference standard of face-to-face diagnosis by a specialist clinician.

Data collection and analysis: Two review authors independently extracted all data using a standardised data extraction and quality assessment form based on QUADAS-2. We contacted authors of included studies where there

[7] Chuchu N, Dinnes J, Takwoingi Y, et al. Teledermatology for diagnosing skin cancer in adults. *Cochrane Database Syst Rev.* 2018;12(12):CD013193. Published 2018 Dec 4. doi:10.1002/14651858.CD013193
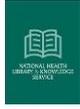
were information related to the target condition of any skin cancer missing. Data permitting, we estimated summary sensitivities and specificities using the bivariate hierarchical model. Due to the scarcity of data, we undertook no covariate investigations for this review. For illustrative purposes, we plotted estimates of sensitivity and specificity on coupled forest plots for diagnostic threshold and target condition under consideration.

Main results: The review included 22 studies reporting diagnostic accuracy data for 4057 lesions and 879 malignant cases [16 studies] and referral accuracy data for reported data for 1449 lesions and 270 positive cases as determined by the reference standard face-to-face decision [6 studies]. Methodological quality was variable with poor reporting hindering assessment. The overall risk of bias was high or unclear for participant selection, reference standard, and participant flow and timing in at least half of all studies; the majority were at low risk of bias for the index test. The applicability of study findings were of high or unclear concern for most studies in all domains assessed due to the recruitment of participants from secondary care settings or specialist clinics rather than from primary or community-based settings in which teledermatology is more likely to be used and due to the acquisition of lesion images by dermatologists or in specialist imaging units rather than by primary care clinicians.Seven studies provided data for the primary target condition of any skin cancer: 1588 lesions and 638 malignancies. For the correct diagnosis of lesions as malignant using photographic images, summary sensitivity was 94.9% (95% confidence interval (CI) 90.1% to 97.4%) and summary specificity was 84.3% (95% CI 48.5% to 96.8%). Individual study estimates using dermoscopic images or a combination of photographic and dermoscopic images generally suggested similarly high sensitivities with highly variable specificities. Limited comparative data suggested similar diagnostic accuracy between teledermatology assessment and in-person diagnosis by a dermatologist; however, data were too scarce to draw firm conclusions. For the detection of invasive melanoma or atypical intraepidermal melanocytic variants both sensitivities and specificities were more variable. Sensitivities ranged from 59% (95% CI 42% to 74%) to 100% (95% CI 48% to 100%) and specificities from 30% (95% CI 22% to 40%) to 100% (95% CI 93% to 100%), with reported diagnostic thresholds including the correct diagnosis of melanoma, classification of lesions as 'atypical' or 'typical, and the decision to refer or to excise a lesion.Referral accuracy data comparing teledermatology against a face-to-face reference standard suggested good agreement for lesions considered to require some positive action by face-to-face assessment. For

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lesions considered of less concern when assessed face-to-face eg for lesions not recommended for excision or referral agreement was more variable with teledermatology specificities ranging from 57% (95% CI 39% to 73%) to 100% (95% CI 86% to 100%), suggesting that remote assessment is more likely recommend excision, referral or follow-up compared to in-person decisions.

Authors' Conclusions: Studies were generally small and heterogeneous and methodological quality was difficult to judge due to poor reporting. Bearing in mind concerns regarding the applicability of study participants and of lesion image acquisition in specialist settings, our results suggest that teledermatology can correctly identify the majority of malignant lesions. Using a more widely defined threshold to identify possibly malignant cases or lesions that should be considered for excision is likely to appropriately triage those lesions requiring face-to-face assessment by a specialist. Despite the increasing use of teledermatology on an international level, the evidence base to support its ability to accurately diagnose lesions and to triage lesions from primary to secondary care is lacking and further prospective and pragmatic evaluation is needed.

Clark et al (2018) [Systematic Review] Systematic review of mobile phone-based teledermatology[8]

Teledermatology is an expanding field within dermatology that has grown and become more clinically accepted by both patients and doctors. With approximately 260 million mobile phone users in the US and 4-6 billion worldwide with access to mobile phones, teledermatology serves as a potentially useful tool for diagnosis and management. In this review, we provide a detailed overview of mobile phone technology and the accumulating evidence for its incorporation into dermatology. Key questions addressed include accuracy and concordance between mobile teledermatology and face-to-face dermatology for the diagnosis of skin conditions. Similarly, accuracy and concordance were compared for the management of skin conditions. To track the development of mobile phone technology, we also assessed how data were captured, stored, and displayed in teledermatology studies.

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[8] Clark AK, Bosanac S, Ho B, Sivamani RK. Systematic review of mobile phone-based teledermatology. *Arch Dermatol Res*. 2018;310(9):675-689. doi:10.1007/s00403-018-1862-4

Mounessa et al (2018) [Systematic Review] A systematic review of satisfaction with teledermatology[9]

Background: The two most commonly used modalities of teledermatology (TD) are store-and-forward (SF) and live-interactive (LI) TD. Existing studies have not compared these tools with respect to patient and provider satisfaction.

Objective: To systematically review all published studies of patient and provider satisfaction with SF and LI TD. Methods PubMed, EMBASE, and Cochrane databases were systematically searched for studies on provider or patient satisfaction with SF or LI TD between January 2000 and June 2016. Results: Forty eligible studies were identified: 32 with SF TD, 10 with LI TD, and 2 evaluating both. With SF TD, 96% of studies assessing patient satisfaction and 82% of studies assessing provider satisfaction demonstrated satisfaction (n = 24 and 17, respectively). With LI TD, 89% of studies assessing patient satisfaction and all studies assessing provider satisfaction revealed satisfaction (n = 9 and 6, respectively). Conclusion: Patients and providers are satisfied with both SF and LI TD. Studies assessing satisfaction with LI have not been conducted in recent years, and have only been conducted in limited geographic patient populations. Further research assessing satisfaction with TD will help address any dissatisfaction with its uses and allow for increased support and funding of future programmes.

Svendsen et al (2018) [Systematic Review] eHealth Technologies as an intervention to improve adherence to topical antipsoriatics: a systematic review[10]

Background: Topical antipsoriatics are recommended first-line treatment of psoriasis, but rates of adherence are low. Patient support by use of electronic health services is suggested to improve medical adherence. Objective: To review randomised controlled trials (RCTs) testing eHealth interventions designed to improve adherence to topical antipsoriatics and to review applications for smartphones incorporating the word psoriasis. Results: Only one RCT was included, reporting on psoriasis patients' Internet reporting their status of psoriasis over a 12-month period. The rate of adherence was measured by Medication Event Monitoring System (MEMS®).

[9] Mounessa JS, Chapman S, Braunberger T, et al. A systematic review of satisfaction with teledermatology. *J Telemed Telecare*. 2018;24(4):263-270. doi:10.1177/1357633X17696587

[10] Svendsen MT, Andersen F, Andersen KE. eHealth Technologies as an intervention to improve adherence to topical antipsoriatics: a systematic review. *J Dermatolog Treat*. 2018;29(2):123-128. doi:10.1080/09546634.2017.1341612

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An improvement in medical adherence and reduction of severity of psoriasis were reported. A total 184 apps contained the word psoriasis were found. Conclusion: There is a critical need for high-quality RCTs testing if the ubiquitous eHealth technologies, for example, some of the numerous apps, can improve psoriasis patients' rates of adherence to topical antipsoriatics.

Finnane et al (2017) [Systematic Review] Teledermatology for the Diagnosis and Management of Skin Cancer: A Systematic Review[11]
Importance: As technology becomes more commonplace in dermatological practice, it is essential to continuously review the accuracy of teledermatology devices and services compared with in-person care. The last systematic review was conducted over 5 years ago.
Objective: To synthesize and assess the quality of the evidence to address 3 research questions: 1. How accurate is teledermatology for skin cancer diagnosis compared with usual care [FTF diagnosis]? 2. Does teledermatology save clinician and/or patient time, compared with usual care? 3. What are the enablers and barriers to adoption of teledermatology in clinical practice for the diagnosis of skin cancer?
Evidence Review: The review protocol was registered in the PROSPERO database. Six databases ◻ Cochrane, PubMed, Medline, Science Direct, Embase, and Web of Science ◻ were searched for studies investigating the diagnostic accuracy and concordance, management accuracy and concordance, measures of time, and enablers and barriers to implementation. Potentially eligible articles were screened by 2 reviewers. The QUADAS-2 tool was used to evaluate the risk of bias and applicability of individual studies assessing diagnostic accuracy.
Findings: Twenty-one studies were reviewed. The diagnostic accuracy ◻ defined as agreement with histopathology for excised lesions or clinical diagnosis for nonexcised lesions ◻ of FTF dermatology consultation remains higher (67%-85% agreement with reference standard, Cohen κ, 0.90) when compared with teledermatology (51%-85% agreement with reference standard, κ, 0.41-0.63), for the diagnosis of skin cancer. However, some studies do report high accuracy of teledermatology diagnoses. Most studies of diagnostic accuracy and concordance had significant methodological limitations. Studies of health service outcomes found teledermatology reduced waiting times and could result in earlier assessment and treatment.

[11] Finnane A, Dallest K, Janda M, Soyer HP. Teledermatology for the Diagnosis and Management of Skin Cancer: A Systematic Review. *JAMA Dermatol.* 2017;153(3):319-327. doi:10.1001/jamadermatol.2016.4361
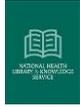
Patients reported high satisfaction and were willing to pay out of pocket for access to such services.

Conclusions and Relevance: Robust implementation studies of teledermatology are needed, paying careful attention to reducing risk of bias when assessing diagnostic accuracy. Teledermatology services consistently reduced waiting times to assessment and diagnosis, and patient satisfaction was high.

Vyas et al (2017) [Systematic Review] A Systematic Review of the Use of Telemedicine in Plastic and Reconstructive Surgery and Dermatology[12]

Background: Telemedicine, the use of information technology and telecommunication to provide healthcare at a distance, is a burgeoning field with applications throughout medicine. Given the visual nature of plastic surgery and dermatology, telemedicine has a myriad of potential applications within the field.

Methods: A comprehensive literature review of articles published on telemedicine since January 2010 was performed. Articles were selected for their relevance to plastic and reconstructive surgery and dermatology, and then reviewed for their discussion of the applications, benefits, and limitations of telemedicine in practice.

Results: A total of 3119 articles were identified in the initial query. Twenty-three articles met the inclusion criteria in plastic surgery: 7 wound management, 5 burn management, 5 trauma, 4 free flap care, 2 in cleft lip/palate repair. Twenty-three (100%) reported a benefit of telemedicine often related to improved postoperative monitoring, increased access to expertise in rural settings, and cost savings, either predicted or actualized. Eight (35%) reported limitations and barriers to the application of telemedicine, including overdiagnosis and dependence on functional telecommunication systems. Sixty-six articles focused on telemedicine in dermatology and also demonstrated significant promise.

Conclusions: Telemedicine holds special promise in increasing the efficiency of postoperative care for microsurgical procedures, improving care coordination and management of burn wounds, facilitating interprofessional collaboration across time and space, eliminating a significant number of unnecessary referrals, and connecting patients located far from major medical centers with professional expertise without impinging on–and in some cases improving–the quality or accuracy of care provided.

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[12] Vyas KS, Hambrick HR, Shakir A, et al. A Systematic Review of the Use of Telemedicine in Plastic and Reconstructive Surgery and Dermatology. *Ann Plast Surg*. 2017;78(6):736-768. doi:10.1097/SAP.0000000000001044
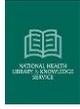
Teledermatology consultation was found to be safe and has a comparable or superior efficacy to the traditional in-patient consultation. The system was consistently rated as convenient and easy to use by patients, referring physicians, and consulting dermatologists. Teledermatology has also been used as an educational tool for patients. A significant number of studies detailed strategies to improve the current state of teledermatology, either by implementing new programs or improving technologies. Telemedicine use is widespread among plastic surgeons and is enabling the spread of expertise beyond major medical centers. Further research is needed to conclusively demonstrate benefit in routine clinical care.

Randomised Controlled Trials

Janda et al (2020) [Randomised Controlled Trial] Accuracy of mobile digital teledermoscopy for skin self-examinations in adults at high risk of skin cancer: an open-label, randomised controlled trial[13]

Skin self-examinations supplemented with mobile teledermoscopy might improve early detection of skin cancers compared with naked-eye skin self-examinations. We aimed to assess whether mobile teledermoscopy-enhanced skin self-examination can improve sensitivity and specificity of self-detection of skin cancers when compared with naked-eye skin self-examination.

Methods: This randomised, controlled trial was done in Brisbane, Australia. Eligible participants aged ≥18 years had at least two skin cancer risk factors as self-reported in the eligibility survey and had to own or have access to an iPhone compatible with a dermatoscope attachment iPhone versions 5–8. Participants were randomly assigned (1:1), via a computer-generated randomisation procedure, to the intervention group [mobile dermoscopy-enhanced self-skin examination] or the control group [naked-eye skin self-examination]. Control group and intervention group participants received web-based instructions on how to complete a whole body skin self-examination. All participants completed skin examinations at baseline, 1 month, and 2 months; intervention group participants submitted

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[13] Janda M, Horsham C, Vagenas D, et al Accuracy of mobile digital teledermoscopy for skin self-examinations in adults at high risk of skin cancer: an open-label, randomised controlled trial. *Lancet Digit Health*. 2020 2(3) e129-e137. https://doi.org/10.1016/S2589-7500(20)30001-7.

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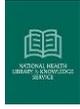
photographs of suspicious lesions to a dermatologist for telediagnosis after each skin examination and control group participants noted lesions on a body chart that was sent to the research team after each skin examination. All participants had an in-person whole-body clinical skin examination within 3 months of their last skin self-examination. Primary outcomes were sensitivity and specificity of skin self-examination, patient selection of clinically atypical lesions suspicious for melanoma or keratinocyte skin cancers [body sites examined, number of lesions photographed, types of lesions, and lesions missed], and diagnostic concordance of telediagnosis versus in-person whole-body clinical skin examination diagnosis. All primary outcomes were analysed in the modified intention-to-treat population, which included all patients who had a clinical skin examination within 3 months of their last skin self-examination. This trial was registered with the Australian and New Zealand Clinical Trials Registry, ACTRN12616000989448.

Findings: Between March 6, 2017, and June 7, 2018, 234 participants consented to enrol in the study, of whom 116 (50%) were assigned to the intervention group and 118 (50%) were assigned to the control group. 199 participants (98 participants in the intervention group and 101 participants in the control group) attended the clinical skin examination and thus were eligible for analyses. Participants in the intervention group submitted 615 lesions (median 6·0 per person; range 1–24) for telediagnosis and participants in the control group identified and recorded 673 lesions (median 6·0 per person; range 1–16). At the lesion level, sensitivity for lesions clinically suspicious for skin cancer was 75% (95% CI 63–84) in the intervention group and 88% (95% CI 80–91) in the control group (p=0·04). Specificity was 87% (95% CI 85–90) in the intervention group and 89% (95% CI 87–91) in the control group (p=0·42). At the individual level, the intervention group had a sensitivity of 87% (95% CI 76–99) compared with 97% (95% CI 91–100) in the control group (p=0·26), and a specificity of 95% (95% CI 90–100) compared with 96% (95% CI 91–100) in the control group. The overall diagnostic concordance between the telediagnosis and in-person clinical skin examination was 88%.

Interpretation: The use of mobile teledermoscopy did not increase sensitivity for the detection of skin cancers compared with naked-eye skin self-

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examination; thus, further evidence is necessary for inclusion of skin self-examination technology for public health benefit.

Walter et al (2020) [Randomised Controlled Trial] [Effect of a Skin Self-monitoring Smartphone Application on Time to Physician Consultation Among Patients With Possible Melanoma: A Phase 2 Randomized Clinical Trial](14)

Importance: Melanoma is among the most lethal skin cancers; it has become the fifth most common cancer in the UK, and incidence rates are rising. Population approaches to reducing incidence have focused on mass media campaigns to promote earlier presentation and potentially improve melanoma outcomes; however, interventions using smartphone applications targeting those with the greatest risk could promote earlier presentation to health care professionals for individuals with new or changing skin lesions.

Objective: To study the effect of a commercially available skin self-monitoring (SSM) smartphone application among individuals with increased risk of melanoma on their decision to seek help for changing skin lesions.

Design, setting, and participants: This phase 2 randomized clinical trial was conducted in 12 family practices in Eastern England between 2016 and 2017. A total of 238 participants, aged 18 to 75 years and with an increased risk of melanoma, were identified using a real-time melanoma risk assessment tool in family practice waiting rooms. Analysis was intention to treat. Participants were observed for 12 months, and data analysis was conducted from January to August 2018.

Intervention: The intervention and control groups received a consultation with standard written advice on sun protection and skin cancer detection. The intervention group had an SSM application loaded on their smartphone and received instructions for use and monthly self-monitoring reminders.

Main Outcomes and Measures: The coprimary outcomes were skin consultation rates with family practice physicians and patient intervals, measured as the time between noticing a skin change and consulting with a family practice clinician. Follow-up questionnaires were sent at 6 and 12 months, and consultation rates were extracted from family practice records. Secondary Outcomes: included skin self-examination benefits and barriers,

14 Walter FM, Pannebakker MM, Barclay ME, et al. Effect of a Skin Self-monitoring Smartphone Application on Time to Physician Consultation Among Patients With Possible Melanoma: A Phase 2 Randomized Clinical Trial. *JAMA Netw Open*. 2020;3(2):e200001. Published 2020 Feb 5. doi:10.1001/jamanetworkopen.2020.0001

self-efficacy for consulting without delay, perceived melanoma risk, sun protection habits, and potential harms.

Results: A total of 238 patients were randomized (median [interquartile range] age, 55 [43-65] years, 131 [55.0%] women, 227 [95.4%] white British; 119 [50.0%] randomized to the intervention group). Overall, 51 participants (21.4%) had consultations regarding skin changes during the 12 months of follow-up, and 157 participants (66.0%) responded to at least 1 follow-up questionnaire. There were no significant differences in skin consultation rates (adjusted risk ratio, 0.96; 95% CI, 0.56 to 1.66; P = .89), measures of SSM (adjusted mean difference, 0.08; 95% CI, -0.83 to 1.00; P = .86), or psychological harm (eg Melanoma Worry Scale: adjusted mean difference, -0.12; 95% CI, -0.56 to 0.31; P = .58).

Conclusions and Relevance: In this study, recruitment, retention, and initial delivery of the intervention were feasible, and this research provided no evidence of harm from the SSM smartphone application. However, no evidence of benefit on skin self-examination or health care consulting was found, and there is no reason at this stage to recommend its implementation in this population at increased risk of melanoma.

Ford et al (2019) [Randomised Controlled Trial] Access to Dermatological Care with an Innovative Online Model for Psoriasis Management: Results from a Randomized Controlled Trial[15]

Background: Many patients with chronic skin diseases lack regular access to dermatologists in the United States and suffer poor clinical outcomes.

Introduction: We performed a 12-month randomized controlled trial to evaluate the impact of an online, collaborative connected health (CCH) model for psoriasis management on access to specialty care.

Materials and Methods: The 300 enrolled patients were randomized to online or in-person care. We compared distance traveled as well as transportation and in-office waiting time between the two groups and obtained patient and provider perspectives on CCH.

Results: At baseline, no differences existed between the groups in difficulties obtaining specialty care. Over 12 months, the mean distance traveled to and from appointments was 174.8 (±577.4) km/person for the in-person group and 2.2 (±14.2) km/person for the online group (p = 0.0003). The mean (SD) time spent on transportation and in-office waiting for in-person

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[15] Ford AR, Gibbons CM, Torres J, et al. Access to Dermatological Care with an Innovative Online Model for Psoriasis Management: Results from a Randomized Controlled Trial. *Telemed J E Health.* 2019;25(7):619-627. doi:10.1089/tmj.2018.0160

appointments was 4.0 (±4.5) h/person for the in-person group and 0.1 (±0.4) h/person for the online group (p = 0.0001). Patients found CCH to be safe, accessible, equitable, efficient, effective, and patient-centered. Providers found CCH to be useful for providing psoriasis care.

Discussion: The CCH model resulted in significantly less distance traveled as well as transportation and in-office waiting time compared to in-person care. Both patients and providers were highly satisfied with CCH.

Conclusions: The CCH model resulted in increased access to specialty care and enabled patient-centered, safe, and effective management of psoriasis patients.

Young et al (2019) [Randomised Controlled Trial] Effects of Online Care on Functional and Psychological Outcomes in Patients with Psoriasis: A Randomized Controlled Trial[16]

Background: The impact of online care on patients' functional and psychological outcomes is critical to determine yet still unknown.

Objective: To evaluate how a novel online health model that facilitates physician-patient collaboration compares with in-person care for improving psoriasis patients' functional status and mental health.

Methods: This 12-month randomized controlled equivalency trial randomized psoriasis patients 1:1 to online or in-person care. Functional impairment and depression were assessed at baseline and at 3-month intervals using the 5-level EuroQol-5 Dimensions (EQ-5D-5L) and Patient Health Questionnare-9 (PHQ-9).

Results: 296 patients were randomized to online or in-person groups. The between-group difference in overall improvement in EQ VAS (EuroQol Visual Analogue Scale) was -0.002 (95% CI -2.749, 2.745), falling within equivalence margin ±8. The between-group difference in overall improvement in EQ-5D-5L index was 0 (95% CI -0.003, 0.003), falling within equivalence margin ±0.1. The between-group difference in overall improvement in PHQ-9 was -0.33 (95% CI -1.20, 0.55), falling within equivalence margin ±3.

Limitations: Slightly different attrition rates between online and in-person arms (11% versus 9%), but no impact on outcomes.

Conclusion: The online health model was equivalent to in-person care for reducing functional impairment and depressive symptoms in psoriasis patients.

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[16] Young PM, Chen AY, Ford AR, Cheng MY, Lane CJ, Armstrong AW. Effects of Online Care on Functional and Psychological Outcomes in Patients with Psoriasis: A Randomized Controlled Trial [published online ahead of print, 2019 Jun 5]. *J Am Acad Dermatol.* 2019;S0190-9622(19)30893-X. doi:10.1016/j.jaad.2019.05.089

Armstrong et al (2018) [Randomised Controlled Trial] Effectiveness of Online vs In-Person Care for Adults With Psoriasis: A Randomized Clinical Trial[17]

Importance: Innovative, online models of specialty-care delivery are critical to improving patient access and outcomes.

Objective: To determine whether an online, collaborative connected-health model results in equivalent clinical improvements in psoriasis compared with in-person care.

Design, Setting, and Participants: The Patient-Centered Outcomes Research Institute Psoriasis Teledermatology Trial is a 12-month, pragmatic, randomized clinical equivalency trial to evaluate the effect of an online model for psoriasis compared with in-person care. Participant recruitment and study visits took place at multicenter ambulatory clinics from February 2, 2015, to August 18, 2017. Participants were adults with psoriasis in Northern California, Southern California, and Colorado. The eligibility criteria were an age of 18 years or older, having physician-diagnosed psoriasis, access to the internet and a digital camera or mobile phone with a camera, and having a primary care physician. Analyses were on an intention-to-treat basis.

Interventions: Participants were randomized 1:1 to receive online or in-person care (148 randomized to online care and 148 randomized to in-person care). The online model enabled patients and primary care physicians to access dermatologists online asynchronously. The dermatologists provided assessments, recommendations, education, and prescriptions online. The in-person group sought care in person. The frequency of online or in-person visits was determined by medical necessity. All participants were exposed to their respective interventions for 12 months.

Main outcomes and measures: The prespecified primary outcome was the difference in improvement in the self-administered Psoriasis Area and Severity Index (PASI) score between the online and in-person groups. Prespecified secondary outcomes included body surface area (BSA) affected by psoriasis and the patient global assessment score.

Results: Of the 296 randomized participants, 147 were women, 149 were men, 187 were white, and the mean (SD) age was 49 (14) years. The adjusted difference between the online and in-person groups in the mean change in the self-administered PASI score during the 12-month study period was -

[17] Armstrong AW, Chambers CJ, Maverakis E, et al. Effectiveness of Online vs In-Person Care for Adults With Psoriasis: A Randomized Clinical Trial. *JAMA Netw Open*. 2018;1(6):e183062. Published 2018 Oct 5. doi:10.1001/jamanetworkopen.2018.3062

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0.27 (95% CI, -0.85 to 0.31). The difference in the mean change in BSA affected by psoriasis between the 2 groups was -0.05% (95% CI, -1.58% to 1.48%). Between-group differences in the PASI score and BSA were within prespecified equivalence margins, which demonstrated equivalence between the 2 interventions. The difference in the mean change in the patient global assessment score between the 2 groups was -0.11 (95% CI, -0.32 to 0.10), which exceeded the equivalence margin, with the online group displaying greater improvement.

Conclusions and relevance: The online, collaborative connected-health model was as effective as in-person management in improving clinical outcomes among patients with psoriasis. Innovative telehealth delivery models that emphasize collaboration, quality, and efficiency can be transformative to improving patient-centered outcomes in chronic diseases.

Bosanac et al (2018) [Randomised Controlled Trial] Randomized and controlled pilot study of the pragmatic use of mobile phone based follow up of actinic keratoses treated with topical 5-fluorouracil[18]

Store-and-forward teledermatology involves transmission of a patient's images to a healthcare provider and subsequent response from the provider about the diagnosis or management. Furthermore, teledermatology in which mobile phones are utilized for communication between the patient and their provider is referred to as mobile-teledermatology. In this study, we investigate the use of mobile-teledermatology in the management of actinic keratoses. We demonstrate that mobile-teledermatology may enhance communication between the patient and their provider when managing cutaneous disease and that even individuals in older age groups are highly satisfied with this type of follow up.

Marek et al (2018) [Randomised Controlled Trial] Piloting the Use of Smartphones, Reminders, and Accountability Partners to Promote Skin Self-Examinations in Patients with Total Body Photography: A Randomized Controlled Trial[19]

Objective: The aim of this study was to evaluate the use of a mobile application in patients already using total body photography (TBP) to

[18] Bosanac SS, Nguyen V, Bui D, Eisen DB, Sivamani RK. Randomized and controlled pilot study of the pragmatic use of mobile phone based follow up of actinic keratoses treated with topical 5-fluorouracil. *Dermatol Online J.* 2018;24(4):13030/qt2kh302f2. Published 2018 Apr 15.

[19] Marek AJ, Chu EY, Ming ME, Khan ZA, Kovarik CL. Piloting the Use of Smartphones, Reminders, and Accountability Partners to Promote Skin Self-Examinations in Patients with Total Body Photography: A Randomized Controlled Trial. *Am J Clin Dermatol.* 2018;19(5):779-785. doi:10.1007/s40257-018-0372-7
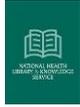
increase skin self-examination (SSE) rates and pilot the effectiveness of examination reminders and accountability partners.

Design: Randomized controlled trial with computer generated randomization table to allocate interventions.

Setting: University of Pennsylvania pigmented lesion clinic.

Participants: 69 patients aged 18 years or older with an iPhone/iPad, who were already in possession of TBP photographs.

Intervention: A mobile app loaded with digital TBP photos for all participants, and either 1. the mobile app only; 2. skin examination reminders; 3. an accountability partner; or 4. remnders and an accountability partner.

Main Outcome Measure: Change in SSE rates as assessed by enrollment and end-of-study surveys 6 months later.

Results: Eighty-one patients completed informed consent, however 12 patients did not complete trial enrollment procedures due to device incompatibility, leaving 69 patients who were randomized and analyzed [mean age 54.3 years, standard deviation 13.9]. SSE rates increased significantly from 58% at baseline to 83% at 6 months (odds ratio 2.64, 95% confidence interval 1.20-4.09), with no difference among the intervention groups. The group with examination reminders alone had the highest (94%) overall satisfaction, and the group with accountability partners alone accounted for the lowest (71%).

Conclusion: A mobile app alone, or with reminders and/or accountability partners, was found to be an effective tool that can help to increase SSE rates. Skin examination reminders may help provide a better overall experience for a subset of patients.

Svendsen et al (2018) [Randomised Controlled Trial] A smartphone application supporting patients with psoriasis improves adherence to topical treatment: a randomized controlled trial[20]

Background: Adherence to topical psoriasis treatments is low, which leads to unsatisfactory treatment results. Smartphone applications for patient support exist but their potential to improve adherence has not been systematically evaluated.

Objectives: To evaluate whether a study-specific app improves adherence and reduces psoriasis symptoms compared with standard treatment.

[20] Svendsen MT, Andersen F, Andersen KH, et al. A smartphone application supporting patients with psoriasis improves adherence to topical treatment: a randomized controlled trial. *Br J Dermatol.* 2018;179(5):1062-1071. doi:10.1111/bjd.16667

Methods: We conducted a randomized controlled trial. Patients received once-daily medication [calcipotriol/betamethasone dipropionate (Cal/BD) cutaneous foam] and were randomized to no app (n = 66) or app intervention (n = 68) groups. In total, 122 patients (91%) completed the 22-week follow-up. The primary outcome was adherence, which was defined as medication applied ≥ 80% of days during the treatment period and assessed by a chip integrated into the medication dispenser. Secondary outcomes were psoriasis severity measured by the Lattice System Physician's Global Assessment (LS-PGA) and quality of life, measured using the Dermatology Life Quality Index (DLQI) at all visits.

Results: Intention-to-treat analyses using regression was performed. More patients in the intervention group were adherent to Cal/BD cutaneous foam than those in the nonintervention group at week 4 (65% vs. 38%, P = 0·004). The intervention group showed a greater LS-PGA reduction than the nonintervention group at week 4 (mean 1·86 vs. 1·46, P = 0·047). A similar effect was seen at weeks 8 and 26, although it did not reach statistical significance.

Conclusions: This RCT demonstrates that the app improved short-term adherence to Cal/BD cutaneous foam treatment and psoriasis severity.

Ferrandiz et al (2017) [Randomised Controlled Trial] Internet-based skin cancer screening using clinical images alone or in conjunction with dermoscopic images: A randomized teledermoscopy trial[21]

Background: Teledermoscopy involves the use of dermoscopic images for remote consultation and decision-making in skin cancer screening.

Objective: We sought to analyze the potential benefits gained from the addition of dermoscopic images to an internet-based skin cancer screening system.

Methods: A randomized clinical trial assessed the diagnostic performance and cost-effectiveness of clinical teleconsultations (CTC) and clinical with dermoscopic teleconsultations.

Results: A total of 454 patients were enrolled in the trial. Teledermoscopy improved sensitivity and specificity (92.86% and 96.24%, respectively) compared with CTC (86.57% and 72.33%, respectively). Correct decisions were made in 94.30% of patients through clinical with dermoscopic

[21] Ferrándiz L, Ojeda-Vila T, Corrales A, et al. Internet-based skin cancer screening using clinical images alone or in conjunction with dermoscopic images: A randomized teledermoscopy trial. *J Am Acad Dermatol.* 2017;76(4):676-682. doi:10.1016/j.jaad.2016.10.041

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teleconsultations and in 79.20% in CTC (P < .001). The only variable associated with an increased likelihood of correct diagnosis was management using teledermoscopy (odds ratio 4.04; 95% confidence interval 2.02-8.09; P < .0001). The cost-effectiveness analysis showed teledermoscopy as the dominant strategy, with a lower cost-effectiveness ratio (65.13 vs 80.84).

Limitations: Potentially, a limitation is the establishment of an experienced dermatologist as the gold standard for the in-person evaluation.

Conclusions: The addition of dermoscopic images significantly improves the results of an internet-based skin cancer screening system, compared with screening systems based on clinical images alone.

Gernart et al (2017) [Randomised Controlled Trial] ItchApp©: An App-based eDiary for Assessment of Chronic Pruritus in Clinical Trials[22]
Performing a reliable assessment of chronic pruritus remains a challenge. Electronic diaries are often used, but many of the scales have not been validated. ItchApp© was developed for Android smartphones in order to address this lack. A total of 40 subjects with chronic pruritus completed questionnaires both on paper and with ItchApp© (verbal rating scale, numerical rating scale, dynamic pruritus score) in order to validate the software application. Strong correlations were found for test-retest reliability (intraclass correlation coefficient: 0.865-0.977) and convergent validity (Spearman's r: 0.442-0.924). A feasibility questionnaire for ItchApp© revealed a high level of user friendliness and compliance. This was confirmed in a randomized controlled trial with 68 subjects, for which the clinically important difference in the numerical rating scale values for ItchApp© was calculated (2.61 points). In summary, ItchApp© is a recently developed eDiary that can provide experts with a reliable evaluation of patients with chronic pruritus. It will be made available for future clinical trials.

[22] Gernart M, Tsianakas A, Zeidler C, et al. ItchApp©: An App-based eDiary for Assessment of Chronic Pruritus in Clinical Trials. *Acta Derm Venereol.* 2017;97(5):601-606. doi:10.2340/00015555-2602
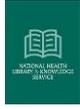
Kornmehl et al (2017) [Randomised Controlled Trial] Direct-Access Online Care for the Management of Atopic Dermatitis: A Randomized Clinical Trial Examining Patient Quality of Life[23]

Background: Atopic dermatitis (AD) is a chronic disease requiring regular follow-up. To increase access to dermatological care, online management of AD is being studied. However, a critical knowledge gap exists in determining AD patients' quality of life in direct-to-patient online models. In this study, we examined quality of life in AD patients managed through a direct-access online model.

Materials and Methods: We randomized 156 patients to receiving care through a direct-access online platform or in person. Patients were seen for six visits over 12 months. At each visit, the patients completed Dermatology Life Quality Index/Children's Dermatology Life Quality Index (DLQI/CDLQI), and Short Form (SF-12).

Results: Between baseline and 12 months, the mean (standard deviation, SD) within-group difference in DLQI score in the online group was 4.1 (±2.3); for the in-person group, the within-group difference was 4.8 (±2.7). The mean (SD) within-group difference in CDLQI score in the online group was 4.7 (±2.8); for the in-person group, the within-group difference was 4.9 (±3.1). The mean (SD) within-group difference in physical component score (PCS) and mental component score (MCS) SF-12 scores in the online group was 6.5 (±3.8) and 8.6 (±4.3); for the in-person group, it was 6.8 (±3.2) and 9.1(±3.8), respectively. The difference in the change in DLQI, CDLQI, SF-12 PCS, and SF-12 MCS scores between the two groups was 0.72 (95% confidence interval [90% CI], -0.97 to 2.41), 0.23 (90% CI, -2.21 to 2.67), 0.34 (90% CI, -1.16 to 1.84), and 0.51 (90% CI, -1.11 to 2.13), respectively. All differences were contained within their equivalence margins.

Conclusion: Adult and pediatric AD patients receiving direct-access online care had equivalent quality of life outcomes as those see in person. The direct-access online model has the potential to increase access to care for patients with chronic skin diseases.

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[23] Kornmehl H, Singh S, Johnson MA, Armstrong AW. Direct-Access Online Care for the Management of Atopic Dermatitis: A Randomized Clinical Trial Examining Patient Quality of Life. *Telemed J E Health*. 2017;23(9):726-732. doi:10.1089/tmj.2016.0249

Piette et al (2017) [Randomised Controlled Trial] Impact of a store-and-forward teledermatology intervention versus usual care on delay before beginning treatment: A pragmatic cluster-randomized trial in ambulatory care[24]

Introduction: In France, 66% of patients forego getting specialized care by dermatologists because of difficulty obtaining appointments. Store-and-forward teledermatology could improve how promptly treatment begins by reducing the delay in obtaining a specialist's opinion. In this study, we compared the delay before care between general practitioners using a store-and-forward teledermatology intervention and GPs addressing their patients with a standard referral letter.

Methods: We performed an open-label, pragmatic cluster-randomized controlled trial with two parallel arms. GP clinics in Paris were randomly assigned to use either teledermatology referral [use of electronics to send clinical images taken using a mobile phone] or conventional referral [using standard letters] to care for patients for whom a dermatologist's advice was needed for the diagnosis or treatment of skin lesions. Dermatologists integrated responses to teledermatology requests in their usual schedule. Patients were followed up for three months. Primary outcome was the delay, in days, between the GP's consultation and a reply by the specialist allowing treatment to begin. Analyses were adjusted for clustering of GPs and identities of dermatologists. Results: Between February and June 2014, 103 patients were included in the study (53 patients of 20 GPs in the intervention group). The median delay between the initial GP's consultation and the reply allowing for treatment to begin was four days in the intervention group and 40 days in the control group (adjusted hazard ratio = 2.55; p < 0.011).

Discussion: We showed that a simple store-and-forward teledermatology intervention significantly reduced the delay before beginning care.

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[24] Piette E, Nougairède M, Vuong V, Crickx B, Tran VT. Impact of a store-and-forward teledermatology intervention versus usual care on delay before beginning treatment: A pragmatic cluster-randomized trial in ambulatory care. *J Telemed Telecare*. 2017;23(8):725-732. doi:10.1177/1357633X16663328

Armstrong et al (2015) [Randomised Controlled Trial] Patient-centered, direct-access online care for management of atopic dermatitis: a randomized clinical trial[25]

Importance: New models of health care delivery for dermatological care have the potential to increase access and improve patient-centered outcomes.

Objective: To compare effectiveness of a direct-access, online model for follow-up dermatologic care in pediatric and adult patients with atopic dermatitis with that of in-person office visits.

Design, setting, and participants: This was a 1-year, randomized controlled equivalency clinical trial in medically underserved areas, outpatient clinics, and the general community. Participants included children and adults with atopic dermatitis with access to the Internet, computers, and digital cameras.

Interventions: After an initial in-person visit, patients were randomized 1:1 to direct-access online or usual in-person care for follow-up management of atopic dermatitis. In the direct-access online group, patients captured and transmitted clinical images and history asynchronously to dermatologists online; dermatologists evaluated the clinical information, provided recommendations and education, and prescribed medications online asynchronously. In the in-person group, patients visited dermatologists in their offices for follow-up care.

Main Outcomes and Measures: Atopic dermatitis disease severity as assessed by patient-oriented eczema measure (POEM) and investigator global assessment (IGA).

Results: A total of 156 children and adults were randomized. Between baseline and 12 months, the mean (SD) within-group difference in POEM score in patients in the direct-access online group was -5.1 (5.48) (95% CI, -6.32 to -3.88); in the in-person group, the within-group difference was -4.86 (4.87) (95% CI, -6.27 to -3.46). The difference in the change in POEM scores between the 2 groups was 0.24 (6.59) (90% CI, -1.70 to 1.23), which was contained within the predetermined 2.5 equivalence margin. The percentage of patients achieving clearance or near-clearance of their disease (IGA score of 0 or 1) was 38.4% (95% CI, 27.7% to 49.3%) in the direct-access online group and 43.6% (95% CI, 32.6%-54.6%) in the in-person group. The difference in the percent of patients achieving clearance or near-clearance

[25] Armstrong AW, Johnson MA, Lin S, Maverakis E, Fazel N, Liu FT. Patient-centered, direct-access online care for management of atopic dermatitis: a randomized clinical trial. *JAMA Dermatol.* 2015;151(2):154-160. doi:10.1001/jamadermatol.2014.2299

between the 2 groups was 5.1% (90% CI, 1.7%-8.6%), which was contained within the predetermined 10% equivalence margin.

Conclusions and Relevance: The direct-access online model results in equivalent improvements in atopic dermatitis clinical outcomes as in-person care. Direct-access online care may represent an innovative model of delivering dermatological services to patients with chronic skin diseases.

Fruhauf et al (2015) [Randomised Controlled Trial] Mobile teledermatology helping patients control high-need acne: a randomized controlled trial[26]

Background: Acne is an important health issue with a major psychological impact in addition to the physical problems it causes.

Objectives: To investigate the superiority of mobile teledermatology in the care of patients with high-need facial acne in comparison to outpatient services with particular attention to treatment efficacy, safety, and patient compliance. Further, patient satisfaction with remote care was evaluated.

Methods: Sixty-nine consecutive patients (f: 25, m: 44, median age: 19 years, range: 13-37 years) were randomly allocated to either the teleconsultation (TCA) or the outpatient consultation (OCA) arm of the trial to receive isotretinoin treatment in weight and severity-dependent dosages over 24 weeks. Acne grading was performed by one examiner using the Global Acne Severity Scale (GEA) and the total lesion counting (TLC).

Results: Due to noncompliance issues, 17 of 69 (24.6%) patients were excluded from the study, of who 10 had been assigned to the TCA (10/34; 29.4%) and 7 to the OCA (7/35; 20%). Both, in the TCA (GEA-score: △ = 2.25; TLC: △ = 89.08) and in the OCA (GEA-score: △ = 2.0; TLC: △ = 91.21) excellent and almost equivalent therapeutic outcomes were achieved. In the TCA, however, less patients experienced adverse reactions (P = 0.55). Even though additional live supervision would have been appreciated in some teledermatology cases, patients were satisfied with the mobile service and no consultation request was created.

Conclusion: Mobile teledermatology is an efficient, safe and well-accepted tool among patients with high-need acne constituting at least a valuable adjunct to outpatient care services. Further larger studies would be useful to confirm our findings.

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[26] Frühauf J, Kröck S, Quehenberger F, et al. Mobile teledermatology helping patients control high-need acne: a randomized controlled trial. *J Eur Acad Dermatol Venereol*. 2015;29(5):919-924. doi:10.1111/jdv.12723

Abbott et al (2020) [Practice guidelines for teledermatology in Australia](#)[27]
Despite the potential of teledermatology to increase access to dermatology services and improve patient care, it is not widely practised in Australia. In an effort to increase uptake of teledermatology by Australian dermatologists and support best practice, guidelines for teledermatology for the Australian context have been developed by The University of Queensland's Centre for Online Health in collaboration with The Australasian College of Dermatologists' E-Health Committee. The guidelines are presented in two sections: 1. Guidelines and 2. Notes to support their application in practice, when feasible and appropriate. Content was last updated March 2020 and includes modalities of teledermatology; patient selection and consent; imaging; quality and safety; privacy and security; communication; and documentation and retention of clinical images. The guidelines educate dermatologists about the benefits and limitations of telehealth while articulating how to enhance patient care and reduce risk when practicing teledermatology.

Abbott et al (2020) [A review of literature supporting the development of practice guidelines for teledermatology in Australia](#)[28]
Despite the potential of teledermatology to increase access to dermatology services and improve patient care, it is not widely practised in Australia. In an effort to increase uptake of teledermatology, Australian-specific practice guidelines for teledermatology are being developed by the Australasian College of Dermatologist. This paper reports finding from literature reviews that were undertaken to inform the development of these guidelines. Results cover the following sections: Modalities of teledermatology; Patient selection and consent; Imaging; Quality and safety; Privacy and security; Communication; and Documentation and retention. The document educates providers about the benefits and limitations of telehealth while articulating how to enhance patient care and reduce risk when practicing teledermatology.

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[27] Abbott LM, Miller R, Janda M, et al. Practice guidelines for teledermatology in Australia [published online ahead of print, 2020 May 3]. *Australas J Dermatol.* 2020;10.1111/ajd.13301. doi:10.1111/ajd.13301
[28] Abbott LM, Miller R, Janda M, et al. A review of literature supporting the development of practice guidelines for teledermatology in Australia. *Australas J Dermatol.* 2020;61(2):e174-e183. doi:10.1111/ajd.13249

Abbott and Soyer (2020) [A CLOSE-UP guide to capturing clinical images](29)
Telemedicine is rapidly becoming ubiquitous as the medical profession adjusts its practice to provide optimal care to patients in the context of the COVID19 pandemic. The ability to provide accurate dermatological advice via telemedicine is dependent on the receipt of high-quality clinical images and accurate clinical context, on which clinicians receive little education during medical school and subsequent training. Clinicians can improve their capture, delivery and storage of images using the CLOSE-UP acronym, which encapsulates important considerations in the clinical photography process.

Bianchi et al (2020) [Benefits of Teledermatology for Geriatric Patients: Population-Based Cross-Sectional Study](30)
Background: Teledermatology is a health care tool that has been increasingly used around the world, mostly because dermatology has an emphasis on visual diagnosis. Many studies have shown that access to specialized care improves using teledermatology, which provides accurate diagnosis and reduces the time taken for treatment, with high patient satisfaction. As the population around the world grows old, there will be even more demand for dermatologists in years to come. It is essential to know which are the most prevalent skin conditions in the primary care population and if they can be addressed through teledermatology.
Objective: Our main goal was to evaluate the proportion of lesions in individuals aged 60 years and older that could be managed using teledermatology in conjunction with primary care physicians. Second, we aimed to assess the most frequent skin lesions, the most common treatments provided to patients, and the distribution and causes of referrals made by the teledermatologists.
Methods: This was a retrospective cohort study from July 2017 to July 2018 in São Paulo, Brazil. We included 6633 individuals aged 60 years and older who presented with 12,770 skin lesions. Teledermatologists had three options to refer patients: 1. to undergo biopsy directly; 2. to an in-person dermatologist visit; and 3. back to the primary care physician with the most probable diagnosis and treatment.
Results: Teledermatology managed 66.66% (8408/12614) of dermatoses with the primary care physician without the need for an in-presence visit;

29 Abbott LM, Soyer HP. A CLOSE-UP guide to capturing clinical images [published online ahead of print, 2020 May 18]. *Australas J Dermatol.* 2020;10.1111/ajd.13330. doi:10.1111/ajd.13330
30 G Bianchi M, Santos A, Cordioli E. Benefits of Teledermatology for Geriatric Patients: Population-Based Cross-Sectional Study. *J Med Internet Res.* 2020;22(4):e16700. Published 2020 Apr 21. doi:10.2196/16700

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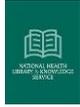
27.10% (3419/12614) were referred to dermatologists, and 6.24% (787/12614) directly to biopsy. The most frequent diseases were seborrheic keratosis, solar lentigo, onychomycosis, melanocytic nevus, benign neoplasms, actinic keratosis, epidermoid cyst, xerosis, leucoderma, and wart, with significant differences between sexes. Malignant tumors increased with age and were the leading cause for biopsies, while infectious skin conditions and pigmentary disorders decreased. Emollient was the most frequent treatment prescribed, in 31.88% (909/2856) of the cases.

Conclusions: Teledermatology helped to treat 67% of the dermatoses of older individuals, addressing cases of minor complexity quickly and conveniently together with the primary care physician, thus optimizing dermatological appointments for the most severe, surgical, or complex diseases. Teledermatology does not aim to replace a face-to-face visit with the dermatologist; however, it might help to democratize dermatological treatment access for patients and decrease health care expenses.

Brunasso and Massone (2020) [Teledermatologic monitoring for chronic cutaneous autoimmune diseases with smartworking during COVID-19 emergency in a tertiary center in Italy](link)[31]

Because of the coronavirus disease 2019 (COVID-19) emergency, on March 9, 2020 Italy went in lock-down imposing the closure of non-urgent outpatient clinics devoted to care of chronic, severe, inflammatory skin diseases that require periodic follow-up. In this emergency situation, due to the lack of a teledermatology platform and in order not to leave our vulnerable high-need patients without proper follow-up, we started a teledermatologic service in smartworking using phone calls and emails. The total number of patients scheduled was 195; in 12 cases, we were not able to talk to the patients. Remote monitoring was performed in 183 patients [126 moderate to severe psoriasis, 10 severe acne, 11 severe atopic dermatitis, 11 hidradenitis suppurativa, 9 blistering autoimmune diseases, and 16 other autoimmune skin diseases]. During remote-visits, several interventions were conducted: triage for COVID-19 suspected symptoms, email check of clinical pictures and of laboratory examinations, advices for topical and systemic therapy continuation or discontinuation/switch and reschedule of next appointment. Only five patients required personal office visit (2.7%), reducing consistently the number of face-to face visits. Our real-life experience shows that remote

[31]Brunasso AMG, Massone C. Teledermatologic monitoring for chronic cutaneous autoimmune diseases with smartworking during COVID-19 emergency in a tertiary center in Italy [published online ahead of print, 2020 May 26]. *Dermatol Ther*. 2020;e13495. doi:10.1111/dth.13695

monitoring was effective in preventing unnecessary worsening of severe chronic skin diseases and poor outcomes due to withdrawal of current therapy.

Corden et al (2020) [A targeted response to the COVID-19 pandemic: analysing effectiveness of remote consultations for triage and management of routine dermatology referrals](32)

When the UK entered lockdown in March 2020 amidst the COVID-19 pandemic, routine dermatology work was suspended as per national guidance to allow for redeployment of staff to the front line and also reducing risk of patient exposure and travel. New patient referrals from primary care into dermatology services usually enter via one of three routes: 1. 2 week wait for suspected serious skin malignancies; 2. routine non-urgent cases; and 3. emergency referrals via an on call service. All these patients are assessed via a face-to-face consultation, after various waiting times depending on their urgency. As a result of this suspension just over 800 new routinely referred patients had their appointments temporarily suspended, covering a six week period. Many of these patients had already waited up to 18 weeks for an initial assessment. Furthermore, with the dual challenge of a depleted dermatology workforce and the need for reduced face-to-face consultations during the lockdown, it became imperative to develop new solutions to ensure this cohort of patients would receive care within an appropriate timeframe. To evaluate our response to this challenge we prospectively collected data, with the aim to investigate whether the strategy deployed was an efficient way of assessing this large number of referred patients. We also initiate discussion as to whether this novel method of working could yield a framework for providing a future dermatology service in the event of prolonged social distancing.

Dobry et al (2020) [Implementation and Impact of a Store-and-Forward Teledermatology Platform in an Urban Academic Safety-Net Health Care System](33)

Background: Minority and low-income patients disproportionately experience dermatologic access challenges. Store-and-forward (SAF)

[32] Corden E, Rogers A, Woo WA, Simmonds R, Mitchell C. A targeted response to the COVID-19 pandemic: analysing effectiveness of remote consultations for triage and management of routine dermatology referrals [published online ahead of print, 2020 May 16]. *Clin Exp Dermatol*. 2020;10.1111/ced.14289. doi:10.1111/ced.14289

[33] Dobry A, Begaj T, Mengistu K, et al. Implementation and Impact of a Store-and-Forward Teledermatology Platform in an Urban Academic Safety-Net Health Care System [published online ahead of print, 2020 Jun 9]. *Telemed J E Health*. 2020;10.1089/tmj.2020.0069. doi:10.1089/tmj.2020.0069

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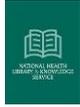
teledermatology has emerged as a model of care delivery that may improve access. We sought to evaluate patterns of utilization and overall impact after SAF teledermatology implementation in a safety-net health care system.

Methods: We performed a retrospective review of 3,285 teledermatology consultations from 2014 to 2017 in an urban academic safety-net health care system.

Results: A total of 1,680 (51.2%) patients were referred for inflammatory/rash conditions and 967 (29.5%) for skin lesions. The teledermatologist recommended in-person evaluation in 1,199 encounters (36.5%). Median wait time for a subsequent appointment was 36 days (range 0-244 days). Of subsequent in-clinic visits, 237 patients (26.4%) underwent skin biopsy. No-show rate after referral was 11.8%. In comparison, median wait time for dermatology appointment through standard referral was 64 days, with a no-show rate of 18.6%. Biopsy rate of patients referred via teledermatology was 26.4%, in comparison to a rate of 10.9% of patients referred directly from primary care provider.

Discussion: Implementation of SAF teledermatology in a safety-net health system resulted in avoidance of 63.5% potential dermatology visits. Consultation typically resulted in a change in suspected diagnosis or management plan. Rates of concordance between teledermatology consults and in-person evaluations were high. Median wait time was reduced by almost half, no-show rate was reduced ~37%, and biopsy rate was more than double for teledermatology patients compared with standard referral.

Conclusion: These findings suggest that SAF teledermatology may improve access to high-quality dermatologic care and increase clinic efficiencies for patients in safety-net health care systems.

Greenwald et al (2020) [Real-world outcomes of melanoma surveillance using the MoleMap NZ telemedicine platform](#)[34]

Background: MoleMap NZ is a novel New Zealand-based store-and-forward telemedicine service to detect melanoma. It uses expert review of total body photography and close-up and dermoscopic images of skin lesions that are suspicious for malignancy.

Objective: The purpose of this study was to assess the effectiveness of MoleMap NZ as a melanoma early detection program.

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[34] Greenwald E, Tan A, Stein JA, Liebman TN, Bowling A, Polsky D. Real-world outcomes of melanoma surveillance using the MoleMap NZ telemedicine platform [published online ahead of print, 2020 Feb 28]. *J Am Acad Dermatol.* 2020;S0190-9622(20)30301-7. doi:10.1016/j.jaad.2020.02.057
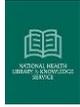
Methods: We conducted a review of 2108 melanocytic lesions recommended for biopsy/excision by MoleMap NZ dermoscopists between January 2015 and December 2016.

Results: Pathologic diagnoses were available for 1571 lesions. Of these, 1303 (83%) lesions were benign and 260 (17%) lesions were diagnosed as melanoma, for a melanoma-specific benign:malignant ratio of 5.0:1. The number needed to biopsy to obtain 1 melanoma was 6. Among melanomas with available tumor thickness data (n = 137), 92% were <0.8 mm (range in situ to 3.1 mm), with in situ melanomas comprising 74%.

Limitations: Only lesions recommended for excision were analyzed. Pathology results were available for 75% of these cases. Tumor thickness data were available for 53% of melanomas diagnosed.

Conclusions: This real-world study of MoleMap NZ, a community-based teledermoscopy program, suggests that it has the potential to increase patients' access to specialist expertise via telemedicine. Additional studies are needed to more accurately define its efficacy.

Hampton et al (2020) Usability testing of MySkinSelfie: a mobile phone application for skin self-monitoring[35]

Teledermatology generally involves doctors taking images of patients; however, patients increasingly want to own or have easy access to their health data. MySkinSelfie is a mobile phone application designed to improve the quality, consistency and accessibility of patient-held photos, and was developed to give patients the ability to generate and hold their own skin images to help guide their skin care. This study assessed the usability of this app in a cohort of patients attending a National Health Service Dermatology clinic. Patients were asked to use the app but were not given specific tasks to achieve. Of the 102 patients recruited, 32 downloaded the app and registered an account, 21 took at least one photo (median 5, range 1-103) and 19 completed the usability questionnaire. The majority of questionnaire respondents found the app easy to use but were more neutral on whether it really helped them to manage their skin problem. MySkinSelfie has been shown to be easy to use. Self-monitoring of skin problems may be useful for a subset of patients, and this is likely to depend on diagnosis, age and other patient factors.

[35] Hampton P, Richardson D, Brown S, Goodhead C, Montague K, Olivier P. Usability testing of MySkinSelfie: a mobile phone application for skin self-monitoring. *Clin Exp Dermatol*. 2020;45(1):73-78. doi:10.1111/ced.13995

Horsham et al (2020) [Is Teledermoscopy Ready to Replace Face-to-Face Examinations for the Early Detection of Skin Cancer? Consumer Views, Technology Acceptance, and Satisfaction with Care](36)

Background: Previous cross-sectional research indicates high acceptance of mobile teledermoscopy-enhanced skin self-examination (SSE) by consumers based on the technology acceptance model (TAM) domains: perceived usefulness, ease of use, compatibility, attitude and intention, subjective norms, facilitator, and trust. However, no study has assessed this outcome longitudinally among people who actually used the technology in their own homes.

Methods: Participants were living in Brisbane, Australia, aged 18 years or older, and at high risk of skin cancer. Participants randomly assigned to the intervention group (n = 98) completed a self-administered questionnaire on mobile teledermoscopy acceptance for skin cancer detection both before use and after performing mobile teledermoscopy-enhanced SSE in their homes. The survey included a 25-item scale assessing seven TAM domains. Item scores ranged from 5 [strongly agree] to 1 [strongly disagree]. Participants also answered survey questions on satisfaction with use of teledermoscopy, and a 9-item Thoughts about Melanoma scale that measures cancer worry.

Results: Participants were 19-73 years old, had high skin cancer risk, blue or grey eyes (53.1%), fair or very fair skin (88.8%), and previous skin cancer treatments (61.2%). Participants were more accepting of mobile teledermoscopy at baseline: mean TAM score of 4.15 (SE 0.05); their level of acceptance decreased significantly after teledermoscopy use: mean score 3.94 (SE 0.05; p = 0.001). In linear regression analysis, the decrease in TAM scores was similar across demographic and skin cancer risk categories. Ninety-two percent (n = 90) of participants agreed that mobile teledermoscopy was easy to use. The mean score of the Thoughts about Melanoma scale did not change significantly from baseline to follow-up.

Conclusion: Consumers had high TAM scores before they used mobile teledermoscopy within a randomised control trial. At the end of the intervention period, TAM scores decreased, although participants' average score still indicated "agreement" that mobile teledermoscopy was acceptable.

36 Horsham C, Snoswell C, Vagenas D, et al. Is Teledermoscopy Ready to Replace Face-to-Face Examinations for the Early Detection of Skin Cancer? Consumer Views, Technology Acceptance, and Satisfaction with Care. *Dermatology*. 2020;236(2):90-96. doi:10.1159/000506154

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Kips et al (2020) Teledermatology in Belgium: a pilot study[37]

Background: Teledermatology, the application of telemedicine in the field of dermatology, can be a valuable tool to improve the efficiency of care in general practice.

Objectives: In this pilot study, we implemented a teledermatology programme in Belgian context to assess the effect on referral rate and to evaluate the acceptability of teledermatology by clinicians and patients.

Material and Methods: A store-and-forward teledermatology service between 12 general practitioners (GPs) and 3 academic dermatologists was evaluated for a period of 3-6 months. Clinicians and patients were questioned about satisfaction, benefits and barriers.

Results: In total, 54 teledermatologic consultations were performed. The referral rate was reduced. Thirty-one teleconsulations were performed instead of physical referral, of which nine patients were actually referred. In 23 cases, performed for a second opinion, two more patients were referred on the dermatologist's advice. All clinicians want to continue working with teledermatology. GPs highlighted the educational benefit, whereas dermatologists were interested in the triage effect and reduced referral rate. Patients indicated that teledermatology would encourage them to consult a GP sooner when experiencing dermatologic problems.

Conclusion: Teledermatology proved to be a feasible and acceptable tool for both clinicians and patients. It also shows to be a valuable for triage and reducing unnecessary referrals. Considering the emergent pressure on health care in the next decades, teledermatology following GP selection could be useful for the Belgian health care system and deserves further elaboration in the search for effective tools to strengthen first line health care and streamline referral to secondary care

Kong et al (2020) [Randomised Controlled Trial] Consumer Preferences for Skin Cancer Screening Using Mobile Teledermoscopy: A Qualitative Study[38]

Background: Mobile teledermoscopy is a rapidly advancing technology that promotes early detection and management of skin cancers. Whilst the use of teledermoscopy has proven to be effective and has a role in the detection of

[37] Kips J, Lambert J, Ongenae K, De Sutter A, Verhaeghe E. Teledermatology in Belgium: a pilot study. *Acta Clin Belg.* 2020;75(2):116-122. doi:10.1080/17843286.2018.1561812

[38] Kong F, Horsham C, Rayner J, et al. Consumer Preferences for Skin Cancer Screening Using Mobile Teledermoscopy: A Qualitative Study. *Dermatology.* 2020;236(2):97-104. doi:10.1159/000505620
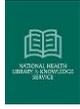
skin cancers, patients' attitudes towards the multiple ways in which this technology can be utilised has not been explored.

Methods: Data were obtained from a large randomised controlled trial comparing mobile teledermoscopy-enhanced skin self-examinations (SSEs) with naked-eye SSE. A semi-structured interview guide was developed by the investigators with questions focusing on people's previous skin screening behaviours and 2 of the major pathways which can be utilised in mobile teledermoscopy: 1. direct-to-consumer; and 2. doctor-to-doctor. All interviews were tape-recorded and transcribed verbatim. Thematic analysis was undertaken by 2 independent researchers.

Results: Twenty-eight participants were interviewed. Eighty-six percent of participants (n = 24/28) had previously had a clinical skin examination. Only 18% of participants (n = 5/28) visited the same doctor for each clinical skin examination. Five main themes were identified in the interviews that affected how people felt about the integration of mobile teledermoscopy into skin screening pathways: history of clinical skin examinations, continuity of the doctor-patient relationship, convenience of the direct-to-consumer teledermoscopy, expedited review enhancing the doctor-to-doctor setting and mobile teledermoscopy as a partner-assisted task.

Conclusions: Overall mobile teledermoscopy was viewed positively for both direct-to-consumer and doctor-to-doctor interaction. Continuity of care in the doctor-patient relationship was not found to be a priority for clinical skin examination with most participants visiting several doctors throughout their clinical skin examination history.

Liu et al (2020) [A deep learning system for differential diagnosis of skin diseases](#)[39]

Skin conditions affect 1.9 billion people. Because of a shortage of dermatologists, most cases are seen instead by general practitioners with lower diagnostic accuracy. We present a deep learning system (DLS) to provide a differential diagnosis of skin conditions using 16,114 de-identified cases from a teledermatology practice serving 17 sites. The DLS distinguishes between 26 common skin conditions, representing 80% of cases seen in primary care, while also providing a secondary prediction covering 419 skin conditions. On 963 validation cases, where a rotating panel of three board-certified dermatologists defined the reference standard, the DLS was non-inferior to six other dermatologists and superior to six primary

[39] Liu Y, Jain A, Eng C, et al. A deep learning system for differential diagnosis of skin diseases. *Nat Med.* 2020;26(6):900-908. doi:10.1038/s41591-020-0842-3

care physicians (PCPs) and six nurse practitioners (NPs) (top-1 accuracy: 0.66 DLS, 0.63 dermatologists, 0.44 PCPs and 0.40 NPs). These results highlight the potential of the DLS to assist general practitioners in diagnosing skin conditions.

Miller et al (2020) [Real-time teledermatology clinics in a tertiary public hospital: A clinical audit](40)

Background: Our metropolitan hospital provides a real-time videoconference teledermatology clinic to enable patients in rural and remote Queensland to access a specialist for dermatology care.

Methods: Retrospective clinical audit of all patient referrals to the videoconference teledermatology clinic for a two-year period.

Results: A total of 483 consultations for 178 patients were conducted by the teledermatology clinic. Most patients were from remote and very remote regions of Queensland with a mean distance from our metropolitan hospital to the patient's town of residence of 1295 km. The most common reason for referral, as per the referral form, was rash (32%), followed by acne (12%) and dermatitis (11%). Most (78%) referrals came from general practitioners. Around 8% of patients seen in the teledermatology clinic were converted to in-person review; 81% of patients were managed via teledermatology, and 10% of patients did not attend the scheduled teleconsultation.

Conclusion: The outpatient teledermatology clinic run through the Telehealth Centre of a metropolitan hospital is an effective way of delivering a general dermatology consultation service to rural and remote patients in a timely manner.

Nicholson et al (2020) [Patient satisfaction with a new skin cancer teledermatology service](41)

Background: Rising numbers of two-week-wait (2WW) skin cancer referrals have caused increasing pressure on UK dermatology departments. Initiatives to address this include teledermatology. Previous studies have indicated good patient acceptability but most have focused on general dermatology rather than skin cancer referrals, and have taken place in rural settings, where teledermatology may be preferable.

40 Miller BJ, Finnane A, Vun Y, et al. Real-time teledermatology clinics in a tertiary public hospital: A clinical audit [published online ahead of print, 2020 May 11]. *Australas J Dermatol.* 2020;10.1111/ajd.13322. doi:10.1111/ajd.13322
41 Nicholson P, Macedo C, Fuller C, Thomas L. Patient satisfaction with a new skin cancer teledermatology service. *Clin Exp Dermatol.* 2020;45(6):691-698. doi:10.1111/ced.14191

Aim: To evaluate patient satisfaction of teledermatology 2WW services in a London-based tertiary National Health Service (NHS) setting.

Methods: A literature search was performed and a patient satisfaction survey was designed to evaluate: 1. ease of completing a questionnaire about the skin lesion; 2. lifestyle impact; 3. preferences regarding electronic data collection and communication of results; and 4. confidence in the service. A five-point Likert scale was used to assess responses. The study took place over a 20-week period.

Results: Over half (51%; n = 31 of 60 patients) were female; 78% (47) were aged ≤ 55 years and 65% (39) were Caucasian. Over 80% (49) would recommend the service, and the majority felt confident with the teledermatology model. Overall, patients would be happy to complete electronic questionnaires and receive results electronically, with younger patients being more amenable to this. Patients with better health status, those of younger age and those with less frequent visits to a dermatologist were more accepting of teledermatology.

Conclusion: To our knowledge, this is the first comprehensive study evaluating patient satisfaction with teledermatology specifically for 2WW referrals in an NHS setting. As skin cancer referrals increase, dermatology departments must adjust. Patient involvement and feedback is paramount in implementing and expanding teledermatology services.

Pasadyn et al (2020) [Store-and-forward teledermatology impact on diagnosis, treatment and dermatology referrals: Comparison between practice settings](#)[42]

Introduction: Store-and-forward (SAF) teledermatology involves non-dermatologists sending clinical images to dermatologists. This improves patient care while reducing unwarranted face-to-face (FTF) specialist office visits. Comparisons between dermatologist diagnostic concordance with referring provider, treatment change recommendations, and FTF referrals have yet to be compared by type of provider and practice setting.

Methods: This retrospective chart review examined SAF teledermatology eConsults from four practice settings: Doctor of Medicine (MD)/Doctor of Osteopathic Medicine (DO) office visits, MD/DO walk-in clinics, nurse practitioner (NP)/physician assistant (PA) office visits and NP/PA walk-in clinics. The most recent 100 MD/DO office- and 100 NP/PA walk-in-referred

[42] Pasadyn SR, McAfee JL, Vij A, Warren CB. Store-and-forward teledermatology impact on diagnosis, treatment and dermatology referrals: Comparison between practice settings [published online ahead of print, 2020 May 23]. *J Telemed Telecare*. 2020;1357633X20925269. doi:10.1177/1357633X20925269

patient charts were reviewed. There were only 71 NP/PA office and 47 MD/DO walk-in eConsults to review.

Results: Teledermatologists agreed with referring provider diagnoses 50% of the time for MD/DO office visits, 29.8% for MD/DO walk-in clinics, 33.8% for NP/PA office visits and 34% for NP/PA walk-in clinics. Diagnostic concordance was significantly higher for eConsults from MD/DO office visits than MD/DO walk-in clinics ($p = 0.021$), NP/PA office visits ($p = 0.035$) or NP/PA walk-in clinics ($p = 0.022$). There were significantly more treatment changes recommended after walk-in eConsults than office visits (67 versus 44%, $p < 0.0001$). FTF visits were recommended more after office visits than walk-in clinics (46 versus 27%, $p = 0.001$). Overall, 21% (68/318) of patients ultimately attended FTF appointments.

Discussion: SAF teledermatology improves diagnosis, reducing barriers to specialty care. Overall, potential FTF visit reduction was 79%. Expanding eConsult programmes, particularly in walk-in settings, and for use by NP/PAs or early career internists, may render dermatological care more expeditiously and avoid unnecessary FTF visits.

Pasquali et al (2020) Teledermatology and its Current Perspective[43]

Teledermatology is one of the most important and commonly employed subsets of telemedicine, a special alternative to face-to-face (FTF) doctor-patient consultation that refers to the use of electronic telecommunication tools to facilitate the provision of healthcare between the seeker and provider. It is used for consultation, education, second opinion, and monitoring medical conditions. This article will review basic concepts, the integration of noninvasive imaging technique images, artificial intelligence, and the current ethical and legal issues.

Peracca et al (2020) Implementing Teledermatology for Rural Veterans: An Evaluation Using the RE-AIM Framework[44]

Introduction: Few systematic evaluations of implementing teledermatology programs in large health care systems exist. We conducted a longitudinal evaluation of a U.S. Department of Veterans Affairs (VA) initiative to expand asynchronous consultative teledermatology services for rural veterans.

[43] Pasquali P, Sonthalia S, Moreno-Ramirez D, et al. Teledermatology and its Current Perspective. *Indian Dermatol Online J.* 2020;11(1):12-20. Published 2020 Jan 13. doi:10.4103/idoj.IDOJ_241_19

[44] Peracca SB, Jackson GL, Lamkin RP, et al. Implementing Teledermatology for Rural Veterans: An Evaluation Using the RE-AIM Framework [published online ahead of print, 2020 Apr 27]. *Telemed J E Health.* 2020;10.1089/tmj.2020.0013. doi:10.1089/tmj.2020.0013

Methods: The reach, effectiveness, adoption, implementation, and maintenance framework guided the evaluation, which included analysis of quantitative VA administrative data as well as an online survey completed by participating facilities. The first 2 years of the program were compared with the year before the start of funding.

Results: Sixteen hub facilities expanded teledermatology's reach over the 2-year period, increasing the number of referral spoke sites, unique patients served, and teledermatology encounters. Effectiveness was reflected as teledermatology constituted an increasing fraction of dermatology activity and served more remotely located patients. Adoption through defined stages of implementation progressed as facilities engaged in a variety of strategies to enhance teledermatology implementation, and facilitators and barriers were identified. Program maintenance was assessed by Program Sustainability Index scores, which reflected the importance of executive support, and ongoing concerns about staffing and longitudinal funding.

Discussion: Enabling hubs to create solutions that best fit their needs and culture likely increased reach and effectiveness. Important facilitators included organizational leadership and encouraging communication between stakeholders before and during the intervention.

Conclusions: A systematic analysis of teledermatology implementation to serve rural sites in VA documented a high degree of implementation and sustainability as well as areas for improvement.

Rizvi et al (2020) [Teledermatology in Norway using a mobile phone app](#)[45]
Rashes, ulcers and skin lesions are well suited for telemedicine. We have developed a smartphone app, the first of its kind in Norway, where a referring physician can write a short medical history and take clinical and dermatoscopic photographs with a smartphone, which is then sent to and evaluated by a dermatologist. In the period from June 1st, 2017, to September 1st, 2019, clinical information and photographs of rash and skin lesions from 171 patients were sent by 40 primary care and nursing home physicians via the smartphone app to four dermatologists for diagnosis and therapeutic advice. A wide range of dermatological conditions were diagnosed, most commonly chronic ulcers (17%), eczema (15%) and pigmented lesions (13%). Assessed later by a dermatologist, referral for regular consultations with a specialist was avoided in 119 patients (70%). Sixteen patients (9%) were recommended a regular consultation with a dermatologist; information for

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prioritization in the specialist healthcare service was then provided. In 36 patients (21%), further measures by the referring physician were recommended. Our experience indicates that many ordinary consultations on rash, ulcers and skin lesions in the specialist healthcare services can be avoided when using the smartphone app.

Vestergaard et al (2020) [Diagnostic accuracy and interobserver concordance: teledermoscopy of 600 suspicious skin lesions in Southern Denmark](46)

Background: Skin cancer incidences are increasing and early diagnosis, especially of malignant melanoma, is crucial. Teledermatology including teledermoscopy (TDS) can be used to triage referrals of suspicious skin lesions, however, this is not currently recommended in Denmark.

Objectives: To evaluate diagnostic accuracy, sensitivity, specificity and interobserver concordance of TDS, and to evaluate the number of incidental lesions potentially missed by TDS.

Methods: Fifty general practices were invited to send images of suspicious skin lesions for evaluation using smartphone TDS. Simultaneously, the patient was referred for a face-to-face (FTF) consultation. Images for TDS were independently evaluated by two dermatologists; a third dermatologist performed the FTF consultation. Diagnosis, management plan and level of diagnostic confidence were noted. For TDS photo quality was rated, and for FTF any incidental findings were described.

Results: Six hundred lesions in 519 patients were included. The diagnostic accuracy was significantly higher on FTF evaluation than on TDS (P < 0.01). However, this was associated with a significant difference in specificity (P ≤ 0.012) whereas no significant difference was found in sensitivity. The concordance between FTF and TDS, and the interobserver concordance of two TDS evaluations was moderate to substantial (AC1 = 0.57-0.71). Incidental melanomas were found in 0.6% of patients on FTF evaluation, adding an extra 13% of melanomas. However, on TDS these patients' photographed lesions all warranted FTF follow-up, where these melanomas would have been identified.

Conclusion: In this large prospective study, no significant difference in sensitivity was observed between FTF and TDS, but specificity was lower on TDS than FTF. Taking management plans into account, we would, however,

46 Vestergaard T, Prasad SC, Schuster A, Laurinaviciene R, Andersen MK, Bygum A. Diagnostic accuracy and interobserver concordance: teledermoscopy of 600 suspicious skin lesions in Southern Denmark [published online ahead of print, 2020 Feb 7]. *J Eur Acad Dermatol Venereol.* 2020;10.1111/jdv.16275. doi:10.1111/jdv.16275
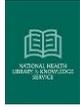
potentially have dismissed 2 of 23 melanomas, if only TDS had been used for assessment. One of these was a melanoma located on the scalp, an anatomic region less suitable for TDS.

Wang et al (2020) [Clinical effectiveness and cost-effectiveness of teledermatology: Where are we now, and what are the barriers to adoption?](47)

There has been rapid growth in teledermatology over the past decade, and teledermatology services are increasingly being used to support patient care across a variety of care settings. Teledermatology has the potential to increase access to high-quality dermatologic care while maintaining clinical efficacy and cost-effectiveness. Recent expansions in telemedicine reimbursement from the Centers for Medicare and Medicaid Services (CMS) ensure that teledermatology will play an increasingly prominent role in patient care. Therefore, it is important that dermatologists be well informed of both the promises of teledermatology and the potential practice challenges a continuously evolving mode of care delivery brings. In this article, we will review the evidence on the clinical and cost-effectiveness of teledermatology and we will discuss system-level and practice-level barriers to successful teledermatology implementation as well as potential implications for dermatologists.

Young et al (2020) [Artificial Intelligence in Dermatology: A Primer](48)

Artificial intelligence is becoming increasingly important in dermatology, with studies reporting accuracy matching or exceeding dermatologists for the diagnosis of skin lesions from clinical and dermoscopic images. However, real-world clinical validation is currently lacking. We review dermatological applications of deep learning, the leading artificial intelligence technology for image analysis, and discuss its current capabilities, potential failure modes, and challenges surrounding performance assessment and interpretability. We address the following three primary applications: 1. teledermatology, including triage for referral to dermatologists; 2. augmenting clinical assessment during face-to-face visits; and 3. dermatopathology. We discuss equity and ethical issues related to future clinical adoption and recommend specific standardization of metrics for reporting model performance.

[47] Wang RH, Barbieri JS, Nguyen HP, et al. Clinical effectiveness and cost-effectiveness of teledermatology: Where are we now, and what are the barriers to adoption?. *J Am Acad Dermatol.* 2020;83(1):299-307. doi:10.1016/j.jaad.2020.01.065

[48] Young AT, Xiong M, Pfau J, Keiser MJ, Wei ML. Artificial Intelligence in Dermatology: A Primer [published online ahead of print, 2020 Mar 27]. *J Invest Dermatol.* 2020;S0022-202X(20)31201-X. doi:10.1016/j.jid.2020.02.026

Bridges et al (2019) **Utility of Dermatology Extension for Community Healthcare Outcomes (ECHO) sessions in the adult and paediatric population**[49]

Introduction: Primary care provider (PCP) competency in dermatology is inadequate despite the high volume of patients with skin conditions. Better education and access to dermatology expertise is vital to improve patient care. We present a comprehensive case-based evaluation of Dermatology Extension for Community Healthcare Outcomes (ECHO) sessions, an innovative videoconferencing educational model, by determining the diagnostic and treatment accuracy of dermatological conditions by PCPs over a 2-year period.

Methods: This is a retrospective cross-sectional study evaluating the use and impact of Dermatology ECHO over a 2-year period. Outcomes assessed include patient demographics, PCPs' diagnostic accuracy, and expert treatment impact. Results were analysed using summary statistics and Pearson's chi-square test to describe the adult and paediatric populations.

Results: One hundred and sixty-seven adult cases and 56 paediatric cases were presented in 2016-2017. Among the 223 cases, 137 adult and 44 paediatric cases were complete and eligible for analysis. The mean lesion duration was 3.3 years in adults and 2.9 years in children prior to presentation. Upon case presentation, almost half (43.8%) of the adult cases were incorrectly diagnosed by their PCP with 18.8% receiving a partially correct diagnosis. PCPs had greater diagnostic accuracy in children (45% correct diagnosis, 27.5% partially correct, 27.5% incorrect). Expert treatment recommendations benefited 83.6% of adult cases and 72.5% of paediatric cases.

Discussion: This study highlights the need for better dermatology access and teaching opportunities among PCPs in Missouri. Dermatology ECHO provides a platform for didactic learning and case presentations to improve dermatology competency among PCPs.

[49] Bridges C, Morris C, McElroy JA, Quinn K, Dyer J, Becevic M. Utility of Dermatology Extension for Community Healthcare Outcomes (ECHO) sessions in the adult and paediatric population [published online ahead of print, 2019 Sep 16]. *J Telemed Telecare*. 2019;1357633X19874200. doi:10.1177/1357633X19874200

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Cheung et al (2019) [Pilot Teledermatology Service for Assessing Solitary Skin Lesions in a Tertiary London Dermatology Center](50)

Background: Efficient clinical pathways are needed to meet the growing pressures in dermatology due to the significant rise in the number of suspected skin cancer referrals. Our hospital serves a wide geographical area and receives a large number of 2-week-wait (2WW) suspected skin cancer referrals. In the United Kingdom, approximately 10-12% of 2WW referrals are diagnosed as skin cancers fulfilling the 2WW criteria.

Purpose: We sought to assess the role of teledermatology in reducing hospital consultations for patients referred via the dermatology 2WW pathway.

Methods: We piloted a teledermatology service and detailed the clinical outcomes of patients with solitary skin lesions of uncertain diagnosis triaged through this pathway. Seventy-six primary care referrals were reviewed by consultant dermatologists and analyzed against the British Association of Dermatologists' teledermatology audit standards.

Results: In 52/76 (68%) of patients, confident benign diagnoses were made, avoiding the need for a face-to-face (FTF) consultation.

Conclusions: Our results showed that with adequate image quality, teledermatology can be used to accurately diagnose skin lesions.

Implications: Teledermatology can significantly reduce the number of urgent referrals necessitating FTF appointments, therefore providing a new solution to streamline care delivery.

Coustasse et al (2019) [Use of Teledermatology to Improve Dermatological Access in Rural Areas](51)

Introduction: Dermatological access in rural regions has been impacted due to an acute, global dermatologist shortage coupled with a striking disparity in dermatologist density between urban and rural areas. As a result, the dermatological arena has been under notable pressure to amplify access. Teledermatology has entailed the use of technology to provide dermatological services to individuals located at a remote distance. The purpose of this literature review was to examine the effect of utilization of

[50] Cheung CM, Muttardi K, Chinthapalli S, Ismail F. Pilot Teledermatology Service for Assessing Solitary Skin Lesions in a Tertiary London Dermatology Center. *J Healthc Qual.* 2019;41(1):e1-e6. doi:10.1097/JHQ.0000000000000142

[51] Coustasse A, Sarkar R, Abodunde B, Metzger BJ, Slater CM. Use of Teledermatology to Improve Dermatological Access in Rural Areas. *Telemed J E Health.* 2019;25(11):1022-1032. doi:10.1089/tmj.2018.0130

teledermatology to determine enhancement of dermatological access to residents of rural areas.

Materials and Methods: This review followed a systematic approach and utilized five electronic databases to obtain peer-reviewed journal articles. A PRISMA approach was used and a total of 86 references were employed.

Results: Teledermatology programs have been able to complement conventional dermatological care to enhance dermatological access to rural areas that have suffered from a shortage of dermatologists and could aid in supplementing traditional care as well. Within rural settings, the results of three studies in this review indicated the importance of improved quality for diagnostic precision, whereas one study reported that clinical images might not provide sufficient insight to deliver clear-cut diagnoses. In addition, enhancements in diagnostic precision could be obtained by upgrades in phone cameras to capture images. Finally, to most of the existing literature, in using teledermatology, physician satisfaction has been stronger than patient satisfaction.

Conclusions: Teledermatology has had a beneficial impact in improving dermatological access to rural areas. The success of this technology is contingent upon the commitment and willingness of the dermatologist in utilizing it.

Gamelas et al (2019) [Positive Predictive Value of Melanoma Diagnosis in Store-and-Forward Teledermatology](#)[52]

Background: Although store-and-forward teledermatology (SFT) has demonstrated good diagnostic sensitivity for melanoma, little is known about the diagnostic precision (positive predictive value, PPV).

Introduction: We conducted this investigation to ascertain the PPV of melanoma diagnosis among teledermatology readers.

Materials and Methods: We reviewed teledermatology consultations on 8,706 patients completed during the period February 1, 2015-January 31, 2016. Melanoma was included in the differential diagnosis of 551 conditions. We conducted a chart review of each condition to determine the final diagnosis.

Results: We ascertained a final diagnosis in 503 conditions. Sixty-nine conditions were ultimately diagnosed as melanoma, a PPV of 13.7%. There was considerable variability in PPV among readers. Image quality was associated with higher PPV.

[52] Gemelas J, Capulong D, Lau C, Mata-Diaz S, Raugi GJ. Positive Predictive Value of Melanoma Diagnosis in Store-and-Forward Teledermatology. *Telemed J E Health*. 2019;25(8):701-707. doi:10.1089/tmj.2018.0056

Discussion: Overall, SFT program PPV compared favourably with that found in two published studies of face-to-face dermatology clinic care.
Conclusion: To increase the diagnostic precision of SFT program melanoma diagnosis, efforts should be directed toward improving selected individual reader's PPV and image quality.

Bianchi et al (2019) Dermatologists' perceptions on the utility and limitations of teledermatology after examining 55,000 lesions[53]
Introduction: Few studies have assessed the perception of teledermatologists about the utility and limitations of teledermatology, especially to diagnose a broad range of skin diseases. This study aimed to evaluate dermatologists' confidence in teledermatology, its utility and limitations for dermatological conditions in primary care.
Methods: An analytical study that used a survey for dermatologists who diagnosed 30,916 patients with 55,012 lesions through teledermatology during a 1-year project in São Paulo, Brazil.
Results: Dermatologists found teledermatology useful for triage and diagnosis, especially for xerotic eczema, pigmentary disorders and superficial infections. Their confidence in teledermatology was statistically higher by the end of the project (p = 0.0012). Limitations included some technical issues and the impossibility to suggest how soon the patient should be assisted face-to-face by a dermatologist. The most treatable group of diseases by teledermatology was superficial infections (92%). The use of dermoscopy images would significantly increase the confidence to treat atypical naevi and malign tumours (p < 0.0001 and p = 0.0003 respectively). Follow-ups by teledermatology or feedback from primary-care physicians would be desirable, according to the dermatologists.
Discussion: We found it interesting that dermatologists became increasingly confident in teledermatology after the project and how they classified teledermatology as useful for triage, diagnosis and even treatment of most types of skin conditions followed at primary care. Dermoscopy should definitely be added to the photographs, especially for malignant tumours and atypical naevi. Most of the technical limitations found could be solved with a few improvements in the software/platform.

[53] Giavina Bianchi M, Santos A, Cordioli E. Dermatologists' perceptions on the utility and limitations of teledermatology after examining 55,000 lesions [published online ahead of print, 2019 Aug 14]. *J Telemed Telecare*. 2019;1357633X19864829. doi:10.1177/1357633X19864829

Ikoma et al (2019) Measurement of Nocturnal Scratching in Patients with Pruritus Using a Smartwatch: Initial Clinical Studies with the Itch Tracker App[54]

Three clinical studies were conducted to test a newly-developed app for smartwatches, which included an algorithm to measure nocturnal scratching using acceleration data. The first study in 5 patients with atopic dermatitis demonstrated high reliability of the app for measurement of scratching compared with video monitoring (positive predictive value 90.2 ± 6.6%, sensitivity 84.6 ± 10.2%, correlation of scratching duration per h r = 0.851-0.901, p < 0.001). The second study in 20 patients with atopic dermatitis and 10 healthy volunteers showed that total scratching duration in patients was significantly longer than in healthy volunteers and correlated positively with Eczema Area and Severity Index (EASI) scores. In the third study, conducted in an open-entry manner in which 201 evaluable participants measured nocturnal scratching, those who self-reported itch or pruritic diseases had a significantly longer duration of scratching than those who did not. In conclusion, this app has a high reliability and potential clinical usefulness for measurement of nocturnal scratching.

Koh et al (2019) Consumer Acceptance and Expectations of a Mobile Health Application to Photograph Skin Lesions for Early Detection of Melanoma[55]

Background: Mobile teledermoscopy may facilitate skin self-examinations (SSEs) and further improve monitoring and detection of melanoma.

Objective: To assess consumer acceptability and expectations of a mobile health app used to: 1. instruct SSE; and 2. conduct consumer-performed mobile teledermoscopy.

Methods: People aged 18 years and above were invited to participate in either an online survey or a focus group in Brisbane, Australia. Participants were asked about their SSE practices, mobile teledermoscopy acceptance, and app design and functionality. The online survey responses and focus group discussions were coded by two researchers who conducted thematic analysis.

Results: Four focus groups were held with a total of 28 participants; 88 participants completed the online survey. The mean ages of participants in

[54] Ikoma A, Ebata T, Chantalat L, et al. Measurement of Nocturnal Scratching in Patients with Pruritus Using a Smartwatch: Initial Clinical Studies with the Itch Tracker App. *Acta Derm Venereol.* 2019;99(3):268-273. doi:10.2340/00015555-3105

[55] Koh U, Horsham C, Soyer HP, et al. Consumer Acceptance and Expectations of a Mobile Health Application to Photograph Skin Lesions for Early Detection of Melanoma. *Dermatology.* 2019;235(1):4-10. doi:10.1159/000493728

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the focus group and online survey were 46 and 38 years, respectively. There were more males in the focus groups (61%, 17/28) compared to the online survey (19%, 17/88). Regular SSEs were conducted by 56 (64%) of the online survey participants. Barriers to SSE were forgetfulness (44%), low self-perceived risk of melanoma (25%) and low confidence in conducting SSEs (25%). The large majority of online survey participants (95%) would consider sending photos of their skin lesions to a medical practitioner via an app. Focus group participants reported that they would accept using mobile teledermoscopy; however, they would prefer to use it to monitor lesions between face-to-face consultations.

Conclusions: Overall, participants had positive views on using mobile teledermoscopy to send images of skin lesions to a dermatologist or other medical practitioner.

Marwaha et al (2019) Comparative effectiveness study of face-to-face and teledermatology workflows for diagnosing skin cancer[56]

Background: The effectiveness and value of teledermatology and face-to-face workflows for diagnosing lesions are not adequately understood.

Objective: We compared the risks of biopsy and cancer diagnosis among 2 face-to-face workflows [direct referral and roving dermatologist] and 4 teledermatology workflows.

Methods: Retrospective study of 59,279 primary care patients presenting with a lesion from January through June 2017.

Results: One teledermatology workflow achieved high-resolution images with use of a dermatoscope-fitted digital camera, a picture archiving and communication system, and image retrieval to a large computer monitor in contrast to a smartphone screen. Compared with direct referral, this workflow was associated with a 9% greater probability of cancer detection (95% confidence interval [CI], 2%-16%), a 4% lower probability of biopsy (relative risk, 0.96; 95% CI, 0.93-0.99), and 39% fewer face-to-face visits (relative risk, 0.61; 95% CI, 0.57-0.65). Other workflows were less effective.

Limitations: Differing proficiencies across teledermatology workflows and selection of patients for direct referral could have caused bias.

Conclusion: Implementation is critical to the effectiveness of teledermatology.

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[56] Marwaha SS, Fevrier H, Alexeeff S, et al. Comparative effectiveness study of face-to-face and teledermatology workflows for diagnosing skin cancer. *J Am Acad Dermatol.* 2019;81(5):1099-1106. doi:10.1016/j.jaad.2019.01.067
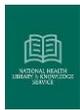
Mehrtens et al (2019) [A 14-year review of a UK teledermatology service: experience of over 40 000 teleconsultations](#)[57]

Background: There is a paucity of published evidence of established teledermatology (TD) services in the UK. An in-house TD service using store-and-forward technology was set up at a large regional dermatology department in 2004.

Aim: To review the TD service at our centre, including teleconsultation numbers, coding of diagnoses and patient outcomes.

Methods: Retrospective data were retrieved using the electronic patient database, from 31 July 2004 to 31 July 2018. More detailed information on patient outcomes was obtained from patient notes and histology records. A paper questionnaire was distributed to 100 patients to obtain patient feedback.

Results: In total, 40 201 teleconsultations were made over 14 years, and 64% of cases were coded (n = 25 555), of which 77% were lesions. The most common coded lesions were benign naevus (25%), seborrhoeic keratosis (22%) and basal cell carcinoma (19%). Of the total number of cases, 50% were discharged to their general practitioner with advice, 34% were booked for surgery and 16% were booked for a face-to-face appointment. In the survey, 82% of patients surveyed felt that the service was 'good' or 'very good'. A detailed study between 1 January 2015 and 1 January 2016 showed that there were 383 patients (10%) with no diagnosis made following teleconsultation, suggesting diagnostic uncertainty. Reasons for this included lack of diagnostic features, possibility of malignancy and service factors. Within this cohort, there was 68% diagnostic concordance.

Conclusions: We have set up a successful TD service at a UK centre, which has prevented 16 282 face-to-face appointments over 14 years. Patient feedback has been very good. Review of cases with diagnostic uncertainty provides important information for service improvement and has not previously been documented.

[57] Mehrtens SH, Shall L, Halpern SM. A 14-year review of a UK teledermatology service: experience of over 40 000 teleconsultations. *Clin Exp Dermatol.* 2019;44(8):874–881. doi:10.1111/ced.13928
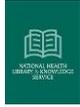
Phillips et al (2019) <u>Assessment of Accuracy of an Artificial Intelligence Algorithm to Detect Melanoma in Images of Skin Lesions</u>[58]

Importance: A high proportion of suspicious pigmented skin lesions referred for investigation are benign. Techniques to improve the accuracy of melanoma diagnoses throughout the patient pathway are needed to reduce the pressure on secondary care and pathology services.

Objective: To determine the accuracy of an artificial intelligence algorithm in identifying melanoma in dermoscopic images of lesions taken with smartphone and digital single-lens reflex (DSLR) cameras.

Design, Setting, and Participants: This prospective, multicenter, single-arm, masked diagnostic trial took place in dermatology and plastic surgery clinics in 7 UK hospitals. Dermoscopic images of suspicious and control skin lesions from 514 patients with at least 1 suspicious pigmented skin lesion scheduled for biopsy were captured on 3 different cameras. Data were collected from January 2017 to July 2018. Clinicians and the Deep Ensemble for Recognition of Malignancy, a deterministic artificial intelligence algorithm trained to identify melanoma in dermoscopic images of pigmented skin lesions using deep learning techniques, assessed the likelihood of melanoma. Initial data analysis was conducted in September 2018; further analysis was conducted from February 2019 to August 2019.

Interventions: Clinician and algorithmic assessment of melanoma.

Main Outcomes and Measures: Area under the receiver operating characteristic curve (AUROC), sensitivity, and specificity of the algorithmic and specialist assessment, determined using histopathology diagnosis as the criterion standard.

Results: The study population of 514 patients included 279 women (55.7%) and 484 white patients (96.8%), with a mean (SD) age of 52.1 (18.6) years. A total of 1550 images of skin lesions were included in the analysis (551 [35.6%] biopsied lesions; 999 [64.4%] control lesions); 286 images (18.6%) were used to train the algorithm, and a further 849 (54.8%) images were missing or unsuitable for analysis. Of the biopsied lesions that were assessed by the algorithm and specialists, 125 (22.7%) were diagnosed as melanoma. Of these, 77 (16.7%) were used for the primary analysis. The algorithm achieved an AUROC of 90.1% (95% CI, 86.3%-94.0%) for biopsied lesions and 95.8% (95% CI, 94.1%-97.6%) for all lesions using iPhone 6s images; an AUROC of 85.8% (95% CI, 81.0%-90.7%) for biopsied lesions and 93.8% (95% CI, 91.4%-

[58] Phillips M, Marsden H, Jaffe W, et al. Assessment of Accuracy of an Artificial Intelligence Algorithm to Detect Melanoma in Images of Skin Lesions [published correction appears in JAMA Netw Open. 2019 Nov 1;2(11):e1916430]. *JAMA Netw Open*. 2019;2(10):e1913436. Published 2019 Oct 2. doi:10.1001/jamanetworkopen.2019.13436

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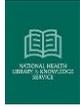
96.2%) for all lesions using Galaxy S6 images; and an AUROC of 86.9% (95% CI, 80.8%-93.0%) for biopsied lesions and 91.8% (95% CI, 87.5%-96.1%) for all lesions using DSLR camera images. At 100% sensitivity, the algorithm achieved a specificity of 64.8% with iPhone 6s images. Specialists achieved an AUROC of 77.8% (95% CI, 72.5%-81.9%) and a specificity of 69.9%. Conclusions and Relevance: In this study, the algorithm demonstrated an ability to identify melanoma from dermoscopic images of selected lesions with an accuracy similar to that of specialists.

Schnitzler et al (2019) [Validation of 'ItchApp©' in Poland and in the USA: multicentre validation study of an electronical diary for the assessment of pruritus](#)[59]

Background: Although chronic pruritus affects a large part of the population, its reliable assessment remains difficult. Electronical diaries are often used in multicentre clinical trials. The ItchApp© for Android was developed to assess itch intensity and course and was validated for the German language in 2017.

Objective: To validate ItchApp© for the use in the Polish and US English languages.

Methods: Fifty-three subjects in Poland and thirty subjects in the USA with chronic pruritus completed the paper-based and app-based questionnaires. These questionnaires contained items for measuring the itch intensity, including a numerical rating scale (NRS) and verbal rating scale (VRS), and for detecting the change of pruritus since the beginning of treatment.

Results: The ItchApp© showed a high level of test-retest reliability [Intraclass correlation, Kappa and Kendall-Tau B coefficients: 0.915-1.000 (Poland) and 0.863-1.000 (USA)]. The convergent validity showed strong correlation between the itch intensity scales on the ItchApp© (Items II-IV = VRS mean, NRS mean and NRS worst) and the paper-based itch intensity scales (mean and worst: VRS, NRS, VAS) [Spearman-Rho and Pearson correlation coefficients: 0.710-0.987 (Poland) and 0.646-0.954 (USA)]. The ItchApp© items moderately correlated with the ItchyQol scores [Spearman-Rho and Pearson correlation coefficients: 0.303-0.554 (Poland) and 0.275-0.447 (USA)]. After completing the ItchApp© questionnaire, a feasibility questionnaire was completed and showed that subjects feel the app is well suited for assessing pruritus.

[59] Schnitzler C, Rosen J, Szepietowski JC, et al. Validation of 'ItchApp©' in Poland and in the USA: multicentre validation study of an electronical diary for the assessment of pruritus. *J Eur Acad Dermatol Venereol.* 2019;33(2):398-404. doi:10.1111/jdv.15300

Conclusion: We provide evidence for the ItchApp© as a validated eDiary for the assessment of pruritus in Polish and US English languages, enabling its use in multicentre international clinical trials.

Seite et al (2019) [Development and accuracy of an artificial intelligence algorithm for acne grading from smartphone photographs](60)
We developed an artificial intelligence algorithm (AIA) for smartphones to determine the severity of facial acne using the GEA scale and to identify different types of acne lesion [comedonal, inflammatory] and postinflammatory hyperpigmentation (PIHP) or residual hyperpigmentation. Overall, 5972 images obtained with smartphones from 1072 acne patients were collected. Three trained dermatologists assessed the acne severity for each patient. One acne severity grade per patient ▯ grade given by the majority of the three dermatologists from the two sets of three images ▯ was used to train the algorithm. Acne lesion identification was performed from a subgroup of 348 images using a tagging tool; tagged images served to train the algorithm. The algorithm evolved and was adjusted for sensibility, specificity and correlation using new images. The correlation between the GEA grade and the quantification and qualification of acne lesions both by the AIA and the experts for each image were evaluated for all AIA versions. At final version 6, the GEA grading provided by AIA reached 68% and was similar to that provided by the dermatologists. Between version 4 and version 6, AIA improved precision results multiplied by 1.5 for inflammatory lesions, 2.5 for non-inflammatory lesions and by 2 for PIHP; recall was improved by 2.6, 1.6 and 2.7. The weighted average of precision and recall or F1 score was 84% for inflammatory lesions, 61% for non-inflammatory lesions and 72% for PIHP.

Singh and Gupta (2019) [Recent advancement in the early detection of melanoma using computerized tools: An image analysis perspectiv](61)
Background: The paper reviews the advancement of tools and current technologies for the detection of melanoma. We discussed several computational strategies from pre- to postprocessing image operations, descriptors, and popular classifiers to diagnose a suspected skin lesion based on its virtual similarity to the malignant lesion with known

60 Seité S, Khammari A, Benzaquen M, Moyal D, Dréno B. Development and accuracy of an artificial intelligence algorithm for acne grading from smartphone photographs. *Exp Dermatol.* 2019;28(11):1252-1257. doi:10.1111/exd.14022
61 Singh N, Gupta SK. Recent advancement in the early detection of melanoma using computerized tools: An image analysis perspective. *Skin Res Technol.* 2019;25(2):129-141. doi:10.1111/srt.12622

histopathology. We reviewed the current state of smart phone-based apps as diagnostic tools for screening.

Methods: A literature survey was conducted using a combination of keywords in the bibliographic databases: PubMed, AJCC, PH2, EDRA, and ISIC melanoma project. A number of melanoma detection apps were downloaded for two major mobile operating systems, iOS and Android; their important uses, key challenges, and various expert opinions were evaluated and also discussed.

Results: We have provided an overview of research on the computer-aided diagnosis methods to estimate melanoma risk and early screening. Dermoscopic images are the most viable option for the advent of new image processing technologies based on which many of the skin cancer detection apps are being developed recently. We have categorized and explored their potential uses, evaluation criteria, limitations, and other details.

Conclusion: Such advancements are helpful in the sense they are raising awareness. Diagnostic accuracy is the major issue of smart phone-based apps and it cannot replace an adequate clinical experience and biopsy procedures.

Von Wangenheim and Nunes (2019) [Creating a Web Infrastructure for the Support of Clinical Protocols and Clinical Management: An Example in Teledermatology](#)[62]

Introduction: We describe a teledermatology infrastructure, implemented as part of a statewide large-scale telemedicine network, designed to provide comprehensive support for examination and clinical management protocols, which includes telediagnostic and patient triage and referral. It was implemented as a web-based system and an associated mobile application that supports both the primary healthcare facility team and the specialist during the patient care process.

Methods: We describe the process models, protocols and technology employed, and the requirements generated for their development. We also present the results and experiences gained in implementing the model. The teledermatology service was implemented in 313 primary healthcare facilities in 286 municipalities in the State of Santa Catarina, Brazil. This study covers the period from January 2014 to June, 2018.

Results: During this period, the teledermatology infrastructure processed 83,100 teledermatology examinations, of which 75,832 were validated and

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[62] von Wangenheim A, Nunes DH. Creating a Web Infrastructure for the Support of Clinical Protocols and Clinical Management: An Example in Teledermatology. *Telemed J E Health*. 2019;25(9):781-790. doi:10.1089/tmj.2018.0197

employed for patient triage and clinical management. Teledermatology allowed 33,112 patients to avoid further referral and be treated locally. Of this cohort, 7,513 patients presented more complex dermatoses that could be treated at the primary care level using telehealth-supported clinical management.

Conclusions: Results indicate that this model contributes not only to the resolution of cases at the primary care level but also to the progressive improvement of the technical quality of dermatological examinations performed by technical staff at the primary healthcare.

Abbott et al (2018) Smartphone use in dermatology for clinical photography and consultation: Current practice and the law[63]

Background: Smartphones are rapidly changing the way doctors capture and communicate clinical information, particularly in highly visual specialties such as dermatology. An understanding of how and why smartphones are currently used in clinical practice is critical in order to evaluate professional and legal risks, and to formulate policies that enable safe use of mobile technologies for the maximal benefit of practitioners and patients.

Methods: Australian dermatologists and dermatology trainees were surveyed on their current practices relating to clinical smartphone use.

Results: Of the 105 respondents, 101 provided useable results. The data show clinical smartphone use is common and frequent, with more than 50% of respondents sending and receiving images on their smartphones at least weekly. Clinical photographs were usually sent via multimedia message or email and were commonly stored on smartphones (46%). Security measures adopted to protect data were limited. There was inadequate documentation of consent for transmission of photographs and advice provided. Only 22% of respondents were aware of clear policies in their workplace regarding smartphone use, and a majority desired further education on digital image management.

Conclusions: In respect of the frequency of use and the degree of importance placed on the ability to send and receive clinical images, clinical smartphone use will persist and will likely increase over time. Current practices are insufficient to comply with professional and legal obligations, and increase practitioners' vulnerability to civil and disciplinary proceedings. Further education, realistic policies and adequate software resources are critical to

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[63] Abbott LM, Magnusson RS, Gibbs E, Smith SD. Smartphone use in dermatology for clinical photography and consultation: Current practice and the law. *Australas J Dermatol*. 2018;59(2):101-107. doi:10.1111/ajd.12583

ensure protection of patients, practitioners and the reputation of the dermatological profession.

Barcaui and Lima (2019) [Application of Teledermoscopy in the Diagnosis of Pigmented Lesions](64)

Background: Dermatology, due to the peculiar characteristic of visual diagnosis, is suitable for the application of modern telemedicine techniques, such as mobile teledermoscopy.

Objectives: To evaluate the feasibility and reliability of the technique for the diagnosis of pigmented lesions.

Methods: Through the storage and routing method, 41 pigmented lesions were analyzed. After the selection of the lesions during the outpatient visit, the clinical and dermatoscopic images were obtained by the resident physician through the cellphone camera and sent to the assistant dermatologist by means of an application for exchange of messages between mobile platforms. Firstly, the assistant dermatologist described the visualized dermatoscopic structures and defined its diagnosis and conduct, based solely on the evaluation of the clinical and dermatoscopic images, without having the knowledge of the anamnesis data. Afterwards, the same assistant dermatologist evaluated the patient face to face, defining the dermatoscopic structures, diagnosis, and conduct. The data obtained through teledermoscopy and face-to-face assessments were compared and accuracy was defined as the concordance between the diagnoses.

Results: A match rate of 90% between teledermoscopic and face-to-face diagnosis was demonstrated; McNemar's statistical analysis, whose p value was 0.1366, showed no evidence to support the inferiority of the teledermoscopic method.

Brinker et al (2015) [Teledermatology: Comparison of Store-and-Forward Versus Live Interactive Video Conferencing](65)

A decreasing number of dermatologists and an increasing number of patients in Western countries have led to a relative lack of clinicians providing expert dermatologic care. This, in turn, has prolonged wait times for patients to be examined, putting them at risk. Store-and-forward teledermatology improves patient access to dermatologists through asynchronous consultations, reducing wait times to obtain a consultation.

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[64] Barcaui CB, Lima PMO. Application of Teledermoscopy in the Diagnosis of Pigmented Lesions. *Int J Telemed Appl.* 2018;2018:1624073. Published 2018 Oct 10. doi:10.1155/2018/1624073

[65] Brinker TJ, Hekler A, von Kalle C, et al. Teledermatology: Comparison of Store-and-Forward Versus Live Interactive Video Conferencing. *J Med Internet Res.* 2018;20(10):e11871. Published 2018 Oct 24. doi:10.2196/11871

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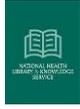
However, live video conferencing as a synchronous service is also frequently used by practitioners because it allows immediate interaction between patient and physician. This raises the question of which of the two approaches is superior in terms of quality of care and convenience. There are pros and cons for each in terms of technical requirements and features. This viewpoint compares the two techniques based on a literature review and a clinical perspective to help dermatologists assess the value of teledermatology and determine which techniques would be valuable in their practice.

Dahlen Gyllencreutz et al (2018) [Teledermoscopy images acquired in primary health care and hospital settings - a comparative study of image quality](66)

Background: The incidence of melanoma and non-melanoma skin cancer is increasing, which has also lead to an increase in referrals between primary health care (PHC) and dermatology departments, putting a strain on healthcare services. Teledermoscopy (TDS) referrals from PHC can improve the triage process for patients with suspicious skin tumours, but the quality of the images included could potentially affect its usefulness.

Objective: To critically appraise the quality of the dermoscopic images of a smartphone TDS system, by comparing the TDS referral images with images of the same tumours acquired at the department of dermatology.

Methods: Two dermatologists rated the image quality of two image sets from 172 skin tumours separately. The dermatologists also decided on a main diagnosis, differential diagnoses and described the visible dermoscopic structures.

Results: The images acquired in PHC were rated as having slightly lower quality, but there was no significant difference. PHC images and dermatology images were of intermediate-to-high quality in 95.5%-97.7% and 96.5%-98.8%, respectively. There was no difference in agreement between the TDS diagnosis based on the two image sets with the final clinical or histopathological diagnosis. Most image pairs (81.4% and 83.7%) received the same main diagnosis by the two evaluators. When this was not the case, the most common reasons were poor focus, excessive pressure applied when acquiring the image or inadequate amount of zoom.

66 Dahlén Gyllencreutz J, Johansson Backman E, Terstappen K, Paoli J. Teledermoscopy images acquired in primary health care and hospital settings - a comparative study of image quality. *J Eur Acad Dermatol Venereol*. 2018;32(6):1038-1043. doi:10.1111/jdv.14565

Conclusion: TDS performed in PHC with a smartphone-based system does not seem to negatively affect the usefulness of TDS referrals. Thus, physicians at PHC do not necessarily need to be trained photographers to ensure adequate TDS image quality. Knowledge about technical difficulties could however be used when training PHC staff, to improve the image quality further.

Lee and English (2018) [Teledermatology: A Review and Update](#)[67]
Telemedicine is slowly transforming the way in which healthcare is delivered and has the potential to improve access to subspecialty expertise, reduce healthcare costs, and improve the overall quality of care. While many subspecialty fields within medicine today have either experimented with or begun to implement telemedicine platforms to enable remote consultation and care, dermatology is particularly suited for this care system as skin disorders are uniquely visible to the human eye. Through teledermatology, diagnostic images of skin disorders with accompanying clinical histories can be remotely reviewed by teledermatologists by any number of modalities, such as photographic clinical images or live video teleconferencing. Diagnoses and treatment recommendations can then be rendered and implemented remotely. The evidence to date supports both its diagnostic and treatment accuracy and its cost effectiveness. Administrative, regulatory, privacy, and reimbursement policies surrounding this dynamic field continue to evolve. In this review, we examine the history, evidence, and administrative landscape surrounding teledermatology and discuss current practice guidelines and ongoing controversies.

Singer et al (2018) [Using Network Oriented Research Assistant (NORA) Technology to Compare Digital Photographic With In-Person Assessment of Acne Vulgaris](#)[68]
Importance: Teledermatology has undergone exponential growth in the past 2 decades. Many technological innovations are becoming available without necessarily undergoing validation studies for specific dermatologic applications.
Objective: To determine whether patient-taken photographs of acne using Network Oriented Research Assistant (NORA) result in similar lesion counts

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[67] Lee JJ, English JC 3rd. Teledermatology: A Review and Update. *Am J Clin Dermatol.* 2018;19(2):253-260. doi:10.1007/s40257-017-0317-6
[68] Singer HM, Almazan T, Craft N, et al. Using Network Oriented Research Assistant (NORA) Technology to Compare Digital Photographic With In-Person Assessment of Acne Vulgaris. *JAMA Dermatol.* 2018;154(2):188-190. doi:10.1001/jamadermatol.2017.5141

and Investigator's Global Assessment (IGA) findings compared with in-person examination findings.

Design, Setting, and Participants: This pilot reliability study enrolled consecutive patients with acne vulgaris from a single general dermatology practice in Los Angeles, California, who were able to use NORA on an iPhone 6 to take self-photographs. Patients were enrolled from January 1 through March 31, 2016. Each individual underwent in-person and digital evaluation of his or her acne by the same dermatologist. A period of at least 1 week separated the in-person and digital assessments of acne.

Interventions: All participants were trained on how to use NORA on the iPhone 6 and take photographs of their face with the rear-facing camera.

Main outcomes and measures: Reliability of patient-taken photographs with NORA for acne evaluation compared with in-person examination findings. Acne assessment measures included lesion count [total, inflammatory, noninflammatory, and cystic] and IGA for acne severity.

Results: A total of 69 patients (37 male [54%] and 32 female [46%]; mean [SD] age, 22.7 [7.7] years) enrolled in the study. The intraclass correlation coefficients of in-person and photograph-based acne evaluations indicated strong agreement. The intraclass correlation coefficient for total lesion count was 0.81; for the IGA, 0.75. Inflammatory lesion count, noninflammatory lesion count, and cyst count had intraclass correlation coefficients of 0.72, 0.72, and 0.82, respectively.

Conclusions and Relevance: This study found agreement between acne evaluations performed in person and from self-photographs with NORA. As a reliable telehealth technology for acne, NORA can be used as a teledermatology platform for dermatology research and can increase access to dermatologic care.

Trettel et al (2018) [**Telemedicine in dermatology: findings and experiences worldwide - a systematic literature review**](#)[69]
Telemedicine has become an important element of health care in many countries and profited from the technological progress of the last two decades. Due to the visual character of the dermatological specialty, teledermatology in particular participated in that development and is becoming a major tool in dermatological consultation. The objective of this article was to identify the use of teledermatology across the world based on published original articles. A systematic literature search of the MEDLINE

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[69] Trettel A, Eissing L, Augustin M. Telemedicine in dermatology: findings and experiences worldwide - a systematic literature review. *J Eur Acad Dermatol Venereol.* 2018;32(2):215-224. doi:10.1111/jdv.14341
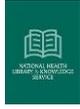
and Embase databases for eligible publications with predefined inclusion and exclusion criteria, and a cross-validation search were conducted. Search results were reviewed systematically. The search resulted in 204 publications meeting the inclusion criteria for analysis. The highest number of published studies on teledermatology was performed in the United States, followed by the United Kingdom, Spain, the Netherlands, Italy and Austria. The majority of dermatological indications for telemedical consultations were not specified or included various kinds of skin diseases, followed by skin cancer and wounds. Research questions predominantly focused on concordance, effectiveness and cost-effectiveness to determine the value. Teledermatology proved to be a reliable consultation tool in the majority of studies. If specified, telemedicine was used in daily dermatological routine for patient management purposes, to consult patients in peripheral locations, or for medical support in nursing homes or home care settings. The application of teledermatology worldwide is highest in North American and European countries, while countries with poor geographical distribution of physicians seem to be under-represented in teledermatological use, as concluded from publication output. Regarding indications, comparison with classic consultation and area of application, most studies were of general nature. For precise determination of the value, systematic studies would be needed. However, teledermatology is already accepted as a valid tool.

Walter et al (2018) [A Teledermatology Scale-Up Framework and Roadmap for Sustainable Scaling: Evidence-Based Development](#)[70]
Background: The objectives of South Africa's electronic health strategy recognize the value proposition that telemedicine practices hold for rural and urban referrals, but a lack of accepted and formalized scale-up has impeded realization of benefits. While both synchronous and asynchronous teledermatology exist, these remain localized and not scaled-up. Skin pathology is often the first sign of an HIV/AIDS infection, which remains a major cause of morbidity and mortality in South Africa. It is essential to replace the current inefficient dermatology referral process with a swift, organized, and efficacious one.
Objective: The objective of this study is to present an evidenced-based teledermatology scale-up framework (TDSF) and implementation roadmap (TDSF-IR).

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[70]Walters LEM, Scott RE, Mars M. A Teledermatology Scale-Up Framework and Roadmap for Sustainable Scaling: Evidence-Based Development. *J Med Internet Res*. 2018;20(6):e224. Published 2018 Jun 20. doi:10.2196/jmir.9940

Methods: A qualitative method with a design science research process model was used which consisted of 5 phases: 1. awareness, which confirmed the need for an evidence-based TDSF and supporting TDSF-IR; 2. suggestion, where a proposal was delivered on how to develop a TDSF and TDSF-IR; 3. development, where we identified recommended design requirements and used these to identify and critique existing teledermatology or related scale-up frameworks; 4. evaluation and validation, where we assessed outputs of the development phase against the design requirements and validated by confirming the veracity of the TDSF and TDSF-IR [validation involved 4 key senior teledermatology stakeholders using a questionnaire with a 5-point Likert scale]; and 5. conclusion, where validation results were used to finalize and communicate the TDSF and TDSF-IR to users.

Results: The study identified 5 TDSF components: eHealth building blocks, eHealth strategic objectives and budget, scale-up continuum periods, scale-up drivers, and scale-up phases. In addition, 36 subcomponents were identified. Each was further characterized and described to enable design of the final evidence-based TDSF. An implementation roadmap (TDSF-IR) was also prepared as a guide for an implementer with step-by-step instructions for application of the TDSF. For the validation study of the TDSF and supporting TDSF-IR, 4 purposively selected key senior teledermatology management stakeholders were asked if they found it useful as a guide to assist the South African public health system with teledermatology scale-up. The mean (SD) of Likert-scale rating was 4.0 (0.53) where 4=Agree and 33 of 36 responses were either agree or strongly agree.

Conclusions: This study developed a TDSF and supporting roadmap (TDSF-IR) that are evidence-based. The proposed approach and described tools could be adapted to assist with ensuring scale-up and sustainability for other eHealth practices in other locations.

Altieri et al (2017) Interobserver reliability of teledermatology across all Fitzpatrick skin types[71]
Introduction: Demand for dermatologic services in safety net hospitals, which disproportionately serve patients with darker coloured skin, is growing. Teledermatology has the potential to increase access and improve outcomes, but studies have yet to demonstrate the reliability of teledermatology for all Fitzpatrick skin types. Methods: We assessed the reliability of teledermatologists' diagnoses and management

[71] Altieri L, Hu J, Nguyen A, et al. Interobserver reliability of teledermatology across all Fitzpatrick skin types. *J Telemed Telecare*. 2017;23(1):68-73. doi:10.1177/1357633X15621226

recommendations for store-and-forward teledermatology in patients with lightly pigmented (Fitzpatrick skin types I-III) versus darkly pigmented (Fitzpatrick skin types IV-VI) skin, when compared to in-person diagnosis and management decisions. This prospective study enrolled 232 adult patients, presenting with new, visible skin complaints in a Los Angeles county dermatology clinic. Forty-seven percent of patients were Fitzpatrick skin types I-III, and 53% were Fitzpatrick skin types IV-VI. Results: Percent concordance for the identical primary diagnosis was 53.2% in lighter (Fitzpatrick I-III) skin types and 56.0% in darker (Fitzpatrick IV-VI) skin types. There was no statistically significant difference in concordance rates between lighter and darker skin types for primary diagnosis. Concordance rates for diagnostic testing, clinic-based therapy, and treatments were similar in both groups of Fitzpatrick skin types. Discussion: These results suggest that teledermatology is reliable for the diagnosis and management of patients with all Fitzpatrick skin types.

Ariens et al (2017) [Barriers and Facilitators to eHealth Use in Daily Practice: Perspectives of Patients and Professionals in Dermatology](#)[72]
Background: The number of eHealth interventions in the management of chronic diseases such as atopic dermatitis (AD) is growing. Despite promising results, the implementation and use of these interventions is limited.
Objectives: This study aimed to assess opinions of the most important stakeholders influencing the implementation and use of eHealth services in daily dermatology practice.
Methods: The perspectives of health care professionals and patients towards the implementation and use of eHealth services in daily practice were assessed by using a mixed method design. A cross-sectional survey based on the eHealth implementation toolkit (eHit) was conducted to explore factors influencing the adoption of eHealth interventions offering the possibility of e-consultations, Web-based monitoring, and Web-based self-management training among dermatologists and dermatology nurses. The perspectives of patients with atopic dermatitis (AD) regarding the use of eHealth services were discussed in an online focus group.
Results: Health care professionals (n=99) and patients (n=9) acknowledged the value of eHealth services and were willing to use these digital tools in

daily dermatology practice. Key identified barriers ⬚ statements with <50% of the participants scoring totally agree or agree ⬚ in the implementation and adoption of eHealth interventions included concerns about the availability (12/99, 12%) and allocation (14/99, 14%) of resources, financial aspects (26/99, 26%), reliability, security, and confidentially of the intervention itself (29/99, 29%), and the lack of education and training (6/99, 6%). Conclusions: Health care professionals and patients acknowledge the benefits arising from the implementation and use of eHealth services in daily dermatology practice. However, some important barriers were identified that might be useful in addressing the implementation strategy in order to enhance the implementation success of eHealth interventions in dermatology.

Boissin et al (2017) [Image-based teleconsultation using smartphones or tablets: qualitative assessment of medical experts](#)[73]

Background: Mobile health has promising potential in improving healthcare delivery by facilitating access to expert advice. Enabling experts to review images on their smartphone or tablet may save valuable time. This study aims at assessing whether images viewed by medical specialists on handheld devices such as smartphones and tablets are perceived to be of comparable quality as when viewed on a computer screen.
Methods: This was a prospective study comparing the perceived quality of 18 images on three different display devices ⬚ smartphone, tablet and computer ⬚ by 27 participants (4 burn surgeons and 23 emergency medicine specialists). The images, presented in random order, covered clinical ⬚ dermatological conditions, burns, electrocardiographs and X-rays ⬚ and non-clinical subjects and their perceived quality was assessed using a 7-point Likert scale. Differences in devices' quality ratings were analysed using linear regression models for clustered data adjusting for image type and participants' characteristics: age, gender and medical specialty.
Results: Overall, the images were rated good or very good in most instances and more so for the smartphone (83.1%, mean score 5.7) and tablet (78.2%, mean 5.5) than for a standard computer (70.6%, mean 5.2). Both handheld devices had significantly higher ratings than the computer screen, even after controlling for image type and participants' characteristics. Nearly all

[73] Boissin C, Blom L, Wallis L, Laflamme L. Image-based teleconsultation using smartphones or tablets: qualitative assessment of medical experts. *Emerg Med J.* 2017;34(2):95-99. doi:10.1136/emermed-2015-205258

experts expressed that they would be comfortable using smartphones (n=25) or tablets (n=26) for image-based teleconsultation.
Conclusion: This study suggests that handheld devices could be a substitute for computer screens for teleconsultation by physicians working in emergency settings.

Chao et al (2017) Smartphone-Based Applications for Skin Monitoring and Melanoma Detection[74]

With the advancement of mobile technologies, smartphone applications have become widely available and gained increasing attention as a novel tool to deliver dermatologic care. This article presents a review of various apps for skin monitoring and melanoma detection and a discussion of current limitations in the field of dermatology. Concerns regarding quality, transparency, and reliability have emerged because there are currently no established quality standards or regulatory oversight of mobile medical apps. Only a few apps have been evaluated clinically. Further research is needed to evaluate the utility and efficacy of smartphone apps in skin cancer screening and early melanoma detection.

Creighton-Smith et al (2017) Incidence of melanoma and keratinocytic carcinomas in patients evaluated by store-and-forward teledermatology vs. dermatology clinic[75]

Background: It is unclear whether incidence of detected skin cancer in patients evaluated by store-and-forward teledermatology (SAF) vs. face-to-face consultation (F2F) significantly differs, and whether such differences are because of variations in patient demographics, diagnostic accuracy, or both.
Methods: This retrospective cohort study compares patient skin cancer risk profile, pre-post biopsy diagnostic accuracy, and detection rates of any skin cancer, melanoma, and keratinocytic carcinoma between all SAF teledermatology patients and a subset of randomly selected F2F consultations at VA-Boston Healthcare System in 2014.
Results: Patients in the teledermatology (n = 434) and F2F visit cohorts (n = 587) had similar baseline demographics except a higher proportion of F2F patients had prior history of skin cancer, 22% (131/587) vs. 10% (45/434), P <

[74] Chao E, Meenan CK, Ferris LK. Smartphone-Based Applications for Skin Monitoring and Melanoma Detection. *Dermatol Clin.* 2017;35(4):551-557. doi:10.1016/j.det.2017.06.014

[75] Creighton-Smith M, Murgia RD 3rd, Konnikov N, Dornelles A, Garber C, Nguyen BT. Incidence of melanoma and keratinocytic carcinomas in patients evaluated by store-and-forward teledermatology vs. dermatology clinic. *Int J Dermatol.* 2017;56(10):1026-1031. doi:10.1111/ijd.13672

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0.001, and received biopsies, 27.2% (160/587) vs. 11.5% (50/434), P < 0.001. When adjusted for age, immunosuppression, and personal and family history of skin cancer, there were no significant differences between the two cohorts in detection rates for any skin cancer (9.5% vs. 5.8%, P = 0.3), melanoma (0.6% vs. 0%, P = N/A), or keratinocytic carcinoma (8.5% vs. 5.5%, P = 0.7). The two cohorts also had similar pre-post biopsy perfect diagnostic concordance, time from initial consult request to biopsy (45.5 d vs. 47.3 d, P = 0.8), and time from biopsy to definitive treatment (67.5 d vs. 65.4 d, P = 0.8). Conclusion: F2F patients were more likely to have prior history of skin cancer and receive biopsies. When adjusted for presence of skin cancer risk factors, incidence of detected melanoma, keratinocytic carcinoma, and any skin cancer was similar between SAF teledermatology and F2F patients.

Dahlen Gyllencreutz et al (2018) [Diagnostic agreement and interobserver concordance with teledermoscopy referrals](#)[76]
Background: Malignant melanoma and non-melanoma skin cancers are among the fastest increasing malignancies in many countries. With the help of new tools, such as teledermoscopy referrals between primary health care and dermatology clinics, the management of these patients could be made more efficient.
Objective: To evaluate the diagnostic agreement and interobserver concordance achieved when assessing referrals sent through a mobile teledermoscopic referral system as compared to referrals sent via the current paper-based system without images.
Methods: The referral information from 80 teledermoscopy referrals and 77 paper referrals were evaluated by six Swedish dermatologists. They were asked to answer questions about the probable diagnosis, the priority, and a management decision.
Results: Teledermoscopy generally resulted in higher diagnostic agreement, better triaging and more malignant tumours being booked directly to surgery. The largest difference between the referral methods was seen for invasive melanomas. Referrals for benign lesions were significantly more often correctly resent to primary health care with teledermoscopy. However, referrals for cases of melanoma in situ were also incorrectly resent five times. The interobserver concordance was moderate with both methods.
Conclusion: By adding clinical and dermoscopic images to referrals, the triage process for both benign and dangerous skin tumours can be improved.

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[76] Dahlén Gyllencreutz J, Paoli J, Bjellerup M, et al. Diagnostic agreement and interobserver concordance with teledermoscopy referrals. *J Eur Acad Dermatol Venereol.* 2017;31(5):898-903. doi:10.1111/jdv.14147

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With teledermoscopy, patients with melanoma especially can receive treatment more swiftly.

Dugonik et al (2017) [e-Derma - a Novel Wireless Dermatoscopy System](#)[77]
Cutaneous Melanoma (CM) is a malignant tumour, and is one of the most rapidly growing cancers. Discovering a melanoma in the early stages of the disease is extremely difficult and, as such, only an invasive disease stage can be identified easily with the naked eye. Dermatoscopy is a diagnostic method intended to maximise early detection of CM performed by the dermatoscopy system. To address the limitations of existing systems a novel, wireless digital dermatoscopy system is presented for providing high-resolution images. It integrates a wire-free camera operation and offers a safe transfer of captured images to the computer. The working process of available dermatoscopy systems was studied, which are the most commonly used in everyday dermatology practice. Some findings such as operability, image quality, scalability, user-friendliness, and safeness were used for the development of an e-Derma dermatoscopy system. An assessment method was performed by a group of dermatoscopy trained dermatologists to evaluate the quality of the testing images. Finally, a laboratory evaluation of images in regard to different parameters such as sharpness, colour representation and illumination was performed with the side-by-side comparison of images of available dermatoscopy systems. e-Derma is a novel dermatoscopy system, which eliminates some limitations of existing systems and provides high-quality images. A novel low-budget highly capable dermatoscopy system is presented. The integrated wireless image transfer technology eliminates the movement limitations of a therapist. The image resolution is not limited by the integrated camera; it is easily upgradable with a wide range of on market alternative or improved camera models.

Finnane et al (2017) [Proposed Technical Guidelines for the Acquisition of Clinical Images of Skin-Related Conditions](#)[78]
Importance: Standardizing dermatological imaging is important to improve monitoring of skin lesions and skin conditions, ensure the availability of high-

[77] Dugonik B, Dugonik A, Horvat D, Žalik B, Špelič D. e-Derma - a Novel Wireless Dermatoscopy System. *J Med Syst*. 2017;41(12):205. Published 2017 Nov 11. doi:10.1007/s10916-017-0849-6

[78] Finnane A, Curiel-Lewandrowski C, Wimberley G, et al. Proposed Technical Guidelines for the Acquisition of Clinical Images of Skin-Related Conditions. *JAMA Dermatol*. 2017;153(5):453-457. doi:10.1001/jamadermatol.2016.6214

quality images for teledermatology, and contribute to the development of a robust archive of skin images to be used for research.

Objective: To provide guidelines for the clinical application of the Standards for Dermatological Imaging set forward by the ISIC.

Evidence Review: The ISIC recommendations were developed through a hybrid Delphi methodology. The methods for achieving consensus have been described previously. The practical application of these recommendations was evaluated by 2 clinical photographers with expertise in skin imaging. Images corresponding to each recommendation were taken by a clinical photographer and provided as visual examples of how these recommendations can be implemented in clinical practice.

Results: The Standards for Dermatological Imaging developed by the ISIC members could be followed in the clinical setting. Images showing appropriate lighting, background color, field of view, image orientation, focus and depth of field, resolution, and scale and color calibration were obtained by the clinical photographer, by following the detailed recommendations for regional, close-up and dermoscopic images.

Conclusions and Relevance: Adhering to the recommendations is both feasible and achievable in practice. Adopting these Standards is the first step in achieving international standardization of skin imaging, with the potential to improve clinical outcomes and research activities.

Foolad et al (2017) International inter-rater agreement in scoring acne severity utilizing cloud-based image sharing of mobile phone photographs[79]

Background: Cloud-based image sharing technology allows facilitated sharing of images. Cloud-based image sharing technology has not been well-studied for acne assessments or treatment preferences, among international evaluators. We evaluated inter-rater variability of acne grading and treatment recommendations among an international group of dermatologists that assessed photographs.

Methods: This is a prospective, single visit photographic study to assess inter-rater agreement of acne photographs shared through an integrated mobile device, cloud-based, and HIPAA-compliant platform. Inter-rater agreements for global acne assessment and acne lesion counts were evaluated by the Kendall's coefficient of concordance while correlations

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[79] Foolad N, Ornelas JN, Clark AK, et al. International inter-rater agreement in scoring acne severity utilizing cloud-based image sharing of mobile phone photographs. *Int J Dermatol.* 2017;56(9):920-925. doi:10.1111/ijd.13621

between treatment recommendations and acne severity were calculated by Spearman's rank correlation coefficient.

Results: There was good agreement for the evaluation of inflammatory lesions (KCC = 0.62, P < 0.0001), noninflammatory lesions (KCC = 0.62, P < 0.0001), and the global acne grading system score (KCC = 0.69, P < 0.0001). Topical retinoid, oral antibiotic, and isotretinoin treatment preferences correlated with photographic based acne severity.

Conclusions: Our study supports the use of mobile phone based photography and cloud-based image sharing for acne assessment. Cloud-based sharing may facilitate acne care and research among international collaborators.

Grey et al (2017) Utility of Store and Forward Teledermatology for Skin Patch Test Readings[80]

Background: Teledermatology (TD) is the use of imaging technology to provide dermatology services at a distance. To date, studies assessing its application for grading skin patch test reactions have been lacking.

Objectives: The aim was to compare conventional, in-person (IP) grading of skin patch test reactions with store-forward TD.

Methods: Patients undergoing patch testing to the North American Contact Dermatitis Group (NACDG) screening series were invited to participate in this repeated-measures study. Photographs of the NACDG screening series patch sites were obtained at 2 time points: 48-hour and final readings. Teledermatology assessments were completed by the same staff dermatologist who performed the IP readings; 48-hour and final TD photographs were viewed at weeks 4 and 8 after the IP encounter, respectively, to prevent recall bias. Staff dermatologists were blinded to IP grading results. The main outcome was percent agreement. Eight categories of agreement were created according to possible pairings of TD and IP reading results. Three final outcome groups of success, indeterminate and failure were defined based on clinical significance.

Results: One hundred one participants completed the study. There were 7070 comparison points between IP and TD final readings. Excluding negative/negative agreement, there was success of TD in 54% of final readings. Indeterminate agreement with possible clinical significance was present in 40% of final readings. There was failure [definite clinical significance] in 6% of final readings.

[80] Grey KR, Hagen SL, Hylwa SA, Warshaw EM. Utility of Store and Forward Teledermatology for Skin Patch Test Readings. *Dermatitis*. 2017;28(2):152-161. doi:10.1097/DER.0000000000000258

Conclusions: Teledermatology may be a viable option for grading skin patch test reactions, particularly for clinicians who perform limited patch testing. However, a clinically significant "failure" rate of 6% and practical barriers to TD implementation may preclude its widespread use for skin patch testing in tertiary referral centers where large numbers of patches are tested per patient.

Marchell et al (2017) [Comparing High Definition Live Interactive and Store-and-Forward Consultations to In-Person Examinations](81)

Background: There is little teledermatology research directly comparing remote methods, even less research with two in-person dermatologist agreement providing a baseline for comparing remote methods, and no research using high definition video as a live interactive method.

Objective: To compare in-person consultations with store-and-forward and live interactive methods, the latter having two levels of image quality.

Methods: A controlled study was conducted where patients were examined in-person, by high definition video, and by store-and-forward methods. The order patients experienced methods and residents assigned methods rotated, although an attending always saw patients in-person. The type of high definition video employed, lower resolution compressed or higher resolution uncompressed, was alternated between clinics. Primary and differential diagnoses, biopsy recommendations, and diagnostic and biopsy confidence ratings were recorded.

Results: Concordance and confidence were significantly better for in-person versus remote methods and biopsy recommendations were lower. Store-and-forward and higher resolution uncompressed video results were similar and better than those for lower resolution compressed video.

Limitations: Dermatology residents took store-and-forward photos and their quality was likely superior to those normally taken in practice. There were variations in expertise between the attending and second and third year residents.

Conclusion: The superiority of in-person consultations suggests the tendencies to order more biopsies or still see patients in-person are often justified in teledermatology and that high resolution uncompressed video can close the resolution gap between store-and-forward and live interactive methods.

[81] Marchell R, Locatis C, Burges G, Maisiak R, Liu WL, Ackerman M. Comparing High Definition Live Interactive and Store-and-Forward Consultations to In-Person Examinations. *Telemed J E Health*. 2017;23(3):213-218. doi:10.1089/tmj.2016.0093

Marchell et al (2017) Patient and Provider Satisfaction with Teledermatology[82]

Background: There is little research comparing dermatologist and patient satisfaction with in-person, store-and-forward, and live interactive examinations.

Objective: To compare satisfaction with in-person examinations to store-and-forward and live interactive consultations having two types of video.

Methods: A controlled study was conducted where patients referred for dermatology consultations were examined in-person, by video, and by store-and-forward methods. Video changed between compressed and uncompressed on alternate clinics. Patients and dermatologists rated encounters after each examination. Dermatologists doing store-and-forward evaluations rated the quality of information provided. After experiencing all methods patients ranked their preferences. Dermatologists ranked their preferences at the end of the study.

Results: In-person examinations were preferred by both patients and dermatologists. Overall, satisfaction with teledermatology was still high. Patients were evenly divided in preferring store-and-forward workups or live interactive video. Dermatologists were also divided on store-and-forward and uncompressed video, but tended toward the latter. Compressed video was the least preferred method among dermatologists.

Limitations: Dermatology residents took store-and-forward photos and their quality was likely superior to those normally taken in practice.

Conclusions: Patients and dermatologists prefer in-person examinations and diverge on preferring store-and-forward and live interactive when video is not compressed. The amount of video compression that can be applied without noticeable image degradation is a question for future research.

Markun et al (2017) Mobile teledermatology for skin cancer screening: A diagnostic accuracy study[83]

Skin cancer screening has undoubted potential to reduce cancer-specific morbidity and mortality. Total-body exams remain the prevailing concept of skin cancer screening even if effectiveness and value of this method are controversial. Meanwhile, store and forward teledermatology was shown to be a reliable instrument for several diagnostic purposes mostly in specialized dermatology settings. The objective of this study was to evaluate

[82] Marchell R, Locatis C, Burgess G, Maisiak R, Liu WL, Ackerman M. Patient and Provider Satisfaction with Teledermatology. _Telemed J E Health_. 2017;23(8):684-690. doi:10.1089/tmj.2016.0192

[83] Markun S, Scherz N, Rosemann T, Tandjung R, Braun RP. Mobile teledermatology for skin cancer screening: A diagnostic accuracy study. _Medicine (Baltimore)_. 2017;96(10):e6278. doi:10.1097/MD.0000000000006278

most convenient mobile teledermatology interventions as instruments for skin cancer screening in a representative population. Prospective diagnostic study with visitors of a skin cancer screening campaign in Switzerland. Histopathology was used as reference standard. Mobile teledermatology with or without dermoscopic images was assessed for performance as a screening test: ie rule-in or rule-out the need for further testing. Outcomes were sensitivity, specificity, and predictive values.Seven cases of skin cancer were present among 195 skin lesions. All skin cancers were ruled-in by teledermatology with or without dermoscopic images (sensitivity and negative predictive value 100%). The addition of dermoscopic images to conventional images resulted in higher specificity (85% vs. 77%), allowing reduction of unnecessary further testing in a larger proportion of skin lesions. Store and forward mobile teledermatology could serve as an instrument for population-based skin cancer screening because of favorable test performance.

O'Toole et al (2017) [The association between question type and the outcomes of a Dermatology eConsult service](#)[84]

Background: eConsult is a web based service that facilitates communication between primary care providers (PCPs) and specialists, which can reduce the need for face-to-face consultations with specialists. One example is the Champlain BASE (Building Access to Specialist through eConsultation) service with dermatology being the largest specialty consulted.

Methods: Dermatology eConsults submitted from July 2011 to January 2015 were reviewed. Post eConsult surveys for PCPs were analyzed to determine the number of traditional consults avoided and perceived value of eConsults. The time it took the PCP to receive a reply and the amount of time reported by the specialist to answer eConsult were proactively recorded and analyzed. A subset of 154 most recent eConsults was categorized for dermatology content and question type [eg diagnosis or management] using a validated taxonomy.

Results: A total of 965 eConsults were directed to dermatology from 217 unique PCPs. The majority of eConsults (64%) took the specialist between 10 and 15 minutes to answer. The overall value of this service to the provider was rated as very good or excellent in 95% of cases. In 49%, traditional in-person assessments were avoided. In the subset of the most recent cases,

84 O'Toole A, Joo J, DesGroseilliers JP, et al. The association between question type and the outcomes of a Dermatology eConsult service. *Int J Dermatol.* 2017;56(8):836–841. doi:10.1111/ijd.13628
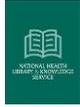
diagnosis was the most common question type asked (65.2%) followed by management (29%) and drug treatment (10.6%). The top five subject areas (40%) were: Dermatitis, Infections, Neoplasm, Nevi, and Pruritus. Conclusion: eConsults was feasible and well received by PCPs, which improves access to dermatology care with a potential to reduce wait times for traditional consultation.

Wang et al (2017) [Diagnosis and Management of Malignant Melanoma in Store-and-Forward Teledermatolog](85)

Background: Published studies have led to concern that store-and-forward teledermatology (SFT) diagnosis and management of melanomas may be inferior to face-to-face (FTF) dermatology care.

Introduction: To ascertain the frequency of correctly managed and diagnosed melanomas within a population of veterans in Veterans Integrated Service Network 20 SFT.

Materials and methods: We conducted a retrospective chart review of 7,960 veterans seen by SFT between July 1, 2009 and December 31, 2011.

Results: Of the 61 veterans that met inclusion and exclusion criteria, 45 (74%) melanomas were correctly diagnosed and 57 (93%) were correctly managed.

Discussion: Diagnostic and management accuracy of SFT is comparable to FTF. Incorrect diagnosis or management of melanomas did not prove to have significant consequences for patient care. Cases subject to analysis of this study are not demographically representative of the general population.

Conclusion: Diagnosis and management of melanoma in SFT is comparable to FTF care.

Witkowski et al (2017) [Improving diagnostic sensitivity of combined dermoscopy and reflectance confocal microscopy imaging through double reader concordance evaluation in telemedicine settings: A retrospective study of 1000 equivocal cases](86)

Background: Reflectance confocal microscopy (RCM) is an imaging device that permits non-invasive visualization of cellular morphology and has been shown to improve diagnostic accuracy of dermoscopically equivocal cutaneous lesions. The application of double reader concordance evaluation

85 Wang M, Gendreau JL, Gemelas J, et al. Diagnosis and Management of Malignant Melanoma in Store-and-Forward Teledermatology. *Telemed J E Health*. 2017;23(11):877-880. doi:10.1089/tmj.2017.0009

86 Witkowski AM, Łudzik J, Arginelli F, et al. Improving diagnostic sensitivity of combined dermoscopy and reflectance confocal microscopy imaging through double reader concordance evaluation in telemedicine settings: A retrospective study of 1000 equivocal cases. *PLoS One*. 2017;12(11):e0187748. Published 2017 Nov 9. doi:10.1371/journal.pone.0187748

of dermoscopy-RCM image sets in retrospective settings and its potential application to telemedicine evaluation has not been tested in a large study population.

Objective: To improve diagnostic sensitivity of RCM image diagnosis using a double reader concordance evaluation approach; to reduce mismanagement of equivocal cutaneous lesions in retrospective consultation and telemedicine settings.

Methods: 1000 combined dermoscopy-RCM image sets were evaluated in blind by 10 readers with advanced training and internship in dermoscopy and RCM evaluation. We compared sensitivity and specificity of single reader evaluation versus double reader concordance evaluation as well as the effect of diagnostic confidence on lesion management in a retrospective setting.

Results: Single reader evaluation resulted in an overall sensitivity of 95.2% and specificity of 76.3%, with misdiagnosis of 8 melanomas, 4 basal cell carcinomas and 2 squamous cell carcinomas. Combined double reader evaluation resulted in an overall sensitivity of 98.3% and specificity of 65.5%, with misdiagnosis of 1 in-situ melanoma and 2 basal cell carcinomas.

Conclusion: Evaluation of dermoscopy-RCM image sets of cutaneous lesions by single reader evaluation in retrospective settings is limited by sensitivity levels that may result in potential mismanagement of malignant lesions. Double reader blind concordance evaluation may improve the sensitivity of diagnosis and management safety. The use of a second check can be implemented in telemedicine settings where expert consultation and second opinions may be required.

Arzberger et al (2016) [Teledermoscopy in High-risk Melanoma Patients: A Comparative Study of Face-to-face and Teledermatology Visits](87)
Teledermoscopy is considered a reliable tool for the evaluation of pigmented skin lesions. We compared the management decision in face-to-face visits vs. teledermatology in a high-risk melanoma cohort using total-body photography, macroscopic and dermoscopic images of single lesions. Patients were assessed both face-to face and by 4 remote teledermatologists. Lesions identified as suspicious for skin cancer by face-to-face evaluation underwent surgical excision. The teledermatologists recommended self-monitoring, short-term monitoring, or excision. A 4-year monitoring was completed in a cohort of participating subjects. The general

[87] Arzberger E, Curiel-Lewandrowski C, Blum A, et al. Teledermoscopy in High-risk Melanoma Patients: A Comparative Study of Face-to-face and Teledermatology Visits. *Acta Derm Venereol.* 2016;96(6):779-783. doi:10.2340/00015555-2344
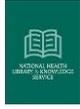
agreement, calculated by prevalence and bias-adjusted κ (PABAK), showed almost perfect agreement (PABAK 0.9-0.982). A total of 23 lesions were excised; all teledermatologists identified the 9 melanomas. The greatest discrepancy was detected in "short-term monitoring". During 4-year monitoring one melanoma was excised that had been considered benign. In conclusion, melanoma identification by experts in pigmented lesions appears to be equivalent between face-to-face and teledermatological consultation.

Chen et al (2016) Validation of a Skin-Lesion Image-Matching Algorithm Based on Computer Vision Technolog[88]

Background: Melanoma incidence is increasing globally, but consistently accurate skin-lesion classification methods remain elusive. We developed a simple software system to classify potentially all types of skin lesions. In the current study, we evaluated the system's ability to identify melanomas with a diameter of 10 mm or larger.

Materials and methods: The skin-lesion classification system is composed of a proprietary database of nearly 12,000 diagnosed skin-lesion images and a computer algorithm based on the principles of content-based image retrieval. The algorithm compares characteristics of new skin-lesion images with images in the database to identify the nearest-match diagnosis.

Results: Nearly all classification accuracy measures for this new system exceeded 90%, with results for sensitivity of 90.4% (95% confidence interval, 85.6-93.7%), specificity of 91.5% (85.4-95.2%), positive predictive value of 94.5% (90.4-96.9%), negative predictive value of 85.5% (78.7-90.4%), and overall classification accuracy of 90.8% (87.2-93.4%).

Conclusions: The image-matching algorithm performed with high accuracy for the classification of larger melanomas. Furthermore, the system does not require a dermoscope or any other specialized hardware; any close-focusing camera will do. This system has the potential to be an inexpensive and accurate tool for the evaluation of skin lesions in ethnically and geographically diverse populations.

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[88] Chen RH, Snorrason M, Enger SM, et al. Validation of a Skin-Lesion Image-Matching Algorithm Based on Computer Vision Technology. *Telemed J E Health.* 2016;22(1):45-50. doi:10.1089/tmj.2014.0249

De Giorgi et al (2016) Teledermoscopy in doubtful melanocytic lesions: is it really useful?[89]

Introduction: The diagnosis of cutaneous pigmented lesions remains a challenge for both dermatologists and pathologists. Our aim was to determine the diagnostic concordance between the conventional face-to-face diagnosis and the telediagnosis of 10 dermatologists with expertise in dermato-oncology of 10 challenging pigmented lesions.

Methods: Using a store-and-forward teledermatology method, clinical and dermoscopic digital images of all selected lesions were transmitted via e-mail to 10 dermatologists. Dermatologists were called to provide their telediagnoses with a step-by-step approach. When the dermatologists responded with their first clinical telediagnosis, they received a second email that contained dermoscopic images of the 10 cases. Final histopathological diagnosis was considered the gold standard for comparison with face-to-face and teledermatology diagnoses in statistical analysis.

Results: Face-to-face results indicated moderate agreement between clinical and histopathological diagnoses (K = 0.6). After the first clinical step, interobserver concordance of telediagnosis was lower than face-to-face diagnosis (K = 0.52). After the second dermoscopy step, the concordance declined further (K = 0.38).

Conclusions: Teledermatology was inferior to face-to-face dermatology. Moreover, the diagnostic concordance of telediagnosis decreased after the teledermoscopic step. This finding may be justified by the dermoscopic difficulty of the selected lesions, including Spitzoid proliferations and atypical melanocytic nevi of the elderly. These lesions may represent a potential diagnostic pitfall given their confounding dermoscopic aspects.

Bashshur et al (2015) The Empirical Foundations of Teledermatology: A Review of the Research Evidence[90]

Introduction: This article presents the scientific evidence for the merit of telemedicine interventions in the diagnosis and management of skin disorders [teledermatology] in the published literature. The impetus for this work derives from the high prevalence of skin disorders, the high cost, the limited availability of dermatologists in certain areas, and the promise of teledermatology to address unmet needs in this area.

[89] de Giorgi V, Gori A, Savarese I, et al. Teledermoscopy in doubtful melanocytic lesions: is it really useful?. *Int J Dermatol*. 2016;55(10):1119-1123. doi:10.1111/ijd.13281

[90] Bashshur RL, Shannon GW, Tejasvi T, Kvedar JC, Gates M. The Empirical Foundations of Teledermatology: A Review of the Research Evidence. *Telemed J E Health*. 2015;21(12):953-979. doi:10.1089/tmj.2015.0146
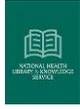
Materials and Methods: The findings are based on a targeted review of scientific studies published from January 2005 through April 2015. The initial search yielded some 5,020 articles in Google Scholar and 428 in PubMed. A review of the abstracts yielded 71 publications that met the inclusion criteria for this analysis. Evidence is organized according to the following: feasibility and acceptance; intermediate outcomes [use of service, compliance, and diagnostic and treatment concordance and accuracy]; outcomes [health improvement and problem resolution]; and cost savings. A special section is devoted to studies conducted at the Veterans Health Administration.

Results: Definitions of teledermatology varied across a wide spectrum of skin disorders, technologies, diagnostic tools, provider types, settings, and patient populations. Outcome measures included diagnostic concordance, treatment plans, and health.

Conclusions: Despite these complexities, sufficient evidence was observed consistently supporting the effectiveness of teledermatology in improving accessibility to specialty care, diagnostic and treatment concordance, and skin care provided by primary care physicians, while also reducing cost. One study reported suboptimal clinical results from teledermatology for patients with pigmented skin lesions. On the other hand, confocal microscopy and advanced dermoscopy improved diagnostic accuracy, especially when rendered by experienced teledermatologists.

Ford and Pereiria (2015) [Does teledermatology reduces secondary care referrals and is it acceptable to patients and doctors? A service evaluation](#)[91]

Rationale, aims and objectives: Referrals to dermatology for skin lesions is increasing. Teledermatology allows patients to obtain specialist advice remotely. The aim of this study is to assess if teledermatology reduces secondary care dermatology referrals and evaluate its acceptability to patients and clinicians.

Methods: A 24-month before and after comparative evaluation of a teledermatology service was undertaken involving four non-randomly allocated intervention practices and 18 control practices. Referral data for 12 months before and after the introduction of teledermatology was compared in intervention and control practices. Patient questionnaires explored their satisfaction and structured user dialogues explored the usefulness and

[91] Ford JA, Pereira A. Does teledermatology reduces secondary care referrals and is it acceptable to patients and doctors?: a service evaluation. *J Eval Clin Pract*. 2015;21(4):710-716. doi:10.1111/jep.12373
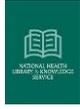
benefits to clinicians. Time series analysis, adjusted for age and sex, was undertaken to assess the impact on secondary care referrals.

Results: There were 195 Telederm referrals during the 12-month pilot period. Seborrhoeic keratosis was the commonest diagnosis. No action was required in 86 patients. Urgent referral to secondary care was recommended in 64 patients and routine referral in 19. The difference in referral rate before and after was +2.11 referrals per 1000 practice population in the teledermatology group and +1.39 in the control group. This was statistically significant in the adjusted, but not unadjusted, analysis. There was a 14% response rate for the questionnaire. The service was very popular with patients and clinicians. Clinicians highlighted the significant educational benefit.

Conclusion: We did not find any evidence that teledermatology reduced secondary care referral rates but in this small pilot, we found that it increased referrals in the short term. It was very popular among patients and clinicians, especially for its educational value.

Wu et al (2015) [Feasibility and Efficacy of Patient-Initiated Mobile Teledermoscopy for Short-term Monitoring of Clinically Atypical Nevi](#)[92]

Importance: Patient-driven mobile teledermoscopy may be applicable for monitoring of skin lesions.

Objective: To assess the feasibility, efficacy, and patient receptivity of teledermoscopy for short-term monitoring of clinically atypical nevi.

Design, setting, and participants: This was a prospective cohort study performed at an institutional referral center in New York. Consecutive patients 18 years or older, with 1 or more clinically atypical nevi that required short-term monitoring and were accessible by a mobile imaging device were recruited for the study. All 34 patients consented to the study, and 29 completed follow-up. Dermoscopic images were obtained in the office-based setting by a dermatologist and with an iPhone by the patient at baseline and follow-up [3-4 months]. Patients completed surveys that included questions about skincare awareness and attitudes toward teledermoscopy. Standard dermoscopic images were evaluated by the office-based dermatologist, and mobile dermoscopic images were sent via the Internet to a teledermatologist to evaluate image quality and presence of significant clinical lesion change. The decisions of the teledermatologist and office-based dermatologist were compared.

92 Wu X, Oliveria SA, Yagerman S, et al. Feasibility and Efficacy of Patient-Initiated Mobile Teledermoscopy for Short-term Monitoring of Clinically Atypical Nevi. *JAMA Dermatol.* 2015;151(5):489-496. doi:10.1001/jamadermatol.2014.3837

Main Outcomes and Measures: 1. feasibility of using mobile dermatoscope by patients; 2. diagnostic concordance of teledermoscopy vs conventional office-based visit; and 3. patient receptivity to teledermoscopy for short-term monitoring of nevi.

Results: Of the 29 patients who completed the study, 28 (97%) were able to acquire baseline and follow-up images that were subsequently deemed evaluable by the teledermatologist. The diagnostic concordance between conventional office-based visits and teledermoscopy encounters was 0.87 (SE, 0.13) (κ statistic). In addition, patients reported high receptivity to teledermoscopy for short-term monitoring of nevi.

Conclusions and Relevance: Results from this pilot study suggest that teledermoscopy is feasible and effective as a method for short-term monitoring of clinically atypical nevi. The implementation of teledermoscopy can potentially enhance patient convenience, optimize physician scheduling, and promote efficiency.

Pediatric Dermatology

> Randomised
> Controlled Trials

O'Connor et al (2017) [Randomised Controlled Trial] Diagnostic Accuracy of Pediatric Teledermatology Using Parent-Submitted Photographs: A Randomized Clinical Trial[93]

Importance: Advances in smartphone photography ⬚ both quality and image transmission ⬚ may improve access to care via direct parent-to-clinician telemedicine. However, the accuracy of diagnoses that are reliant on parent-provided photographs has not been formally compared with diagnoses made in person.

Objective: To assess whether smartphone photographs of pediatric skin conditions taken by parents are of sufficient quality to permit accurate diagnosis.

Design, Setting, and Participants: A prospective study was conducted among 40 patient-parent dyads at a pediatric dermatology clinic at the Children's

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[93] O'Connor DM, Jew OS, Perman MJ, Castelo-Soccio LA, Winston FK, McMahon PJ. Diagnostic Accuracy of Pediatric Teledermatology Using Parent-Submitted Photographs: A Randomized Clinical Trial. *JAMA Dermatol.* 2017;153(12):1243-1248. doi:10.1001/jamadermatol.2017.4280

Hospital of Philadelphia from March 1 to September 30, 2016, to assess concordance between diagnoses made by an independent pediatric dermatologist based on in-person examination and those based on parental photographs. Half of the patient-parent dyads were randomized for a secondary analysis to receive instructions on how best to take photographs with smartphones. Clinicians were blinded to whether parents had received photography instructions.

Exposures: Half of the patient-parent dyads received a simple, 3-step instruction sheet on how best to take photographs using a smartphone [intervention group]; the other half did not [control group].

Main Outcomes and Measures: Concordance between photograph-based vs in-person diagnosis in the intervention vs control groups, as quantified using Cohen κ, a measure of interrater agreement that takes into account the possibility of agreement occurring by chance.

Results: Among the 40 patient-parent dyads (22 female children and 18 male children; mean [SD] age, 6.96 [5.23] years), overall concordance between photograph-based vs in-person diagnosis was 83% (95% CI, 71%-94%; κ = 0.81). Diagnostic concordance was 89% (95% CI, 75%-97%; κ = 0.88) in a subgroup of 37 participants with photographs considered of high enough quality to make a diagnosis. No statistically significant effect of photography instructions on concordance was detected (group that received instructions, 85%; group that did not receive instructions, 80%; P = .68). In cases of diagnostic disagreement, appropriate follow-up was suggested.

Conclusions and Relevance: Parent-operated smartphone photography can accurately be used as a method to provide pediatric dermatologic care.

Miscellaneous

Bettloch-Mas et al (2020) [Descriptive Study] Teledermatology in paediatrics: Health-care impact on the early treatment of infantile haemangiomas[94]

Introduction: Teledermatology can solve diagnostic and therapeutic problems in paediatrics, for example in infantile haemangiomas (IHs) requiring early treatment with propranolol. This study aims to assess the

[94] Betlloch-Mas I, Martínez-Miravete MT, Berbegal-DeGracia L, Sánchez-Vázquez L, Sánchez-Payá J. Teledermatology in paediatrics: Health-care impact on the early treatment of infantile haemangiomas [published online ahead of print, 2020 Mar 18]. *J Telemed Telecare*. 2020;1357633X20904901. doi:10.1177/1357633X20904901
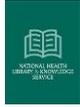
impact of teledermatology following its implementation in a health area of Spain, specifically analysing its effectiveness in reducing the age of first propranolol treatment for IH.

Methods: This was a descriptive study of paediatric teledermatology from 2015 to 2018, studying age, sex, diagnosis, time and mode of resolution. All IHs referred via teledermatology were analysed, and age at propranolol initiation was compared to the period prior to implementation (2008-2014). We also analysed IHs according to referral pathways: teledermatology vs. conventional pathways.

Results: We included 432 consultations (47.7% boys). The main diagnoses were IH, erythematous-desquamative diseases and infections. Concordance in diagnosis between paediatricians and dermatologists was good, and 48.12% of cases consulted via teledermatology were resolved remotely. Response time was 2.81 days on average. Children younger than two months of age showed the highest proportion of in-person visits. In 2015-2018, children with IHs began treatment with propranolol at a mean age of 4.5 months [1.9 months in those referred via teledermatology vs. 5.6 months in those using conventional referral pathways]. In 2008-2014, the mean age at referral was 7.1 months. These differences were significant.

Discussion: Teledermatology is a fast and effective tool to resolve paediatric cases, enabling a significant decrease in the age of treatment in infants with IH.

Frieden et al (2020) **Management of infantile hemangiomas during the COVID pandemic**[95]

The COVID-19 pandemic has caused significant shifts in patient care including a steep decline in ambulatory visits and a marked increase in the use of telemedicine. Infantile hemangiomas (IH) can require urgent evaluation and risk stratification to determine which infants need treatment and which can be managed with continued observation. For those requiring treatment, prompt initiation decreases morbidity and improves long-term outcomes. The Hemangioma Investigator Group has created consensus recommendations for management of IH via telemedicine. FDA/EMA-approved monitoring guidelines, clinical practice guidelines, and relevant, up-to-date publications regarding initiation and monitoring of beta-blocker therapy were used to inform the recommendations. Clinical decision-making guidelines about when telehealth is an appropriate alternative to in-office

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[95] Frieden IJ, Püttgen KB, Drolet BA, et al. Management of infantile hemangiomas during the COVID pandemic. *Pediatr Dermatol.* 2020;37(3):412-418. doi:10.1111/pde.14196

visits, including medication initiation, dosage changes, and ongoing evaluation, are included. The importance of communication with caregivers in the context of telemedicine is discussed, and online resources for both hemangioma education and propranolol therapy are provided.

Gehris and Herman (2020) [Review] Pediatric Teledermatology: a Review[96]

Purpose of Review: Only a small number of dermatologists are also certified in pediatric dermatology by the American Board of Dermatology, creating an access barrier that is amenable to teledermatology. More than 50% of pediatric dermatologists currently practice teledermatology, but there is a dearth of literature validating the collective experience. This article reviews teledermatology terminology and summarizes the recent literature supporting pediatric teledermatology's diagnostic accuracy, efficacy, usability and cost-effectiveness. Recent findings: Diagnoses rendered using pediatric teledermatology share high concordance rates with in-person diagnoses. While most dermatologists prefer store and forward compared to real-time interactive teledermatology, a hybrid model may be advantageous for complex cases. Physician-to-physician teledermatology is ideal for pediatric inpatient and outpatient consultations, while direct-to-patient teledermatology may be more efficient for non-emergent pediatric outpatient visits. Eczema, acne, rashes and birthmarks lend themselves better to teledermatology than do pigmented lesions. Summary: This article summarizes the recent literature addressing the current state of pediatric teledermatology and reviews terminology, care models, pediatric best practices and benefits as well as challenges.

Seiger et al (2020) [Retrospective Cohort Study] Pediatric dermatology eConsults: Reduced wait times and dermatology office visits[97]

Background and Objectives: Store-and-forward teledermatology provides pediatricians with specialist guidance in managing skin disease. This study evaluates wait times and face-to-face (FTF) dermatology visit avoidance associated with a pediatric dermatology eConsult program at an urban academic medical center.

[96] Gehris, R.P., Herman, E.I.X. Pediatric Teledermatology: a Review. *Curr Derm Rep* 2020; 9 114–122: https://doi.org/10.1007/s13671-020-00294-2

[97] Seiger K, Hawryluk EB, Kroshinsky D, Kvedar JC, Das S. Pediatric dermatology eConsults: Reduced wait times and dermatology office visits [published online ahead of print, 2020 Jun 16]. *Pediatr Dermatol*. 2020;10.1111/pde.14187. doi:10.1111/pde.14187

Methods: In this retrospective cohort study, electronic medical records were reviewed for patients under age 18 for whom a dermatology eConsult was completed between November 1, 2014, and December 31, 2017. Wait times for eConsult completion and initial FTF dermatology appointments were calculated and compared to average wait times for new patient dermatology office appointments from 2016 to 2017. Recommendations for FTF dermatology visits were assessed, along with FTF visit attendance and potential cost savings.

Results: One hundred eighty pediatric patients with 188 unrelated skin conditions were referred to the program. Of 188 cases, FTF dermatology visits were recommended for 60 (31.9%). Actual FTF dermatology visit avoidance was 53.7% of total cases [n = 101 for whom FTF visit was not recommended and no dermatology visit occurred within 90 days after eConsult submission]. The program generated potential savings of $24,059 in 2016 dollars. Average turnaround for eConsult completion was 1.8 calendar days (median: 1 calendar day; target: 2 business days). Average wait time to initial FTF dermatology evaluation was 37.3 calendar days versus 54.1 days for pediatric patients referred directly to dermatology clinic between 2016 and 2017.

Conclusion: Pediatric dermatology eConsults reduce wait times for specialist care, triage cases for in-office evaluation, reduce need for FTF dermatology visits, and offer potential cost savings for payers and patients.

Giavina Bianchi et al (2019) [Cross-Sectional Retrospective Study] The majority of skin lesions in pediatric primary care attention could be managed by Teledermatology[98]

Background: Teledermatology is a tool that provides accurate diagnosis and has been gaining more emphasis over time. It can be used for triage in primary care attention to address skin conditions improving access and reducing time to treatment for surgical, severe or even lethal diseases.

Objectives: Our main goal was to evaluate the proportion of pediatric patient's lesions that could be managed using teledermatology in primary care attention. Secondly, we wanted to assess the ten most frequent skin conditions, the most common treatments and the referrals made by the teledermatologists to biopsy, in-presence dermatologist or kept at primary care attention.

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[98] Giavina Bianchi M, Santos AP, Cordioli E. The majority of skin lesions in pediatric primary care attention could be managed by Teledermatology. *PLoS One*. 2019;14(12):e0225479. Published 2019 Dec 2. doi:10.1371/journal.pone.0225479

Methods: A cross-sectional retrospective study involving 6,879 individuals and 10,126 lesions was conducted by store-and-forward teledermatology during one year in the city of Sao Paulo, Brazil. If the photographs taken had enough quality, teledermatologist would diagnose, treat and orient each lesion, if possible, and choose one of three options for referral: direct to biopsy, in-presence dermatologist or kept at primary care attention.

Results: Teledermatology managed 62% of the lesions to be kept at primary care attention, 37% were referred to dermatologists and 1% to biopsy, reducing the mean waiting time for an in-presence visit in 78%. In patients 0-2 years old, lesions related to eczema and benign congenital lesions predominated. From 3-12 years old, eczema was still a major cause of complaint, as well as warts and molluscum. From 13-19 years old, acne was the most significant problem, followed by atopic dermatitis, nevi and warts. The most frequent treatment was emollient.

Conclusion: Teletriage addressed 63% of the lesions without the need for an in-presence visit, suggesting that teledermatology can manage common diseases and optimize dermatological appointments for the most serious, surgical or complex skin illnesses, reducing the mean waiting time for them.

Fiks et al (2018) Usability, Acceptability, and Impact of a Pediatric Teledermatology Mobile Health Application[99]

Objective: Pediatric dermatology appointment wait times often exceed several months. We evaluated the usability, acceptability, and clinical impact of a store-and-forward teledermatology mobile application linking families with pediatric dermatologists.

Methods: Parents of children age 6 weeks to 17 years or individuals 18-21 years old were invited by e-mail or referral to participate in this single group, prospective study. Within the app, users photographed the skin condition, answered questions, and submitted their case for review. One pediatric dermatologist viewed cases, diagnosed conditions, and provided instructions and prescriptions. User surveys immediately following app use and 1 week later, supplemented by electronic logs, assessed usability, acceptability, and impact.

Results: One hundred ninety-seven parents and one adolescent submitted cases within 39 days of invitation. App users were more likely to be white than those in the population invited (67% vs. 34%, p < 0.001) and their children were slightly younger (mean 7.3 vs. 9.0 years, p < 0.001). A majority,

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[99] Fiks AG, Fleisher L, Berrigan L, et al. Usability, Acceptability, and Impact of a Pediatric Teledermatology Mobile Health Application. *Telemed J E Health*. 2018;24(3):236-245. doi:10.1089/tmj.2017.0075
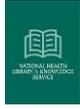
83% found the app easy to use, 97% felt that submitting a case took the right amount of time, 87% were satisfied, and 93% would use the app again. Prescription receipt was associated with increased app satisfaction (p = 0.008). The median user received a response in 2.8 h [interquartile range 1.1-6.4]. Had the app been unavailable, 44% reported that they would have waited for primary care, 32% for a dermatology appointment, and 7% would have gone to an urgent care clinic.

Conclusions: A mobile health app allowing families to directly consult a pediatric dermatologist was usable, acceptable, and expedited care.

Feigenbaum et al (2017) [Can You See Me Now? Video Supplementation for Pediatric Teledermatology Cases](100)

Background: Digital video is widely available and is used sporadically in clinical settings to evaluate patients, but whether it helps improve clinical management has not been determined. The aim of this study was to assess whether recorded video in addition to still images can improve residents' diagnostic and management accuracy and confidence with pediatric teledermatology cases.

Methods: Dermatology residents from three programs were assigned alternately to an online survey with 15 pediatric teledermatology cases presented with still images only or still images plus recorded video. Participants provided free-text diagnoses and management recommendations and rated their confidence and image quality. Responses were scored using a modified script concordance grading key based on reference panelists' responses.

Results: Thirty-one residents participated (response rate 57%). Participants in the mixed group scored significantly higher on management accuracy (87.6 ± 12.9 vs 71.7 ± 14.2; p = 0.003). Both groups performed better on more common conditions than less common conditions. The mixed group outperformed the still group on less common conditions with respect to management recommendations.

Conclusion: This novel study suggests that supplemental recorded video may improve the management accuracy of pediatric teledermatology consultations, particularly for complex cases. Residents may benefit from training in recording and interpreting video.

100 Feigenbaum DF, Boscardin CK, Frieden IJ, Mathes EFD. Can You See Me Now? Video Supplementation for Pediatric Teledermatology Cases. *Pediatr Dermatol.* 2017;34(5):566-571. doi:10.1111/pde.13210

Naka et al (2017) [Teledermatology: Kids are not just little people](#)[101]
Teledermatology has emerged as a promising solution for pediatric and adult patients accessing dermatologic care in a health care environment fraught with barriers to access. Teledermatology has been extensively evaluated in terms of diagnostic accuracy, clinical outcomes, patient and provider satisfaction, and costs, relative to traditional health care delivery models. Current research indicates that teledermatology is effective and efficient in diagnosis and management of skin diseases. The majority of studies on the subject, however, rely on adult patient data. Pediatric patients, with their unique clinical features and challenges, may interact with telemedicine differently than their adult counterparts. Maximizing the benefits of teledermatology in pediatric dermatologic care is dependent on future research. We review and analyze the commonalities and differences between pediatric and adult patient care using teledermatology.

Fogel et al (2016) [Direct-to-consumer teledermatology services for pediatric patients: Room for improvement](#)[102]
Direct-to-consumer teledermatology is radically changing the way some patients obtain dermatologic care. Many direct-to-consumer teledermatology services offer care to patients younger than 18 years, but policies and standards are nonuniform. For pediatric patients, direct-to-consumer teledermatology is a substantial departure from in-person care. More consensus, standards, and guidelines are necessary.

Fogel and Teng (2015) [Pediatric teledermatology: a survey of usage, perspectives, and practice](#)[103]
Pediatric dermatology is one of the smallest subspecialties, and expanding the availability of care is of great interest. Teledermatology has been proposed as a way to expand access and improve care delivery, but no current assessment of pediatric teledermatology exists. The objective of the current study was to assess usage and perspectives on pediatric teledermatology. Surveys were distributed electronically to all 226 board-certified U.S. pediatric dermatologists; 44% (100/226) responded. Nearly all respondents (89%) have experience with teledermatology. Formal

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[101] Naka F, Makkar H, Lu J. Teledermatology: Kids are not just little people. *Clin Dermatol.* 2017;35(6):594-600. doi:10.1016/j.clindermatol.2017.08.009
[102] Fogel AL, Teng J, Sarin KY. Direct-to-consumer teledermatology services for pediatric patients: Room for improvement. *J Am Acad Dermatol.* 2016;75(5):887-888. doi:10.1016/j.jaad.2016.08.002
[103] Fogel AL, Teng JM. Pediatric teledermatology: a survey of usage, perspectives, and practice. *Pediatr Dermatol.* 2015;32(3):363-368. doi:10.1111/pde.12533

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teledermatology reimbursement success rates have increased to 35%. Respondents were positive about teledermatology's present and future prospects, and 41% want to use teledermatology more often, although they viewed teledermatology as somewhat inferior to in-person care regarding accuracy of diagnosis and appropriation of management plans. Significant differences were found between formal teledermatology users and nonusers in salary structure, practice environment, sex, and region. Substantial increases in pediatric teledermatology have occurred in the last 5 to 10 years, and there remains cause for optimism for teledermatology's future. Concerns about diagnostic confidence and care quality indicate that teledermatology may be best for care of patients with characteristic clinical presentations or management of patients with established diagnoses.

Karlsson et al (2015) **Mobile teledermatology is a valid method to estimate prevalence of melanocytic naevi in children**[104]
The prevalence of melanocytic naevi in children correlates with sun exposure and may serve as an objective population risk indicator of future melanoma incidence. The aim was to investigate if mobile teledermatology could offer a valid methodology compared with standard manual, face-to-face counting of naevi on the back of children. Ninety-seven children aged 7-16 years were enrolled. One dermatologist performed manual naevi counting and imaging of the child's back using an iPhone 4S comprising a safe-coded mobile application. Two other dermatologists independently counted naevi from the images. Cohen's weighted kappa (κw) coefficient demonstrated substantial agreement for both dermatologists: κw = 0.69 (0.57-0.81 [95% confidence intervals]) and κw = 0.78 (0.70-0.86), compared with the manual assessment. Inter-rater reliability was also substantial (κw = 0.80 [0.73-0.87]). Use of mobile teledermatology proved valid for estimating naevi prevalence on the back and could provide a more feasible methodology following trends in sun exposure in children.

Paradela-De-La-Morena et al (2015) **[Retrospective Cohort Study]** **Teledermatology: diagnostic reliability in 383 children**[105]
Background: There are few studies of teledermatology focused on the pediatric age group. The aim of this study was to assess the validity and

[104]Karlsson MA, Lindelöf B, Wahlgren CF, Wiklund K, Rodvall Y. Mobile teledermatology is a valid method to estimate prevalence of melanocytic naevi in children. *Acta Derm Venereol.* 2015;95(3):303-306. doi:10.2340/00015555-1950
[105] Paradela-De-La-Morena S, Fernandez-Torres R, Martínez-Gómez W, Fonseca-Capdevila E. Teledermatology: diagnostic reliability in 383 children. *Eur J Dermatol.* 2015;25(6):563-569. doi:10.1684/ejd.2015.2658

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reliability of store-and-forward teledermatology (STD) as a diagnostic tool for pediatricians and to reduce face-to-face consultations.

Material and Methods: A retrospective, observational study of 383 children and adolescents under 15 years of age, referred from primary care to Dermatology Department of University Hospital of La Coruña, Spain, between 2011 and 2013, using a STD consult system.

Results: Diagnoses concordance between pediatricians and teledermatologists was 39.2% of cases and partial concordance 16.7%. Agreement for global diagnosis was $\kappa = 0.78$ (p = 0.000) and for specific diagnosis was $\kappa = 0.73$ (p = 0.000). Management was concordant in 28.7% and partially concordant in 15.4%. Lower reliability was statistically associated with modification of the lesions by inappropriate treatments, incomplete clinical data or bad-quality photographic images included in the referral consultation, diagnosis of infectious diseases and rare dermatoses. The filtering percentage as the percentage of avoided clinic-based evaluations was 64.5%. The mean response time of the consultant dermatologists was 3.62 days. Referrals for live consultations due to poor clinical information or insufficient quality of pictures were necessary in only 10% of the cases.

Conclusion: The degree of diagnostic accuracy for the pediatric population using STD as a diagnostic tool was similar to that achieved in adults. Its usefulness for filtering dermatologic referral was also demonstrated in the study, so it could be suitable for integration into the routine practice of pediatricians.

CHAPTER 8
Telemedicine and Diabetes Mellitus

Systematic Reviews

Avidor, Daniel et al (2020) [Systematic Review] Cost-effectiveness of Diabetic Retinopathy Screening Programs Using Telemedicine: A Systematic Review[1]

Diabetic retinopathy (DR) is a significant global public health and economic burden. DR accounts for approximately 15-17% of all cases of total blindness in the USA and Europe. Telemedicine is a new intervention for DR screening, however, there is not enough evidence to support its cost-effectiveness. The aim of this study is to review the most recent published literature on economic evaluations of telemedicine in DR screening and summarize the evidence on the cost-effectiveness of this technology. A systematic search of PubMed, Embase and Google Scholar for relevant articles published between January 2010 and January 2020. Studies were included if they met the following criteria: 1. recruited subjects with either type 1 or type 2 diabetes; 2. evaluated telemedicine technology; 3. patients underwent primary screening for DR; 4. compared a telemedicine-based intervention with standard care; 5. performed an economic evaluation or provided sufficient data for evaluating the cost-effectiveness of the technology used. Results: Of 2,238 articles screened, seven studies were included. Four of the studies were conducted in developed countries: the United States, Singapore and two studies in Canada. Three studies were conducted in developing countries: India, Brazil and South Africa. The patient populations in all studies were diabetic patients over the age of 18, previously not screened for DR. All seven studies used a telemedicine program which included capturing a retinal image and subsequently transmitting it to an ocular imaging center to assess the severity of DR. All studies compared telemedicine to a standard screening method for DR, including the option of no screening as standard of care. Although telemedicine requires initial and maintenance costs, it has the

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potential to provide significant cost savings by increasing patients' working ability, increasing independent living ability, increasing quality of life and reducing travel costs. Conclusions: Diabetic retinopathy telemedicine technology has the potential to provide significant cost savings, especially in low-income populations and rural patients with high transportation costs.

Hazenberg, C et al (2020) [Systematic Review] [Telehealth and Telemedicine Applications for the Diabetic Foot: A Systematic Review](2)
The aim of this systematic review is to assess the peer-reviewed literature on the psychometric properties, feasibility, effectiveness, costs, and current limitations of using telehealth and telemedicine approaches for prevention and management of diabetic foot disease. MEDLINE/PubMed was searched for peer-reviewed studies on telehealth and telemedicine approaches for assessing, monitoring, preventing, or treating diabetic foot disease. Four modalities were formulated: dermal thermography, hyperspectral imaging, digital photographic imaging, and audio/video/online communication. Outcome measures were: validity, reliability, feasibility, effectiveness, and costs. Sixty-one studies were eligible for analysis. Three randomized controlled trials showed that handheld infrared dermal thermography as home-monitoring tool is effective in reducing ulcer recurrence risk, while one small trial showed no effect. Hyperspectral imaging has been tested in clinical settings to assess and monitor foot disease and conflicting results on its diagnostic use show that this method is still in an experimental stage. Digital photography is used to assess and monitor foot ulcers and pre-ulcerative lesions and was found to be a valid, reliable, and feasible method for telehealth purposes. Audio/video/online communication is mainly used for foot ulcer monitoring. Two randomized controlled trials show similar healing efficacy compared with regular outpatient clinic visits, but no benefit in costs. In conclusion, several technologies with good psychometric properties are available that may be of benefit in helping to assess, monitor, prevent, or treat diabetic foot disease, but in most cases, feasibility, effectiveness, and cost savings still need to be demonstrated to become accepted and used modalities in diabetic foot care.

Timpel, Patrick et al (2020) [Systematic Review] **Mapping the Evidence on the Effectiveness of Telemedicine Interventions in Diabetes, Dyslipidemia, and Hypertension: An Umbrella Review of Systematic Reviews and Meta-Analyses**[3]

Background: Telemedicine is defined by three characteristics: 1. using information and communication technologies; 2. covering a geographical distance; and 3. involving professionals who deliver care directly to a patient or a group of patients. It is said to improve chronic care management and self-management in patients with chronic diseases. However, currently available guidelines for the care of patients with diabetes, hypertension, or dyslipidemia do not include evidence-based guidance on which components of telemedicine are most effective for which patient populations. Objective: The primary aim of this study was to identify, synthesize, and critically appraise evidence on the effectiveness of telemedicine solutions and their components on clinical outcomes in patients with diabetes, hypertension, or dyslipidemia. Methods: We conducted an umbrella review of high-level evidence, including systematic reviews and meta-analyses of randomized controlled trials. On the basis of predefined eligibility criteria, extensive automated and manual searches of the databases PubMed, EMBASE, and Cochrane Library were conducted. Two authors independently screened the studies, extracted data, and carried out the quality assessments. Extracted data were presented according to intervention components and patient characteristics using defined thresholds of clinical relevance. Overall certainty of outcomes was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) tool. Results: Overall, 3,564 references were identified, of which 46 records were included after applying eligibility criteria. The majority of included studies were published after 2015. Significant and clinically relevant reduction rates for glycated hemoglobin (HbA1c; ≤-0.5%) were found in patients with diabetes. Higher reduction rates were found for recently diagnosed patients and those with higher baseline HbA1c (>8%). Telemedicine was not found to have a significant and clinically meaningful impact on blood pressure. Only reviews or meta-analyses reporting lipid outcomes in patients with diabetes were found. GRADE assessment revealed that the overall quality of the evidence was low to very low. Conclusions: The results of this umbrella review indicate that telemedicine has the potential to improve clinical

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[3] Timpel P, Oswald S, Schwarz PEH, Harst L. Mapping the Evidence on the Effectiveness of Telemedicine Interventions in Diabetes, Dyslipidemia, and Hypertension: An Umbrella Review of Systematic Reviews and Meta-Analyses. *J Med Internet Res*. 2020;223.:e16791. Published 2020 Mar 18. doi:10.2196/16791
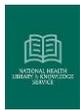
outcomes in patients with diabetes. Although subgroup-specific effectiveness rates favoring certain intervention and population characteristics were found, the low GRADE ratings indicate that evidence can be considered as limited. Future updates of clinical care and practice guidelines should carefully assess the methodological quality of studies and the overall certainty of subgroup-specific outcomes before recommending telemedicine interventions for certain patient populations.

Wang, Youfa et al (2020) [Systematic Review] Effectiveness of Mobile Health Interventions on Diabetes and Obesity Treatment and Management: Systematic Review of Systematic Reviews[4]
Background: Diabetes and obesity have become epidemics and costly chronic diseases. The impact of mobile health (mHealth) interventions on diabetes and obesity management is promising; however, studies showed varied results in the efficacy of mHealth interventions. Objective: This review aimed to evaluate the effectiveness of mHealth interventions for diabetes and obesity treatment and management on the basis of evidence reported in reviews and meta-analyses and to provide recommendations for future interventions and research. Methods: We systematically searched the PubMed, IEEE Xplore Digital Library, and Cochrane databases for systematic reviews published between January 1, 2005, and October 1, 2019. We analyzed 17 reviews, which assessed 55,604 original intervention studies, that met the inclusion criteria. Of those, 6 reviews were included in our meta-analysis. Results: The reviews primarily focused on the use of mobile apps and text messaging and the self-monitoring and management function of mHealth programs in patients with diabetes and obesity. All reviews examined changes in biomarkers, and some reviews assessed treatment adherence (n=7) and health behaviors (n=9). Although the effectiveness of mHealth interventions varied widely by study, all reviews concluded that mHealth was a feasible option and had the potential for improving patient health when compared with standard care, especially for glycemic control (-0.3% to -0.5% greater reduction in hemoglobin A1c) and weight reduction (-1.0 kg to -2.4 kg body weight). Overall, the existing 6 meta-analysis studies showed pooled favorable effects of these mHealth interventions (-0.79, 95% CI -1.17 to -0.42; I2=90.5). Conclusions: mHealth interventions are promising, but there is limited evidence about their effectiveness in glycemic control

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[4] Wang Y, Min J, Khuri J et al Effectiveness of Mobile Health Interventions on Diabetes and Obesity Treatment and Management: Systematic Review of Systematic Reviews. *JMIR Mhealth Uhealth*. 2020;84.:e15400. Published 2020 Apr 28. doi:10.2196/15400

and weight reduction. Future research to develop evidence-based mHealth strategies should use valid measures and rigorous study designs. To enhance the effectiveness of mHealth interventions, future studies are warranted for the optimal formats and the frequency of contacting patients, better tailoring of messages, and enhancing usability, which places a greater emphasis on maintaining effectiveness over time.

Haider, Rabbia et al (2019) [Systematic Review] Mobile phone text messaging in improving glycaemic control for patients with type 2 diabetes mellitus: A systematic review and meta-analysis[5]

Background: Mobile health is the use of mobile technology in developing healthcare, with the aim of reminding and motivating patients to adopt a healthy lifestyle. We conducted a systematic review assessing the effectiveness of text-messaging interventions on HbA1c in patients with Type 2 diabetes mellitus (T2DM). Methods: Two authors independently searched MEDLINE, Embase, CINAHL, Cochrane Register of Randomized Control Trials and PsychInfo. The review included randomized control trials with at least 4 weeks follow up, evaluating the effect of text messaging on HbA1c, in patients with T2DM. Trials involving participants with Type 1 diabetes mellitus, pre-diabetes or gestational diabetes, or other forms of telemedicine were excluded. Studies employing bi-directional messaging were excluded. Results: 208 papers were identified as meeting inclusion criteria and their abstracts reviewed. Of these, we examined the full text article of forty-four studies. Eleven randomized controlled trials were included in the final review, with a total of 1710 participants. One study focused on medication adherence only, while the remaining had educational and motivational messages. Five studies showed a significant improvement in HbA1c with the intervention. The remaining studies demonstrated a trend to improvement in HbA1c. Our meta-analysis on 9 of the 11 studies found an overall reduction in HbA1c of 0.38% (-0.53; -0.23, p-value <0.001). Conclusion: Lifestyle-focused text messaging is a low cost initiative aimed at motivating patients with T2DM to adhere to a healthy lifestyle. We demonstrate that lifestyle focused text messaging is effective, with a significant improvement in HbA1c in the meta-analysis.

[5] Haider R, Sudini L, Chow CK, Cheung NW. Mobile phone text messaging in improving glycaemic control for patients with type 2 diabetes mellitus: A systematic review and meta-analysis. *Diabetes Res Clin Pract.* 2019;150:27-37. doi:10.1016/j.diabres.2019.02.022

Hu, Yuli et al (2019) [Systematic Review] Effect of telemedicine intervention on hypoglycaemia in diabetes patients: A systematic review and meta-analysis of randomised controlled trials[6]

Introduction: Hypoglycaemia is a clinical syndrome from various causes, which happens when the blood glucose concentration is too low. Many studies show that telemedicine intervention can improve glycemic control and has a positive impact on the management of diabetic patients. The purpose of this study was to evaluate the effect of telemedicine intervention on hypoglycemic event occurrences and results on hemoglobin A1c (HbA1c) and body mass index (BMI). Methods: We searched the Cochrane Library, PubMed, Web of Science, the EBSCO host, and OVID to identify relevant studies published from January 2006 to December 2017. The work of searching, selecting and assessing risk of bias was administrated by two independent reviewers. The primary outcomes were hypoglycemic event rate and HbA1c; the secondary outcome was BMI. Results: From 1246 articles, we identified 14 eligible RCTs (n = 1324). Compared to usual care, telemedicine was found to reduce the odds of hypoglycaemia (odds ratio (OR) = 0.42; 95% confidence interval (CI) = 0.29-0.59; I2 = 32%; p < 0.00001). We found that the clinical relevance declined in HbA1c level compared to control group (mean difference = -0.28; 95% CI = -0.45 to -0.12; I2 = 53%; p = 0.0005), but that telemedicine had no effect on BMI (mean difference = -0.27; 95% CI = -0.86-0.31; I2 = 40%; p = 0.35). Discussion: Compared to usual care, the use of telemedicine was found to improve HbA1c and reduce the risk of moderate hypoglycaemia in diabetic patients, but without significant difference in BMI.

Lee, Puikwan A et al (2018) [Systematic Review] The Impact of Telehealth Remote Patient Monitoring on Glycemic Control in Type 2 Diabetes: A Systematic Review and Meta-Analysis of Systematic Reviews of Randomised Controlled Trials[7]

Background: There is a growing body of evidence to support the use of telehealth in monitoring HbA1c levels in people living with type 2 diabetes. However, the overall magnitude of effect is yet unclear due to variable results reported in existing systematic reviews. The objective of this study is

[6] Hu Y, Wen X, Wang F et al Effect of telemedicine intervention on hypoglycaemia in diabetes patients: A systematic review and meta-analysis of randomised controlled trials. *J Telemed Telecare*. 2019;257.:402- 413. doi:10.1177/1357633X18776823
[7] Lee PA, Greenfield G, Pappas Y. The impact of telehealth remote patient monitoring on glycemic control in type 2 diabetes: a systematic review and meta-analysis of systematic reviews of randomised controlled trials. *BMC Health Serv Res*. 2018;181.:495. Published 2018 Jun 26. doi:10.1186/s12913-018-3274-8

to conduct a systematic review and meta-analysis of systematic reviews of randomised controlled trials to create an evidence-base for the effectiveness of telehealth interventions on glycemic control in adults with type 2 diabetes. Methods: Electronic databases including The Cochrane Library, MEDLINE, EMBASE, HMIC, and PsychINFO were searched to identify relevant systematic reviews published between 1990 and April 2016, supplemented by references search from the relevant reviews. Two independent reviewers selected and reviewed the eligible studies. Of the 3279 references retrieved, 4 systematic reviews reporting in total 29 unique studies relevant to our review were included. Both conventional pairwise meta-analyses and network meta-analyses were performed. Results: Evidence from pooling four systematic reviews found that telehealth interventions produced a small but significant improvement in HbA1c levels compared with usual care (MD: -0.55, 95% CI: -0.73 to - 0.36). The greatest effect was seen in telephone-delivered interventions, followed by Internet blood glucose monitoring system interventions and lastly interventions involving automatic transmission of SMBG using a mobile phone or a telehealth unit. Conclusion: Current evidence suggests that telehealth is effective in controlling HbA1c levels in people living with type 2 diabetes. However, there is need for better quality primary studies as well as systematic reviews of RCTs in order to confidently conclude on the impact of telehealth on glycemic control in type 2 diabetes.

Faruque, Labib Imran et al (2017) [Systematic Review] Effect of Telemedicine on Glycated Hemoglobin in Diabetes: A Systematic Review and Meta-Analysis of Randomized Trials[8]

Background: Telemedicine, the use of telecommunications to deliver health services, expertise and information, is a promising but unproven tool for improving the quality of diabetes care. We summarized the effectiveness of different methods of telemedicine for the management of diabetes compared with usual care. Methods: We searched MEDLINE, Embase and the Cochrane Central Register of Controlled Trials databases (to November 2015) and reference lists of existing systematic reviews for randomized controlled trials (RCTs) comparing telemedicine with usual care for adults with diabetes. Two independent reviewers selected the studies and assessed risk of bias in the studies. The primary outcome was glycated hemoglobin (HbA1C) reported at 3 time points (≤ 3 mo, 4-12 mo and > 12 mo). Other

[8] Faruque LI, Wiebe N, Ehteshami-Afshar A et al Effect of telemedicine on glycated hemoglobin in diabetes: a systematic review and meta-analysis of randomized trials. *CMAJ.* 2017;189(9):E341- E364. doi:10.1503/cmaj.150885

outcomes were quality of life, mortality and episodes of hypoglycemia. Trials were pooled using randomeffects meta-analysis, and heterogeneity was quantified using the I2 statistic. Results: From 3688 citations, we identified 111 eligible RCTs (n = 23 648). Telemedicine achieved significant but modest reductions in HbA1C in all 3 follow-up periods (difference in mean at ≤ 3 mo: -0.57%, 95% confidence interval [CI] -0.74% to -0.40% [39 trials]; at 4-12 mo: -0.28%, 95% CI -0.37% to -0.20% [87 trials]; and at > 12 mo: -0.26%, 95% CI -0.46% to -0.06% [5 trials]). Quantified heterogeneity (I2 statistic) was 75%, 69% and 58%, respectively. In meta-regression analyses, the effect of telemedicine on HbA1C appeared greatest in trials with higher HbA1C concentrations at baseline, in trials where providers used Web portals or text messaging to communicate with patients and in trials where telemedicine facilitated medication adjustment. Telemedicine had no convincing effect on quality of life, mortality or hypoglycemia. Interpretation: Compared with usual care, the addition of telemedicine, especially systems that allowed medication adjustments with or without text messaging or a Web portal, improved HbA1C but not other clinically relevant outcomes among patients with diabetes.

Lee, Shaun Wen Huey et al (2017) [Systematic Review] Comparative effectiveness of telemedicine strategies on type 2 diabetes management: A systematic review and network meta-analysis[9]

The effects of telemedicine strategies on the management of diabetes is not clear. This study aimed to investigate the impact of different telemedicine strategies on glycaemic control management of type 2 diabetes patients. A search was performed in 6 databases from inception until September 2016 for randomized controlled studies that examined the use of telemedicine in adults with type 2 diabetes. Studies were independently extracted and classified according to the following telemedicine strategies: teleeducation, telemonitoring, telecase-management, telementoring and teleconsultation. Traditional and network meta-analysis were performed to estimate the relative treatment effects. A total of 107 studies involving 20,501 participants were included. Over a median of 6 months follow-up, telemedicine reduced haemoglobin A1c (HbA1c) by a mean of 0.43% (95% CI: -0.64% to -0.21%). Network meta-analysis showed that all telemedicine strategies were effective in reducing HbA1c significantly compared to usual care except for

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[9] Lee SWH, Chan CKY, Chua SS, Chaiyakunapruk N. Comparative effectiveness of telemedicine strategies on type 2 diabetes management: A systematic review and network meta-analysis. *Sci Rep.* 2017;71.:12680. Published 2017 Oct 4. doi:10.1038/s41598-017-12987-z

telecase-management and telementoring, with mean difference ranging from 0.37% and 0.71%. Ranking indicated that teleconsultation was the most effective telemedicine strategy, followed by telecase-management plus telemonitoring, and finally teleeducation plus telecase-management. The review indicates that most telemedicine strategies can be useful, either as an adjunct or to replace usual care, leading to clinically meaningful reduction in HbA1c.

Tchero, Huidi et al (2017) [Systematic Review] **Telemedicine in Diabetic Foot Care: A Systematic Literature Review of Interventions and Meta-analysis of Controlled Trials[10]**

The care of individuals with diabetic foot ulcers is costly and requires multiple hospital visits. Inadequate care leads to serious complications and a high risk of lower extremity amputation. In this review, we aimed at evaluating whether telemedicine can be effective in diabetic foot patient care. We searched Medline through Embase and PubMed and Cochrane Central Register of Controlled Trials (CENTRAL) for relevant studies, published up to April 2017. The studies were summarized and discussed in a narrative method and a meta-analysis of 2 controlled trials was conducted using the fixed-effects model. The main outcomes, assessed in the retrieved studies were the healing rate and satisfaction of patients and health care personnel. Most of the studies showed that implementing telemonitoring programs increased the rate of complete ulcer healing, while the patients were highly satisfied. Two trials providing data on 213 patients on telemedicine and 301 patients on usual care were included for meta-analysis. Subjects in telemedicine, as well as control groups had statistically similar healing time (43 vs 45 days; P = .83), healing time ratio adjusted for age (1 vs 1.4; P = .1), unhealed ulcers or loss to follow-up (3 of 20 vs 7 of 120; P = .13), and amputations (12 of 193 vs 14 of 182; P = .59). Subjects in the telemedicine group experienced a significantly higher mortality rate (8 of 193 vs 1 of 181; P = .0001) due to unexplained factors. No adverse events were attributed to using the telemedicine technology. The odds of complete ulcer healing were statistically similar between the telemedicine group and controls (odds ratio = 0.86; 95% CI = 0.57-1.33; P = .53). Telemedicine care is promising for the management of diabetic foot patients as the results were

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[10] Tchero H, Noubou L, Becsangele B, Mukisi-Mukaza M, Retali GR, Rusch E. Telemedicine in Diabetic Foot Care: A Systematic Literature Review of Interventions and Meta-analysis of Controlled Trials. *Int J Low Extrem Wounds*. 2017;164.:274- 283. doi:10.1177/1534734617739195

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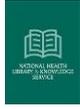
comparable with usual care. However, further large-scale studies need to be undertaken before it can be implemented widely.

Alharbi, Nouf Sahal et al (2016) [Systematic Review] Impact of **Information Technology-Based Interventions for Type 2 Diabetes Mellitus on Glycemic Control: A Systematic Review and Meta-Analysis**[11] Background: Information technology-based interventions are increasingly being used to manage health care. However, there is conflicting evidence regarding whether these interventions improve outcomes in people with type 2 diabetes. Objective: The objective of this study was to conduct a systematic review and meta-analysis of clinical trials, assessing the impact of information technology on changes in the levels of hemoglobin A1c (HbA1c) and mapping the interventions with chronic care model (CCM) elements. Methods: Electronic databases PubMed and EMBASE were searched to identify relevant studies that were published up until July 2016, a method that was supplemented by identifying articles from the references of the articles already selected using the electronic search tools. The study search and selection were performed by independent reviewers. Of the 1082 articles retrieved, 32 trials (focusing on a total of 40,454 patients) were included. A random-effects model was applied to estimate the pooled results. Results: Information technology-based interventions were associated with a statistically significant reduction in HbA1c levels (mean difference -0.33%, 95% CI -0.40 to -0.26, P<.001). Studies focusing on electronic self-management systems demonstrated the largest reduction in HbA1c (0.50%), followed by those with electronic medical records (0.17%), an electronic decision support system (0.15%), and a diabetes registry (0.05%). In addition, the more CCM-incorporated the information technology-based interventions were, the more improvements there were in HbA1c levels. Conclusions: Information technology strategies combined with the other elements of chronic care models are associated with improved glycemic control in people with diabetes. No clinically relevant impact was observed on low-density lipoprotein levels and blood pressure, but there was evidence that the cost of care was lower.

[11] Alharbi NS, Alsubki N, Jones S, Khunti K, Munro N, de Lusignan S. Impact of Information Technology-Based Interventions for Type 2 Diabetes Mellitus on Glycemic Control: A Systematic Review and Meta-Analysis. *J Med Internet Res*. 2016;18(11):e310. Published 2016 Nov 25. doi:10.2196/jmir.5778

Su, Dejun et al (2016) [Meta-Analysis] Does telemedicine improve treatment outcomes for diabetes? A meta-analysis of results from 55 randomized controlled trials[12]

Aims: To assess the overall effect of telemedicine on diabetes management and to identify features of telemedicine interventions that are associated with better diabetes management outcomes. Methods: Hedges's g was estimated as the summary measure of mean difference in HbA1c between patients with diabetes who went through telemedicine care and those who went through conventional, non-telemedicine care using a random-effects model. Q statistics were calculated to assess if the effect of telemedicine on diabetes management differs by types of diabetes, age groups of patients, duration of intervention, and primary telemedicine approaches used. Results: The analysis included 55 randomized controlled trials with a total of 9258 patients with diabetes, out of which 4607 were randomized to telemedicine groups and 4651 to conventional, non-telemedicine care groups. The results favored telemedicine over conventional care (Hedges's g = -0.48, p<0.001) in diabetes management. The beneficial effect of telemedicine were more pronounced among patients with type 2 diabetes (Hedges's g = -0.63, p<0.001) than among those with type 1 diabetes (Hedges's g = -0.27, p=0.027) (Q=4.25, p=0.04). Conclusions: Compared to conventional care, telemedicine is more effective in improving treatment outcomes for diabetes patients, especially for those with type 2 diabetes.

Jalil, Sakib et al (2015) [Meta-Analysis] A Meta-Synthesis of Behavioral Outcomes from Telemedicine Clinical Trials for Type 2 Diabetes and the Clinical User-Experience Evaluation (CUE)[13]

A worldwide demographic shift is in progress and the aged population proportion is projected to more than double across the next four decades. Our current healthcare models may not be adequate to handle this shift in demography, which may have serious consequences for the ageing population who are more prone to chronic diseases. One proposed remediation is to provide in-home assisted healthcare with technology-intervened approaches. Telemedicine, telehealth, e-health are paradigms found in scientific literature that provide clinical treatment through a technology intervention. In evidence-based medical science, these

[12] Su D, Zhou J, Kelley MS et al Does telemedicine improve treatment outcomes for diabetes? A meta-analysis of results from 55 randomized controlled trials. *Diabetes Res Clin Pract.* 2016;116:136-148. doi:10.1016/j.diabres.2016.04.019

[13] Jalil S, Myers T, Atkinson I. A meta-synthesis of behavioral outcomes from telemedicine clinical trials for type 2 diabetes and the Clinical User-Experience Evaluation (CUE). *J Med Syst.* 2015;393.:28. doi:10.1007/s10916-015-0191-9

technology interventions are evaluated through clinical trials, which are targeted to measure improvements in medical conditions and the treatment's cost effectiveness. However, effectiveness of a technology also depends on the interaction pattern between the technology and its' users, especially the patients. This paper presents: 1. a meta-synthesis of clinical trials for technology-intervened treatments of type 2 diabetes; and 2. the Clinical User-Experience Evaluation (CUE). CUE is a recommendation for future telemedicine clinical trials that focuses on the patient as the user from Human-Computer Interaction (HCI) perspective and was developed as part of this research. The clinical trials reviewed were interpreted from a technology perspective and the non-medical or non-biological improvements of the users (patients) rather than the medical outcome. Results show that technology-intervened treatments provide positive behavior changes among patients and are potentially highly beneficial for chronic illness management such as type 2 diabetes. The results from the CUE method show how it complements clinical trials to capture patients' interaction with a technology.

Mushcab, Hayat et al (2015) [Systematic Review] [Web-Based Remote Monitoring Systems for Self-Managing Type 2 Diabetes: A Systematic Review](#)[14]

This systematic review aims to evaluate evidence for viability and impact of web-based telemonitoring for managing type 2 diabetes mellitus. A review protocol included searching Medline, EMBASE, CINAHL, AMED, the Cochrane Library, and PubMed using the following terms: telemonitoring, type 2 diabetes mellitus, self-management, and web-based Internet solutions. The technology used, trial design, quality of life measures, and the glycated hemoglobin (HbA1c) levels were extracted. This review identified 426 publications; of these, 19 met preset inclusion criteria. Ten quasi-experimental research designs were found, of which seven were pre-posttest studies, two were cohort studies, and one was an interrupted time-series study; in addition, there were nine randomized controlled trials. web-based remote monitoring from home to hospital is a viable approach for healthcare delivery and enhances patients' quality of life. Six of these studies were conducted in South Korea, five in the United States, three in the UK, two in Taiwan, and one each in Spain, Poland, and India. The duration of the studies varied from 4 weeks to 18 months, and the participants were all

[14] Mushcab H, Kernohan WG, Wallace J, Martin S. Web-Based Remote Monitoring Systems for Self-Managing Type 2 Diabetes: A Systematic Review. *Diabetes Technol Ther.* 2015;177.:498– 509. doi:10.1089/dia.2014.0296

adults. Fifteen studies showed positive improvement in HbA1c levels. One study showed high acceptance of the technology among participants. It remains challenging to identify clear evidence of effectiveness in the rapidly changing area of remote monitoring in diabetes care. Both the technology and its implementations are complex. The optimal design of a telemedicine system is still uncertain, and the value of the real-time blood glucose transmissions is still controversial.

Randomised Controlled Trials

Lee, Jung Yang et al (2020) [Randomised Controlled Trial] Telemonitoring and Team-Based Management of Glycemic Control on People with Type 2 Diabetes: a Cluster-Randomized Controlled Trial[15]
Background: Connected devices that allow people with diabetes to monitor their blood glucose levels remotely with data visualization have been shown to improve self-care behavior in diabetes management. However, their effectiveness and usability for a low-middle-income, racially diverse population are unknown. Objective: This study aims to evaluate the effects of remote telemonitoring with team-based management on people with uncontrolled type 2 diabetes. Design: This was a pragmatic 52-week cluster-randomized controlled study among 11 primary care government practices in Malaysia. Participants: People with type 2 diabetes aged 18 and above, who had hemoglobin A1c ≥ 7.5% but less than 11.0% within the past 3 months and resided in the state of Selangor. Intervention: The intervention group received home gluco-telemonitors and transmitted glucose data to a care team who could adjust therapy accordingly. The team also facilitated self-management by supporting participants to improve medication adherence, and encourage healthier lifestyle and use of resources to reduce risk factors. Usual care group received routine healthcare service. Main measure: The primary outcome was the change in HbA1c at 24 weeks and 52 weeks. Secondary outcomes included change in fasting plasma glucose, blood pressure, lipid levels, health-related quality of life, and diabetes self-efficacy. Results: A total of 240 participants were recruited in this study. The telemonitoring group reported larger improvements in glycemic control compared with control at the end of study (week 24, - 0.05%; 95% CI - 0.10 to

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[15] Lee JY, Chan CKY, Chua SS et al Telemonitoring and Team-Based Management of Glycemic Control on People with Type 2 Diabetes: a Cluster-Randomized Controlled Trial. *J Gen Intern Med.* 2020;351.:87- 94. doi:10.1007/s11606-019-05316-9
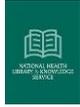
0.00%) and at follow-up (week 52, - 0.03%; - 0.07 to 0.02%, p = 0.226). Similarly, no differences in other secondary outcomes were observed, including the number of adverse events and health-related quality of life. Conclusion: This study indicates that there is limited benefit of replacing telemedicine with the current practice of self-monitoring of blood glucose. Further innovative methods to improve patient engagement in diabetes care are needed. Trial registration: ClinicalTrials.gov identifier: NCT02466880.

Benson, Gretchen A et al (2019) [Randomised Controlled Trial] [Impact of ENHANCED (diEtitiaNs Helping pAtieNts CarE for Diabetes) Telemedicine Randomized Controlled Trial on Diabetes Optimal Care Outcomes in Patients with Type 2 Diabetes](#)[16]
Background: Clinical care for type 2 diabetes has improved but remains suboptimal. Collaborative, team-based models that maximize skills of different disciplines may improve care for individuals with diabetes, but few have been tested using rigorous research designs. Objective: To investigate the efficacy of a registered dietitian nutritionist-led telemedicine program compared with that of a control group in terms of diabetes optimal care goals. Design: A randomized controlled trial in which participants were assigned to a control or intervention group. Participants/setting: One hundred eighteen adults with type 2 diabetes (mean age, 60 years; 45% female) participated in the study between April 2016 and December 2017. Participants were recruited from separate primary care clinics in two rural Minnesota communities. Intervention: For those assigned to the intervention, registered dietitian nutritionists used a treatment protocol to initiate and titrate therapies for blood glucose, hypertension, and lipid levels in addition to providing medical nutrition therapy; telemedicine visits supplemented usual care. Main outcome measures: Primary outcomes included composite and individual diabetes optimal care goals: hemoglobin A1c, blood pressure, not using tobacco, and taking a statin and aspirin (as appropriate). Secondary measures included physical activity, breakfast, fruits and vegetables, whole grains, body mass index, low-density lipoprotein, and medication adherence. Statistical analysis: Mixed-model regression was used to examine outcomes between baseline and 1-year follow-up. Results: A modest but significantly greater improvement in the number of diabetes optimal care measures met at follow-up was found in the intervention group (3.7 vs 3.2 in the control

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[16] Benson GA, Sidebottom A, Hayes J et al Impact of ENHANCED (diEtitiaNs Helping pAtieNts CarE for Diabetes) Telemedicine Randomized Controlled Trial on Diabetes Optimal Care Outcomes in Patients with Type 2 Diabetes. *J Acad Nutr Diet*. 2019;1194.:585- 598.
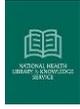
group [P=0.017]). Among individual measures, the intervention group had significantly greater medication use, with 2.5 and 2.2 higher odds (compared with the control group) of taking a statin [95% CI, 1.0 to 6.24]) and aspirin [95% CI, 0.90 to 5.19] as appropriate, respectively. Conclusions: ENHANCED (diEtitiaNs Helping pAtieNts CarE for Diabetes) findings suggest that registered dietitian nutritionists following medication treatment protocols can effectively improve care for adults with type 2 diabetes and can serve an instrumental role as part of the health care team in providing evidence-based, patient-centered care. Trial registration: ClinicalTrials.gov NCT02980978.

Franc, Sylvia et al (2019) [Randomised Controlled Trial] Efficacy of two telemonitoring systems to improve glycaemic control during basal insulin initiation in patients with type 2 diabetes: The TeleDiab-2 randomized controlled trial[17]
TeleDiab-2 was a 13-month randomized controlled trial evaluating the efficacy and safety of two telemonitoring systems to optimize basal insulin (BI) initiation in subjects with inadequately controlled type 2 diabetes (HbA1c, 7.5%-10%). A total of 191 participants (mean age 58.7 years, mean HbA1c 8.9%) were randomized into three groups: group 1(G1, standard care, n = 63), group 2 (G2, interactive voice response system, n = 64) and group 3 (G3, Diabeo-BI app software, n = 64). The two telemonitoring systems proposed daily adjustments of BI doses, in order to facilitate the achievement of fasting blood glucose (FBG) values targeted at ~100 mg/dL. At 4 months follow-up, HbA1c reduction was significantly higher in the telemonitoring groups (G2: -1.44% and G3: -1.48% vs. G1: -0.92%; P < 0.002). Moreover, target FBG was reached by twice as many patients in the telemonitoring groups as in the control group, and insulin doses were also titrated to higher levels. No severe hypoglycaemia was observed in the telemonitoring groups and mild hypoglycaemia frequency was similar in all groups. In conclusion, both telemonitoring systems improved glycaemic control to a similar extent, without increasing hypoglycaemic episodes.

[17] Franc S, Joubert M, Daoudi A et al Efficacy of two telemonitoring systems to improve glycaemic control during basal insulin initiation in patients with type 2 diabetes: The TeleDiab-2 randomized controlled trial. *Diabetes Obes Metab*. 2019;21(10):2327-2332. doi:10.1111/dom.13806

Yaron, Marianna et al (2019) [Randomised Controlled Trial] A Randomized Controlled Trial Comparing a Telemedicine Therapeutic Intervention With Routine Care in Adults With Type 1 Diabetes Mellitus Treated by Insulin Pumps[18]

Aim: To examine the effectiveness and safety over a 12-month period of a telemedicine intervention in adults with type 1 diabetes (T1D) treated with insulin pumps. Methods: 74 T1D patients on insulin pumps for at least 1 year (mean 19.5 [11.5] years) and HbA1c ≥ 6.5% (≥ 48 mmol/mol) were randomized to the telemedicine (n = 37) or the standard care group (n = 37). The intervention group was instructed to download data from insulin pumps and glucometers monthly. They received immediate phone feedback and recommendations for insulin dose adjustment; and face-to-face visits once in 6 months, compared to once every 3 months for the standard care group. Satisfaction with treatment, quality of life and frequency of hypoglycemic events was evaluated. Results: The mean changes in HbA1c adjusted to baseline were - 0.08% (0.25 mmol/mol) vs. - 0.01% (0.03 mmol/mol), in the intervention and control groups, respectively (p = 0.18) at 12 months, without an increased frequency of hypoglycemia. Patients in the intervention group felt satisfied and interested in continuing with the treatment (p = 0.04). The quality of life scores were similar in both groups. Direct total costs were 24% less in the intervention group, and indirect total costs decreased by 22% compared to the year preceding the study. Conclusions: Internet-based insulin dose adjustment is as effective and safe as routine care in adults with type 1 diabetes treated by insulin pumps. For suitable patients, some of the time-consuming routine visits may be replaced by user-friendly digital medicine. Clinical trial registration: Clinical Trial.gov Identifier NCT01887431.

Bertuzzi, Federico et al (2018) [Randomised Controlled Trial] Teleconsultation in type 1 diabetes mellitus (TELEDIABE)[19]

Aims: The growing incidence of diabetes and the need to contain healthcare costs emphasize the necessity to identify new models of care. Telemedicine offers an acknowledged instrument to provide clinical health care at a distance, increasing patient compliance and the achievement of therapeutical goals. The objective was to test the feasibility and the efficacy

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[18] Yaron M, Sher B, Sorek D et al A randomized controlled trial comparing a telemedicine therapeutic intervention with routine care in adults with type 1 diabetes mellitus treated by insulin pumps. *Acta Diabetol.* 2019;566.:667- 673. doi:10.1007/s00592-019-01300-1

[19] Bertuzzi F, Stefani I, Rivolta B et al Teleconsultation in type 1 diabetes mellitus (TELEDIABE). *Acta Diabetol.* 2018;552.:185- 192. doi:10.1007/s00592-017-1084-9

in the improvement of the glycemic control of the teleconsultation for patients with type 1 diabetes mellitus. Methods: A randomized open-label, parallel arm, controlled trial was conducted in two diabetes centers in Italy. Participants affected by type 1 diabetes mellitus have been randomly (1:1) assigned to receive their visits as standard or a web-based care. Patients in the teleconsultation group can arrange their appointments on a Web site and can also have access to web educational courses or to nutritional and psychological counseling. The primary outcome was the assessment of glycemic control by HbA1c measurement after a 12-month follow-up. Results: Overall 74 participants were followed for 1 year. HbA1c changes were not statistically different within (p = 0.56 for standard care group; p = 0.45 for telemedicine group) and between (p = 0.60) groups when considering differences from baseline to the end of the study. Patients randomized to teleconsultation reported reduced severe hypoglycemic episodes (p = 0.03). In addition, they were largely satisfied with the activities, perceived a good improvement in the self-management of the diabetes, and reported to have a time saving and a cost reduction. Conclusions: In conclusion, TELEDIABE proposes a new system for the management of patients with type 1 diabetes mellitus.

Smith-Strom, Hilde et al (2018) [Randomised Controlled Trial] The Effect of Telemedicine Follow-up Care on Diabetes-Related Foot Ulcers: A Cluster-Randomized Controlled Noninferiority Trial[20]
Objective: To evaluate whether telemedicine (TM) follow-up of patients with diabetes-related foot ulcers (DFUs) in primary health care in collaboration with specialist health care was noninferior to standard outpatient care (SOC) for ulcer healing time. Further, we sought to evaluate whether the proportion of amputations, deaths, number of consultations per month, and patient satisfaction differed between the two groups. Research design and methods: Patients with DFUs were recruited from three clinical sites in western Norway (2012-2016). The cluster-randomized controlled noninferiority trial included 182 adults (94/88 in the TM/SOC groups) in 42 municipalities/districts. The intervention group received TM follow-up care in the community; the control group received SOC. The primary end point was healing time. Secondary end points were amputation, death, number of consultations per month, and patient satisfaction. Results: Using mixed-

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[20] Smith-Strøm H, Igland J, Østbye T et al The Effect of Telemedicine Follow-up Care on Diabetes-Related Foot Ulcers: A Cluster-Randomized Controlled Noninferiority Trial. *Diabetes Care*. 2018;411.:96- 103. doi:10.2337/dc17-1025

effects regression analysis, we found that TM was noninferior to SOC regarding healing time (mean difference -0.43 months, 95% CI -1.50, 0.65). When competing risk from death and amputation were taken into account, there was no significant difference in healing time between the groups (subhazard ratio 1.16, 95% CI 0.85, 1.59). The TM group had a significantly lower proportion of amputations (mean difference -8.3%, 95% CI -16.3%, -0.5%), and there were no significant differences in the proportion of deaths, number of consultations, or patient satisfaction between groups, although the direction of the effect estimates for these clinical outcomes favored the TM group. Conclusions: The results suggest that use of TM technology can be a relevant alternative and supplement to usual care, at least for patients with more superficial ulcers. Trial registration: ClinicalTrials.gov NCT01710774.

Sood, Ajay et al (2018) [Randomised Controlled Trial] Telemedicine consultation for patients with diabetes mellitus: a cluster randomised controlled trial[21]
Introduction: There is a widening discrepancy between the increasing number of patients with diabetes mellitus and the health care resources available to manage these patients. Telemedicine has been used in a number of instances to improve and deliver health care where traditional care delivery methods may encounter difficulty. We conducted a cluster randomised controlled trial of telemedicine consultation to manage patients with diabetes mellitus. Methods: Eleven primary care centres attached to one Veteran Administration tertiary care centre were randomised to provide patients with diabetes consultation referral either by usual consultation in diabetes clinic or telemedicine consultations via videoconference. Results: Altogether, 199 patients were managed by telemedicine consultation and 83 by usual consultation. Patients in both groups showed a small decrease in haemoglobin A1c, with no statistical difference between the groups (telemedicine consultation -1.01% vs usual consultation -0.68%, p = 0.19). Surveys of patients and semi-structured interviews with primary care providers showed better response and satisfaction with telemedicine consultations. Discussion: This study shows similar clinical outcomes as measured by glycaemic control for patients with diabetes mellitus having a specialist consultation using real-time telemedicine consultation as

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[21] Sood A, Watts SA, Johnson JK, Hirth S, Aron DC. Telemedicine consultation for patients with diabetes mellitus: a cluster randomised controlled trial. *J Telemed Telecare*. 2018;246.:385- 391. doi:10.1177/1357633X17704346

compared to in-clinic consultation. Telemedicine consultation was also associated with better patient and primary care provider satisfaction.

Di Bartolo, Paolo et al (2017) [Randomised Controlled Trial] Young patients with type 1 diabetes poorly controlled and poorly compliant with self-monitoring of blood glucose: can technology help? Results of the i-NewTrend randomized clinical trial[22]

Aims: To compare iBGStar™ + DMApp [experimental meter + telemedicine system] (iBGStar) with a traditional glucose meter (Control) in type 1 diabetes adolescents/young adults. Methods: i-NewTrend was a multicenter, open-label, randomized trial involving subjects aged 14-24 years, on basal-bolus insulin, HbA1c ≥ 8.0%, and poorly compliant with SMBG: ie <30% of the recommended frequency. Primary end points were change in HbA1c and achievement of compliance with SMBG ≥30% of the recommended frequency after 6 months. Quality of life was also evaluated. A post-trial observational phase was conducted, where both groups used the experimental device. Results: Of 182 randomized patients (51.1% male; age 17.7 ± 3.0 years; diabetes duration 8.8 ± 4.7 years; HbA1c levels 10.0% ± 1.4), 92 were allocated to iBGStar and 90 to Control; 6.5% in iBGStar and 8.9% in Control dropped-out. After 6 months, HbA1c changes (±SE) were -0.44% ± 0.13 in iBGStar and -0.32% ± 0.13 in Control (p = 0.51). In the post-trial phase, HbA1c changes from 6 months (±SE) were -0.07% ± 0.14 in iBGStar and -0.31% ± 0.14 in Control (p = 0.24). Compliance end point was reached by 53.6% in iBGStar and 55.0% in Control (p = 0.86). Mean daily SMBG measurements increased from 1.1 to 2.3 in both groups without worsening quality of life. Compliant subjects showed a greater reduction in HbA1c levels (-0.60% ± 0.23 in iBGStar; -0.41% ± 0.21 in Control; p = 0.31). Within iBGStar group, telemedicine users (38.0%) reduced HbA1c by -0.58 ± 0.18. Conclusions: iBGStar was not superior to the traditional meter. Irrespective of the strategy, increasing from 1 to 2 SMBG tests/day was associated with HbA1c reduction in both groups, without pharmacologic interventions. Identifying new technologies effective and acceptable to patients is an option to improve adherence to diabetes care. Trial registration: the trial was registered at ClinicalTrials.gov, registration number NCT02073188.

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[22] Di Bartolo P, Nicolucci A, Cherubini V, Iafusco D, Scardapane M, Rossi MC. Young patients with type 1 diabetes poorly controlled and poorly compliant with self-monitoring of blood glucose: can technology help? Results of the i-NewTrend randomized clinical trial. *Acta Diabetol.* 2017;544.:393- 402. doi:10.1007/s00592-017-0963-4

Hansen, Caroline Raun et al (2017) [Randomised Controlled Trial] Video Consultations as Add-On to Standard Care Among Patients With Type 2 Diabetes Not Responding to Standard Regimens: A Randomized Controlled Trial[23]

Objective: To examine whether video consultations preceded by measurements of blood glucose, weight and blood pressure as add-on to standard care could contribute to achieving and maintaining good diabetes control among patients with poorly regulated type 2 diabetes (T2D). Design: Randomized controlled trial. Methods: 165 patients with T2D were randomized 1:1 to telemedicine intervention as add-on to clinic-based care or control [clinic-based care]. The intervention consisted of monthly video conferences with a nurse via a tablet computer and lasted for 32 weeks. Regularly self-monitored measurements of blood sugar, blood pressure and weight were uploaded and visible to patient and nurse. Both groups were followed up six months after the end of the intervention period. Primary endpoint: HbA1c after eight months. Results: Video conferences preceded by uploads of measurements as add-on to clinic-based care led to a significant reduction of HbA1c compared to that in standard care (0.69% vs 0.18%, P = 0.022). However, at six-month follow-up, the inter-group difference in HbA1c-reduction was no longer significant. Non-completers had higher HbA1c levels at baseline and a lower degree of education. Conclusion: Video consultations preceded by uploading relevant measurements can lead to clinically and statistically significant improvements in glycemic control among patients who have not responded to standard regimens. However, continuing effort and attention are essential as the effect does not persist when intervention ends. Furthermore, future studies should focus on differentiation as the most vulnerable patients are at greater risk of non-adherence. Trial registration: ClinicalTrials.gov NCT01688778.

Nicolucci, Antonio et al (2015) [Randomised Controlled Trial] A Randomized Trial on Home Telemonitoring for the Management of Metabolic and Cardiovascular Risk in Patients with Type 2 Diabetes[24]

Background: This study evaluated whether a home telehealth (HT) system enabling the patient to monitor body weight, blood glucose values, and blood

[23] Hansen CR, Perrild H, Koefoed BG, Zander M. Video consultations as add-on to standard care among patients with type 2 diabetes not responding to standard regimens: a randomized controlled trial. *Eur J Endocrinol.* 2017;1766.:727-736. doi:10.1530/EJE-16-0811

[24] Nicolucci A, Cercone S, Chiriatti A, Muscas F, Gensini G. A Randomized Trial on Home Telemonitoring for the Management of Metabolic and Cardiovascular Risk in Patients with Type 2 Diabetes. *Diabetes Technol Ther.* 2015;178.:563-570. doi:10.1089/dia.2014.0355

pressure values, associated with remote educational support and feedback to the general practitioner, can improve metabolic control and overall cardiovascular risk in individuals with type 2 diabetes mellitus, compared with usual practice. Materials and Methods: This was a randomized, parallel-group (1:1), open-label, multicenter study conducted in general practice. Follow-up was for 12 months. Results: Overall, 29 general practitioners enrolled 302 patients, 153 assigned to the HT group and 149 to the control group. Use of the HT system was associated with a statistically significant reduction in glycated hemoglobin (HbA1c) levels compared with the control group (estimated mean difference, 0.33±0.1; P=0.001). No difference emerged as for body weight, blood pressure, and lipid profile. The proportion of patients reaching the target of HbA1c <7.0% was higher in the HT group than in the control group after 6 months (33.0% vs. 18.7%; P=0.009) and 12 months (28.1% vs. 18.5%; P=0.07). As for quality of life evaluated with the 36-item Short Form health survey, significant differences in favor of the HT group were detected as for physical functioning (P=0.01), role limitations due to emotional problems (P=0.02), mental health (P=0.005), and mental component summary (P=0.03) scores. A lower number of specialist visits was reported in the telemedicine group (incidence rate ratio, 0.72; 95% confidence interval, 0.51-1.01; P=0.06). Conclusions: Use of the HT system was associated with better metabolic control and quality of life; a marginally nonsignificant lower resource utilization was also documented. No impact was documented on blood pressure, lipid profile, and body weight. Trial registration: ClinicalTrials.gov NCT02194608.

Miscellaneous

Banks, JL et al (2020) [Use of a Remote Temperature Monitoring Mat for the Early Identification of Foot Ulcers](#)[25]
Diabetic foot ulcers (DFUs) are responsible for considerable morbidity, mortality, and cost. Remote temperature monitoring (RTM) is an evidenced-based and recommended component of standard foot care for at-risk patients. Although previous research has demonstrated the value of RTM for foot ulcer prevention, its benefits related to the early identification of

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[25] Banks JL, Petersen BJ, Rothenberg GM, Jong AS, Page JC. Use of a Remote Temperature Monitoring Mat for the Early Identification of Foot Ulcers. *Wounds*. 2020;322.:44- 49.

diabetic foot complications may be underappreciated. This article presents a case series supporting the use of RTM for early identification of DFUs. Materials and methods: The cases of 4 veteran patients who presented consecutively with inflammation, which was detected by a telemedicine temperature monitoring mat, are reported. The authors collected subjective history from each patient via telephone outreach and triaged these patients according to standard diabetic foot care recommendations. Each patient required a clinical exam prompted by the mat and the patient's subjective history. In each case, the patient required callus debridement upon which a pre-ulcerative lesion or partial-thickness wound was discovered. The DFUs in these 4 cases healed quickly and without complication. In 2 of the cases, the outreach prompted by the mat reestablished specialist foot care after a prolonged period without routine exam. In each of these cases, the RTM mat detected inflammation accompanying a preulcerative lesion or a partial-thickness wound, allowing for timely intervention and treatment, including debridement and offloading, which may have the potential to improve care and reduce morbidity, mortality, and costs.

Cai, Xiaoling et al (2020) [Achieving Effective and Efficient Basal Insulin Optimal Management by Using Mobile Health Application (APP) for Type 2 Diabetes Patients in China](#)[26]
Aim: To evaluate the effectiveness of the mobile health application (APP) education in basal insulin optimal management program for insulin-naive type 2 diabetes (T2D) patients in China. Methods: The basal insulin optimal management program was launched in 297 hospitals in China, throughout the six main regions of China. A total of 17,208 insulin-naive patients with T2D who started to use basal insulin were screened. The mobile health APP was downloaded in each recruited patient's mobile phone and the doctor's mobile phone. Then, according to the instructions and education materials in the APP, these patients began their self-management of insulin dosage titrations and contacted their doctors by APP if they need help. Results: Overall, 12,530 patients with T2D were finally included in the analysis. The average age was 51.97±12.76 years, and 58% of them were males. The average body mass index is 24.46±3.83 kg/m2, and the average HbA1c at baseline was 8.33±2.11% with 24% of the subjects reaching the target of HbA1c<7.0% at baseline. After 3 months of treatment and educations

[26] Cai X, Zhang F, Lin C et al Achieving Effective and Efficient Basal Insulin Optimal Management by Using Mobile Health Application (APP) for Type 2 Diabetes Patients in China. *Diabetes Metab Syndr Obes*. 2020;13:1327-1338. Published 2020 Apr 23. doi:10.2147/DMSO.S244826

through the APP, HbA1c decreased significantly from baseline (-1.02±1.72%), with 59% of the patients reaching HbA1c<7.0%. After 6 months, the glycemic control of HbA1c also decreased from baseline significantly (-1.01±1.67%). Dosage of insulin daily was 0.23±0.09 IU/kg at baseline, and 0.23±0.23 IU/kg after 6 months of treatment. Regarding the profiles of hypoglycemia treatment, 3145 patients received basal insulin in combination with mono oral anti-diabetic drug (OAD), 1204 patients with dual OADs, 208 patients with triple OADs, and 17 patients with quarter OADs. Conclusion: Patients could benefit from the basal insulin optimal management program in self-management by using mobile health APP educations. For T2D patients who are going to start insulin treatment, mobile health APP can help them to reach the target of glycemic control with appropriate dosage of insulin.

Crossen, Stephanie et al (2020) Top 10 Tips for Successfully Implementing a Diabetes Telehealth Program[27]

Diabetes management is well suited to use of telehealth, and recent improvements in both diabetes technology and telehealth policy make this an ideal time for diabetes providers to begin integrating telehealth into their practices. This article provides background information, specific recommendations for effective implementation, and a vision for the future landscape of telehealth within diabetes care to guide interested providers and practices on this topic.

Garg, Satisk K et al (2020) Managing New-Onset Type 1 Diabetes During the COVID-19 Pandemic: Challenges and Opportunities[28]

Background: The current COVID-19 pandemic provides an incentive to expand considerably the use of telemedicine for high-risk patients with diabetes, and especially for the management of type 1 diabetes (T1D). Telemedicine and digital medicine also offer critically important approaches to improve access, efficacy, efficiency, and cost-effectiveness of medical care for people with diabetes. Methods: Two case reports are presented where telemedicine was used effectively and safely after day 1 in person patient education. These aspects of the management of new-onset T1D patients [adult and pediatric] included ongoing diabetes education of the patient and family digitally. The patients used continuous glucose

[27] Crossen S, Raymond J, Neinstein A. Top 10 Tips for Successfully Implementing a Diabetes Telehealth Program [published online ahead of print, 2020 Apr 21]. *Diabetes Technol Ther*. 2020;10.1089/dia.2020.0042. doi:10.1089/dia.2020.0042
[28] Garg SK, Rodbard D, Hirsch IB, Forlenza GP. Managing New-Onset Type 1 Diabetes During the COVID-19 Pandemic: Challenges and Opportunities [published online ahead of print, 2020 Apr 17]. *Diabetes Technol Ther*. 2020;10.1089/dia.2020.0161. doi:10.1089/dia.2020.0161

monitoring with commercially available analysis software to generate ambulatory glucose profiles and interpretive summary reports. The adult subject used multiple daily insulin injections; the pediatric patient used an insulin pump. The subjects were managed using a combination of e-mail, Internet via Zoom, and telephone calls. Results: These two cases show the feasibility and effectiveness of use of telemedicine in applications in which we had not used it previously: new-onset diabetes education and insulin dosage management. Conclusions: The present case reports illustrate how telemedicine can be used safely and effectively for new-onset T1D training and education for both pediatric and adult patients and their families. The COVID-19 pandemic has acutely stimulated the expansion of the use of telemedicine and digital medicine. We conclude that telemedicine is an effective approach for the management of patients with new-onset T1D.

Ghosh, Amerta et al (2020) Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: Guidelines for physicians[29]

Background and aims: In view of restrictions on mobility of patients because of COVID-19 pandemic, face-to-face consultations are difficult. We sought to study the feasibility of telemedicine in this scenario. Results: We discuss evidence and general guidelines regarding the role of telemedicine in patients with diabetes along with its utility and limitations. Conclusions: Telemedicine is a useful tool for managing patients of diabetes during this lockdown period. However, there is limited data and further research is required.

Karpova, Elena V et al (2020) Wearable Non-Invasive Monitors of Diabetes and Hypoxia Through Continuous Analysis of Sweat[30]

We present here wearable devices for continuous monitoring of diabetes and hypoxia based on continuous analysis of sweat. To induce sweating the clinically relevant procedure [pilocarpine electrophoresis] is used. Being a sufficient requirement for diagnostics, positive correlations in variation rates between glucose and lactate concentrations in sweat and the corresponding values in blood are shown. Continuous monitoring of human condition is possible only with the use of flow-through wearable devices providing a

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[29] Ghosh A, Gupta R, Misra A. Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: Guidelines for physicians [published online ahead of print, 2020 Apr 4]. *Diabetes Metab Syndr*. 2020;144.:273– 276. doi:10.1016/j.dsx.2020.04.001

[30] Karpova EV, Karyakina EE, Karyakin AA. Wearable non-invasive monitors of diabetes and hypoxia through continuous analysis of sweat. *Talanta*. 2020;215:120922. doi:10.1016/j.talanta.2020.120922

delivery of sweat to the biosensor almost immediately after secretion. Evaluating blood glucose through continuous sweat analysis upon glucose tolerance test, we clearly show that diabetics can actually be monitored reliably via non-invasive approach.

Michaud, Tzeyu L et al (2020) [Program completion and glycemic control in a remote patient monitoring program for diabetes management: Does gender matter?](#)[31]

Aims: To examine gender differences in program completion and glycemic outcomes for patients with type 2 diabetes (T2D) in a remote patient monitoring (RPM) program for diabetes management. Methods: Based on data from an RPM program that enrolled post-discharge T2D patients (n = 1645) in 2014-2017, logistic regression models were estimated to assess gender difference in the likelihood of completing the three-month RPM program; whereas ordinary least squares (OLS) regression models were used to examine gender difference in post-RPM hemoglobin A1c (HbA1c), controlling for demographics, baseline health status, including HbA1c, patient activation scores, and physiological data upload frequency for patients who had completed the program. Results: Among enrolled participants, men had lower odds of completing the three-month RPM program than women (adjusted odds ratio, 0.61; 95% confidence interval [CI], 0.39-0.95). However, among those who completed the program, men had lower post-RPM HbA1c than women (-0.18; 95% CI, -0.33, -0.03) after controlling for baseline HbA1c and other covariates. Conclusions: While female patients with T2D were more likely to complete the RPM program, they showed a higher glycemic level at the end of the program compared to male patients. To close gender disparities in health, interventions through telemedicine tailored towards women's diabetes outcomes and men's engagement level are warranted.

Andres, E et al (2019) [Update on research projects in the field of telemedicine in diabetes, with a focus on remote monitoring (telemonitoring) 2.0 projects](#)[32]

Background: This is a narrative review of remote monitoring projects within the field of type 1 (T1D) and type 2 diabetes (T2D), with special attention

[31] Michaud TL, Siahpush M, King KM et al Program completion and glycemic control in a remote patient monitoring program for diabetes management: Does gender matter?. *Diabetes Res Clin Pract*. 2020;159:107944. doi:10.1016/j.diabres.2019.107944
[32] Andres E, Meyer L et al Update on research projects in the field of telemedicine in diabetes, with a focus on remote monitoring (telemonitoring) 2.0 projects. *Médecine des Maladies Métaboliques*. 2019;131.:75-87.

placed on telemedicine 2.0 projects and studies. Results: Since the beginning of the 1990's, several telemedicine projects and studies focused on T1D and T2D have been developed. Mainly, these projects and studies show that telemonitoring diabetic result in: improved blood glucose control, a significant reduction in HbA1c, improved patient ownership of the disease, greater patient adherence to therapeutic and hygiene-dietary measures, positive impact on comorbidities (hypertension, weight, dyslipidemia), improved quality of life for patients, and at least good patient receptivity and accountability. To date, the magnitude of its effects remain debatable, especially with the variation in patients' characteristics (eg background ability for self-management, medical condition), samples selection and approach of treatment of control groups. Over the last 5 years, numerous telemedicine projects based on connected objects and new information and communication technologies (ICT) ⬜ elements defining telemedicine 2.0 ⬜ have emerged or are still under development. Two examples are the DIABETe and TELESAGE telemonitoring project which perfectly fits within the telemedicine 2.0 framework, being the firsts to include artificial intelligence (AI) with MyPrediTM and DiabeoTM.

Holubova, Anna et al (2019) [Customizing the Types of Technologies Used by Patients With Type 1 Diabetes Mellitus for Diabetes Treatment: Case Series on Patient Experience](#)[33]
Background: Despite the fact there are many wearable and mobile medical devices that enable patients to better self-manage their diabetes, not many patients are aware of all the options they have. In addition, there are those who are not fully satisfied with the devices they use, and those who often do not use them effectively. Objective: The study aimed to propose possible changes to the combination of devices used by 6 specific patients for diabetes self-management. We assessed the suitability of selected technical devices for diabetes control. Methods: Data of 6 patients (3 men and 3 women) with type 1 diabetes mellitus, who had been using the Diani telemedicine system for at least 3 months, were analyzed. The suitability of selected technical devices for diabetes control was ascertained using the data obtained via the Diani telemedicine system, as well as the patients' subjective feelings and statements, their everyday life habits, and self-management of diabetes. Informed consent was signed and obtained from

[33] Holubová A, Vlasáková M, Mužík J, Brož J. Customizing the Types of Technologies Used by Patients With Type 1 Diabetes Mellitus for Diabetes Treatment: Case Series on Patient Experience. *JMIR Mhealth Uhealth*. 2019;77.:e11527. Published 2019 Jul 9. doi:10.2196/11527

each of the patients included. Results: Each of the presented case studies describes how a given patient handled the system and its specific components based on his or her lifestyle, level of education, habits related to diabetes management, personality type, and other factors. At the conclusion of each case study, the best composition of devices for patients with similar personal descriptions was suggested. Conclusions: We believe this study can provide relevant guidance on how to help particular patients choose the technology that is best suited for their needs, based on the specific patient information we are able to obtain from them. Furthermore, clinicians or educators should be aware of available technologies a given patient can choose from. In addition, there is a substantial need for proper patient education in order for them to effectively use devices for diabetes self-management.

Lee, Jung Yan et al (2019) [Using telemedicine to support care for people with type 2 diabetes mellitus: A qualitative analysis of patients' perspectives](#)[34]

Objective: Telemedicine has been promoted as an economical and effective way to enhance patient care, but its acceptance among patients in low-income and middle-income countries is poorly understood. This study is aimed to explore the experiences and perspectives of people with type 2 diabetes mellitus that used telemedicine to manage their condition. Design: In-depth and focus group interviews were conducted with participants who have engaged in telemedicine. Questions included were participants' perception on the programme being used, satisfaction as well as engagement with the telemedicine programme. All interviews and focus groups were audio-recorded and transcribed verbatim. Data were analysed using a thematic approach. Participants and setting: People with type 2 diabetes (n=48) who participated in a randomised controlled study which examined the use of telemedicine for diabetes management were recruited from 11 primary care clinics located within the Klang Valley. Results: Twelve focus groups and two in-depth interviews were conducted. Four themes emerged from the analysis: 1. generational difference; 2. independence and convenience, 3. sharing of health data and privacy and 4. concerns and challenges. The main obstacles found in patients using the telemedicine systems were related to Internet connectivity and difficulties experienced with system interface. Cost was also another significant concern raised by

participants. Participants in this study were primarily positive about the benefits of telemedicine, including its ability to provide real-time data and disease monitoring and the reduction in clinic visits. Conclusion: Despite the potential benefits of telemedicine in the long-term care of diabetes, there are several perceived barriers that may limit the effectiveness of this technology. As such, collaboration between educators, healthcare providers, telecommunication service providers and patients are required to stimulate the adoption and the use of telemedicine. Trial registration: ClinicalTrials.gov NCT02466880.

Dastjerdi, Mansour Siavash et al (2019) [A Roundup of the Simplest Mobile Phone Uses in Diabetes Management](35)
With the increasing use of mobile phones, mHealth has grown to be a very promising subject. However, mHealth programs haven't been widespread in many countries, especially in developing countries. Health-related phone applications, and in particular diabetes-related mobile apps, are gaining more popularity by the day. Yet, there are still some concerns about the safety and effectiveness of these apps. In this short commentary, we will discuss the simple uses of mobile phones and how they can contribute to the communication between patients and health professional providers.

Yaslam, Maram et al (2019) [Non-mydriatic Fundus Camera Screening With Diagnosis by Telemedicine for Diabetic Retinopathy Patients With Type 1 and Type 2 Diabetes: A Hospital-Based Cross-Sectional Study](36)
Background: Diabetic retinopathy (DR) is considered the fifth leading cause of visual impairment worldwide and is associated with a huge social and economic burden. Objective: Describe the practicality of non-mydriatic funduscopic screening photography for the detection of DR among patients with type 1 and type 2 diabetes. Design: Cross-sectional hospital-based study. Setting: Diabetes center, Riyadh. Patients and methods: Between July and December 2017, patients with diabetes and aged ≥18 years were selected by systematic random sampling from the University Diabetes Center. Fundoscopic eye examination was performed using the TRC-NW8 non-mydriatic camera, which performs ocular coherence tomography (OCT) to detect macular edema. Using telemedicine, pictures were graded by a

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[35] Siavash Dastjerdi M, Tabatabaee A. A roundup of the simplest mobile phone uses in diabetes management. *Diabetes Res Clin Pract.* 2019;158:107895. doi:10.1016/j.diabres.2019.107895

[36] Yaslam M, Al Adel F, Al-Rubeaan K et al Non-mydriatic fundus camera screening with diagnosis by telemedicine for diabetic retinopathy patients with type 1 and type 2 diabetes: a hospital-based cross-sectional study. *Ann Saudi Med.* 2019;395.:328-336. doi:10.5144/0256-4947.2019.328

retinal-specialized ophthalmologist using the international clinical DR disease severity scale. Patients were classified according to the type and severity of DR. Main outcome measures: Detection and classification of DR. Sample size: 978 Saudi patients with diabetes. Results: Of 426 (43.5%) patients with DR, 370 had nonproliferative DR and 55 had proliferative DR. Nineteen (1.9%) had macular edema. The most important risk factors for DR were longer diabetes duration and poor glycemic control. Both older age and insulin use contributed to the higher prevalence of DR and macular edema. DR was more common among type 1 patients at 55.4% compared with 49% among type 2 patients. In addition, more females had macular edema (57.1% versus 42.9% among males). Nine patients with macular edema (47.3%) had hypertension while 154 of 426 patients with DR (36.2%) had hypertension. Conclusion: Non-mydriatic funduscopic screening photography was practical and useful for the detection of DR in patients with type 1 and type 2 diabetes.

Kolltveit, Beate-Christin Hope et al (2018) [Telemedicine follow-up facilitates more comprehensive diabetes foot ulcer care: A qualitative study in home-based and specialist health care](#)[37]

Aims and objectives: To investigate the application of a telemedicine intervention in diabetes foot ulcer care, and its implications for the healthcare professionals in the clinical field. Background: Contextual factors are found to be important when applying technology in health care and applying telemedicine in home-based care has been identified as particularly complex. Design and methods: We conducted field observations and individual interviews among healthcare professionals in home-based care and specialist health care in a diabetes foot care telemedicine RCT [Clin.Trial.gov: NCT01710774] during 2016. This study was guided by Interpretive Description, an inductive qualitative methodology. Results: Overall, we identified unequal possibilities for applying telemedicine in diabetes foot ulcer care within the hospital and home care contexts. Different circumstances and possibilities in home-based care made the application of telemedicine as intended more difficult. The healthcare professionals in both care contexts perceived the application of telemedicine to facilitate a more comprehensive approach towards the patients, but with different possibilities to enact it. Conclusions: Application of telemedicine in

[37] Kolltveit BH, Thorne S, Graue M, Gjengedal E, Iversen MM, Kirkevold M. Telemedicine follow-up facilitates more comprehensive diabetes foot ulcer care: A qualitative study in home-based and specialist health care. *J Clin Nurs*. 2018;27(5-6):e1134- e1145. doi:10.1111/jocn.14193
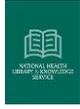
home-based care was more challenging than in the outpatient clinic setting. Introducing more updated equipment and minor structural adjustments in consultation time and resources could make the use of telemedicine in home-based care more robust. Relevance to clinical practice: Application of telemedicine in diabetes foot ulcer follow-up may enhance the nursing staff's ability to conduct comprehensive assessment and care of the foot ulcer as well as the patient's total situation. Access to adequate equipment and time, particularly in home-based care, is necessary to capitalise on this new technology.

Naik, Sapna et al (2018) [Identification of factors to increase efficacy of telemedicine screening for diabetic retinopathy in endocrinology practices using the Intelligent Retinal Imaging System (IRIS) platform](38)

Aims: Diabetic retinopathy (DR) and diabetic macular edema (DME) can be evaluated using telemedicine systems, such as the Intelligent Retinal Imaging Systems (IRIS), in patients with Diabetes Mellitus (DM). In an endocrinology-based population utilizing IRIS we determine prevalence rates of DR and DME, and identify associated epidemiologic correlations. Methods: This is a multicenter, retrospective chart review using screening data from IRIS. Centers for Disease Control and Prevention (CDC) data on epidemiologic variables (by county) namely, prevalence of DM, incidence of DM, obesity, and time of physical inactivity, were compared against prevalence rates of DR found at screening. Results: A total of 10,223 eyes of 5,242 patients with DM were imaged. DR and DME were noted in 1781 (33.98%) and 226 imaging studies (4.31%) respectively. The coefficient of determination was greatest for incidence of DM ($R2 = 0.92$), followed by DM prevalence ($R2 = 0.79$), obesity, ($R2 = 0.67$), and physical inactivity ($R2 = 0.34$). The presence of DR during screening varied significantly by county ($p < 0.001$). Conclusions: Screening in counties with a higher incidence of DM led to a higher prevalence of identified DR at time of screening. The current work suggests that telemedicine screening in areas known to have a higher incidence of DM may be worthwhile.

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[38] Naik S, Wykoff CC, Ou WC, Stevenson J, Gupta S, Shah AR. Identification of factors to increase efficacy of telemedicine screening for diabetic retinopathy in endocrinology practices using the Intelligent Retinal Imaging System (IRIS) platform. *Diabetes Res Clin Pract*. 2018;140:265-270.
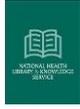
Reid, Mark W et al (2018) CoYoT1 Clinic: Home Telemedicine Increases Young Adult Engagement in Diabetes Care[39]
Background: Young adults with type 1 diabetes (T1D) experience poor glycemic control, disengagement in care, and are often lost to the medical system well into their adult years. Diabetes providers need a new approach to working with the population. The goal of this study was to determine whether an innovative shared telemedicine appointment care model (CoYoT1 Clinic [pronounced as "coyote"; Colorado Young Adults with T1D]) for young adults with T1D improves care engagement, satisfaction, and adherence to American Diabetes Association (ADA) guidelines regarding appointment frequency. Subjects and methods: CoYoT1 Clinic was designed to meet the diabetes care needs of young adults (18-25 years of age) with T1D through home telemedicine. Visits occurred every 3 months over the 1-year study (three times by home telemedicine and one time in-person). Outcomes were compared to patients receiving treatment as usual (control). Results: Compared with controls, CoYoT1 patients attended significantly more clinic visits (P < 0.0001) and increased their number of clinic visits from the year before the intervention. Seventy-four percent of CoYoT1 patients were seen four times over the 12-month study period, meeting ADA guidelines, but none in the control group met the ADA recommendation. CoYoT1 patients used diabetes technologies more frequently and reported greater satisfaction with care compared with controls. Conclusions: Delivering diabetes care by home telemedicine increases young adults' adherence to ADA guidelines and usage of diabetes technologies, and improves retention in care when compared to controls. Home telemedicine may keep young adults engaged in their diabetes care during this challenging transition period.

Kolltveit, Beate-Christin Hope et al (2017) Conditions for success in introducing telemedicine in diabetes foot care: a qualitative inquiry[40]
Background: The uptake of various telehealth technologies to deliver health care services at a distance is expanding; however more knowledge is needed to help understand vital components for success in using telehealth in different work settings. This study was part of a larger trial designed to investigate the effect of an interactive telemedicine platform. The platform consisted of a web based ulcer record linked to a mobile phone to provide

[39] Reid MW, Krishnan S, Berget C et al CoYoT1 Clinic: Home Telemedicine Increases Young Adult Engagement in Diabetes Care. *Diabetes Technol Ther.* 2018;205.:370- 379. doi:10.1089/dia.2017.0450

[40] Kolltveit BH, Gjengedal E, Graue M, Iversen MM, Thorne S, Kirkevold M. Conditions for success in introducing telemedicine in diabetes foot care: a qualitative inquiry. *BMC Nurs.* 2017;16:2. Published 2017 Jan 13. doi:10.1186/s12912-017-0201-y

care for people with diabetic foot ulcers in outpatient clinics in specialist hospital care in collaboration with primary health care. The aim of this qualitative study was to identify perceptions of health care professionals in different working settings with respect to facilitators to engagement and participation in the application of telemedicine. Methods: Ten focus groups were conducted with health care professionals and leaders in Western Norway between January 2014 and June 2015 using Interpretive Description, an applied qualitative research strategy. Results: Four key conditions for success in using telemedicine as a new technology in diabetes foot care were identified: technology and training that were user-friendly; having a telemedicine champion in the work setting; the support of committed and responsible leaders; and effective communication channels at the organizational level. Conclusions: Successful larger scale implementation of telemedicine must involve consideration of complex contextual and organizational factors associated with different work settings. This form of new care technology in diabetes foot care often involves health care professionals working across different settings with different management systems and organizational cultures. Therefore, attention to the distinct needs of each staff group seems an essential condition for effective implementation.

Porta, Massimo et al (2017) [Systematic screening of Retinopathy in Diabetes (REaD project): an Italian implementation campaign](#)[41]
Purpose: To evaluate the use of telemedicine retinal screening in Italy and to identify potential elements of implementation of this system. Methods: Patients with either new-onset diabetes or no ophthalmologic visit over the previous 2 years and attending 33 referral diabetic centers between mid-April 2013 and mid December 2015 were screened. Two partially overlapping nonstereoscopic 45° digital color images were captured from each eye using a fully automated nonmydriatic digital fundus camera. Factors limiting the assessment of retinopathy were explored. Results: Out of 24,473 eligible individuals, 22,466 had complete data. Among them, good-quality images enabling appropriate evaluation of at least one eye were obtained from 19,712 patients (both eyes, n = 18,887). Although nonmydriatic retinographs were provided, 39% of patients were evaluated using mydriasis. The rate of low-quality images in each center was inversely associated with the number of patients assessed. This was more evident for screening in mydriasis:

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[41] Porta M, Boscia F, Lanzetta P, Mannucci E, Menchini U, Simonelli F. Systematic screening of Retinopathy in Diabetes (REaD project): an Italian implementation campaign. *Eur J Ophthalmol.* 2017;272.:179-184. doi:10.5301/ejo.5000912

adjusted odds ratio (OR) 0.79 (95% confidence interval (CI) 0.76-0.82) (p<0.001) vs 0.96 (95% CI 0.94-0.97) (p<0.001). Finally, both the number of patients assessed and use of mydriasis were inversely related to the presence of diabetic retinopathy (DR): adjusted OR 0.93 (95% CI 0.92-0.93) (p<0.001) and 0.88 (95% CI 0.82-0.96) (p<0.001), respectively. Conclusions: This program confirmed a role for teleophthalmology in the systematic screening of DR and provided important suggestions to improve the system deployed. A high level of training is required for operators to optimize imaging. The role of mydriasis should be evaluated further.

Vujosevic, Stela et al (2017) **A decade-long telemedicine screening program for diabetic retinopathy in the north-east of Italy**[42]
Aim: To describe a decade long telemedicine screening for diabetic retinopathy (DR) in the metropolitan area of Padova (North-East Italy) and to report about prevalence/incidence of DR and maculopathy, rate of progression to STDR and optimal screening interval in patients with no DR at first examination. Methods: Observational, longitudinal, cohort study; 9347 patients with Type 1 and Type 2 diabetes mellitus (DM) underwent 17,344 fundus exams (three-45° color photos per eye) in two diabetes clinics and were graded in the Reading Centre, by certified personnel. The incidence of STDR, progression of maculopathy and risk factors were evaluated by log Rank test (Kaplan-Meier method). A receiver operating curve was used to determine the optimal screening interval in patients who at the first examination had no DR. Results: The overall prevalence of DR was 27.6%:12.5% mild non proliferative (NPDR), 11.3% moderate NPDR, 2.9% severe NPDR and 0.9% proliferative (PDR). The overall prevalence of maculopathy was 5.7%: 2.8% mild, 2.2% moderate, and 0.7% severe maculopathy. The 10-year incidence of STDR was: 0.6% in no DR, 5.5% in mild NPDR and 21.1% in moderate NPDR at first examination. The 10-year incidence of maculopathy was: 2.1% mild, 1.7% moderate and 0.2% severe. The incidence of STDR in patients with type 1 and type 2 DM and duration>10years was 8.21% and 8.15%; in type 1 DM with duration <10years was 5.5% and in type 2 DM and duration <10years was 1.91%.In patients with no DR at first screening, the best (sensitivity-specificity) follow-up interval is 2.5years. Conclusions: Screening every 2.5-year in patients without DR at the first examination seems to be adequate. Duration of disease is a relevant risk

[42] Vujosevic S, Pucci P, Casciano M et al A decade-long telemedicine screening program for diabetic retinopathy in the north-east of Italy. *J Diabetes Complications*. 2017;318.:1348- 1353. doi:10.1016/j.jdiacomp.2017.04.010

factor for progression to STDR, however patients with type 1 DM and duration <10years have greater incidence of STDR than patients with type 2 DM and similar disease duration. Epidemiologic data from this decade-long screening program in the North East of Italy may serve for implementing a national screening program.

DeBuc, Delia Cabrera (2016) The Role of Retinal Imaging and Portable Screening Devices in Tele-ophthalmology Applications for Diabetic Retinopathy Management[43]

In the years since its introduction, retinal imaging has transformed our capability to visualize the posterior pole of the eye. Increasing practical advances in mobile technology, regular monitoring, and population screening for diabetic retinopathy management offer the opportunity for further development of cost-effective applications through remote assessment of the diabetic eye using portable retinal cameras, smart-phone-based devices and telemedicine networks. Numerous retinal imaging methods and mobile technologies in tele-ophthalmology applications have been reported for diabetic retinopathy screening and management. They provide several advantages of automation, sensitivity, specificity, portability, and miniaturization for the development of point-of-care diagnostics for eye complications in diabetes. The aim of this paper is to review the role of retinal imaging and mobile technologies in tele-ophthalmology applications for diabetic retinopathy screening and management. At large, although improvements in current technology and telemedicine services are still needed, telemedicine has demonstrated to be a worthy tool to support health caregivers in the effective management and prevention of diabetes and its complications.

Eszes, Dora J et al (2016) Diabetic Retinopathy Screening Using Telemedicine Tools: Pilot Study in Hungary[44]

Introduction. Diabetic retinopathy (DR) is a sight-threatening complication of diabetes. Telemedicine tools can prevent blindness. We aimed to investigate the patients' satisfaction when using such tools and the effect of demographic and socioeconomic factors on participation in screening. Methods. Pilot study involving fundus camera screening and self-

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[43] DeBuc DC. The Role of Retinal Imaging and Portable Screening Devices in Tele-ophthalmology Applications for Diabetic Retinopathy Management. *Curr Diab Rep*. 2016;16(12):132. doi:10.1007/s11892-016-0827-2

[44] Eszes DJ, Szabó DJ, Russell G et al Diabetic Retinopathy Screening Using Telemedicine Tools: Pilot Study in Hungary. *J Diabetes Res*. 2016;2016:4529824. doi:10.1155/2016/4529824

administered questionnaire on participants' experience during fundus examination (comfort, reliability, and future interest in participation), as well as demographic and socioeconomic factors was performed on 89 patients with known diabetes in Csongrád County, a south-eastern region of Hungary. Results. Thirty percent of the patients had never participated in any ophthalmological screening, while 25.7% had DR of some grade based upon a standard fundus camera examination and UK-based DR grading protocol (Spectra™ software). Large majority of the patients were satisfied with the screening and found it reliable and acceptable to undertake examination under pupil dilation; 67.3% were willing to undergo nonmydriatic fundus camera examination again. There was a statistically significant relationship between economic activity, education and marital status, and future interest in participation. Discussion. Participants found digital retinal screening to be reliable and satisfactory. Telemedicine can be a strong tool, supporting eye care professionals and allowing for faster and more comfortable DR screening.

Murchison, Ann P et al (2016) [A Multi-Center Diabetes Eye Screening Study in Community Settings: Study Design and Methodology][45]
Purpose: Diabetes is the leading cause of new cases of blindness among adults aged 20-74 years within the United States. The Innovative Network for Sight Research group (INSIGHT) designed the Diabetic Eye Screening Study (DESS) to examine the feasibility and short-term effectiveness of non-mydriatic diabetic retinopathy (DR) screening for adults with diabetes in community-based settings. Methods: Study enrollment began in December 2011 at four sites: an internal medicine clinic at a county hospital in Birmingham, Alabama; a Federally-qualified community healthcare center in Miami-Dade County, Florida; a university-affiliated outpatient pharmacy in Philadelphia, Pennsylvania; and a medical home in Winston-Salem, North Carolina. People 18 years or older with previously diagnosed diabetes were offered free DR screening using non-mydriatic retinal photography that was preceded by a brief questionnaire addressing demographic information and previous eye care use. Visual acuity was also measured for each eye. Images were evaluated at a telemedicine reading center by trained evaluators using the National Health System DR grading classification. Participants and their physicians were sent screening report results and telephoned for a follow-up survey 3 months post-screening to determine whether participants had

[45] Murchison AP, Friedman DS, Gower EW et al A Multi-Center Diabetes Eye Screening Study in Community Settings: Study Design and Methodology. *Ophthalmic Epidemiol.* 2016;232.:109-115. doi:10.3109/09286586.2015.1099682

sought follow-up comprehensive eye care and their experiences with the screening process. Results: Target enrolment at each site was a minimum of 500 persons. Three of the four sites met this enrolment goal. Conclusion: The INSIGHT/DESS is intended to establish the feasibility and short-term effectiveness of DR screening using non-mydriatic retinal photography in persons with diabetes who seek services in community-based clinic and pharmacy settings.

Martinez-Millana, A et al (2015) [Performance assessment of a closed-loop system for diabetes management](#)[46]

Telemedicine systems can play an important role in the management of diabetes, a chronic condition that is increasing worldwide. Evaluations on the consistency of information across these systems and on their performance in a real situation are still missing. This paper presents a remote monitoring system for diabetes management based on physiological sensors, mobile technologies and patient/doctor applications over a service-oriented architecture that has been evaluated in an international trial [83,905 operation records]. The proposed system integrates three types of running environments and data engines in a single service-oriented architecture. This feature is used to assess key performance indicators comparing them with other type of architectures. Data sustainability across the applications has been evaluated showing better outcomes for full integrated sensors. At the same time, runtime performance of clients has been assessed spotting no differences regarding the operative environment.

[46] Martinez-Millana A, Fico G, Fernández-Llatas C, Traver V. Performance assessment of a closed-loop system for diabetes management. Med Biol Eng Comput. 2015;53(12):1295-1303. doi:10.1007/s11517-015-1245-3

CHAPTER 9
Telemedicine and Dialysis

Systematic Reviews

Cartwright, EJ et al (2020) [Systematic Review] eHealth Interventions to Support Patients in Delivering and Managing Peritoneal Dialysis at Home: A Systematic Review[1]

Peritoneal dialysis (PD) requires patients to develop a variety of self-management skills in order to effectively deliver and manage their dialysis at home. eHealth interventions may provide patients with accessible information to develop the skills and knowledge they require to manage their treatment. This review aims to identify and evaluate 'active' eHealth interventions in supporting patients on PD. Six databases were included within the review using the terms Peritoneal Dialysis, eHealth, telemedicine and remote consultation. Studies which explored patients who were delivering PD, an intervention where the main component involved a digital device and required active engagement from patients were included. The primary outcomes examined were identified using the core outcomes recommended by the Standardised Outcomes in Nephrology in Peritoneal Dialysis initiative (PD infection, cardiovascular disease, mortality, PD failure and life participation). Hospitalisation rates were also considered as a primary outcome. Secondary outcomes included quality of life, patient skills, patient knowledge and satisfaction. Using the inclusion criteria, 15 studies [1,334 participants] were included in the study. The effectiveness of eHealth interventions was mixed. Due to high heterogeneity, a meta-analysis was not possible, and quality of evidence was low. Risk of bias across the randomised studies was unclear but bias across non-randomised studies was identified as critical. There were no reported adverse effects of eHealth interventions within the included studies. Despite the high interest of

eHealth interventions in PD, good quality evidence is needed to explore their effectiveness before a wider application of eHealth interventions.

Scotland, Graham et al (2018) [Systematic Review] Multiple-frequency Bioimpedance Devices for Fluid Management in People With Chronic Kidney Disease Receiving Dialysis: A Systematic Review and Economic Evaluation[2]

Background: Chronic kidney disease (CKD) is a long-term condition requiring treatment such as conservative management, kidney transplantation or dialysis. To optimise the volume of fluid removed during dialysis to avoid underhydration or overhydration, people are assigned a 'target weight', which is commonly assessed using clinical methods, such as weight gain between dialysis sessions, pre- and post-dialysis blood pressure and patient-reported symptoms. However, these methods are not precise, and measurement devices based on bioimpedance technology are increasingly used in dialysis centres. Current evidence on the role of bioimpedance devices for fluid management in people with CKD receiving dialysis is limited. Objectives: To evaluate the clinical effectiveness and cost-effectiveness of multiple-frequency bioimpedance devices versus standard clinical assessment for fluid management in people with CKD receiving dialysis. Data sources: We searched major electronic databases [eg MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, EMBASE, Science Citation Index and Cochrane Central Register of Controlled Trials (CENTRAL)] conference abstracts and ongoing studies. There were no date restrictions. Searches were undertaken between June and October 2016. Review methods: Evidence was considered from randomised controlled trials comparing fluid management by multiple-frequency bioimpedance devices and standard clinical assessment in people receiving dialysis, and non-randomised studies evaluating the use of the devices for fluid management in people receiving dialysis. One reviewer extracted data and assessed the risk of bias of included studies. A second reviewer cross-checked the extracted data. Standard meta-analyses techniques were used to combine results from included studies. A Markov model was developed to assess the cost-effectiveness of the interventions. Results: Five RCTs (with 904 adult participants) and eight non-randomised studies (with 4,915 adult

[2] Scotland G, Cruickshank M, Jacobsen E et al Multiple-frequency bioimpedance devices for fluid management in people with chronic kidney disease receiving dialysis: a systematic review and economic evaluation. *Health Technol Assess.* 2018;221.:1-138. doi:10.3310/hta22010
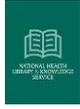
participants) assessing the use of the Body Composition Monitor (BCM) were included. Both absolute overhydration and relative overhydration were significantly lower in patients evaluated using BCM measurements than for those evaluated using standard clinical methods [weighted mean difference -0.44, 95% confidence interval (CI) -0.72 to -0.15, p = 0.003, I2 = 49%; and weighted mean difference -1.84, 95% CI -3.65 to -0.03; p = 0.05, I2 = 52%, respectively]. Pooled effects of bioimpedance monitoring on systolic blood pressure (SBP) (mean difference -2.46 mmHg, 95% CI -5.07 to 0.15 mmHg; p = 0.06, I2 = 0%), arterial stiffness (mean difference -1.18, 95% CI -3.14 to 0.78; p = 0.24, I2 = 92%) and mortality (hazard ratio = 0.689, 95% CI 0.23 to 2.08; p = 0.51) were not statistically significant. The economic evaluation showed that, when dialysis costs were included in the model, the probability of bioimpedance monitoring being cost-effective ranged from 13% to 26% at a willingness-to-pay threshold of £20,000 per quality-adjusted life-year gained. With dialysis costs excluded, the corresponding probabilities of cost-effectiveness ranged from 61% to 67%. Limitations: Lack of evidence on clinically relevant outcomes, children receiving dialysis, and any multifrequency bioimpedance devices, other than the BCM. Conclusions: BCM used in addition to clinical assessment may lower overhydration and potentially improve intermediate outcomes, such as SBP, but effects on mortality have not been demonstrated. If dialysis costs are not considered, the incremental cost-effectiveness ratio falls below £20,000, with modest effects on mortality and/or hospitalisation rates. The current findings are not generalisable to paediatric populations nor across other multifrequency bioimpedance devices. Future work: Services that routinely use the BCM should report clinically relevant intermediate and long-term outcomes before and after introduction of the device to extend the current evidence base. Study registration: This study is registered as PROSPERO CRD42016041785.

Randomised
Controlled Trials

Cao, F et al (2018) [Randomised Controlled Trial] Application of Instant Messaging Software in the Follow-Up of Patients Using Peritoneal Dialysis, a Randomised Controlled Trial[3]

Aims and Objectives: This study aims to investigate the application value of Internet-based instant messaging software in the follow-up of patients using peritoneal dialysis.

Background: Peritoneal dialysis is an effective renal replacement treatment for end-stage renal disease. The clinical usefulness of Internet-based instant messaging software in the follow-up of peritoneal dialysis patients, including the incidence of peritonitis and exit-site infection, the levels of albumin and electrolytes and the degree of patients' satisfaction, remains unknown.

Design: Between January 2009-April 2016, a total of 160 patients underwent continuous peritoneal dialysis in the Department of Nephrology, Fujian Provincial Hospital were invited to participate voluntarily in this study. The patients were randomly assigned to the instant messenger (QQ) follow-up group (n = 80) and the traditional follow-up group (n = 80). The differences in death, hospitalisation, peritonitis, exit-site infection, and patients' satisfaction were investigated during 1 year of follow-up. The mean follow-up duration is 11.4 ± 1.5 months.

Results: Compared with the patients in the traditional follow-up group, patients in the QQ follow-up group showed higher levels of serum albumin (p = .009) and haemoglobin (p = .009), lower levels of phosphorus (p < .001) and calcium-phosphorus product (p = .001), and better degree of satisfaction (p < .001).

Relevance to Clinical Practice: Internet-based follow-up by instant messaging software appears to be a feasible and acceptable method of delivering peritoneal dialysis treatment for patients with end-stage renal disease.

[3] Cao F, Li L, Lin M, Lin Q, Ruan Y, Hong F. Application of instant messaging software in the follow-up of patients using peritoneal dialysis, a randomised controlled trial. *J Clin Nurs*. 2018;27(15-16):3001- 3007. doi:10.1111/jocn.14487

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Miscellaneous

Dang, BV et al (2020) [Toward Portable Artificial Kidneys: The Role of Advanced Microfluidics and Membrane Technologies in Implantable Systems](#)[4]

Globally, around 2.6 million people receive renal replacement therapy (RRT), and a further 4.9-9.7 million people need, but do not have access to, RRT. The next generation RRT devices will certainly be in demand due to the increasing occurrence of diabetes, atherosclerosis and the growing population of older citizens. This review provides a comprehensive, yet concise overview of the cleared and remaining hurdles in the development of artificial kidneys to move beyond traditional dialysis technology-the current baseline of renal failure treatment. It compares and contrasts the state-of-the-art in 'cell-based' and 'non-cell-based' approaches. Based on this study, a new engineering perspective on the future of artificial kidneys is described. This review suggests that stem-cell-based artificial kidneys represent a long-term, complete solution but it can take years of development due to the limitations of current cell seeding technology, viability and complicated behaviour control. Alternatively, there is much potential for near- and medium- term solutions with the development of non-cell-based wearable and implantable devices to support current therapies. Based on recent fundamental advances in microfluidics, membranes and related research, it may be possible to integrate these technologies to enable implantable artificial kidneys (iAK) in the near future.

Hojs, N et al (2020) [Review] [Ambulatory Hemodialysis-Technology Landscape and Potential for Patient-Centered Treatment](#)[5]

CKD is a worldwide health problem and the number of patients requiring kidney replacement therapy is rising. In the United States, most patients with ESKD rely on in-center hemodialysis, which is burdensome and does not provide the same long-term benefits as kidney transplantation. Intensive hemodialysis treatments have demonstrated improved clinical outcomes, but its wider adoption is limited by equipment complexity and patient apprehension. Ambulatory devices for hemodialysis offer the potential for

[4] Dang BV, Taylor RA, Charlton AJ, Le-Clech P, Barber TJ. Toward Portable Artificial Kidneys: The Role of Advanced Microfluidics and Membrane Technologies in Implantable Systems. *IEEE Rev Biomed Eng*. 2020;13:261- 279. doi:10.1109/RBME.2019.2933339

[5] Hojs N, Fissell WH, Roy S. Ambulatory Hemodialysis-Technology Landscape and Potential for Patient-Centered Treatment. *Clin J Am Soc Nephrol*. 2020;151.:152- 159. doi:10.2215/CJN.01970219
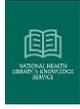
self-care treatment outside the clinical setting as well as frequent and prolonged sessions. This article explains the motivation for ambulatory hemodialysis and provides an overview of the necessary features of key technologies that will be the basis for new wearable and implantable devices. Early work by pioneers of hemodialysis is described followed by recent experience using a wearable unit on patients. Finally, ongoing efforts to develop an implantable device for kidney replacement and its potential for implantable hemodialysis are presented.

Kooman, JP et al (2020) [Review] Wearable Health Devices and Personal Area Networks: Can They Improve Outcomes in Haemodialysis Patients?[6]
Wearable devices are becoming widespread in a wide range of applications, from healthcare to biomedical monitoring systems, which enable continuous measurement of critical biomarkers for medical diagnostics, physiological health monitoring and evaluation. Especially as the elderly population grows globally, various chronic and acute diseases become increasingly important, and the medical industry is changing dramatically due to the need for point-of-care (POC) diagnosis and real-time monitoring of long-term health conditions. Wearable devices have evolved gradually in the form of accessories, integrated clothing, body attachments and body inserts. Over the past few decades, the tremendous development of electronics, biocompatible materials and nanomaterials has resulted in the development of implantable devices that enable the diagnosis and prognosis through small sensors and biomedical devices, and greatly improve the quality and efficacy of medical services. This article summarizes the wearable devices that have been developed to date, and provides a review of their clinical applications. We will also discuss the technical barriers and challenges in the development of wearable devices, and discuss future prospects on wearable biosensors for prevention, personalized medicine and real-time health monitoring.

Ray, A et al (2020) Measurement of Serum Phosphate Levels Using a Mobile Sensor[7]
The measurement of serum phosphate concentration is crucial for patients with advanced chronic kidney disease (CKD) and those on maintenance

[6] Kooman JP, Wieringa FP, Han M et al Wearable health devices and personal area networks: can they improve outcomes in haemodialysis patients?. *Nephrol Dial Transplant*. 2020;35(Supplement_2):ii43–ii50. doi:10.1093/ndt/gfaa015
[7] Ray A, Esparza S, Wu D et al Measurement of serum phosphate levels using a mobile sensor. *Analyst*. 2020;1455.:1841–1848. doi:10.1039/c9an02215e

dialysis, as abnormal phosphate levels may be associated with severe health risks. It is important to monitor serum phosphate levels on a regular basis in these patients; however, such measurements are generally limited to every 0.5-3 months, depending on the severity of CKD. This is due to the fact that serum phosphate measurements can only be performed at regular clinic visits, in addition to cost considerations. Here we present a portable and cost-effective point-of-care device capable of measuring serum phosphate levels using a single drop of blood (<60 μl). This is achieved by integrating a paper-based microfluidic platform with a custom-designed smartphone reader. This mobile sensor was tested on patients undergoing dialysis, where whole blood samples were acquired before starting the hemodialysis and during the three-hour treatment. This sampling during the hemodialysis, under patient consent, allowed us to test blood samples with a wide range of phosphate concentrations, and our results showed a strong correlation with the ground truth laboratory tests performed on the same patient samples (Pearson coefficient r = 0.95 and p < 0.001). Our 3D-printed smartphone attachment weighs about 400 g and costs less than 80 USD, whereas the material cost for the disposable test is <3.5 USD (under low volume manufacturing). This low-cost and easy-to-operate system can be used to measure serum phosphate levels at the point-of-care in about 45 min and can potentially be used on a daily basis by patients at home

Viglino, G et al (2020) Videodialysis: A Pilot Experience of Telecare for Assisted Peritoneal Dialysis[8]

Background: We report our experience with Videodialysis (VD), a new telemedicine system created in our Center to overcome physical, cognitive and psychological barriers to PD.
Methods: We analyzed the technical and clinical care results of VD in the period from 01/01/2009 to 12/31/2018.
Results: The VD components are: a Remote Station at the patient's home (video camera, monitor, microphone, technological connectivity box), and a Control Station in the Center (PC with high resolution monitor, webcam, speakerphone) with software that manages 6 audio-video connections simultaneously as well as the Remote Station video cameras. In 2015 a second model of VD was designed to further improve ease of transport, installation, user interface, software functionality and connectivity. VD

[8] Viglino G, Neri L, Barbieri S, Tortone C. Videodialysis: a pilot experience of telecare for assisted peritoneal dialysis. *J Nephrol.* 2020;331.:177- 182. doi:10.1007/s40620-019-00647-6

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proved to be highly reliable during 21,000 connections, and easy to use by patients/caregivers without technological skills. During the observational period, 107 patients started PD; of these 77 had barriers to PD: in 15 we overcame the barriers by VD-Assisted PD and in 62 we used other modalities of Assisted PD. During a follow-up of 285 months on VD-Assisted, 5 patients died, 3 were transferred to HD (UFF; leakage; onset of barriers insurmountable with VD), 3 to traditional Assisted PD and 4 remained on VD-Assisted PD. Peritonitis incidence in VD-Assisted PD was 1/84.2 pt/mths, not significantly different to that of the patients not using VD. Sense of confidence was the aspect most highly-appreciated by VD-Assisted PD patients.

Conclusions: VD-Assisted PD is a reliable, safe system which requires no technological know-how and it is easy to use when self-care is not possible due to physical, cognitive or psychological barriers.

Yang, Y et al (2020) [Scoping Review] Intervention and Evaluation of Mobile Health Technologies in Management of Patients Undergoing Chronic Dialysis: Scoping Review[9]

Background: Studies have shown the effectiveness and user acceptance of mobile health (mHealth) technologies in managing patients with chronic kidney disease (CKD). However, incorporating mHealth technology into the standard care of patients with CKD still faces many challenges. To our knowledge, there are no reviews on mHealth interventions and their assessments concerning the management of patients undergoing dialysis.

Objective: This study provided a scoping review on existing apps and interventions of mHealth technologies in adult patients undergoing chronic dialysis and identified the gaps in patient outcome assessment of mHealth technologies in the literature.

Methods: We systematically searched PubMed (MEDLINE), Scopus, and the Cumulative Index to Nursing and Allied Health Literature databases, as well as gray literature sources. Two keywords, "mHealth" and "dialysis," were combined to address the main concepts of the objectives. Inclusion criteria were as follows: 1. mHealth interventions, which are on a smartphone, tablet, or web-based portals that are accessible through mobile devices; and 2. adult patients (age ≥18 years) on chronic dialysis. Only English papers published from January 2008 to October 2018 were included. Studies with

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mHealth apps for other chronic conditions, based on e-consultation or videoconferencing, non-English publications, and review papers were excluded.

Results: Of the 1054 papers identified, 22 met the inclusion and exclusion criteria. Most studies (n=20) were randomized controlled trials and cohort studies. These studies were carried out in 7 countries. The main purposes of these mHealth interventions were as follows: nutrition or dietary self-monitoring (n=7), remote biometric monitoring (n=7), web-based portal (n=4), self-monitoring of in-session dialysis-specific information (n=3), and self-monitoring of lifestyle or behavioral change (n=1). The outcomes of the 22 included studies were organized into five categories: 1. patient satisfaction and acceptance, 2. clinical effectiveness, 3. economic assessment, 4. health-related quality of life, and 5. impact on lifestyle or behavioral change. The mHealth interventions showed neutral to positive results in chronic dialysis patient management, reporting no to significant improvement of dialysis-specific measurements and some components of the overall quality of life assessment. Evaluation of these mHealth interventions consistently demonstrated evidence in patients' satisfaction, high level of user acceptance, and reduced use of health resources and cost savings to health care services. However, there is a lack of studies evaluating safety, organizational, sociocultural, ethical, and legal aspects of mHealth technologies. Furthermore, a comprehensive cost-effectiveness and cost-benefit analysis of adopting mHealth technologies was not found in the literature.

Conclusions: The gaps identified in this study will inform the creation of health policies and organizational support for mHealth implementation in patients undergoing dialysis. The findings of this review will inform the development of a comprehensive service model that utilizes mHealth technologies for home monitoring and self-management of patients undergoing chronic dialysis.

Yeter, HH et al (2020) [Observational Study] <u>Automated Remote Monitoring for Peritoneal Dialysis and Its Impact on Blood Pressure</u>[10]
Introduction: Peritoneal dialysis (PD) provides a safe, home-based continuous renal replacement therapy for patients. The adherence of the patients to the prescribed dialysis fluids cannot always be monitored by

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[10] Yeter HH, Akcay OF, Ronco C, Derici U. Automated Remote Monitoring for Peritoneal Dialysis and Its Impact on Blood Pressure. *Cardiorenal Med.* 2020;103.:198- 208. doi:10.1159/000506699

physicians. Remote monitoring automated peritoneal dialysis (RM-APD) can affect patients' compliance with treatment and, thus, clinical outcomes. Objective: We aimed to evaluate the clinical outcomes of patients with a remote access program.

Methods: This was an observational study. We analyzed the effect of RM-APD on treatment adherence, dialysis adequacy, and change in blood pressure control, sleep quality, and health-related quality of life during the 6 months of follow-up.

Results: A total of 15 patients were enrolled in this study. It was found that there was a significant decrease (99 ± 19 vs. 89 ± 11 mm Hg) in mean arterial blood pressure of patients, and a considerable increase in Kt/V was observed in the sixth month after the RM-APD switch (2.11 ± 0.4 vs. 2.25 ± 0.5). A significant increase was found when comparing the 3-month and 6-month ultrafiltration amounts before RM-APD and the ultrafiltration amount within 6 months after RM-APD (800 mL [500-1,000] and 752 mL [490-986] vs. 824 mL [537-1,183]). The daily antihypertensive pill need (4 [0-7] vs. 2 [0-6]) and alarms received from the device decreased (from 4 [3-8] to 2 [0-3]) at the sixth month of the switch. There was no significant change in sleep quality and health-related quality of life within 6 months.

Conclusion: This study showed that treatment adherence and ultrafiltration amounts of patients increased with the use of RM-APD, as well as better blood pressure control with fewer antihypertensive drugs.

Castro, A et al (2019) [Review] How Can We Advance in Renal Replacement Therapy Techniques?[11]

End-Stage Renal Disease (ESRD) is one of the major causes of morbidity and mortality worldwide. Although the incidence of ESRD is relatively stable, the prevalence of maintenance dialysis is increasing, and it is expected to reach a staggering 5439 million patients worldwide by 2030. Despite the great technological evolution that has taken place in recent years, most patients are still treated with in-centre haemodialysis and their prognosis remains far from desirable. Since 1980, there has been an increasing interest in the development of a portable device for renal replacement therapy (RRT), which ultimately led to the creation of the Wearable Artificial Kidney (WAK) and the Wearable Ultrafiltration (WUF) system. Portable RRT devices may be acceptable alternatives that deal with several unmet clinical needs of ESRD

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[11] Castro A, Neri M, Karopadi AN, Lorenzin A, Marchionna N, Ronco C. How can we advance in renal replacement therapy techniques?. *Nefrologia*. 2019;394.:372- 378. doi:10.1016/j.nefro.2018.08.012

patients. So far, 3 important human studies with WAK and WUF have been carried out and, although these devices require considerable technological improvement, their safety and efficacy in solute clearance and fluid removal is undeniable. In this article, we review the evolution of the WAK and the WUF and the main clinical trials performed, highlighting some of their technical features. Some of the main possible clinical advantages that could be achieved with these devices, as well as some economic aspects, are also pointed out. In the future, all renal replacement therapy techniques should evolve to perfectly match the clinical and personal needs of each patient, allowing for an improved health-related quality of life.

Chen, WL et al (2019) [Feasibility Study] Feasibility of smart hemodialysis patient care using sensors embedded in personalized 3D printing cast[12]

This project is to design a wearable medical device which can measure and monitor the fluid dynamics of the dialysis access using sensor of phonoangiography (PAG) for exploring vascular pitch pattern and sensor of Photoplethysmography (PPG) for estimating the flow volume as a double checking of the AV access condition. We use arteriovenous access (AVA) stenosis detector based on phonoangiography technique and autoregressive model to detect access stenosis and simultaneously estimate the status of AVA life cycle by tracking and obtaining changes in frequency spectra domain. It helps hemodialysis patients to be aware earlier of the dysfunction of AVA and reminds them to make a return visit. The purpose of the complement deployment of vital sign sensors is to improve the prognosis and optimize overall health by providing analysis of physiological signals, including water content index, pulse oximetry, and blood pressure at the same time. With these sensors, the concept of holistic hemodialysis patient care (HHPC) might be proved.

Hueso, M et al (2019) [Review] Progress in the Development and Challenges for the Use of Artificial Kidneys and Wearable Dialysis Devices[13]

Background: Renal transplantation is the treatment of choice for chronic kidney disease (CKD) patients, but the shortage of kidneys and the disabling medical conditions these patients suffer from make dialysis essential for

[12] Chen WL, Yang TL, Lee PL, Kan CH. Feasibility of smart hemodialysis patient care using sensors embedded in personalized 3D printing cast. *J Mech Med Biol* 2019 192. 1940017 https://doi.org/10.1142/S0219519419400177 [Accessed 21 May 2020]
[13] Hueso M, Navarro E, Sandoval D, Cruzado JM. Progress in the Development and Challenges for the Use of Artificial Kidneys and Wearable Dialysis Devices. *Kidney Dis (Basel)*. 2019;51.:3-10. doi:10.1159/000492932
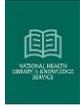
most of them. Since dialysis drastically affects the patients' lifestyle, there are great expectations for the development of wearable artificial kidneys, although their use is currently impeded by major concerns about safety. On the other hand, dialysis patients with hemodynamic instability do not usually tolerate intermittent dialysis therapy because of their inability to adapt to a changing scenario of unforeseen events. Thus, the development of novel wearable dialysis devices and the improvement of clinical tolerance will need contributions from new branches of engineering such as artificial intelligence (AI) and machine learning (ML) for the real-time analysis of equipment alarms, dialysis parameters, and patient-related data with a real-time feedback response. These technologies are endowed with abilities normally associated with human intelligence such as learning, problem solving, human speech understanding, or planning and decision-making. Examples of common applications of AI are visual perception (computer vision), speech recognition, and language translation. In this review, we discuss recent progresses in the area of dialysis and challenges for the use of AI in the development of artificial kidneys.

great opportunities for dialysis therapy, but much innovation is needed before we achieve a smart dialysis machine able to analyze and understand changes in patient homeostasis and to respond appropriately in real time. Great efforts are being made in the fields of tissue engineering and regenerative medicine to provide alternative cell-based approaches for the treatment of renal failure, including bioartificial renal systems and the implantation of bioengineered kidney constructs.

Lew, SQ et al (2019) Impact of Remote Biometric Monitoring on Cost and Hospitalization Outcomes in Peritoneal Dialysis[14]
Introduction: Peritoneal dialysis is a home-based therapy for individuals with end-stage renal disease. Telehealth, and in particular - remote monitoring, is making inroads in managing this cohort.
Methods: We examined whether daily remote biometric monitoring (RBM) of blood pressure and weight among peritoneal dialysis patients was associated with changes in hospitalization rate and hospital length of stay, as well as outpatient, inpatient and overall cost of care.
Results: Outpatient visit claim payment amounts (in US dollars derived from CMS data) decreased post-intervention relative to pre-intervention for those at age 18-54 years. For certain subgroups, non- or nearly-significant changes

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[14] Lew SQ, Sikka N, Thompson C, Magnus M. Impact of remote biometric monitoring on cost and hospitalization outcomes in peritoneal dialysis. *J Telemed Telecare*. 2019;25(10):581- 586. doi:10.1177/1357633X18784417

were found among female and Black participants. There was no change in inpatient costs post-intervention relative to pre-intervention for females and while the overall visit claim payment amounts increased in the outpatient setting slightly (US$511.41 (1990.30) vs. US$652.61 (2319.02), p = 0.0783) and decreased in the inpatient setting (US$10,835.30 (6488.66) vs. US$10,678.88 (15,308.17), p = 0.4588), these differences were not statistically significant. Overall cost was lower if RBM was used for assessment of blood pressure and/or weight (US$-734.51, p < 0.05). Use of RBM collected weight was associated with fewer hospitalizations (adjusted odds ratio 0.54, 95% confidence interval 0.33-0.89) and fewer days hospitalized (adjusted odds ratio 0.46, 95% confidence interval 0.26-0.81). Use of RBM collected blood pressure was associated with increased days of hospitalization and increased odds of hospitalization.

Conclusions: RBM offers a powerful opportunity to provide care to those receiving home therapies such as peritoneal dialysis. RBM may be associated with reduction in both inpatient and outpatient costs for specific sub-groups receiving peritoneal dialysis

Milan Manani, S et al (2019) [Longitudinal Experience With Remote Monitoring for Automated Peritoneal Dialysis Patients](#)[15]
Background: Peritoneal dialysis (PD) is an ideal model for testing remote monitoring (RM). In this study, we evaluated the RM application longitudinally in stable patients undergoing automated PD (APD).
Methods: This was an observational study, comparing outcomes in patients with [current patients] and without [historical data] exposure of RM. We analyzed cost-effectiveness of RM-APD measuring the number of night alarms, number of hospital visits, direct and indirect costs.
Results: Changes in APD prescription were almost double in the case group (RM) compared to the control group (p = 0.0005). The need for in-person visits and nocturnal alarms was significantly less in RM-APD than in traditional APD (p = 0.01 and p = 0.002, respectively). The distance traveled by patients in the case of RM-APD was reduced by 1,134 km with a time saving of 1,554 min for patients. The overall cost reduction for the PD center in terms of time/nurse and time/physician was 2,647 and 3,673 min, respectively. All these advantages were obtained in the presence of an improved technique survival with a significant reduction of dropouts. All

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[15] Milan Manani S, Rosner MH, Virzì GM et al Longitudinal Experience with Remote Monitoring for Automated Peritoneal Dialysis Patients. *Nephron*. 2019;1421.:1- 9. doi:10.1159/000496182

patients found that it is easy to use the RM system and were satisfied with the high level of interaction with the care team and with the possibility of timely resolving technical problems.

Conclusion: These data confirm the long-term benefits of RM applied to APD. RM-APD is cost-effective; it allows early detection and resolution of problems, improved treatment compliance, reduction of patient's access to hospital center for technical and clinical complications with consequent savings, and improved patient's quality of life.

Olivares-Gandy, HJ et al (2019) [A Telemonitoring System for Nutritional Intake in Patients With Chronic Kidney Disease Receiving Peritoneal Dialysis Therapy](16)

Patients undergoing peritoneal dialysis (PD) therapy may present complications of protein-energy wasting, which may be partially produced by inadequate nutrition management and a protein or energy deficiency in the predialytic phase. Therefore, accurate monitoring of the nutrition status during PD therapy can prevent risk conditions in patients with chronic kidney disease (CKD). In this study, we present the analysis, design, and development of a telemonitoring system for the nutritional intake of patients with CKD receiving PD therapy. The proposed system consists of a mobile web application addressed to the nutrition specialist and a native Android application aimed at patients undergoing PD. Our system optimizes nutrition administration by providing services that allow the nutritionist to monitor the patient, assign a nutrition scheme based on the patient profile, manage intake phases and send recommendations to the patient. Furthermore, the system allows the patient to record the intake data daily, receive updates on diets generated by the nutritionist and communicate with the nutritionist through a consultation module. Finally, we performed a usability assessment of our system based on a laboratory study with two users: a nutritionist and a patient undergoing peritoneal dialysis treatment. Based on the obtained results, our telemonitoring system shows a favorable opinion in terms of usability from the perspectives of the patient and nutritionist.

16 Olivares-Gandy HJ, Domínguez-Isidro S, López-Domínguez E, Hernández-Velázquez Y, Tapia-McClung H, Jorge de-la-Calleja. A telemonitoring system for nutritional intake in patients with chronic kidney disease receiving peritoneal dialysis therapy. *Comput Biol Med.* 2019;109:1- 13. doi:10.1016/j.compbiomed.2019.04.012

Panda, B et al (2019) Flexible, Skin Coupled Microphone Array for Point of Care Vascular Access Monitoring[17]

Point-of-care screening for hemodialysis vascular access dysfunction requires tools that are objective and efficient. Listening for bruits during physical exam is a subjective examination which can detect stenosis [vascular narrowing] when properly performed. Phonoangiograms (PAGs)-mathematical analysis of bruits-increases the objectivity and sensitivity and permits quantification of stenosis location and degree of stenosis (DOS). This work describes a flexible and body-conformal multi-channel sensor and associated signal processing methods for automated DOS characterization of vascular access. The sensor used an array of thin-film PVDF microphones integrated on polyimide to record bruits at multiple sites along a vascular access. Nonlinear signal processing was used to extract spectral features, and cardiac cycle segmentation was used to improve sensitivity. PAG signal processing algorithms to detect stenosis location and severity are also presented. Experimental results using microphone arrays on a vascular access phantom demonstrated that stenotic lesions were detected within 1 cm of the actual location and graded to three levels (mild, moderate, or severe). Additional PAG features were also used to define a simple binary classifier aimed at patients with failing vascular accesses. The classifier achieved 90% accuracy, 92% specificity, and 91% sensitivity at detecting stenosis greater than 50%. These results suggest that point-of-care screening using microphone arrays can identify at-risk patients using automated signal analysis.

Castro, AC et al (2018) [Review] Wearable Artificial Kidney and Wearable Ultrafiltration Device Vascular Access-Future Directions[18]

Background: Since 2005, three human clinical trials have been performed with the Wearable Artificial Kidney (WAK) and Wearable Ultrafiltration (WUF) device. The lack of an adequate vascular access (VA) has been pointed out as the main limitation to their implementation. Based on the current level of understanding, we will make the first conceptual proposal of an adequate VA suitable for the WAK and the WUF.

Methods: All the literature related to WAK and WUF was reviewed. Based on eight main publications the VA major characteristics were defined: a mean

[17] Panda B, Mandal S, Majerus SJA. Flexible, Skin Coupled Microphone Array for Point of Care Vascular Access Monitoring. *IEEE Trans Biomed Circuits Syst.* 2019;136.:1494–1505. doi:10.1109/TBCAS.2019.2948303

[18] Castro AC, Neri M, Nayak Karopadi A, Lorenzin A, Marchionna N, Ronco C. Wearable artificial kidney and wearable ultrafiltration device vascular access-future directions. *Clin Kidney J.* 2018;122.:300–307. Published 2018 Sep 19. doi:10.1093/ckj/sfy086

blood flow of 100 mL/min; the capability to allow prolonged and frequent dialysis treatments, without interfering in activities of daily living (ADL); safe and convenient connection/disconnection systems; reduced risk of biofilm formation and coagulation; high biocompatibility. A research was done in order to answer to each necessary technological prerequisites.

Results: The use of a device similar to a CVC with a 5Fr lumen, seems to be the most feasible option. Totally subcutaneous port devices such as the LifeSite(R) or Dialock (R) systems can be a solution to allow WAK or WUF to operate continuously while patients carry out their ADL. Recently, macromolecules that reduce the risk of thrombosis and infection and are integrated into a CVC have been developed and have the capability of overcoming these major limitations.

Conclusion: With an adequate VA, portable HD devices can be acceptable options to address several unmet clinical needs of HD patients.

Drepper, VJ et al (2018) [Case Report] Remote Patient Management in Automated Peritoneal Dialysis: A Promising New Tool[19]

Remote patient management (RPM) has the potential to help clinicians detect early issues, allowing intervention prior to development of more significant problems. A 23-year-old end-stage kidney disease patient required urgent start of renal replacement therapy. A newly available automated peritoneal dialysis (APD) RPM system with cloud-based connectivity was implemented in her care. Pre-defined RPM threshold parameters were set to identify clinically relevant issues. Red flag dashboard alerts heralded prolonged drain times leading to clinical evaluation with subsequent diagnosis of and surgical repositioning for catheter displacement, although it took several days for newly-RPM-exposed staff to recognize this issue. Post-PD catheter repositioning, drain times were again normal as indicated by disappearance of flag alerts and unremarkable cycle volume profiles. Identification of < 90% adherence to prescribed PD therapy was then documented with the RPM system, alerting the clinical staff to address this important issue given its association with significant negative clinical outcomes. Healthcare providers face a "learning curve" to effect optimal utilization of the RPM tool. Larger scale observational studies will determine the impact of RPM on APD technique survival and resource utilization.

[19] Drepper VJ, Martin PY, Chopard CS, Sloand JA. Remote Patient Management in Automated Peritoneal Dialysis: A Promising New Tool. *Perit Dial Int*. 2018;381.:76- 78. doi:10.3747/pdi.2017.00054

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Garcia, Marcos Antonio Martinez et al (2018) [Observational Study]
Telemonitoring System for Patients With Chronic Kidney Disease Undergoing Peritoneal Dialysis: Usability Assessment Based on a Case Study[20]

There are two million people with chronic kidney disease (CKD) worldwide. In Mexico, it is estimated that by 2025, there will be 212 thousand CKD cases. Among the renal replacement treatments, peritoneal dialysis (PD) exists either in the continuous ambulatory (CAPD) or automated (APD) mode, which requires continuous monitoring and strict control. Thus, several software systems have been proposed to perform reliable remote monitoring of patients using PD but also to achieve the goal with effectiveness, efficiency and satisfaction; ie, in software engineering, this is called usability. However, few studies have addressed usability issues using case studies with patients and medical staff in real domains. In this paper, we present a usability assessment of a telemonitoring system for patients with CKD on peritoneal dialysis treatment through a case study with patients and medical staff of the Mexican Institute of Social Security (IMSS). The usability evaluation was carried out through the application of two satisfaction instruments. These instruments evaluated multiple usability criteria, such as navigability, interactivity, motivation, satisfaction, and applicability. The results obtained from the usability evaluation show that, on average, the services offered by the system have 91.3% acceptance by users (patient-doctors), with the APD and CAPD exchange data registration services having the highest acceptance for patients, with a positive perception of 94.5% and 92.3%, respectively. Meanwhile, for the doctors and nurses, the alarm reception for patients in a risk situation was highest with 95% acceptance. Based on the obtained results, the evaluated telemonitoring system holds wide acceptance, satisfaction, and applicability from patients' and doctors' perspectives. It is also noted that the evaluated system considers and satisfies the requirements and suitable parameters that should be monitored in PD treatment according to studies presented in the literature.

[20] Martínez García MA, Fernández Rosales MS, López Domínguez E, Hernández Velázquez Y, Domínguez Isidro S. Telemonitoring system for patients with chronic kidney disease undergoing peritoneal dialysis: Usability assessment based on a case study. *PLoS One*. 2018;13(11):e0206600. Published 2018 Nov 6. doi:10.1371/journal.pone.0206600
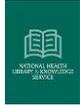
Makhija, Dilip et al (2018) [Simulation Study] Remote Monitoring of Automated Peritoneal Dialysis Patients: Assessing Clinical and Economic Value[21]

Background: For chronic kidney disease patients who progress to end-stage renal disease, survival is dependent on renal replacement therapy in the form of kidney transplantation or chronic dialysis. Peritoneal dialysis (PD), which can be performed at home, is both more convenient and less costly than hemodialysis that requires three 4-h visits per week to the dialysis facility and complicated equipment. Remote therapy management (RTM), technologies that collect medical information and transmit it to healthcare providers for patient management, has the potential to improve the outcomes of patients receiving automated peritoneal dialysis (APD) at home. Objective: Estimate through a simulation study the potential impact of RTM on APD patients use of healthcare resources and costs in the United States, Germany, and Italy. Methods: Twelve APD patient profiles were developed to reflect potential clinical scenarios of APD therapy. Two versions of each profile were created to simulate healthcare resource use, one assuming use of RTM and one with no RTM. Eleven APD teams with one nephrologist and one nurse were the estimated resources that would be used. Results: Results from U.S., German, and Italian clinicians found that RTM could avoid use of 59, 49, and 16 resources over the 12 profiles, respectively. Estimated reduced utilization across the three countries ranged from one to two hospitalizations, one to four home visits, two to five emergency room visits, and four to eight unplanned clinic visits. Total savings across all scenarios were $23,364 in the United States, $11,477 in Germany, and $7,088 in Italy. Conclusion: In a simulated environment, early intervention enabled by RTM reduced healthcare resource utilization and associated costs.

Milan Malani, S et al (2018) [Observational Study] Remote Monitoring of Automated Peritoneal Dialysis Improves Personalization of Dialytic Prescription and Patient's Independence[22]

Background: Remote monitoring (RM) supports a healthcare model that enhances patients' self-management. We evaluated the utility of RM in patients undergoing automated peritoneal dialysis (APD).

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[21] Makhija D, Alscher MD, Becker S et al Remote Monitoring of Automated Peritoneal Dialysis Patients: Assessing Clinical and Economic Value. *Telemed J E Health*. 2018;244.:315- 323. doi:10.1089/tmj.2017.0046
[22] Milan Manani S, Crepaldi C, Giuliani A et al Remote Monitoring of Automated Peritoneal Dialysis Improves Personalization of Dialytic Prescription and Patient's Independence. *Blood Purif*. 2018;462.:111- 117. doi:10.1159/000487703

Methods: We observed 37 -RM-APD patients, 16 incidents, and 21 prevalents switched from traditional APD (T-APD). We observed the number of changes for APD prescription, the frequency of visits, and PD adequacy parameters during 1 year of RM utilization in APD.

Results: The APD prescriptions were modified more frequently in RM-APD vs. T-APD in incident (p = 0.002) and prevalent patients (p = 0.045). Visits were significant less in -RM-APD than in T-APD for incident patient (p = 0.008). No significant difference was found between prevalent populations. PD adequacy was similar in both groups.

Conclusions: Our results demonstrate that RM allows an efficient use of healthcare resources, helping to improve personalization of APD prescription and to intervene early with troubleshooting, thereby reducing the frequency of in-person visits for emergency problems.

Panda, B et al (2018) Skin-coupled PVDF microphones for noninvasive vascular blood sound monitoring[23]

Vascular access is the "Achilles Heel" of hemodialysis, as maintaining high flow characteristics [access patency] is critical to achieving efficient dialysis treatment. Thus, monitoring of vascular access is essential for maintaining long-term dialysis success. Blood sounds change in the presence of stenosis and can be analyzed digitally as phonoangiograms (PAGs) to determine changes in hemodynamic flow. We propose a multi-channel PAG recording sensor suitable for rapid, non-invasive vascular access monitoring. Here we present the initial design and characterization of sensors appropriate for recording PAGs from the skin surface. An optimized sensor size and backing material was selected to improve sensitivity and to provide a neutral frequency response. The sensor performance was finally compared with a conventional stethoscope on a controlled blood flow stenosis benchtop phantom.

[23] Panda B, Chin S, Mandal S, Majerus S. Skin-coupled PVDF microphones for noninvasive vascular blood sound monitoring. *IEEE Signal Process Med Biol Symp.* 2018;2018:10.1109/SPMB.2018.8615606. doi:10.1109/SPMB.2018.8615606

Uchiyama, K et al (2018) [Simulation Study] The Impact of a Remote Monitoring System of Healthcare Resource Consumption in Patients on Automated Peritoneal Dialysis (APD): A Simulation Study[24]

Aims: Remote monitoring (RM) can improve management of chronic diseases. We evaluated the impact of RM in automated peritoneal dialysis (APD) in a simulation study.

Materials and methods: We simulated 12 patient scenarios with common clinical problems and estimated the likely healthcare resource consumption with and without the availability of RM (RM+ and RM- groups, respectively). Scenarios were evaluated 4 times by randomly allocated nephrologist-nurse teams or nephrologist-alone assessors.

Results: The RM+ group was assessed as having significantly lower total healthcare resource consumption compared with the RM- group (36.8 vs. 107.5 total episodes of resource consumption, p = 0.002). The RM+ group showed significantly lower "unplanned hospital visits" (2.3 vs. 11.3, p = 0.005), "emergency room visits" (0.5 vs. 5.3, p = 0.003), "home visits" (0.5 vs. 5.8, p = 0.016), "exchanges over the telephone" (18.5 vs. 57.8, p = 0.002), and "change to hemodialysis" (0.5 vs. 2.5, p = 0.003). Evaluations did not differ between nephrologist-nurse teams vs. nephrologist-alone assessors.

Conclusion: RM can be expected to reduce healthcare resource consumption in APD patients.

Weinhandl, ED, Collins, AJ (2018) Relative Risk of Home Hemodialysis Attrition in Patients Using a Telehealth Platform[25]

Introduction: Home hemodialysis (HHD) facilitates increased treatment frequency, which may improve patient outcomes. However, attrition due to technique failure limits the clinical effectiveness of the modality. Nx2me Connected Health is a telehealth platform that enables ongoing assessment of HHD patients using NxStage equipment, and that may reduce patient burden. We aimed to assess whether use of Nx2me was associated with risk of HHD attrition.

Methods: We compared risks of all-cause attrition, dialysis cessation (ie, death or transplant), and technique failure in Nx2me users and matched control patients, using a retrospective cohort study. We also compared the likelihood of HHD training graduation in patients who initiated use of Nx2me

[24] Uchiyama K, Washida N, Yube N et al The impact of a remote monitoring system of healthcare resource consumption in patients on automated peritoneal dialysis (APD): A simulation study. *Clin Nephrol.* 2018;905.:334- 340. doi:10.5414/CN109471
[25] Weinhandl ED, Collins AJ. Relative risk of home hemodialysis attrition in patients using a telehealth platform. *Hemodial Int.* 2018;223.:318- 327. doi:10.1111/hdi.12621
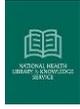
during training with the likelihood in matched control patients. Matching factors included date of HHD initiation, NxStage treatment duration at initiation of follow-up, and prescribed treatment frequency. We used stratified Fine-Gray and Cox regression to compare risks, with adjustment for demographic factors and vascular access modality, and stratification by matched cluster.

Findings: We identified 606 Nx2me users; 49.5% initiated use of Nx2me in <3 months after initiation of HHD with NxStage equipment. Adjusted hazard ratios (AHRs) of all-cause attrition, dialysis cessation, and technique failure were 0.80 (95% confidence interval, 0.68-0.95), 1.10 (0.86-1.41), and 0.71 (0.57-0.87), respectively, for Nx2me users vs. matched controls. AHRs were similar in patients who initiated use of Nx2me in <3 months after initiation of HHD. The AHR of HHD training graduation was 1.61 (1.10-2.36) in patients who initiated use of Nx2me within 2 weeks of training initiation vs. matched controls.

Discussion: Use of Nx2me was associated with lower risk of all-cause attrition, lower risk of technique failure, and higher likelihood of HHD training graduation. Further studies are needed to identify the mechanisms by which use of a telehealth platform may improve clinical outcomes and reduce patient burden.

Bernardo, AA et al (2017) Clinical Safety and Performance of VIVIA: A Novel Home Hemodialysis System[26]

Background: The VIVIA Hemodialysis System (Baxter Healthcare Corporation, Deerfield, IL, USA) was designed for patient use at home to reduce the burden of treatment and improve patient safety. It has unique features including extended use of the dialyzer and blood set through in situ hot-water disinfection between treatments; generation of on-line infusible-quality dialysate for automated priming, rinseback and hemodynamic support during hypotension and a fully integrated access disconnect sensor.

Methods: The safety and performance of VIVIA were assessed in two clinical studies. A first-in-man study was a prospective, single-arm study that involved 22 prevalent hemodialysis (HD) patients who were treated for ~4 h, four times a week, for 10 weeks. A second clinical study was a prospective, single-arm study (6-8 h of dialysis treatment at night three times a week) that involved 17 prevalent patients treated for 6 weeks.

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[26] Bernardo AA, Marbury TC, McFarlane PA et al Clinical safety and performance of VIVIA: a novel home hemodialysis system. *Nephrol Dial Transplant*. 2017;324.:685- 692. doi:10.1093/ndt/gfw044

Results: There were 1,114 treatments from the two studies (first-in-man study, 816; extended duration study, 298). Adverse events (AEs) were similar in the two studies to those expected for prevalent HD patients. No deaths and no device-related serious AEs occurred. Adequacy of dialysis (Kt / V) urea in both clinical trials was well above the clinical guidelines. VIVIA performed ultrafiltration accurately as prescribed in the two studies. The majority of patients achieved 10 or more uses of the dialyzer. Endotoxin levels and bacterial dialysate sampling met infusible-quality dialysate standards.

Conclusion: These results confirm the safety and expected performance of VIVIA.

Ditchburn, JL, Marshall, A (2017) [Renal Telemedicine Through Video-As-A-Service Delivered to Patients on Home Dialysis: A Qualitative Study on the Renal Care Team Members' Experience](27)

Background: The Lancashire Teaching Hospitals NHS Trust in the UK has been providing renal care through video-as-a-service (VAAS) to patients since 2013, with support from the North West NHS Shared Infrastructure Service, a collaborative team that supports information and communication technology use in the UK National Health Service.

Introduction: Renal telemedicine offered remotely to patients on home dialysis supports renal care through the provision of a live high-quality video link directly to unsupported patients undergoing haemodialysis at home. Home haemodialysis is known to provide benefits to patients, particularly in making them more independent. The use of a telemedicine video-link in Lancashire and South Cumbria, UK, further reduces patient dependence on the professional team.

Objective: The purpose of this paper is to present the perspectives of the renal care team members using the renal telemedicine service to understand the perceived benefits and issues with the service.

Method: Ten semi-structured interviews with members of the renal care team [two renal specialists, one matron, two renal nurses, one business manager, one renal technical services manager, two IT technicians and one hardware maintenance technician] were conducted. Thematic analysis was undertaken to analyse the qualitative data.

Results: A range of incremental benefits to the renal team members were reported, including more efficient use of staff time, reduced travel, peace of

[27] Ditchburn JL, Marshall A. Renal telemedicine through video-as-a-service delivered to patients on home dialysis: A qualitative study on the renal care team members' experience. *J Ren Care.* 2017;433.:175- 182. doi:10.1111/jorc.12207

mind and a strong sense of job satisfaction. Healthcare staff believed that remote renal care through video was useful, encouraged concordance and could nurture confidence in patients. Key technological issues and adjustments which would improve the renal telemedicine service were also identified.

Conclusion: The impact of renal telemedicine was positive on the renal team members. The use of telemedicine has been demonstrated to make home dialysis delivery more efficient and safe. The learning from staff feedback could inform development of services elsewhere.

Imtiaz, R et al (2017) [Pilot Study] A Pilot Study of OkKidney, a Phosphate Counting Application in Patients on Peritoneal Dialysis[28]

Background: Hyperphosphatemia is associated with adverse outcomes in patients treated with peritoneal dialysis (PD). We have shown that a fixed meal phosphate binder dosing schedule is not appropriate. The purpose of this study was to evaluate the beta version of OkKidney, a phosphate counting app that matches meal phosphate content with binder dose.

Methods: A convenience sample of adult patients treated with PD completed a pre-survey that included the technology readiness index (TRI 2.0). After a short information session, patients used OkKidney for 30 days. Pre- and post-intervention serum calcium, serum phosphate, and calcium carbonate binder intake were collected and compared using a paired t-test. A post-intervention survey using a 5-point Likert scale was used to gather patient feedback.

Results: Ten patients (5M, 5F) completed the study protocol. Participants were 55 ± 17 years old, predominately Caucasian, retired (60%), and owned a smartphone (70%). The median TRI score was 3.66 (max 5), indicating a moderate level of readiness. The post-survey results indicated a favorable rating for ease of use ($\mu = 4.4 \pm 0.84$) and usefulness ($\mu = 4.3 \pm 0.68$) of OkKidney. The average serum phosphate ($p = 0.99$) and calcium ($p = 0.68$) were not different pre-/post-intervention, but calcium carbonate intake tended to decrease ($p = 0.12$).

Conclusion: Patients reported a positive experience with OkKidney. Further patient-specific adjustments of the binder dose to meal phosphate content may be required to demonstrate a statistically significant decrease in

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[28] Imtiaz R, Atkinson K, Guerinet J, Wilson K, Leidecker J, Zimmerman D. A Pilot Study of OkKidney, a Phosphate Counting Application in Patients on Peritoneal Dialysis. *Perit Dial Int.* 2017;376.:613- 618. doi:10.3747/pdi.2017.00050

phosphate levels. We believe a larger trial is warranted to investigate the clinical implications of this app.

Lew, SQ et al (2017) Adoption of Telehealth: Remote Biometric Monitoring Among Peritoneal Dialysis Patients in the United States[29]

We examined participant uptake and utilization of remote monitoring devices, and the relationship between remote biometric monitoring (RBM) of weight (Wt) and blood pressure (BP) with self-monitoring requirements. Participants on peritoneal dialysis (PD) (n = 269) participated in a Telehealth pilot study of which 253 used remote monitoring of BP and 255 for Wt. Blood pressure and Wt readings were transmitted in real time to a Telehealth call center, which were then forwarded to the PD nurses for real-time review. Uptake of RBM was substantial, with 89.7% accepting RBM, generating 74,266 BP and 52,880 Wt measurements over the study period. We found no significant correlates of RBM uptake with regard to gender, marital, educational, socio-economic or employment status, or baseline experience with computers; frequency of use of BP RBM by Black participants was less than non-Black participants, as was Wt RBM, and participants over 55 years old were more likely to use the Wt RBM than their younger counterparts. Having any review of the breach by a nurse was associated with reduced odds of a subsequent BP breach after adjusting for sex, age, and race. Remote biometric monitoring was associated with adherence to self-monitoring BP and Wt requirements associated with PD. Remote biometric monitoring was feasible, allowing for increased communication between patient and PD clinical staff with real-time patient data for providers to act on to potentially improve adherence and outcomes.

Liu, N et al (2017) Remote Monitoring Systems for Chronic Patients on Home Hemodialysis: Field Test of a Copresence-Enhanced Design[30]

Background: Patients undertaking long-term and chronic home hemodialysis (HHD) are subject to feelings of isolation and anxiety due to the absence of physical contact with their health care professionals and lack of feedback in regards to their dialysis treatments. Therefore, it is important for these patients to feel the "presence" of the health care professionals remotely

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[29] Lew SQ, Sikka N, Thompson C, Cherian T, Magnus M. Adoption of Telehealth: Remote Biometric Monitoring Among Peritoneal Dialysis Patients in the United States. *Perit Dial Int*. 2017;375.:576- 578. doi:10.3747/pdi.2016.00272

[30] Liu N, Kim J, Jung Y et al Remote Monitoring Systems for Chronic Patients on Home Hemodialysis: Field Test of a Copresence-Enhanced Design. *JMIR Hum Factors*. 2017;43.:e21. Published 2017 Aug 29. doYasin OZ, Attia Z, Dillon JJ et al Noninvasive blood potassium measurement using signal-processed, single-lead ecg acquired from a handheld smartphone. *J Electrocardiol*. 2017;505.:620- 625. doi:10.1016/j.jelectrocard.2017.06.008i:10.2196/humanfactors.7078
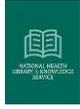
while on hemodialysis at home for better compliance with the dialysis regime and to feel connected with health care professionals.

Objective: This study presents an HHD system design for hemodialysis patients with features to enhance patient's perceived "copresence" with their health care professionals. Various mechanisms to enhance this perception were designed and implemented, including digital logbooks, emotion sharing, and feedback tools. The mechanism in our HHD system aims to address the limitations associated with existing self-monitoring tools for HHD patients.

Methods: A field trial involving 3 nurses and 74 patients was conducted to test the pilot implementation of the copresence design in our HHD system. Mixed method research was conducted to evaluate the system, including surveys, interviews, and analysis of system data.

Results: Patients created 2757 entries of dialysis cases during the period of study. Altogether there were 492 entries submitted with very happy as the emotional status, 2167 entries with a happy status, 56 entries with a neutral status, 18 entries with an unhappy status, and 24 entries with a very unhappy status. Patients felt assured to share their emotions with health care professionals. Health care professionals were able to prioritize the review of the entries based on the emotional status and also felt assured to see patients' change in mood. There were 989 entries sent with short notes. Entries with negative emotions had a higher percentage of supplementary notes entered compared to the entries with positive and neutral emotions. The qualitative data further showed that the HHD system was able to improve patients' feelings of being connected with their health care professionals and thus enhance their self-care on HHD. The health care professionals felt better assured with patients' status with the use of the system and reported improved productivity and satisfaction with the copresence enhancement mechanism. The survey on the system usability indicated a high level of satisfaction among patients and nurses.

Conclusions: The copresence enhancement design complements the conventional use of a digitized HHD logbook and will further benefit the design of future telehealth systems.

Wallace, EL et al (2017) [Review] Remote Patient Management for Home Dialysis Patients[31]

Remote patient management (RPM) offers renal health care providers and patients with end-stage kidney disease opportunities to embrace home dialysis therapies with greater confidence and the potential to obtain better clinical outcomes. Barriers and evidence required to increase adoption of RPM by the nephrology community need to be clearly defined. Ten health care providers from specialties including nephrology, cardiology, pediatrics, epidemiology, nursing, and health informatics with experience in home dialysis and the use of RPM systems gathered in Vienna, Austria to discuss opportunities for, barriers to, and system requirements of RPM as it applies to the home dialysis patient. Although improved outcomes and cost-effectiveness of RPM have been demonstrated in patients with diabetes mellitus and heart disease, only observational data on RPM have been gathered in patients on dialysis. The current review focused on RPM systems currently in use, on how RPM should be integrated into future care, and on the evidence needed for optimized implementation to improve clinical and economic outcomes. Randomized controlled trials and/or large observational studies could inform the most effective and economical use of RPM in home dialysis. These studies are needed to establish the value of existing and/or future RPM models among patients, policy makers, and health care providers.

Yasin, OZ et al (2017) Noninvasive Blood Potassium Measurement Using Signal-Processed, Single-Lead Ecg Acquired From a Handheld Smartphone[32]

Objective: We have previously used a 12-lead, signal-processed ECG to calculate blood potassium levels. We now assess the feasibility of doing so with a smartphone-enabled single lead, to permit remote monitoring. Patients and Methods: Twenty-one hemodialysis patients held a smartphone equipped with inexpensive FDA-approved electrodes for three 2min intervals during hemodialysis. Individualized potassium estimation models were generated for each patient. ECG-calculated potassium values were compared to blood potassium results at subsequent visits to evaluate the accuracy of the potassium estimation models.

[31] Wallace EL, Rosner MH, Alscher MD et al Remote Patient Management for Home Dialysis Patients. *Kidney Int Rep*. 2017;26.:1009-1017. Published 2017 Jul 29. doi:10.1016/j.ekir.2017.07.010
[32] Yasin OZ, Attia Z, Dillon JJ et al Noninvasive blood potassium measurement using signal-processed, single-lead ecg acquired from a handheld smartphone. *J Electrocardiol*. 2017;505.:620-625. doi:10.1016/j.jelectrocard.2017.06.008

Results: The mean absolute error between the estimated potassium and blood potassium 0.38±0.32 mEq/L (9% of average potassium level) decreasing to 0.6 mEq/L using predictors of poor signal.

Conclusions: A single-lead ECG acquired using electrodes attached to a smartphone device can be processed to calculate the serum potassium with an error of 9% in patients undergoing hemodialysis.

Summary: A single-lead ECG acquired using electrodes attached to a smartphone can be processed to calculate the serum potassium in patients undergoing hemodialysis remotely.

Attia, ZI et al (2016) Novel Bloodless Potassium Determination Using a Signal-Processed Single-Lead ECG[33]

Background: Hyper- and hypokalemia are clinically silent, common in patients with renal or cardiac disease, and are life threatening. A noninvasive, unobtrusive, blood-free method for tracking potassium would be an important clinical advance.

Methods and Results: Two groups of hemodialysis patients (development group, n=26; validation group, n=19) underwent high-resolution digital ECG recordings and had 2 to 3 blood tests during dialysis. Using advanced signal processing, we developed a personalized regression model for each patient to noninvasively calculate potassium values during the second and third dialysis sessions using only the processed single-channel ECG. In addition, by analyzing the entire development group's first-visit data, we created a global model for all patients that was validated against subsequent sessions in the development group and in a separate validation group. This global model sought to predict potassium, based on the T wave characteristics, with no blood tests required. For the personalized model, we successfully calculated potassium values with an absolute error of 0.36±0.34 mmol/L (or 10% of the measured blood potassium). For the global model, potassium prediction was also accurate, with an absolute error of 0.44±0.47 mmol/L for the training group (or 11% of the measured blood potassium) and 0.5±0.42 for the validation set (or 12% of the measured blood potassium).

Conclusions: The signal-processed ECG derived from a single lead can be used to calculate potassium values with clinically meaningful resolution using a strategy that requires no blood tests. This enables a cost-effective,

[33] Attia ZI, DeSimone CV, Dillon JJ et al Novel Bloodless Potassium Determination Using a Signal-Processed Single-Lead ECG. *J Am Heart Assoc*. 2016;51.:e002746. Published 2016 Jan 25. doi:10.1161/JAHA.115.002746

noninvasive, unobtrusive strategy for potassium assessment that can be used during remote monitoring.

Bonnet, S et al (2016) Wearable Impedance Monitoring System for Dialysis Patients[34]

This paper describes the development and the validation of a prototype wearable miniaturized impedance monitoring system for remote monitoring in home-based dialysis patients. This device is intended to assess the hydration status of dialysis patients using calf impedance measurements. The system is based on the low-power AD8302 component. The impedance calibration procedure is described together with the Cole parameter estimation and the hydric volume estimation. Results are given on a test cell to validate the design and on preliminary calf measurements showing Cole parameter variations during hemodialysis.

Montalibet, A et al (2016) Design and Development of an Impedimetric-Based System for the Remote Monitoring of Home-Based Dialysis Patients[35]

A key clinical challenge is to determine the desired 'dry weight' of a patient in order to terminate the dialysis procedure at the optimal moment and thus avoid the effects of over- and under-hydration. It has been found that the effects of haemodialysis on patients can be conveniently monitored using whole-body bioimpedance measurements. The identified need of assessing the hydrational status of patients undergoing haemodialysis at home gave rise to the present Dialydom (DIALYse à DOMicile) project. The aim of the project is to develop a convenient miniaturised impedance monitoring device for localised measurements (on the calf) in order to estimate an impedimetric hydrational index of the home-based patient, and to transmit this and other parameters to a remote clinical site. Many challenges must be overcome to develop a robust and valid home-based device. Some of these are presented in the paper.

[34] Bonnet S, Bourgerette A, Gharbi S et al Wearable impedance monitoring system for dialysis patients. *Conf Proc IEEE Eng Med Biol Soc*. 2016;2016:5196-5199. doi:10.1109/EMBC.2016.7591898
[35] Montalibet A, Arkouche W, Bogónez Franco P et al Design and development of an impedimetric-based system for the remote monitoring of home-based dialysis patients. *Stud Health Technol Inform*. 2016;224:78-83.

Nayak, KS et al (2016) [Review] [Telemedicine and Remote Monitoring: Supporting the Patient on Peritoneal Dialysis](#)[36]

This review describes telemedicine platforms used to support home dialysis therapies, specifically peritoneal dialysis (PD), which can support patients living in remote areas and help them maintain a good level of independence while ensuring good outcomes.

Nicdao, MA et al (2016) ['My Home Hemo' app — a new telehealth tool for remote monitoring of patients on home haemodialysis](#)[37]

As opposed to institutional and satellite dialysis, home dialysis is advocated as the preferred and cost-effective alternative to provide dialysis to a rising number of patients with end-stage kidney failure. Ongoing support to ensure success of a home dialysis program can be challenging because of limited nursing resources to visit patients who are often distributed over large geographical areas. Since patients on home haemodialysis (HHD) are reviewed much less frequently compared to those on institutional or satellite haemodialysis, we developed a telehealth information system, the Home Haemodialysis Remote Monitoring System (HHD-RMS), comprising of a mobile device application named 'My Home Hemo' app and a web portal for remote monitoring of patients' dialysis parameters. This study reports our findings from analysing the dialysis data from the app, collected and reviewed on 74 patients over 21 weeks. Using this data increased occasions of patient review by 270% as compared to the previous two years, with an average of 12 patients' dialysis data being remotely reviewed per week, resulting in 26 changes to dialysis prescriptions during the study period, and significant reduction in nursing and patient times associated with consultations and travel. Both patients and nursing staff reported high levels of satisfaction and ease of use. We conclude that this remote monitoring telehealth tool enabled nurses to remotely monitor dialysis parameters of patients on HHD, resulting in improved nursing efficiencies. The data allowed changes to be made to haemodialysis prescriptions and led to savings associated with patient and nursing time from the reduced need for travel. Anecdotally, the app also improved patient and staff satisfaction. This

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[36] Nayak KS, Ronco C, Karopadi AN, Rosner MH. Telemedicine and Remote Monitoring: Supporting the Patient on Peritoneal Dialysis. *Perit Dial Int*. 2016;364.:362- 366. doi:10.3747/pdi.2015.00021

[37] Nicdao, MA, Kin, J, Baldacchino, T et al 'My home hemo app' – a new telehealth tool for remote monitoring of patients on home haemodialysis. *Renal Society of Australasia Journal* 2016; 122. 41-47. {https://www.renalsociety.org/public/6/files/documents/RSAJ/2016%2007/RSAJ%20Nicado%20article.pdf} [Accessed 25 May 2020]

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system has the potential for major health benefits to patients and cost savings to health services.

Tangaro, S et al (2016) Computer Aided Detection System for Prediction of the Malaise During Hemodialysis[38]

Monitoring of dialysis sessions is crucial as different stress factors can yield suffering or critical situations. Specialized personnel is usually required for the administration of this medical treatment; nevertheless, subjects whose clinical status can be considered stable require different monitoring strategies when compared with subjects with critical clinical conditions. In this case domiciliary treatment or monitoring can substantially improve the quality of life of patients undergoing dialysis. In this work, we present a Computer Aided Detection (CAD) system for the telemonitoring of patients' clinical parameters. The CAD was mainly designed to predict the insurgence of critical events; it consisted of two Random Forest (RF) classifiers: the first one (RF1) predicting the onset of any malaise one hour after the treatment start and the second one (RF2) again two hours later. The developed system shows an accurate classification performance in terms of both sensitivity and specificity. The specificity in the identification of nonsymptomatic sessions and the sensitivity in the identification of symptomatic sessions for RF2 are equal to 86.60% and 71.40%, respectively, thus suggesting the CAD as an effective tool to support expert nephrologists in telemonitoring the patients.

Armignacco, P et al (2015) [Review] Wearable Devices for Blood Purification: Principles, Miniaturization, and Technical Challenges[39]

The prevalence of end-stage renal disease (ESRD) and renal replacement therapy (RRT) continue to increase, imposing staggering costs on providers. Strategies to optimize the treatment and improve survival are of fundamental importance. The development of the wearable artificial kidney (WAK) requires incorporation of basic components of a dialysis system into a wearable device that allows mobility, miniaturization, and, above all, patient-oriented management. The technical requirements necessary for WAK can be divided into the following broad categories: dialysis membranes; dialysis regeneration; vascular access; patient monitoring systems; and power

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[38] Tangaro S, Fanizzi A, Amoroso N et al Computer Aided Detection System for Prediction of the Malaise during Hemodialysis. *Comput Math Methods Med.* 2016;2016:8748156. doi:10.1155/2016/8748156

[39] Armignacco P, Lorenzin A, Neri M, Nalesso F, Garzotto F, Ronco C. Wearable devices for blood purification: principles, miniaturization, and technical challenges. *Semin Dial.* 2015;282.:125- 130. doi:10.1111/sdi.12346

sources. Pumping systems for blood and other fluids are the most critical components of the device.

CHAPTER 10
Telemedicine and High-Risk Falls

Systematic Reviews

Baig, MM et al (2020) [Systematic Review] **A Systematic Review of Wearable Sensors and IoT-Based Monitoring Applications for Older Adults - A Focus on Ageing Population and Independent Living[1]**
This review aims to present current advancements in wearable technologies and IoT-based applications to support independent living. The secondary aim was to investigate the barriers and challenges of wearable sensors and Internet-of-Things (IoT) monitoring solutions for older adults. For this work, we considered falls and activity of daily life (ADLs) for the ageing population (older adults). A total of 327 articles were screened, and 14 articles were selected for this review. This review considered recent studies published between 2015 and 2019. The research articles were selected based on the inclusion and exclusion criteria, and studies that support or present a vision to provide advancement to the current space of ADLs, independent living and supporting the ageing population. Most studies focused on the system aspects of wearable sensors and IoT monitoring solutions including advanced sensors, wireless data collection, communication platform and usability. Moderate to low usability/ user-friendly approach is reported in most of the studies. Other issues found were inaccurate sensors, battery/ power issues, restricting the users within the monitoring area/ space and lack of interoperability. The advancement of wearable technology and the possibilities of using advanced IoT technology to assist older adults with their ADLs and independent living is the subject of many recent research and investigation.

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[1] Baig MM, Afifi S, GholamHosseini H, Mirza F. A Systematic Review of Wearable Sensors and IoT-Based Monitoring Applications for Older Adults - a Focus on Ageing Population and Independent Living. *J Med Syst*. 2019;438.:233. Published 2019 Jun 15. doi:10.1007/s10916-019-1365-7 [Accessed 11th May 2020]

Zhong, R, Rau, PP (2020) [Systematic Review] [Are Cost-Effective Technologies Feasible to Measure Gait in Older Adults? A Systematic Review of Evidence-Based Literature](2)

Background: Unrestricted by time and place, innovative technologies seem to provide cost-effective solutions for gait assessment in older adults.

Objective: The objective of this study is to provide an overview of gait assessment for older adults by investigating critical gait characteristics of older adults, discussing advantages and disadvantages of the current gait assessment technologies, as well as device applicability.

Methods: The Preferred Reporting Item for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were followed during the review. Inclusion criteria were: 1. sample consisting of adults older than 60 years; 2. qualitative, quantitative, or mixed-method researches using one or more specific gait assessment technologies; and 3. publication in English between 2000 and 2018.

Results: In total, twenty-one studies were included. Gait speed, stride length, frequency, acceleration root mean square, step-to-step consistency, autocorrelation, harmonic ratio were reported in the existing literatures to be associated with falls. The enrolled studies address the use of pedometer, wearable accelerometer-based devices, Kinect, Nintendo Wii Balance Board as cost-effective gait assessment technologies.

Conclusions: Gait parameters and assessment approaches for older adults are diverse. Cost-effective technologies such as a wearable accelerometer-based device, Kinect, and the Nintendo Wii Balance Board provide potential alternatives for gait assessment with acceptable validity and reliability compared with sophisticated devices. The popularity and development of cost-effective devices have made large-scale data collection for gait assessment possible in the daily environment. Further study could involve older adults and their family members/caregivers in use of these technologies to design elderly-friendly products.

2 Zhong R, Rau PP. Are cost-effective technologies feasible to measure gait in older adults? A systematic review of evidence-based literature. *Arch Gerontol Geriatr.* 2020;87:103970. doi:10.1016/j.archger.2019.103970 [Accessed 11th May 2020]

Bet, P et al (2019) [Systematic Review] Fall Detection and Fall Risk Assessment in Older Person Using Wearable Sensors: A Systematic Review[3]

Background: wearable sensors are often used to acquire data for gait analysis as a strategy to study fall events, due to greater availability of acquisition platforms, and advances in computational intelligence. However, there are no review papers addressing the three most common types of applications related to fall using sensors, namely: fall detection, fallers classification and fall risk screening.

Objective: To identify the state of art of fall-related events detection in older person using wearable sensors, as well as the main characteristics of the studies in the literature, pointing gaps for future studies.

Methods: A systematic review design was used to search peer-reviewed literature on fall detection and risk in elderly through inertial sensors, published in English, Portuguese, Spanish or French between August 2002 and June 2019. The following questions are investigated: the type of sensors and their sampling rate, the type of signal and data processing employed, the scales and tests used in the study and the type of application.

Results: We identified 608 studies, from which 29 were included. The accelerometer, with sampling rate 50 or 100 Hz, allocated in the waist or lumbar was the most used sensor setting. Methods comparing features or variables extracted from the accelerometry signal are the most common, and fall risk screening the most observed application.

Conclusion: This review identifies the main elements to be addressed in studies on the detection of events related to falls in the elderly and may help in future studies on the subject. However, some aspects are still no reach consensus in the literature such as the size of the sample to be studied, the population under study and how to acquire data for each application

Pang, I et al (2019) [Systematic Review] Detection of Near Falls Using Wearable Devices: A Systematic Review[4]

Background and Purpose: Falls among older people are a serious health issue. Remote detection of near falls may provide a new way to identify older people at high risk of falling. This could enable exercise and fall prevention programs to target the types of near falls experienced and the situations that cause near falls before fall-related injuries occur. The purpose of this

[3] Bet P, Castro PC, Ponti MA. Fall detection and fall risk assessment in older person using wearable sensors: A systematic review. *Int J Med Inform*. 2019;130:103946. doi:10.1016/j.ijmedinf.2019.08.006 [Accessed 11 May 2020]

[4] Pang I, Okubo Y, Sturnieks D, Lord SR, Brodie MA. Detection of Near Falls Using Wearable Devices: A Systematic Review. *J Geriatr Phys Ther*. 2019;421.:48–56. doi:10.1519/JPT.0000000000000181 [Accessed 11th May 2020]

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systematic review was to summarize and critically examine the evidence regarding the detection of near falls ⬜ slips, trips, stumbles, missteps, incorrect weight transfer, or temporary loss of balance ⬜ using wearable devices. Methods: CINAHL, EMBASE, MEDLINE, Compendex, and Inspec were searched to obtain studies that used a wearable device to detect near falls in young and older people with or without a chronic disease and were published in English. Results: Nine studies met the final inclusion criteria. Wearable sensors used included accelerometers, gyroscopes, and insole force inducers. The waist was the most common location to place a single device. Both high sensitivity (≥85.7%) and specificity (≥90.0%) were reported for near-fall detection during various clinical simulations and improved when multiple devices were worn. Several methodological issues that increased the risk of bias were revealed. Most studies analyzed a single or few near-fall types by younger adults in controlled laboratory environments and did not attempt to distinguish naturally occurring near falls from actual falls or other activities of daily living in older people. Conclusions: The use of a single lightweight sensor to distinguish between different types of near falls, actual falls, and activities of daily living is a promising low-cost technology and clinical tool for long-term continuous monitoring of older people and clinical populations at risk of falls. However, currently the evidence is limited because studies have largely involved simulated laboratory events in young adults. Future studies should focus on validating near-fall detection in larger cohorts and include data from 1. people at high risk of falling; 2. activities of daily living; 3. both near falls and actual falls; and 4. naturally occurring near falls.

Sun, R, Sosnoff, JJ (2018) [Systematic Review] Novel Sensing Technology in Fall Risk Assessment in Older Adults: A Systematic Review[5]
Background: Falls are a major health problem for older adults with significant physical and psychological consequences. A first step of successful fall prevention is to identify those at risk of falling. Recent advancement in sensing technology offers the possibility of objective, low-cost and easy-to-implement fall risk assessment. The objective of this systematic review is to assess the current state of sensing technology on providing objective fall risk assessment in older adults. Methods: A systematic review was conducted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement (PRISMA).

[5] Sun R, Sosnoff JJ. Novel sensing technology in fall risk assessment in older adults: a systematic review. *BMC Geriatr*. 2018;181.:14. Published 2018 Jan 16. doi:10.1186/s12877-018-0706-6 [Accessed 11th May 2020]

Results: Twenty-two studies out of 855 articles were systematically identified and included in this review. Pertinent methodological features ⬚ sensing technique, assessment activities, outcome variables, and fall discrimination/prediction models ⬚ were extracted from each article. Four major sensing technologies ⬚ inertial sensors, video/depth camera, pressure sensing platform and laser sensing ⬚ were reported to provide accurate fall risk diagnostic in older adults. Steady state walking, static/dynamic balance, and functional mobility were used as the assessment activity. A diverse range of diagnostic accuracy across studies (47.9% - 100%) were reported, due to variation in measured kinematic/kinetic parameters and modelling techniques. Conclusions: A wide range of sensor technologies have been utilized in fall risk assessment in older adults. Overall, these devices have the potential to provide an accurate, inexpensive, and easy-to-implement fall risk assessment. However, the variation in measured parameters, assessment tools, sensor sites, movement tasks, and modelling techniques, precludes a firm conclusion on their ability to predict future falls. Future work is needed to determine a clinical meaningful and easy to interpret fall risk diagnosis utilizing sensing technology. Additionally, the gap between functional evaluation and user experience to technology should be addressed.

Ma, CZ et al (2016) [Systematic Review] Balance Improvement Effects of Biofeedback Systems With State-of-the-Art Wearable Sensors: A Systematic Review[6]
Falls and fall-induced injuries are major global public health problems. Balance and gait disorders have been the second leading cause of falls. Inertial motion sensors and force sensors have been widely used to monitor both static and dynamic balance performance. Based on the detected performance, instant visual, auditory, electrotactile and vibrotactile biofeedback could be provided to augment the somatosensory input and enhance balance control. This review aims to synthesize the research examining the effect of biofeedback systems, with wearable inertial motion sensors and force sensors, on balance performance. Randomized and non-randomized clinical trials were included in this review. All studies were evaluated based on the methodological quality. Sample characteristics, device design and study characteristics were summarized. Most previous

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studies suggested that biofeedback devices were effective in enhancing static and dynamic balance in healthy young and older adults, and patients with balance and gait disorders. Attention should be paid to the choice of appropriate types of sensors and biofeedback for different intended purposes. Maximizing the computing capacity of the micro-processer, while minimizing the size of the electronic components, appears to be the future direction of optimizing the devices. Wearable balance-improving devices have their potential of serving as balance aids in daily life, which can be used indoors and outdoors.

Hu, X, Qu, X (2016) [Systematic Review] Pre-impact Fall Detection[7]
Pre-impact fall detection has been proposed to be an effective fall prevention strategy. In particular, it can help activate on-demand fall injury prevention systems (eg inflatable hip protectors) prior to fall impacts, and thus directly prevent the fall-related physical injuries. This paper gave a systematic review on pre-impact fall detection, and focused on the following aspects of the existing pre-impact fall detection research: fall detection apparatus, fall detection indicators, fall detection algorithms, and types of falls for fall detection evaluation. In addition, the performance of the existing pre-impact fall detection solutions were also reviewed and reported in terms of their sensitivity, specificity, and detection/lead time. This review also summarized the limitations in the existing pre-impact fall detection research, and proposed future research directions in this field.

[7] Hu X, Qu X. Pre-impact fall detection. *Biomed Eng Online*. 2016;151.:61. Published 2016 Jun 1. doi:10.1186/s12938-016-0194-x [Accessed 11th May 2020]

Barker, A et al (2019) [Randomised Controlled Trial] Evaluation of RESPOND, a Patient-Centred Program to Prevent Falls in Older People Presenting to the Emergency Department With a Fall: A Randomised Controlled Trial[8]

Background: Falls are a leading reason for older people presenting to the emergency department (ED), and many experience further falls. Little evidence exists to guide secondary prevention in this population. This randomised controlled trial (RCT) investigated whether a 6-month telephone-based patient-centred program-RESPOND-had an effect on falls and fall injuries in older people presenting to the ED after a fall. Methods and Findings: Community-dwelling people aged 60-90 years presenting to the ED with a fall and planned for discharge home within 72 hours were recruited from two EDs in Australia. Participants were enrolled if they could walk without hands-on assistance, use a telephone, and were free of cognitive impairment (Mini-Mental State Examination > 23). Recruitment occurred between 1 April 2014 and 29 June 2015. Participants were randomised to receive either RESPOND (intervention) or usual care (control). RESPOND comprised 1. home-based risk assessment; 2. 6 months telephone-based education, coaching, goal setting, and support for evidence-based risk factor management; and 3. linkages to existing services. Primary outcomes were falls and fall injuries in the 12-month follow-up. Secondary outcomes included ED presentations, hospital admissions, fractures, death, falls risk, falls efficacy, and quality of life. Assessors blind to group allocation collected outcome data via postal calendars, telephone follow-up, and hospital records. There were 430 people in the primary outcome analysis-217 randomised to RESPOND and 213 to control. The mean age of participants was 73 years; 55% were female. Falls per person-year were 1.15 in the RESPOND group and 1.83 in the control (incidence rate ratio [IRR] 0.65 [95% CI 0.43-0.99]; P = 0.042). There was no significant difference in fall injuries (IRR 0.81 [0.51-1.29]; P = 0.374). The rate of fractures was significantly lower in the RESPOND group compared with the control (0.05

[8] Barker A, Cameron P, Flicker L et al Evaluation of RESPOND, a patient-centred program to prevent falls in older people presenting to the emergency department with a fall: A randomised controlled trial. *PLoS Med.* 2019;165.:e1002807. Published 2019 May 24. doi:10.1371/journal.pmed.1002807 [Accessed 5 May 2020]

versus 0.12; IRR 0.37 [95% CI 0.15-0.91]; P = 0.03), but there were no significant differences in other secondary outcomes between groups: ED presentations, hospitalisations or falls risk, falls efficacy, and quality of life. There were two deaths in the RESPOND group and one in the control group. No adverse events or unintended harm were reported. Limitations of this study were the high number of dropouts (n = 93); possible underreporting of falls, fall injuries, and hospitalisations across both groups; and the relatively small number of fracture events. Conclusions: In this study, providing a telephone-based, patient-centred falls prevention program reduced falls but not fall injuries, in older people presenting to the ED with a fall. Among secondary outcomes, only fractures reduced. Adopting patient-centred strategies into routine clinical practice for falls prevention could offer an opportunity to improve outcomes and reduce falls in patients attending the ED.

Miscellaneous

Antos, SA et al (2020) Smartwatches Can Detect Walker and Cane Use in Older Adults[9]

Background and Objectives: Clinicians commonly prescribe assistive devices such as walkers or canes to reduce older adults' fall risk. However, older adults may not consistently use their assistive device, and measuring adherence can be challenging due to self-report bias or cognitive deficits. Because walking patterns can change while using an assistive device, we hypothesized that smartphones and smartwatches, combined with machine-learning algorithms, could detect whether an older adult was walking with an assistive device. Research Design and Methods: Older adults at an Adult Day Center (n = 14) wore an Android smartphone and Actigraph smartwatch while completing the six-minute walk, 10-meter walk, and Timed Up and Go tests with and without their assistive device on five separate days. We used accelerometer data from the devices to build machine-learning algorithms to detect whether the participant was walking with or without their assistive device. We tested our algorithms using cross-validation.

[9] Antos SA, Danilovich MK, Eisenstein AR, Gordon KE, Kording KP. Smartwatches Can Detect Walker and Cane Use in Older Adults. *Innov Aging*. 2019;31.:igz008. Published 2019 Apr 22. doi:10.1093/geroni/igz008 [Accessed 11th May 2020]

Results: Smartwatch classifiers could accurately detect assistive device use, but smartphone classifiers performed poorly. Customized smartwatch classifiers, which were created specifically for one participant, had greater than 95% classification accuracy for all participants. Noncustomized smartwatch classifiers ▯ ie an off-the-shelf system ▯ had greater than 90% accuracy for 10 of the 14 participants. A noncustomized system performed better for walker users than cane users.

Discussion and Implications: Our approach can leverage data from existing commercial devices to provide a deeper understanding of walker or cane use. This work can inform scalable public health monitoring tools to quantify assistive device adherence and enable proactive fall interventions.

Clemente, J et al (2020) [Smart Seismic Sensing for Indoor Fall Detection, Location, and Notification](#)[10]

This paper presents a novel real-time smart system performing fall detection, location, and notification based on floor vibration data produced by fall downs. Only using floor vibration as the recognition source, the system incorporates a person identification through vibration produced by footsteps to inform who is the fallen person. Our approach operates in a real-time style, which means the system recognizes a fall immediately and can identify a person with only one or two footsteps. A collaborative in-network location method is used in which sensors collaborate with each other to recognize the person walking, and more importantly, detect if the person falls down at any moment. We also introduce a voting system among sensor nodes to improve person identification accuracy. Our system is robust to identify fall downs from other possible similar events, such as jumps, door close, and objects fall down. Such a smart system can also be connected to smart commercial devices for emergency notifications. Our approach represents an advance in smart technology for elder people who live alone. Evaluation of the system shows that it is able to detect fall downs with an acceptance rate of 95.14%, distinguishing from other possible events, and it identifies people with one or two steps in a 97.22% [a higher accuracy than other methods that use more footsteps]. The fall down location error is smaller than 0.27 m, which is acceptable compared with the height of a person.

[10] Clemente J, Li F, Valero M, Song W. Smart Seismic Sensing for Indoor Fall Detection, Location, and Notification. *IEEE J Biomed Health Inform*. 2020;242.:524–532. doi:10.1109/JBHI.2019.2907498 [Accessed 11th May 2020]

Keogh, A et al (2020) Comparing the Usability and Acceptability of Wearable Sensors Among Older Irish Adults in a Real-World Context: Observational Study[11]

Background: Wearable devices are valuable assessment tools for patient outcomes in contexts such as clinical trials. To be successfully deployed, however, participants must be willing to wear them. Another concern is that usability studies are rarely published, often fail to test devices beyond 24 hours, and need to be repeated frequently to ensure that contemporary devices are assessed.

Objective: This study aimed to compare multiple wearable sensors in a real-world context to establish their usability within an older adult (>50 years) population.

Methods: Eight older adults wore seven devices for a minimum of 1 week each: Actigraph GT9x, Actibelt, Actiwatch, Biovotion, Hexoskin, Mc10 Biostamp_RC, and Wavelet. Usability was established through mixed methods using semistructured interviews and three questionnaires, namely, the Intrinsic Motivation Inventory (IMI), the System Usability Scale (SUS), and an acceptability questionnaire. Quantitative data were reported descriptively and qualitative data were analyzed using deductive content analysis. Data were then integrated using triangulation.

Results: Results demonstrated that no device was considered optimal as all scored below average in the SUS (median, IQR; min-max=57.5, 12.5; 47.5-63.8). Hexoskin was the lowest scored device based on the IMI (3.6; 3.4-4.5), while Biovotion, Actibelt, and Mc10 Biostamp_RC achieved the highest median results on the acceptability questionnaire (3.6 on a 6-point Likert scale). Qualitatively, participants were willing to accept less comfort, less device discretion, and high charging burdens if the devices were perceived as useful, namely through the provision of feedback for the user. Participants agreed that the purpose of use is a key enabler for long-term compliance. These views were particularly noted by those not currently wearing an activity-tracking device. Participants believed that wrist-worn sensors were the most versatile and easy to use, and therefore, the most suitable for long-term use. In particular, Actiwatch and Wavelet stood out for their comfort. The convergence of quantitative and qualitative data was demonstrated in the study.

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[11] Keogh A, Dorn JF, Walsh L, Calvo F, Caulfield B. Comparing the Usability and Acceptability of Wearable Sensors Among Older Irish Adults in a Real-World Context: Observational Study. *JMIR Mhealth Uhealth*. 2020;84.:e15704. Published 2020 Apr 20. doi:10.2196/15704 [Accessed 11th May 2020]

Conclusions: Based on the results, the following context-specific recommendations can be made: 1. researchers should consider their device selection in relation to both individual and environmental factors, and not simply the primary outcome of the research study; 2. if researchers do not wish their participants to have access to feedback from the devices, then a simple, wrist-worn device that acts as a watch is preferable; 3. if feedback is allowed, then it should be made available to help participants remain engaged; this is likely to apply only to people without cognitive impairments; 4. battery life of 1 week should be considered as a necessary feature to enhance data capture; 5. researchers should consider providing additional information about the purpose of devices to participants to support their continued use.

Tahir, A et al (2020) Hardware/Software Co-design of Fractal Features Based Fall Detection System[12]

Falls are a leading cause of death in older adults and result in high levels of mortality, morbidity and immobility. Fall Detection Systems (FDS) are imperative for timely medical aid and have been known to reduce death rate by 80%. We propose a novel wearable sensor FDS which exploits fractal dynamics of fall accelerometer signals. Fractal dynamics can be used as an irregularity measure of signals and our work shows that it is a key discriminant for classification of falls from other activities of life. We design, implement and evaluate a hardware feature accelerator for computation of fractal features through multi-level wavelet transform on a reconfigurable embedded System on Chip, Zynq device for evaluating wearable accelerometer sensors. The proposed FDS utilises a hardware/software co-design approach with hardware accelerator for fractal features and software implementation of Linear Discriminant Analysis on an embedded ARM core for high accuracy and energy efficiency. The proposed system achieves 99.38% fall detection accuracy, 7.3× speed-up and 6.53× improvements in power consumption, compared to the software only execution with an overall performance per Watt advantage of 47.6×, while consuming low reconfigurable resources at 28.67%.

[12] Tahir A, Morison G, Skelton DA, Gibson RM. Hardware/Software Co-design of Fractal Features based Fall Detection System. *Sensors (Basel)*. 2020;208.:E2322. Published 2020 Apr 18. doi:10.3390/s20082322 [Accessed 11th May 2020]

Boutellaa, E et al (2019) [Covariance Matrix Based Fall Detection From Multiple Wearable Sensors](#)[13]

Falls are among the critical accidents experienced by elderly people and patients carrying some diseases. Subsequently, the detection and prevention of falls have become a hot research and industrial topic. This is due to the fact that falls are behind numerous irreversible injuries, or even death, and are weighting on the budgets of the health services. Automatic fall detection is one of the proposed solutions which aim at monitoring people who are likely to fall. Such solutions mitigate the fall impact by taking a quick action, eg in case of a fall occurrence, an alert is sent to the hospital. In this paper, we propose a new fall detection system relying on different signals acquired with multiple wearable sensors. Our system makes use of the covariance of the raw signals and the nearest neighbor classifier. Besides feature extraction, we also employ the covariance matrix as a straightforward mean for fusing signals from multiple sensors, to enhance the classification performance. Evaluation on two publicly available fall datasets, namely CogentLabs and DLR, demonstrates that the proposed approach is efficient when exploiting a single sensor as well as when fusing data from multiple sensors. Geodesic metrics are found to provide a higher fall detection accuracy than the Euclidean metric. The best obtained classification accuracies are 92.51% and 98.31% for CogentLabs and DLR datasets, respectively.

Luan-Perejon, F et al (2019) [Wearable Fall Detector Using Recurrent Neural Networks](#)[14]

Falls have become a relevant public health issue due to their high prevalence and negative effects in elderly people. Wearable fall detector devices allow the implementation of continuous and ubiquitous monitoring systems. The effectiveness for analyzing temporal signals with low energy consumption is one of the most relevant characteristics of these devices. Recurrent neural networks (RNNs) have demonstrated a great accuracy in some problems that require analyzing sequential inputs. However, getting appropriate response times in low power microcontrollers remains a difficult task due to their limited hardware resources. This work shows a feasibility study about using RNN-based deep learning models to detect both falls and falls' risks in

[13] Boutellaa E, Kerdjidj O, Ghanem K. Covariance matrix based fall detection from multiple wearable sensors. *J Biomed Inform*. 2019;94:103189. doi:10.1016/j.jbi.2019.103189 [Accessed 11th May 2020]

[14] Luna-Perejón F, Domínguez-Morales MJ, Civit-Balcells A. Wearable Fall Detector Using Recurrent Neural Networks. *Sensors (Basel)*. 2019;19(22):4885. Published 2019 Nov 8. doi:10.3390/s19224885 [Accessed 11th May 2020]

real time using accelerometer signals. The effectiveness of four different architectures was analyzed using the SisFall dataset at different frequencies. The resulting models were integrated into two different embedded systems to analyze the execution times and changes in the model effectiveness. Finally, a study of power consumption was carried out. A sensitivity of 88.2% and a specificity of 96.4% was obtained. The simplest models reached inference times lower than 34 ms, which implies the capability to detect fall events in real-time with high energy efficiency. This suggests that RNN models provide an effective method that can be implemented in low power microcontrollers for the creation of autonomous wearable fall detection systems in real-time.

Scheurer, S et al (2019) Optimization and Technical Validation of the AIDE-MOI Fall Detection Algorithm in a Real-Life Setting With Older Adults[15]
Falls are the primary contributors of accidents in elderly people. An important factor of fall severity is the amount of time that people lie on the ground. To minimize consequences through a short reaction time, the motion sensor AIDE-MOI was developed. AIDE-MOI senses acceleration data and analyzes if an event is a fall. The threshold-based fall detection algorithm was developed using motion data of young subjects collected in a lab setup. The aim of this study was to improve and validate the existing fall detection algorithm. In the two-phase study, twenty subjects (age 86.25 ± 6.66 years) with a high risk of fall (Morse > 65 points) were recruited to record motion data in real-time using the AIDE-MOI sensor. The data collected in the first phase (59 days) was used to optimize the existing algorithm. The optimized second-generation algorithm was evaluated in a second phase (66 days). The data collected in the two phases, which recorded 31 real falls, was split-up into one-minute chunks for labelling as fall or non-fall. The sensitivity and specificity of the threshold-based algorithm improved significantly from 27.3% to 80.0% and 99.9957% (0.43) to 99.9978% (0.17 false alarms per week and subject), respectively.

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[15] Scheurer S, Koch J, Kucera M et al Optimization and Technical Validation of the AIDE-MOI Fall Detection Algorithm in a Real-Life Setting with Older Adults. *Sensors (Basel).* 2019;196.:1357. Published 2019 Mar 18. doi:10.3390/s19061357 [Accessed 11th May 2020]

Lee, Y et al (2018) Virtual Reality Training With Three-Dimensional Video Games Improves Postural Balance and Lower Extremity Strength in Community-Dwelling Older Adults[16]

Avatar-based three-dimensional technology is a new approach to improve physical function in older adults. The aim of this study was to use three-dimensional video gaming technology in virtual reality training to improve postural balance and lower extremity strength in a population of community-dwelling older adults. The experimental group participated in the virtual reality training program for 60 min, twice a week, for 6 weeks. Both experimental and control groups were given three times for falls prevention education at the first, third, and fifth weeks. The experimental group showed significant improvements not only in static and dynamic postural balance but also lower extremity strength (p < .05). Furthermore, the experimental group was improved to overall parameters compared with the control group (p < .05). Therefore, three-dimensional video gaming technology might be beneficial for improving postural balance and lower extremity strength in community-dwelling older adults.

Nizam, Y et al (2018) Development of a User-Adaptable Human Fall Detection Based on Fall Risk Levels Using Depth Sensor[17]

Unintentional falls are a major public health concern for many communities, especially with aging populations. There are various approaches used to classify human activities for fall detection. Related studies have employed wearable, non-invasive sensors, video cameras and depth sensor-based approaches to develop such monitoring systems. The proposed approach in this study uses a depth sensor and employs a unique procedure which identifies the fall risk levels to adapt the algorithm for different people with their physical strength to withstand falls. The inclusion of the fall risk level identification, further enhanced and improved the accuracy of the fall detection. The experimental results showed promising performance in adapting the algorithm for people with different fall risk levels for fall detection.

[16] Lee Y, Choi W, Lee K, Song C, Lee S. Virtual Reality Training With Three-Dimensional Video Games Improves Postural Balance and Lower Extremity Strength in Community-Dwelling Older Adults. *J Aging Phys Act*. 2017;254.:621- 627. doi:10.1123/japa.2015-0271 [Accessed 11th May 2020]

[17] Nizam Y, Mohd MNH, Jamil MMA. Development of a User-Adaptable Human Fall Detection Based on Fall Risk Levels Using Depth Sensor. *Sensors (Basel)*. 2018;187.:2260. Published 2018 Jul 13. doi:10.3390/s18072260 [Accessed 11th May 2020]

Reyes, A et al (2018) [A Standardized Review of Smartphone Applications to Promote Balance for Older Adults](18)

Background: Balance is one of the risk factors for falls in older adults. The use of smartphone applications related to health is increasing and, while there is potential for apps to be used as a self-managed balance intervention, many healthcare providers are concerned about the content and credibility of mHealth apps overall. Purpose: This study evaluates the quality of balance promoting apps and identifies strengths and areas of concern to assist healthcare providers in recommending these resources. Materials and Methods: Balance apps for the general public, offered on the iPhone Operating System (iOS) and Android platforms, were evaluated using the Mobile Application Rating Scale (MARS). Results: Five iOS apps met the inclusion criteria. The mean scores for each of the domains in MARS were: Engagement (3.32), Information (3.7), Functionality (3.8), and Esthetics (3.8). Overall, one app (UStabilize) received a rating of 4.43 in MARS five-point scale, which was considered good. Other apps in the review demonstrated acceptable quality. Conclusions: The reviewed balance apps targeted to improve or maintain physical balance were of acceptable quality. Apps address many current issues older adults have to accessing rehabilitation services and, as such, may be particularly useful for this group. Future research should focus on assessing and comparing app efficacy. Development of balance apps for the Android platform is also necessary. Implications for Rehabilitation Given the availability and accessibility of various mHealth apps and the increasing mobile device usage among older adults, mobile apps are a promising avenue for delivering rehabilitation interventions, such as balance training, to older adults. Smartphone apps exist for balance training but overall confidence in health apps within the healthcare community is low and rigorous evaluation is required. A range of apps exist that demonstrate acceptable to good quality and stakeholders should work towards having these apps listed in credible mHealth clearinghouses.

[18] Reyes A, Qin P, Brown CA. A standardized review of smartphone applications to promote balance for older adults. *Disabil Rehabil.* 2018;406.:690- 696. doi:10.1080/09638288.2016.1250124 [Accessed 5 May 2020]

Rucco, R et al (2018) Type and Location of Wearable Sensors for Monitoring Falls During Static and Dynamic Tasks in Healthy Elderly: A Review[19]

In recent years, the meaning of successful living has moved from extending lifetime to improving the quality of aging, mainly in terms of high cognitive and physical functioning together with avoiding diseases. In healthy elderly, falls represent an alarming accident both in terms of number of events and the consequent decrease in the quality of life. Stability control is a key approach for studying the genesis of falls, for detecting the event and trying to develop methodologies to prevent it. Wearable sensors have proved to be very useful in monitoring and analyzing the stability of subjects. Within this manuscript, a review of the approaches proposed in the literature for fall risk assessment, fall prevention and fall detection in healthy elderly is provided. The review has been carried out by using the most adopted publication databases and by defining a search strategy based on keywords and boolean algebra constructs. The analysis aims at evaluating the state of the art of such kind of monitoring, both in terms of most adopted sensor technologies and of their location on the human body. The review has been extended to both dynamic and static analyses. In order to provide a useful tool for researchers involved in this field, the manuscript also focuses on the tests conducted in the analyzed studies, mainly in terms of characteristics of the population involved and of the tasks used. Finally, the main trends related to sensor typology, sensor location and tasks have been identified.

Sucerquia, A et al (2018) Real-Life/Real-Time Elderly Fall Detection With a Triaxial Accelerometer[20]

The consequences of a fall on an elderly person can be reduced if the accident is attended by medical personnel within the first hour. Independent elderly people often stay alone for long periods of time, being in more risk if they suffer a fall. The literature offers several approaches for detecting falls with embedded devices or smartphones using a triaxial accelerometer. Most of these approaches have not been tested with the target population or cannot be feasibly implemented in real-life conditions. In this work, we propose a fall detection methodology based on a non-linear classification feature and a Kalman filter with a periodicity detector to reduce the false

[19] Rucco R, Sorriso A, Liparoti M et al Type and Location of Wearable Sensors for Monitoring Falls during Static and Dynamic Tasks in Healthy Elderly: A Review [published correction appears in Sensors (Basel). 2018 Jul 30;188.:]. *Sensors (Basel)*. 2018;185.:1613. Published 2018 May 18. doi:10.3390/s18051613 [Accessed 11th May 2020]

[20] Sucerquia A, López JD, Vargas-Bonilla JF. Real-Life/Real-Time Elderly Fall Detection with a Triaxial Accelerometer. *Sensors (Basel)*. 2018;184.:1101. Published 2018 Apr 5. doi:10.3390/s18041101 [Accessed 11th May 2020]

positive rate. This methodology requires a sampling rate of only 25 Hz; it does not require large computations or memory and it is robust among devices. We tested our approach with the SisFall dataset achieving 99.4% of accuracy. We then validated it with a new round of simulated activities with young adults and an elderly person. Finally, we give the devices to three elderly persons for full-day validations. They continued with their normal life and the devices behaved as expected.

Wang, C et al (2018) A Low-Power Fall Detector Balancing Sensitivity and False Alarm Rate[21]

Falls in older people are a major challenge to public health. A wearable fall detector can detect falls automatically based on kinematic information of the human body, allowing help to arrive sooner. To date, most studies have focused on the accuracy of an offline algorithm to distinguish real-world or simulated falls from activities of daily living, while neglecting the false alarm rate and battery life of a real device. To address these two important metrics, which significantly influence user compliance, this paper proposes a low-power fall detector using triaxial accelerometry and barometric pressure sensing. This fall detector minimizes power consumption using both hardware- and firmware-based techniques. Additionally, the fall detection algorithm used in this device is optimized to achieve a balance between sensitivity and false alarm rate, while minimizing the power consumption due to algorithm execution. The fall detector achieved a high sensitivity (91%) with a low false alarm rate (0.1149 alarms per hour), and a commercially-viable battery life.

Yu, S et al (2018) Hidden Markov Model-Based Fall Detection With Motion Sensor Orientation Calibration: A Case for Real-Life Home Monitoring[22]

Falls are a major threat for senior citizens' independent living. Motion sensor technologies and automatic fall detection systems have emerged as a reliable low-cost solution to this challenge. We develop a hidden Markov model (HMM) based fall detection system to detect falls automatically using a single motion sensor for real-life home monitoring scenarios. We propose a new representation for acceleration signals in HMMs to avoid feature engineering and developed a sensor orientation calibration algorithm to

[21] Wang C, Lu W, Redmond SJ, Stevens MC, Lord SR, Lovell NH. A Low-Power Fall Detector Balancing Sensitivity and False Alarm Rate. *IEEE J Biomed Health Inform.* 2018;226.:1929-1937. doi:10.1109/JBHI.2017.2778271 [Accessed 11th May 2020]
[22] Yu S, Chen H, Brown RA. Hidden Markov Model-Based Fall Detection With Motion Sensor Orientation Calibration: A Case for Real-Life Home Monitoring. *IEEE J Biomed Health Inform.* 2018;226.:1847-1853. doi:10.1109/JBHI.2017.2782079 [Accessed 11th May 2020]

resolve sensor misplacement issues [misplaced sensor location and misaligned sensor orientation] in real-world scenarios. HMM classifiers are trained to detect falls based on acceleration signal data collected from motion sensors. We collect a dataset from experiments of simulated falls and normal activities and acquired a dataset from a real-world fall repository (FARSEEING) to evaluate our system. Our system achieves positive predictive value of 0.981 and sensitivity of 0.992 on the experiment dataset with 200 fall events and 385 normal activities, and positive predictive value of 0.786 and sensitivity of 1.000 on the real-world fall dataset with 22 fall events and 2618 normal activities. Our system's results significantly outperform benchmark systems, which shows the advantage of our HMM-based fall detection system with sensor orientation calibration. Our fall detection system is able to precisely detect falls in real-life home scenarios with a reasonably low false alarm rate.

Aziz, O (2017) [Validation of Accuracy of SVM-based Fall Detection System Using Real-World Fall and Non-Fall Datasets](#)[23]

Falls are a major cause of injuries and deaths in older adults. Even when no injury occurs, about half of all older adults who fall are unable to get up without assistance. The extended period of lying on the floor often leads to medical complications, including muscle damage, dehydration, anxiety and fear of falling. Wearable sensor systems incorporating accelerometers and/or gyroscopes are designed to prevent long lies by automatically detecting and alerting care providers to the occurrence of a fall. Research groups have reported up to 100% accuracy in detecting falls in experimental settings. However, there is a lack of studies examining accuracy in the real-world setting. In this study, we examined the accuracy of a fall detection system based on real-world fall and non-fall data sets. Five young adults and 19 older adults went about their daily activities while wearing tri-axial accelerometers. Older adults experienced 10 unanticipated falls during the data collection. Approximately 400 hours of activities of daily living were recorded. We employed a machine learning algorithm, Support Vector Machine (SVM) classifier, to identify falls and non-fall events. We found that our system was able to detect 8 out of the 10 falls in older adults using signals from a single accelerometer [waist or sternum]. Furthermore, our system did not report any false alarm during approximately28.5 hours of recorded data from young adults. However, with older adults, the false

[23] Aziz O, Klenk J, Schwickert L et al Validation of accuracy of SVM-based fall detection system using real-world fall and non-fall datasets. *PLoS One*. 2017;127.:e0180318. Published 2017 Jul 5. doi:10.1371/journal.pone.0180318 [Accessed 11th May 2020]

positive rate among individuals ranged from 0 to 0.3 false alarms per hour. While our system showed higher fall detection and substantially lower false positive rate than the existing fall detection systems, there is a need for continuous efforts to collect real-world data within the target population to perform fall validation studies for fall detection systems on bigger real-world fall and non-fall datasets.

Bayen, E et al (2017) [Reduction in Fall Rate in Dementia Managed Care Through Video Incident Review: Pilot Study][24]
Background: Falls of individuals with dementia are frequent, dangerous, and costly. Early detection and access to the history of a fall is crucial for efficient care and secondary prevention in cognitively impaired individuals. However, most falls remain unwitnessed events. Furthermore, understanding why and how a fall occurred is a challenge. Video capture and secure transmission of real-world falls thus stands as a promising assistive tool.
Objective: The objective of this study was to analyze how continuous video monitoring and review of falls of individuals with dementia can support better quality of care. Methods: A pilot observational study (July-September 2016) was carried out in a Californian memory care facility. Falls were video-captured (24×7), thanks to 43 wall-mounted cameras (deployed in all common areas and in 10 out of 40 private bedrooms of consenting residents and families). Video review was provided to facility staff, thanks to a customized mobile device app. The outcome measures were the count of residents' falls happening in the video-covered areas, the acceptability of video recording, the analysis of video review, and video replay possibilities for care practice. Results: Over 3 months, 16 falls were video-captured. A drop in fall rate was observed in the last month of the study. Acceptability was good. Video review enabled screening for the severity of falls and fall-related injuries. Video replay enabled identifying cognitive-behavioral deficiencies and environmental circumstances contributing to the fall. This allowed for secondary prevention in high-risk multi-faller individuals and for updated facility care policies regarding a safer living environment for all residents. Conclusions: Video monitoring offers high potential to support conventional care in memory care facilities.

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[24] Bayen E, Jacquemot J, Netscher G, Agrawal P, Tabb Noyce L, Bayen A. Reduction in Fall Rate in Dementia Managed Care Through Video Incident Review: Pilot Study. *J Med Internet Res*. 2017;19(10):e339. Published 2017 Oct 17. doi:10.2196/jmir.8095 [Accessed 11th May 2020]

Brodie MA et al (2017) Disentangling the Health Benefits of Walking From Increased Exposure to Falls in Older People Using Remote Gait Monitoring and Multi-Dimensional Analysis[25]

Falls and physical deconditioning are two major health problems for older people. Recent advances in remote physiological monitoring provide new opportunities to investigate why walking exercise, with its many health benefits, can both increase and decrease fall rates in older people. In this paper we combine remote wearable device monitoring of daily gait with non-linear multi-dimensional pattern recognition analysis; to disentangle the complex associations between walking, health and fall rates. One week of activities of daily living (ADL) were recorded with a wearable device in 96 independent living older people prior to completing 6 months of exergaming interventions. Using the wearable device data; the quantity, intensity, variability and distribution of daily walking patterns were assessed. At baseline, clinical assessments of health, falls, sensorimotor and physiological fall risks were completed. At 6 months, fall rates, sensorimotor and physiological fall risks were re-assessed. A non-linear multi-dimensional analysis was conducted to identify risk-groups according to their daily walking patterns. Four distinct risk-groups were identified: The Impaired (93% fallers), Restrained (8% fallers), Active (50% fallers) and Athletic (4% fallers). Walking was strongly associated with multiple health benefits and protective of falls for the top performing Athletic risk-group. However, in the middle of the spectrum, the Active risk-group, who were more active, younger and healthier were 6.25 times more likely to be fallers than their Restrained counterparts. Remote monitoring of daily walking patterns may provide a new way to distinguish Impaired people at risk of falling because of frailty from Active people at risk of falling from greater exposure to situations were falls could occur, but further validation is required. Wearable device risk-profiling could help in developing more personalised interventions for older people seeking the health benefits of walking without increasing their risk of falls.

[25] Brodie MA, Okubo Y, Annegarn J, Wieching R, Lord SR, Delbaere K. Disentangling the health benefits of walking from increased exposure to falls in older people using remote gait monitoring and multi-dimensional analysis. *Physiol Meas.* 2017;381.:45- 62. doi:10.1088/1361-6579/38/1/45 [Accessed 11th May 2020]

De Miguel, K et al (2017) Home Camera-Based Fall Detection System for the Elderly[26]

Falls are the leading cause of injury and death in elderly individuals. Unfortunately, fall detectors are typically based on wearable devices, and the elderly often forget to wear them. In addition, fall detectors based on artificial vision are not yet available on the market. In this paper, we present a new low-cost fall detector for smart homes based on artificial vision algorithms. Our detector combines several algorithms ⬚ background subtraction, Kalman filtering and optical flow as input to a machine learning algorithm with high detection accuracy. Tests conducted on over 50 different fall videos have shown a detection ratio of greater than 96%.

Jatesiktat, P, Wei Tech, A (2017) An Elderly Fall Detection Using a Wrist-Worn Accelerometer and Barometer[27]

As the world population is growing toward an aging society, elderly fall becomes a serious problem. Automatic fall detection and alert systems could shorten their waiting time after a fall and mitigate its physical and mental negative consequences. This work proposes a method that integrates a 3-axis accelerometer and a barometer on a wrist-worn device for the fall detection task. The method focuses on the use of noisy signals from a barometer in both pre-processing steps and feature extractions. A use of free falling events to address the lack of training data in a learning process is also explored. An evaluation using simulated falls and various activities shows a high classification performance except for a few false alarms occurring when sitting on the floor from a standing pose.

Medrano, C et al (2017) Combining Novelty Detectors to Improve Accelerometer-Based Fall Detection[28]

Research on body-worn sensors has shown how they can be used for the detection of falls in the elderly, which is a relevant health problem. However, most systems are trained with simulated falls, which differ from those of the target population. In this paper, we tackle the problem of fall detection using a combination of novelty detectors. A novelty detector can be trained only with activities of daily life (ADL), which are true movements recorded in real

[26] de Miguel K, Brunete A, Hernando M, Gambao E. Home Camera-Based Fall Detection System for the Elderly. *Sensors (Basel)*. 2017;17(12):2864. Published 2017 Dec 9. doi:10.3390/s17122864 [Accessed 11th May 2020]

[27] Jatesiktat P, Wei Tech Ang. An elderly fall detection using a wrist-worn accelerometer and barometer. *Conf Proc IEEE Eng Med Biol Soc*. 2017;2017:125-130. doi:10.1109/EMBC.2017.8036778 [Accessed 11th May 2020]

[28] Medrano C, Igual R, García-Magariño I, Plaza I, Azuara G. Combining novelty detectors to improve accelerometer-based fall detection. *Med Biol Eng Comput*. 2017;55(10):1849-1858. doi:10.1007/s11517-017-1632-z [Accessed 11th May 2020]

life. In addition, they allow adapting the system to new users, by recording new movements and retraining the system. The combination of several detectors and features enhances performance. The proposed approach has been compared with a traditional supervised algorithm, a support vector machine, which is trained with both falls and ADL. The combination of novelty detectors shows better performance in a typical cross-validation test and in an experiment that mimics the effect of personalizing the classifiers. The results indicate that it is possible to build a reliable fall detector based only on ADL.

Minvielle, L et al (2017) Fall Detection Using Smart Floor Sensor and Supervised Learning[29]

Falls are a major risk for elderly people's health and independence. Fast and reliable fall detection systems can improve chances of surviving the accident and coping with its physical and psychological consequences. Recent research has come up with various solutions, all suffering from significant drawbacks, one of them being the intrusiveness into patient's life. This paper proposes a novel fall detection monitoring system based on a sensitive floor sensor made out of a piezoelectric material and a machine learning approach. The detection is done by a combination between a supervised Random Forest and an aggregation of its output over time. The database was made using acquisitions from 28 volunteers simulating falls and other behaviours. Our solution offers the advantages of having a passive sensor (no power supply is needed) and being completely unobtrusive since the sensor comes with the floor. Results are compared with state-of-the-art classification algorithms. On our database, good performance of fall detection was obtained with a True Positive Rate of 94.4% and a False Positive Rate of 2.4%.

Rajagopalan, R et al (2017) Fall Prediction and Prevention Systems: Recent Trends, Challenges, and Future Research Directions[30]

Fall prediction is a multifaceted problem that involves complex interactions between physiological, behavioral, and environmental factors. Existing fall detection and prediction systems mainly focus on physiological factors such as gait, vision, and cognition, and do not address the multifactorial nature of

[29] Minvielle L, Atiq M, Serra R, Mougeot M, Vayatis N. Fall detection using smart floor sensor and supervised learning. *Conf Proc IEEE Eng Med Biol Soc*. 2017;2017:3445-3448. doi:10.1109/EMBC.2017.8037597 [Accessed 11th May 2020]
[30] Rajagopalan R, Litvan I, Jung TP. Fall Prediction and Prevention Systems: Recent Trends, Challenges, and Future Research Directions. *Sensors (Basel)*. 2017;17(11):2509. Published 2017 Nov 1. doi:10.3390/s17112509 [Accessed 11th May 2020]

falls. In addition, these systems lack efficient user interfaces and feedback for preventing future falls. Recent advances in Internet of things (IoT) and mobile technologies offer ample opportunities for integrating contextual information about patient behavior and environment along with physiological health data for predicting falls. This article reviews the state-of-the-art in fall detection and prediction systems. It also describes the challenges, limitations, and future directions in the design and implementation of effective fall prediction and prevention systems.

Demiris, G et al (2016) Older Adults' Experience With a Novel Fall Detection Device[31]

Background: Falls are a significant concern for the older adult (OA) population, many of whom are unable to get up following a fall. Introduction: While many devices exist designed to detect a fall, little work has been conducted to evaluate the usability of such devices. We present a longitudinal usability study of a fall detection (FD) device tested with OAs in real-world settings. Materials and Methods: OAs were recruited and asked to use a wearable FD device for up to 4 months. Participants were interviewed at baseline and 2 and 4 months and encouraged to provide direct feedback on their experience. Results: In total, 18 OAs participated in the study. Eight completed the 4-month trial. We conducted a total of 38 interviews (16 baseline, 7 midpoint, and 15 final) and logged a total of 78 comments. While participants enjoyed the GPS and automatic detection features of the device, they were unhappy with the volume of false alarms and obtrusiveness of the device. Many also did not see a great need for having the device or were embarrassed by the device. Discussion: Engineers must work to better develop this technology so that it is accessible to people with hearing loss, limited dexterity, and low vision. Utilizing age-appropriate design techniques will help make such informatics tools more user friendly. Conclusion: We explored the usability of a particular FD device with OAs and provide design recommendations to help future device manufacturers create more age-appropriate devices.

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[31] Demiris G, Chaudhuri S, Thompson HJ. Older Adults' Experience with a Novel Fall Detection Device. *Telemed J E Health*. 2016;22(9):726- 732. doi:10.1089/tmj.2015.0218 [Accessed 11th May 2020]

Casilari et al (2015) Analysis of Android Device-Based Solutions for Fall Detection[32]

Falls are a major cause of health and psychological problems as well as hospitalization costs among older adults. Thus, the investigation on automatic Fall Detection Systems (FDSs) has received special attention from the research community during the last decade. In this area, the widespread popularity, decreasing price, computing capabilities, built-in sensors and multiplicity of wireless interfaces of Android-based devices (especially smartphones) have fostered the adoption of this technology to deploy wearable and inexpensive architectures for fall detection. This paper presents a critical and thorough analysis of those existing fall detection systems that are based on Android devices. The review systematically classifies and compares the proposals of the literature taking into account different criteria such as the system architecture, the employed sensors, the detection algorithm or the response in case of a fall alarms. The study emphasizes the analysis of the evaluation methods that are employed to assess the effectiveness of the detection process. The review reveals the complete lack of a reference framework to validate and compare the proposals. In addition, the study also shows that most research works do not evaluate the actual applicability of the Android devices with limited battery and computing resources to fall detection solutions.

Casilari, E et al (2015) Automatic Fall Detection System Based on the Combined Use of a Smartphone and a Smartwatch[33]

Due to their widespread popularity, decreasing costs, built-in sensors, computing power and communication capabilities, Android-based personal devices are being seen as an appealing technology for the deployment of wearable fall detection systems. In contrast with previous solutions in the existing literature, which are based on the performance of a single element ⬜ a smartphone ⬜ this paper proposes and evaluates a fall detection system that benefits from the detection performed by two popular personal devices: a smartphone and a smartwatch, both provided with an embedded accelerometer and a gyroscope. In the proposed architecture, a specific application in each component permanently tracks and analyses the

[32] Casilari E, Luque R, Morón MJ. Analysis of Android Device-Based Solutions for Fall Detection. *Sensors (Basel)*. 2015;158.:17827- 17894. Published 2015 Jul 23. doi:10.3390/s150817827 [Accessed 11th May 2020]

[33] Casilari E, Oviedo-Jiménez MA. Automatic Fall Detection System Based on the Combined Use of a Smartphone and a Smartwatch. *PLoS One*. 2015;10(11):e0140929. Published 2015 Nov 11. doi:10.1371/journal.pone.0140929 [Accessed 11th May 2020]

patient's movements. Diverse fall detection algorithms were implemented in the developed Android apps to discriminate falls from the conventional activities of daily living of the patient. As a novelty, a fall is only assumed to have occurred if it is simultaneously and independently detected by the two Android devices which can interact via Bluetooth communication. The system was systematically evaluated in an experimental testbed with actual test subjects simulating a set of falls and conventional movements associated with activities of daily living. The tests were repeated by varying the detection algorithm as well as the pre-defined mobility patterns executed by the subjects: ie the typology of the falls and non-fall movements. The proposed system was compared with the cases where only one device is considered to recognize and discriminate the falls. The obtained results show that the joint use of the two detection devices clearly increases the system's capability to avoid false alarms or false positives while maintaining the effectiveness of the detection decisions, that is to say, without increasing the ratio of false negatives or actual falls that remain undetected.

Garripoli, C et al (2015) Embedded DSP-based Telehealth Radar System for Remote In-Door Fall Detection[34]

Telehealth systems and applications are extensively investigated nowadays to enhance the quality-of-care and, in particular, to detect emergency situations and to monitor the well-being of elderly people, allowing them to stay at home independently as long as possible. In this paper, an embedded telehealth system for continuous, automatic, and remote monitoring of real-time fall emergencies is presented and discussed. The system, consisting of a radar sensor and base station, represents a cost-effective and efficient healthcare solution. The implementation of the fall detection data processing technique, based on the least-square support vector machines, through a digital signal processor and the management of the communication between radar sensor and base station are detailed. Experimental tests, for a total of 65 mimicked fall incidents, recorded with 16 human subjects (14 men and two women) that have been monitored for 320 min, have been used to validate the proposed system under real circumstances. The subjects' weight is between 55 and 90 kg with heights between 1.65 and 1.82 m, while their age is between 25 and 39 years. The experimental results have shown a sensitivity to detect the fall events in real

[34] Garripoli C, Mercuri M, Karsmakers P et al Embedded DSP-based telehealth radar system for remote in-door fall detection. *IEEE J Biomed Health Inform*. 2015;191.:92-101. doi:10.1109/JBHI.2014.2361252 [Accessed 11th May 2020]

time of 100% without reporting false positives. The tests have been performed in an area where the radar's operation was not limited by practical situations, namely, signal power, coverage of the antennas, and presence of obstacles between the subject and the antennas.

Rantz, M et al (2015) [Automated In-Home Fall Risk Assessment and Detection Sensor System for Elders](#)[35]

Purpose of the Study: Falls are a major problem for the elderly people leading to injury, disability, and even death. An unobtrusive, in-home sensor system that continuously monitors older adults for fall risk and detects falls could revolutionize fall prevention and care. Design and Methods: A fall risk and detection system was developed and installed in the apartments of 19 older adults at a senior living facility. The system includes pulse-Doppler radar, a Microsoft Kinect, and 2 web cameras. To collect data for comparison with sensor data and for algorithm development, stunt actors performed falls in participants' apartments each month for 2 years and participants completed fall risk assessments (FRAs) using clinically valid, standardized instruments. The FRAs were scored by clinicians and recorded by the sensing modalities. Participants' gait parameters were measured as they walked on a GAITRite mat. These data were used as ground truth, objective data to use in algorithm development and to compare with radar and Kinect generated variables. Results: All FRAs are highly correlated ($p < .01$) with the Kinect gait velocity and Kinect stride length. Radar velocity is correlated ($p < .05$) to all the FRAs and highly correlated ($p < .01$) to most. Real-time alerts of actual falls are being sent to clinicians providing faster responses to urgent situations. Implications: The in-home FRA and detection system has the potential to help older adults remain independent, maintain functional ability, and live at home longer.

Staranowicz, AN et al (2015) [Easy-to-use, General, and Accurate multi-Kinect Calibration and Its Application to Gait Monitoring for Fall Prediction](#)[36]

Falls are the most-common causes of unintentional injury and death in older adults. Many clinics, hospitals, and health-care providers are urgently seeking accurate, low-cost, and easy-to-use technology to predict falls

[35] Rantz M, Skubic M, Abbott C et al Automated In-Home Fall Risk Assessment and Detection Sensor System for Elders. *Gerontologist*. 2015;55 Suppl 1(Suppl 1):S78- S87. doi:10.1093/geront/gnv044 [Accessed 11th May 2020]

[36] Staranowicz AN, Ray C, Mariottini GL. Easy-to-use, general, and accurate multi-Kinect calibration and its application to gait monitoring for fall prediction. *Conf Proc IEEE Eng Med Biol Soc*. 2015;2015:4994- 4998. doi:10.1109/EMBC.2015.7319513 [Accessed 11th May 2020]

before they happen: eg by monitoring the human walking pattern, or gait. Despite the wide popularity of Microsoft's Kinect and the plethora of solutions for gait monitoring, no strategy has been proposed to date to allow non-expert users to calibrate the cameras, which is essential to accurately fuse the body motion observed by each camera in a single frame of reference. In this paper, we present a novel multi-Kinect calibration algorithm that has advanced features when compared to existing methods: 1. is easy to use; 2. it can be used in any generic Kinect arrangement; and 3. it provides accurate calibration. Extensive real-world experiments have been conducted to validate our algorithm and to compare its performance against other multi-Kinect calibration approaches, especially to show the improved estimate of gait parameters. Finally, a MATLAB Toolbox has been made publicly available for the entire research community.

CHAPTER 11
Telemedicine and Ischemic Heart Disease

Systematic Reviews

Hanlon, Peter et al (2017) [Systematic Review] Telehealth Interventions to Support Self-Management of Long-Term Conditions: A Systematic Metareview of Diabetes, Heart Failure, Asthma, Chronic Obstructive Pulmonary Disease, and Cancer[1]

Background: Self-management support is one mechanism by which telehealth interventions have been proposed to facilitate management of long-term conditions. Objective: The objectives of this meta-review were to 1. assess the impact of telehealth interventions to support self-management on disease control and health care utilization; and 2. identify components of telehealth support and their impact on disease control and the process of self-management. Our goal was to synthesise evidence for telehealth-supported self-management of diabetes, heart failure, asthma, chronic obstructive pulmonary disease (COPD) and cancer to identify components of effective self-management support. Methods: We performed a meta-review [a systematic review of systematic reviews] of randomized controlled trials of telehealth interventions to support self-management in 6 exemplar long-term conditions. We searched 7 databases for reviews published from January 2000 to May 2016 and screened identified studies against eligibility criteria. We weighted reviews by quality, size, and relevance. We then combined our results in a narrative synthesis and using harvest plots. Results: We included 53 systematic reviews, comprising 232 unique RCTs. Reviews concerned diabetes (type 1: n=6; type 2, n=11; mixed, n=19), heart failure (n=9), asthma (n=8), COPD (n=8), and cancer (n=3). Findings varied between and within disease areas. The highest-weighted reviews showed that blood glucose telemonitoring with feedback and some educational and lifestyle interventions improved glycemic control in type 2, but not type 1,

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diabetes, and that telemonitoring and telephone interventions reduced mortality and hospital admissions in heart failure, but these findings were not consistent in all reviews. Results for the other conditions were mixed, although no reviews showed evidence of harm. Analysis of the mediating role of self-management, and of components of successful interventions, was limited and inconclusive. More intensive and multifaceted interventions were associated with greater improvements in diabetes, heart failure, and asthma. Conclusions: While telehealth-mediated self-management was not consistently superior to usual care, none of the reviews reported any negative effects, suggesting that telehealth is a safe option for delivery of self-management support, particularly in conditions such as heart failure and type 2 diabetes, where the evidence base is more developed. Larger-scale trials of telehealth-supported self-management, based on explicit self-management theory, are needed before the extent to which telehealth technologies may be harnessed to support self-management can be established.

Vegesna, Ashok et al (2017) [Systematic Review] Remote Patient Monitoring via Non-Invasive Digital Technologies: A Systematic Review[2] Background: We conducted a systematic literature review to identify key trends associated with remote patient monitoring (RPM) via noninvasive digital technologies over the last decade. Materials and methods: A search was conducted in EMBASE and Ovid MEDLINE. Citations were screened for relevance against predefined selection criteria based on the PICOTS (Population, Intervention, Comparator, Outcomes, Timeframe, and Study Design) format. We included studies published between January 1, 2005 and September 15, 2015 that used RPM via noninvasive digital technology (smartphones/personal digital assistants [PDAs], wearables, biosensors, computerized systems, or multiple components of the formerly mentioned) in evaluating health outcomes compared to standard of care or another technology. Studies were quality appraised according to Critical Appraisal Skills Programme. Results: Of 347 articles identified, 62 met the selection criteria. Most studies were randomized control trials with older adult populations, small sample sizes, and limited follow-up. There was a trend toward multicomponent interventions (n = 26), followed by smartphones/PDAs (n = 12), wearables (n = 11), biosensor devices (n = 7), and

[2] Vegesna A, Tran M, Angelaccio M, Arcona S. Remote Patient Monitoring via Non-Invasive Digital Technologies: A Systematic Review. *Telemed J E Health*. 2017;231.:3–17. doi:10.1089/tmj.2016.0051

computerized systems (n = 6). Another key trend was the monitoring of chronic conditions, including respiratory (23%), weight management (17%), metabolic (18%), and cardiovascular diseases (16%). Although substantial diversity in health-related outcomes was noted, studies predominantly reported positive findings. Conclusions: This review will help decision makers develop a better understanding of the current landscape of peer-reviewed literature, demonstrating the utility of noninvasive RPM in various patient populations. Future research is needed to determine the effectiveness of RPM via noninvasive digital technologies in delivering patient healthcare benefits and the feasibility of large-scale implementation.

Conflict of interest statement: AV is a postdoctoral student from Jefferson College of Population Health and a US HEOR Fellow at Novartis Pharmaceuticals Corporation. MT is a postdoctoral student from Scott and White Health Plan, University of Texas at Austin and a US HEOR Fellow at Novartis Pharmaceuticals Corporation. SA and MA are employees of Novartis Pharmaceuticals Corporation. Novartis Pharmaceuticals Corporation provided funding for this work.

Randomised Controlled Trials

Hale, Timothy M et al (2019) [Randomised Controlled Trial] A Remote Medication Monitoring System for Chronic Heart Failure Patients to Reduce Readmissions: A Two-Arm Randomized Pilot Study[3]

Background: Heart failure (HF) is a chronic condition affecting nearly 5.7 million Americans and is a leading cause of morbidity and mortality. With an aging population, the cost associated with managing HF is expected to more than double from US $31 billion in 2012 to US $70 billion by 2030. Readmission rates for HF patients are high–25% are readmitted at 30 days and nearly 50% at 6 months. Low medication adherence contributes to poor HF management and higher readmission rates. Remote telehealth monitoring programs aimed at improved medication management and adherence may improve HF management and reduce readmissions. Objective: The primary goal of this randomized controlled pilot study is to compare the MedSentry remote medication monitoring system versus usual

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[3] Hale TM, Jethwani K, Kandola MS, Saldana F, Kvedar JC. A Remote Medication Monitoring System for Chronic Heart Failure Patients to Reduce Readmissions: A Two-Arm Randomized Pilot Study [published correction appears in J Med Internet Res. 2019 Feb 05;212.:e13125]. *J Med Internet Res*. 2016;185.:e91. Published 2016 Apr 17. doi:10.2196/jmir.5256
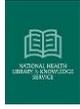
care in older HF adult patients who recently completed a HF telemonitoring program. We hypothesized that remote medication monitoring would be associated with fewer unplanned hospitalizations and emergency department (ED) visits, increased medication adherence, and improved health-related quality of life (HRQoL) compared to usual care. Methods: Participants were randomized to usual care or use of the remote medication monitoring system for 90 days. Twenty-nine participants were enrolled and the final analytic sample consisted of 25 participants. Participants completed questionnaires at enrollment and closeout to gather data on medication adherence, health status, and HRQoL. Electronic medical records were reviewed for data on baseline classification of heart function and the number of unplanned hospitalizations and ED visits during the study period. Results: Use of the medication monitoring system was associated with an 80% reduction in the risk of all-cause hospitalization and a significant decrease in the number of all-cause hospitalization length of stay in the intervention arm compared to usual care. Objective device data indicated high adherence rates (95%-99%) among intervention group participants despite finding no significant difference in self-reported adherence between study arms. The intervention group had poorer heart function and HRQoL at baseline, and HRQoL declined significantly in the intervention group compared to controls. Conclusions: The MedSentry medication monitoring system is a promising technology that merits continued development and evaluation. The MedSentry medication monitoring system may be useful both as a standalone system for patients with complex medication regimens or used to complement existing HF telemonitoring interventions. We found significant reductions in risk of all-cause hospitalization and the number of all-cause length of stay in the intervention group compared to controls. Although HRQoL deteriorated significantly in the intervention group, this may have been due to the poorer HF-functioning at baseline in the intervention group compared to controls. Telehealth medication adherence technologies, such as the MedSentry medication monitoring system, are a promising method to improve patient self-management, the quality of patient care, and reduce health care utilization and expenditure for patients with HF and other chronic diseases that require complex medication regimens. Trial registration: ClinicalTrials.gov NCT01814696

Roberts, Lisa M et al (2019) [Randomised Controlled Trial] Wearable Technology To Reduce Sedentary Behavior And CVD Risk In Older Adults: A Pilot Randomized Clinical Trial[4]

Background: Physical exercise is associated with decreased cardiovascular disease (CVD) risk, but recent large-scale trials suggest that exercise alone is insufficient to reduce CVD events in high-risk older adults. Purpose: This pilot randomized clinical trial aimed to collect critical data on feasibility, safety, and protocol integrity necessary to design a fully powered randomized controlled trial (RCT) and evaluate the impact of combining structured exercise with an intervention designed to enhance non-exercise physical activity (EX+NEPA) compared to EX alone. Methods: Forty participants aged ≥60 years with moderate-to-high risk of coronary heart disease events were randomly assigned to either the EX+NEPA or EX groups and followed for 20 weeks. Both groups underwent a twice-weekly, 8-week center-based exercise intervention with aerobic and resistance exercises. EX+NEPA group also received a wearable activity tracking device along with behavioral monitoring and feedback throughout the study. Study outcomes were evaluated at 8 and 20 weeks. Results: Data are presented as adjusted mean change of the differences over time with 95% confidence intervals at 20 weeks. Relative to EX, the change in steps/day at 20 weeks was 1994 (-40.27, 4028) higher for EX+NEPA. For sedentary time at close-out, the EX+NEPA group was -6.8 (-45.2, 31.6) min/day relative to EX. The between-group differences for systolic and diastolic blood pressure were -9.9 (-19.6, -0.3) and -1.8 (-6.9, 3.3) mmHg, respectively. Conclusion: The addition of wearable technology intervention appeared to positively influence daily activity patterns and changes in blood pressure - potentially improving risk factors for CVD. A fully powered randomized trial is needed to ultimately test this hypothesis.

[4] Roberts LM, Jaeger BC, Baptista LC et al Wearable Technology To Reduce Sedentary Behavior And CVD Risk In Older Adults: A Pilot Randomized Clinical Trial. *Clin Interv Aging*. 2019;14:1817-1828. Published 2019 Oct 23. doi:10.2147/CIA.S222655

Bravo-Escobar, Raquel et al (2018) [Randomised Controlled Trial]

Effectiveness and safety of a home-based cardiac rehabilitation programme of mixed surveillance in patients with ischemic heart disease at moderate cardiovascular risk: A randomised, controlled clinical trial[5]

Background: Previous studies have documented the feasibility of home-based cardiac rehabilitation programmes in low-risk patients with ischemic heart disease, but a similar solution needs to be found for patients at moderate cardiovascular risk. The objective of this study was to analyse the effectiveness and safety of a home-based cardiac rehabilitation programme of mixed surveillance in patients with ischemic cardiopathology at moderate cardiovascular risk. Methods: A randomised, controlled clinical trial was designed wherein 28 patients with stable coronary artery disease at moderate cardiovascular risk, who met the selection criteria for this study, participated. Of these, 14 were assigned to the group undergoing traditional cardiac rehabilitation in hospital [control group] and 14 were assigned to the home-based mixed surveillance programme [experimental group]. The patients in the experimental group went to the cardiac rehabilitation unit once a week and exercised at home, which was monitored with a remote electrocardiographic monitoring device (NUUBO®). The in-home exercises comprised of walking at 70% of heart rate reserve during the first month, and 80% during the second month, for 1 h per day at a frequency of 5 to 7 days per week. A two-way repeated measures analysis of variance (ANOVA) was performed to evaluate the effects of time (before and after intervention) and time-group interaction regarding exercise capacity, risk profile, cardiovascular complications, and quality of life. Results: No significant differences were observed between the traditional cardiac rehabilitation group and the home-based with mixed surveillance group for exercise time and METS achieved during the exertion test, and the recovery rate in the first minute (which increased in both groups after the intervention). The only difference between the two groups was for quality of life scores (10.93 [IC95%: 17.251, 3.334, p = 0.007] vs -4.314 [IC95%: -11.414, 2.787; p = 0.206]). No serious heart-related complications were recorded during the cardiac rehabilitation programme. Conclusions: The home-based cardiac rehabilitation programme with mixed surveillance appears to be as effective and safe as the traditional model in patients with ischemic heart disease

[5] Bravo-Escobar R, González-Represas A, Gómez-González AM et al Effectiveness and safety of a home-based cardiac rehabilitation programme of mixed surveillance in patients with ischemic heart disease at moderate cardiovascular risk: A randomised, controlled clinical trial. *BMC Cardiovasc Disord*. 2017;171.:66. Published 2017 Feb 20. doi:10.1186/s12872-017-0499-0

who are at moderate cardiovascular risk. However, the cardiac rehabilitation programmes carried out in hospital seems to have better results in improving the quality of life. Trial registration: Retrospectively registered NCT02796404 (May 23, 2016).

Vanezis, Andrew Peter et al (2018) [Randomised Controlled Trial] Daily remote ischaemic conditioning following acute myocardial infarction: a randomised controlled trial[6]
Background: Remote ischaemic conditioning (rIC) is a cardioprotective tool which has shown promise in preclinical and clinical trials in the context of acute ischaemia. Repeated rIC post myocardial infarction may provide additional benefits which have not previously been tested clinically. Methods: The trial assessed the role of daily rIC in enhancing left ventricular ejection fraction (LVEF) recovery in patients with impaired LVEF (<45%) after ST segment elevation myocardial infarction (STEMI) treated with primary percutaneous coronary intervention (P-PCI). Patients were recruited from four UK hospitals and randomised to receive either 4 weeks of daily rIC or sham conditioning using the autoRIC Device (CellAegis) starting on day 3 post P-PCI. The primary endpoint was the improvement in LVEF over 4 months assessed by cardiac MRI (CMR). Seventy-three patients (38 cases, 35 controls) completed the study. Results: The treatment and control groups were well matched at baseline including for mean LVEF (42.8% vs 44.3% respectively, p=0.952). There was no difference in the improvement in LVEF over 4 months between the treatment and control groups: 4.8%±7.8% vs 4.6%±5.9% respectively, p=0.924. No differences were seen in the secondary outcome measures including changes in infarct size and left ventricular end-diastolic and systolic volumes, major adverse cardiac and cerebral event, mean Kansas City Cardiomyopathy Questionnaire score and change in N-terminal pro-brain natriuretic peptide levels. Conclusions: Daily rIC starting on day 3 and continued for 4 weeks following successful P-PCI for STEMI did not improve LVEF as assessed by CMR after 4 months when compared with a matched control group. Trial registration: ClinicalTrials.gov NCT01664611

[6] Vanezis AP, Arnold JR, Rodrigo G et al Daily remote ischaemic conditioning following acute myocardial infarction: a randomised controlled trial. *Heart.* 2018;104(23):1955-1962. doi:10.1136/heartjnl-2018-313091

Varma, Niraj et al (2018) [Randomised Controlled Trial] Automatic remote monitoring utilizing daily transmissions: Transmission reliability and implantable cardioverter defibrillator battery longevity in the TRUST trial[7]

Aims: Benefits of automatic remote home monitoring (HM) among implantable cardioverter defibrillator (ICD) patients may require high transmission frequency. However, transmission reliability and effects on battery longevity remain uncertain. We hypothesized that HM would have high transmission success permitting punctual guideline based follow-up, and improve battery longevity. This was tested in the prospective randomized TRUST trial. Methods and Results: Implantable cardioverter defibrillator patients were randomized post-implant 2:1 to HM (n = 908) (transmit daily) or to conventional in-person monitoring [conventional management (CM), n = 431 (HM disabled)]. In both groups, five evaluations were scheduled every 3 months for 15 months. Home Monitoring technology performance was assessed by transmissions received vs. total possible, and number of scheduled HM checks failing because of missed transmissions. Battery longevity was compared in HM vs. CM at 15 months, and again in HM 3 years post-implant using continuously transmitted data. Transmission success per patient was 91% (median follow-up of 434 days). Overall, daily HM transmissions were received in 315 795 of a potential 363 450 days (87%). Only 55/3759 (1.46%) of unsuccessful scheduled evaluations in HM were attributed to transmission loss. Shock frequency and pacing percentage were similar in HM vs. CM. Fifteen month battery longevity was 12% greater in HM (93.2 ± 8.8% vs. 83.5 ± 6.0% CM, P < 0.001). In extended follow-up of HM patients, estimated battery longevity was 50.9 ± 9.1% (median 52%) at 36 months. Conclusion: Automatic remote HM demonstrated robust transmission reliability. Daily transmission load may be sustained without reducing battery longevity. Home Monitoring conserves battery longevity and tracks long term device performance. Clinical trial registration: ClinicalTrials.gov; NCT00336284.

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[7] Varma N, Love CJ, Schweikert R et al Automatic remote monitoring utilizing daily transmissions: transmission reliability and implantable cardioverter defibrillator battery longevity in the TRUST trial. *Europace.* 2018;204.:622- 628. doi:10.1093/europace/eux059

Walker, Paul P et al (2018) [Randomised Controlled Trial] Telemonitoring in chronic obstructive pulmonary disease (chromed) a randomized clinical trial[8]

Rationale: Early detection of chronic obstructive pulmonary disease (COPD) exacerbations using telemonitoring of physiological variables might reduce the frequency of hospitalization. Objectives: To evaluate the efficacy of home monitoring of lung mechanics by the forced oscillation technique and cardiac parameters in older patients with COPD and comorbidities. Methods: This multicenter, randomized clinical trial recruited 312 patients with Global Initiative for Chronic Obstructive Lung Disease grades II to IV COPD (median age, 71 yr [interquartile range, 66-76 yr]; 49.6% grade II, 50.4% grades III-IV), with a history of exacerbation in the previous year and at least one nonpulmonary comorbidity. Patients were randomized to usual care (n = 158) or telemonitoring (n = 154) and followed for 9 months. All telemonitoring patients self-assessed lung mechanics daily, and in a subgroup with congestive heart failure (n = 37) cardiac parameters were also monitored. An algorithm identified deterioration, triggering a telephone contact to determine appropriate interventions. Measurements and main results: Primary outcomes were time to first hospitalization (TTFH) and change in the EuroQoL EQ-5D utility index score. Secondary outcomes included: rate of antibiotic/corticosteroid prescription; hospitalization; the COPD Assessment Tool, Patient Health Questionnaire-9, and Minnesota Living with Heart Failure questionnaire scores; quality-adjusted life years; and healthcare costs. Telemonitoring did not affect TTFH, EQ-5D utility index score, antibiotic prescriptions, hospitalization rate, or questionnaire scores. In an exploratory analysis, telemedicine was associated with fewer repeat hospitalizations (-54%; P = 0.017). Conclusions: In older patients with COPD and comorbidities, remote monitoring of lung function by forced oscillation technique and cardiac parameters did not change TTFH and EQ-5D. Clinical trial registered with www.clinicaltrials.gov (NCT 01960907).

[8] Walker PP, Pompilio PP, Zanaboni P et al Telemonitoring in Chronic Obstructive Pulmonary Disease (CHROMED). A Randomized Clinical Trial. *Am J Respir Crit Care Med.* 2018;1985.:620-628. doi:10.1164/rccm.201712-2404OC

Miscellaneous

Fortunato, Michael et al (2020) [Usability of Wearable Devices to Remotely Monitor Sleep Patterns Among Patients With Ischemic Heart Disease: Observational Study][9]

Background: There is growing interest in using wearable devices to remotely monitor patient behaviors. However, there has been little evaluation of how often these technologies are used to monitor sleep patterns over longer term periods, particularly among more high-risk patients. Objective: The goal of the research was to evaluate the proportion of time that patients with ischemic heart disease used wearable devices to monitor their sleep and identify differences in characteristics of patients with higher versus lower use. Methods: We evaluated wearable device data from a previously conducted clinical trial testing the use of wearable devices with personalized goal-setting and financial incentives. Patients with ischemic heart disease established a sleep baseline and were then followed for 24 weeks. The proportion of days that sleep data was collected was compared over the 24 weeks and by study arm. Characteristics of patients were compared to groups with high, low, or no sleep data. Results: The sample comprised 99 patients with ischemic heart disease, among which 79% (78/99) used the wearable device to track their sleep. During the 6-month trial, sleep data were collected on 60% (10,024/16,632) of patient-days. These rates declined over time from 77% (4292/5544) in months 1 and 2 to 58% (3188/5544) in months 3 and 4 to 46% (2544/5544) in months 5 and 6. Sleep data were collected at higher rates among the intervention group compared with control (67% vs 55%, P<.001). In the main intervention period (months 3 and 4), patients with higher rates of sleep data were on average older (P=.03), had a history of smoking (P=.007), and had higher rates of commercial health insurance (P=.03). Conclusions: Among patients with ischemic heart disease in a physical activity trial, a high proportion used wearable devices to track their sleep; however, rates declined over time. Future research should consider larger evaluations coupled with behavioral interventions. Trial registration: https://clinicaltrials.gov/ct2/show/NCT02531022

[9] Fortunato M, Adusumalli S, Chokshi N, Harrison J, Rareshide C, Patel M. Usability of Wearable Devices to Remotely Monitor Sleep Patterns Among Patients With Ischemic Heart Disease: Observational Study. *JMIR Form Res*. 2020;44.:e14508. Published 2020 Apr 7. doi:10.2196/14508
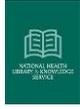
Conflicts of Interest: MP is supported by career development awards from the Department of Veterans Affairs Health Services Research and Development and the Doris Duke Charitable Foundation. MP is founder of Catalyst Health, a technology and behavior change consulting firm. MP also has received research funding from Deloitte, which is not related to the work described in this manuscript. The remaining authors declare no conflict of interest.

Delahaye, C et al (2019) Analysis of remote monitoring of patients with subcutaneous defibrillator[10]

Remote monitoring is associated with a high level of evidence in endovascular ICD recipients. Subcutaneous cardioverter are more and more used but there is no data about remote monitoring for these devices. The aim of this study is to provide a qualitative and quantitative analysis of transmissions received by remote monitoring follow-up on a cohort of patients with subcutaneous ICD versus a control cohort of patients with endovascular ICD, and to evaluate the clinical relevance of these transmissions. Method: From September 2015 to January 2017, we prospectively and consecutively enrolled all patients undergoing a subcutaneous or endovascular ICD implantation. All transmissions from remote follow-up and reactions to these transmissions were collected. The relevance of alerts was evaluated by a ratio: number of alerts per patient/number of alerts leading to a reaction or intervention. Results: A total of 146 patients were included: 69 in the subcutaneous DAI group (44,6 ± 15.6 years old; 25% ischemic cardiopathy), 77 in the endovascular ICD group (64,8 ± 13.9 years old; 77% ischemic cardiopathy) with a mean follow-up of 493 ± 129.6 days. A total of 2393 transmissions were collected including 988 in the endovascular group (41%) and 1405 in the S-ICD group (59%). Twenty-nine internal electrical shocks were collected: 10 in the intravenous ICD cohort and 9 in the subcutaneous ICD patients. The clinical relevance of these transmissions was lower in the subcutaneous group with only 2% of transmissions leading to a medical intervention compared to 14% in the endovascular group (P < 10−3). The ratio: total alert per patient/relevant alert per patient was 3.2% ± 1.1 in the subcutaneous DAI group and 16% ± 4.7 in the endovascular group (P = 0.0391). Conclusion: Remote monitoring of patients

[10] Delahaye, C et al Analysis of remote monitoring of patients with subcutaneous defibrillator. *Archives of Cardiovascular Diseases Supplements*. 2019;111.:86. https://doi.org/10.1016/j.acvdsp.2018.10.189
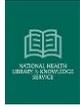
with subcutaneous ICD is associated with a higher burden of transmissions with a lower clinical impact compared to patients with endovascular ICDs.

Health Quality Ontario. (2019) [**Remote Monitoring of Implantable Cardioverter-Defibrillators, Cardiac Resynchronization Therapy and Permanent Pacemakers: A Health Technology Assessment**](#)[11]
Background: Under usual care, people with an implantable cardioverter-defibrillator (ICD), cardiac resynchronization therapy with or without a defibrillator (CRT-D and CRT-P, respectively), or a permanent pacemaker have follow-up in-person clinic visits. Remote monitoring of these devices allows the transfer of the information stored in the device so that it can be accessed by the clinic personnel via a secured website. Methods: We completed a health technology assessment, which included an evaluation of clinical benefits and harms, value for money, and patient preferences for remote monitoring of ICDs, CRTs, and permanent pacemakers plus clinic visits compared with clinic visits alone. This is an update of a 2012 health technology assessment. In addition to the eligible randomized controlled trials (RCTs) from the 2012 publication, we included RCTs identified through a systematic literature search on June 1, 2017. We assessed the risk of bias of each study using the Cochrane risk of bias tool and the quality of the body of evidence according to the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Working Group criteria. We conducted an economic evaluation to determine the cost-effectiveness of remote monitoring blended with in-clinic follow-up compared to in-clinic follow-up alone in patients with an ICD, a CRT-D, or a pacemaker. We determined the budget impact of blended remote monitoring in patients implanted with ICD, CRT-D, CRT-P, or pacemaker devices from the perspective of the Ontario Ministry of Health and Long-Term Care. To understand patient experiences with remote monitoring, we interviewed 16 patients and family members. Results: Based on 15 RCTs in patients with implanted ICDs or CRT-Ds, remote monitoring plus clinic visits resulted in fewer patients with inappropriate ICD shocks within 12 to 37 months of follow-up (moderate quality evidence; absolute risk difference -0.04 (95% confidence interval -0.07 to -0.01)), fewer total clinic visits (moderate quality evidence), and a shorter time to detection and treatment of events (moderate quality evidence) compared with clinic visits alone. There was a similar risk of major adverse events

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[11] Health Quality Ontario . Remote Monitoring of Implantable Cardioverter-Defibrillators, Cardiac Resynchronization Therapy and Permanent Pacemakers: A Health Technology Assessment. *Ont Health Technol Assess Ser*. 2018;187.:1- 199. Published 2018 Oct 24.

(moderate quality evidence). Based on 6 RCTs in patients with pacemakers, remote monitoring plus clinic visits reduced the arrhythmia burden (high quality evidence), the time to detection and treatment of arrhythmias (high quality evidence), and the number of clinic visits (moderate quality evidence) compared with clinic visits alone. Here again, there was a similar risk of major adverse events (high quality evidence). Results from the economic evaluation showed that among ICD and CRT-D recipients, blended remote monitoring [remote monitoring plus in-clinic follow ups] was more costly [incremental value of $4,354 per person] and more effective, providing higher quality-adjusted life years [incremental value of 0.19], compared to in-clinic follow-up alone. Among pacemaker recipients, blended remote monitoring was less costly [with an incremental saving of $2,370 per person] and more effective [with an incremental value of 0.12 quality-adjusted life years] than with in-clinic follow-up alone. We estimated that publicly funding remote monitoring could result in cost savings of $14 million over the first five years. Participants using remote monitoring reported that these devices provide important medical and safety benefits in managing their heart condition. Remote cardiac monitoring provides patients and their family members with an increased freedom. Their belief that the device will help with earlier detection of technical or clinical problems reduces the amount of stress and distraction their condition causes in their lives. Conclusions: Remote monitoring of ICDs, CRT-Ds, and pacemakers plus clinic visits resulted in improved outcomes without increasing the risk of major adverse events compared with clinic visits alone. Remote monitoring is a cost-effective option for patients implanted with cardiac electronic devices. Patients reported positive experiences using remote monitoring, and perceived that the device provided important medical and safety benefits.

Ruiz-Perez, Isabel et al (2019) **Effectiveness of interventions to improve cardiovascular healthcare in rural areas: a systematic literature review of clinical trials**[12]
The objective of this systematic literature review is to examine the impact of interventions to improve cardiovascular disease healthcare provided to people living in rural areas. Systematic electronic searches were conducted in Medline, CINAHL, Embase, Scopus, and Web of Knowledge in July 2018. We included clinical trials assessing the effectiveness of interventions to

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[12] Ruiz-Pérez I, Bastos Á, Serrano-Ripoll MJ, Ricci-Cabello I. Effectiveness of interventions to improve cardiovascular healthcare in rural areas: a systematic literature review of clinical trials. *Prev Med.* 2019;119:132-144. doi:10.1016/j.ypmed.2018.12.012

improve cardiovascular disease healthcare in rural areas. Study eligibility assessment, data extraction, and critical appraisal were undertaken by two reviewers independently. We identified 18 trials (18 interventions). They targeted myocardial infarction (5 interventions), stroke 8., and heart failure 5.. All the interventions for myocardial infarction were based on organizational changes: eg implementation of mobile coronary units. They consistently reduced time to treatment and decreased mortality. All the interventions for heart failure were based on the provision of patient education. They consistently improved patient knowledge and self-care behaviour, but mortality reductions were reported in only some of the trials. Among the interventions for stroke, those based on the implementation of telemedicine (tele-stroke systems or tele-consultations) improved monitoring of stroke survivors; those based on new or enhanced rehabilitation services did not consistently improve mortality or physical function; whereas educational interventions effectively improved patient knowledge and behavioural outcomes. In conclusion, a number of different strategies based on enhancing structures and providing patient education have been proposed to improve cardiovascular disease healthcare in rural areas. Although available evidence show that these interventions can improve healthcare processes, their impact on mortality and other important health outcomes still remains to be established.

Shufelt, Chrisandra et al (2019) [A protocol integrating remote patient monitoring patient reported outcomes and cardiovascular biomarkers](#)[13]
We describe the protocol, design, and methodology of the Prediction, Risk, and Evaluation of Major Adverse Cardiac Events (PRE-MACE) study as a multicomponent remote patient monitoring in cardiology. Using biosensor, biomarkers, and patient-reported outcomes in participants with stable ischemic heart disease, the PRE-MACE study is designed to measure cross-sectional correlations and establish the ability of remote monitoring to predict major adverse cardiovascular event (MACE) biomarkers and incident MACE at baseline and 12-month follow-up. It will further assess the adherence and cost-effectiveness of remote monitoring and blood sampling over the initial months. Despite medication and lifestyle changes, patients with cardiovascular disease can experience MACE due to undertreatment, poor adherence, or failure to recognize clinical or biochemical changes that presage MACE. Identifying patients using remote monitoring to detect MACE

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[13] Shufelt C, Dzubur E, Joung S et al A protocol integrating remote patient monitoring patient reported outcomes and cardiovascular biomarkers. *NPJ Digit Med*. 2019;2:84. Published 2019 Sep 3. doi:10.1038/s41746-019-0145-6

forerunners has potential to improve outcomes, avoid MACE, and reduce resource utilization. Data collection will include: 1. continuous remote monitoring using wearable biosensors; 2. biomarker measurements using plasma and at-home micro-sampling blood collection; and 3. patient-reported outcomes to monitor perceived stress, anxiety, depression, and health-related quality of life. Two hundred participants will be followed for 90 days with a subset (n = 80) monitored for 180 days. All participants will be followed up for MACE at 12 months. The PRE-MACE study will utilize remote monitoring with biosensors, biomarkers, and patient-reported outcomes to identify intermediate biomarkers of MACE in patients with stable ischemic heart disease. If shown to be effective, this intervention can be utilized between health visits to predict MACE and reduce financial impact of MACE.

Castrillon, Reinel et al (2018) [**Electrical Performance of PEDOT:PSS-based Textile Electrodes for Wearable ECG Monitoring: A Comparative Study**](#)[14]
Background: Wearable textile electrodes for the detection of biopotentials are a promising tool for the monitoring and early diagnosis of chronic diseases. We present a comparative study of the electrical characteristics of four textile electrodes manufactured from common fabrics treated with a conductive polymer, a commercial fabric, and disposable Ag/AgCl electrodes. These characteristics will allow identifying the performance of the materials when used as ECG electrodes. The electrodes were subjected to different electrical tests, and complemented with conductivity calculations and microscopic images to determine their feasibility in the detection of ECG signals. Methods: We evaluated four electrical characteristics: contact impedance, electrode polarization, noise, and long-term performance. We analyzed PEDOT:PSS treated fabrics based on cotton, cotton-polyester, lycra and polyester; also a commercial fabric made of silver-plated nylon Shielde® Med-Tex P130, and commercial Ag/AgCl electrodes. We calculated conductivity from the surface resistance and, analyzed their surface at a microscopic level. Rwizard was used in the statistical analysis. Results: The results showed that textile electrodes treated with PEDOT:PSS are suitable for the detection of ECG signals. The error detecting features of the ECG signal was lower than 2% and the electrodes kept working properly after 36 h of continuous use. Even though the contact impedance and the polarization level in textile electrodes were greater than in commercial electrodes, these parameters did not affect the acquisition of the ECG

[14] Castrillón R, Pérez JJ, Andrade-Caicedo H. Electrical performance of PEDOT:PSS-based textile electrodes for wearable ECG monitoring: a comparative study. *Biomed Eng Online*. 2018;171.:38. Published 2018 Apr 2. doi:10.1186/s12938-018-0469-5

signals. Fabrics conductivity calculations were consistent to the contact impedance.

Pignatelli, Niccolo et al (2018) [Low-Cost Mobile Device for Screening of Atherosclerosis and Coronary Arterial Disease](15)[15]

In the context of global health, telemedicine, and low-resource settings, we present a non-invasive smart-phone based device that can be used to screen for atherosclerosis, which is the leading factor for ischemic heart attacks and strokes. Using a custom Android mobile application, our device computes Pulse Wave Velocity (PWV) using the pulse signals from photo-plethysmographic probes, which are simultaneously clipped onto the ear, index finger, and big toe of a human subject. As distinct from other designs which require the use of an ECG reference, our mobile device uses only photo-plethysmographic signals and is entirely powered by the mobile phone via the USB port. Using the ear signal as a reference, we derived PWV values from two locations: the right index finger, and the right big toe. We present data from a recent clinical study with 78 participants (age 26 to 74) who were divided into three groups: Coronary Arterial Disease (CAD), hypertensive group (PreCAD), and Healthy controls. The CAD group was clinically diagnosed and confirmed with a CT-scan and calcium scoring. PWV values derived from the finger was found to have too much variance to be clinically useful. However, PWV values derived from the toe location showed significant differences between the groups, even after accounting for age. Measured PWV values were: 10.07 (8.51-12.01) for the older CAD group, 9.39 (7.44-9.75) for the younger CAD group, 8.26 (7.26-9.22) for the older Pre-CAD group, 10.57 m/s (8.5-11.2) for the younger Pre-CAD group, 7.13 m/s (5.97-7.69) for older healthy controls, and 6.71 m/s (4.86-7.26) for the younger healthy control subjects. These results demonstrate good potential value of this mobile PWV device as a simple low-cost screening tool for atherosclerosis and coronary arterial disease.

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[15] Pignatelli N, Ma B, Sengputa S, Sengupta P, Mungulmare K, Fletcher RR. Low-Cost Mobile Device for Screening of Atherosclerosis and Coronary Arterial Disease. *Conf Proc IEEE Eng Med Biol Soc.* 2018;2018:5325-5328. doi:10.1109/EMBC.2018.8513612

Speier, William et al (2018) Evaluating utility and compliance in a patient-based eHealth study using continuous-time heart rate and activity trackers[16]

Telemedicine has been used to remotely diagnose and treat patients, yet previously applied telemonitoring approaches have been fraught with adherence issues. The primary goal of this study was to evaluate the adherence rates using a consumer-grade continuous-time heart rate and activity tracker in a mid-risk cardiovascular patient population. As a secondary analysis, we show the ability to utilize the information provided by this device to identify information about a patient's state by correlating tracker information with patient-reported outcome survey scores. We showed that using continuous-time activity trackers with heart rate monitors can be effective in a telemonitoring application, as patients had a high level of adherence (90.0% median usage) and low attrition (0.09% decrease per day) over a 90-day period. Furthermore, data collected correlated significantly with clinically relevant patient surveys (r2=0.15 for PROMIS global health scores, p < .00001), and therefore might provide an effective signal for identifying patients in need of intervention.

Zhang, Haoshi et al (2017) A wearable 12-lead ECG acquisition system with fabric electrodes[17]

Continuous electrocardiogram (ECG) monitoring is significant for prevention of heart disease and is becoming an important part of personal and family health care. In most of the existing wearable solutions, conventional metal sensors and corresponding chips are simply integrated into clothes and usually could only collect few leads of ECG signals that could not provide enough information for diagnosis of cardiac diseases such as arrhythmia and myocardial ischemia. In this study, a wearable 12-lead ECG acquisition system with fabric electrodes was developed and could simultaneously process 12 leads of ECG signals. By integrating the fabric electrodes into a T-shirt, the wearable system would provide a comfortable and convenient user interface for ECG recording. For comparison, the proposed fabric electrode and the gelled traditional metal electrodes were used to collect ECG signals on a subject, respectively. The approximate entropy (ApEn) of ECG signals from both types of electrodes were calculated. The experimental results

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[16] Speier W, Dzubur E, Zide M et al Evaluating utility and compliance in a patient-based eHealth study using continuous-time heart rate and activity trackers. *J Am Med Inform Assoc*. 2018;25(10):1386-1391. doi:10.1093/jamia/ocy067

[17] Haoshi Zhang, Lan Tian, Huiyang Lu et al A wearable 12-lead ECG acquisition system with fabric electrodes. *Conf Proc IEEE Eng Med Biol Soc*. 2017;2017:4439-4442. doi:10.1109/EMBC.2017.8037841

show that the fabric electrodes could achieve similar performance as the gelled metal electrodes. This preliminary work has demonstrated that the developed ECG system with fabric electrodes could be utilized for wearable health management and telemedicine applications.

Brunetti, Natale Daniele et al (2016) [Innovations in telemedicine for cardiovascular care](18)

Cardiovascular disease is one of the main fields of application for telemedicine. The greatest impact has been shown in early diagnosis, in second consultation, between non-cardiologist and cardiologist and between cardiologists, and in follow-up and secondary prevention of cardiovascular disease. At present, the main area of implementation for telemedicine in cardiovascular disease is represented by pre-hospital triage, with telemedicine electrocardiogram in acute myocardial infarction. Significant results have also been achieved in the second opinion consultation of pediatric subjects with congenital cardiovascular disease, home-monitoring and the management of patients affected by chronic heart failure or with an implanted device.

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[18] Brunetti ND, Scalvini S, Molinari G. Innovations in telemedicine for cardiovascular care. *Expert Rev Cardiovasc Ther*. 2016;143.:267– 280. doi:10.1586/14779072.2016.1140572

CHAPTER 12
Telemedicine and Motor Neurone Disease

Systematic Reviews

Helleman, J et al (2019) [Systematic Review] The Current Use of Telehealth in ALS Care and the Barriers to and Facilitators of Implementation: A Systematic Review[1]

Objective: We aimed to provide an overview of telehealth used in the care for patients with amyotrophic lateral sclerosis (ALS), and identify the barriers to and facilitators of its implementation. Methods: We searched Pubmed and Embase to identify relevant articles. Full-text articles with original research reporting on the use of telehealth in ALS care, were included. Data were synthesized using the Consolidation Framework for Implementation Research. Two authors independently screened articles based on the inclusion criteria. Results: Sixteen articles were included that investigated three types of telehealth: Videoconferencing, home-based self-monitoring and remote NIV monitoring. Telehealth was mainly used by patients with respiratory impairment and focused on monitoring respiratory function. Facilitators for telehealth implementation were a positive attitude of patients (and caregivers) toward telehealth and the provision of training and ongoing support. Healthcare professionals were more likely to have a negative attitude toward telehealth, due to the lack of personal evaluation/contact and technical issues; this was a known barrier. Other important barriers to telehealth were lack of reimbursement and cost-effectiveness analyses. Barriers and facilitators identified in this review correspond to known determinants found in other healthcare settings. Conclusions: Our findings show that telehealth in ALS care is well-received by patients and their caregivers. Healthcare professionals, however, show mixed experiences and perceive barriers to telehealth use. Challenges related to finance and legislation may hinder telehealth

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implementation in ALS care. Future research should report the barriers and facilitators of implementation and determine the cost-effectiveness of telehealth.

Hobson, EV et al (2016) [Systematic Review] Using Technology to Improve Access to Specialist Care in Amyotrophic Lateral Sclerosis: A Systematic Review[2]

Our objective was to review the evidence for using technology to improve access to specialist care for patients with amyotrophic lateral sclerosis (ALS) and their carers. Medline, Google Scholar and the Cochrane library were searched for articles describing technology that enabled clinical care of patients with ALS or their carers where the patient/carer and clinician were not in the same location. Two applications were identified: telemedicine to facilitate video conferencing as an alternative to outpatient consultations and telehealth monitoring for patients with respiratory failure. One randomized controlled trial using telehealth in patients with respiratory failure including 22 patients with ALS was identified. While rates of hospitalization were reduced, overall mortality was unchanged and there were too few patients with ALS in the study to detect significant benefit. In conclusion, there is limited evidence to support the use of telemedicine or telehealth in the care of patients with ALS. Future research needs to develop an understanding of the key beneficial aspects of the traditional specialist ALS service and how these factors could be delivered using technology. Successful evaluation and implementation of technologies to facilitate access to specialist care will only be possible if all the relevant impacts of an intervention are understood and measured.

Miscellaneous

Haulman, A et al (2020) [Review] The Use of Telehealth to Enhance Care in ALS and Other Neuromuscular Disorders[3]

Telehealth has the potential to improve the efficiency of healthcare while reducing the burden on patients and caregivers. Encounters can be

[2] Hobson EV, Baird WO, Cooper CL, Mawson S, Shaw PJ, Mcdermott CJ. Using technology to improve access to specialist care in amyotrophic lateral sclerosis: A systematic review. *Amyotroph Lateral Scler Frontotemporal Degener*. 2016;17(5-6):313–324. doi:10.3109/21678421.2016.1165255

[3] Haulman A, Geronimo A, Chahwala A, Simmons Z. The Use of Telehealth to Enhance Care in ALS and other Neuromuscular Disorders [published online ahead of print, 2020 Apr 16]. *Muscle Nerve*. 2020;10.1002/mus.26838. doi:10.1002/mus.26838

synchronous or asynchronous. When used for care of those with amyotrophic lateral sclerosis (ALS) by individual health care providers or by a multidisciplinary team, synchronous telehealth is feasible, acceptable, may produce outcomes comparable to those of in-person care, and is cost effective. Individuals with ALS who use telehealth tend to have lower physical and respiratory function and to live farther from an ALS clinic than those who exclusively attend in-person clinic visits. Asynchronous telehealth can be used as a substitute full multidisciplinary visits, or for remote monitoring of pulmonary function, gait/falls, and speech. Barriers to implementing telehealth on a wider scale include disparities in access to technology and challenges surrounding medical licensure and billing, but these are being addressed.

Helleman, J et al (2020) Telehealth as Part of Specialized ALS Care: Feasibility and User Experiences With "ALS Home-Monitoring and Coaching"[4]
Objective: To evaluate the use of telehealth as part of specialized care for patients with amyotrophic lateral sclerosis (ALS) and the user experiences of patients and healthcare professionals. Methods: Fifty patients with ALS were recruited from a single specialist center and used telehealth, consisting of an ALS-app for self-monitoring and messaging, alerts for symptom-worsening, and nurse practitioner follow-up. Patients self-monitored their well-being, body weight and functional status. The use of the telehealth service was evaluated through adoption rate, dropout rate and adherence to self-monitoring. User-experiences were collected through online surveys among 23 patients and nine healthcare professionals, and interviews with 12 patients. Results: The adoption rate was 80%, dropout rate 4% and median follow-up was 11 months. Good adherence was seen in 49% of patients for well-being, 83% for body weight and 87% for functional assessment. For patients who discontinued using telehealth due to the end-of-life phase, median time between last measurement and death was 19 days. The majority of patients experienced using telehealth as easy, helpful, not burdensome, and reported satisfaction with flexible clinic visits and the continuity of care. Healthcare professionals reported that telehealth was of added value in ALS-care. Conclusions: ALS-care supplemented by home-monitoring and nurse practitioner follow-up was shown to be suitable and

[4]Helleman J, Van Eenennaam R, Kruitwagen ET et al Telehealth as part of specialized ALS care: feasibility and user experiences with "ALS home-monitoring and coaching" [published online ahead of print, 2020 Jan 31]. *Amyotroph Lateral Scler Frontotemporal Degener.* 2020;1-10. doi:10.1080/21678421.2020.1718712

widely accepted by patients and healthcare professionals in our ALS clinic. Success factors were low self-monitoring burden, a user-friendly platform and the provision of personalized feedback. Further research is needed to replicate these findings in other ALS clinics.

Ando, H et al (2019) [Experience of Telehealth in People With Motor Neurone Disease Using Noninvasive Ventilation](5)

Introduction: Evidence is emerging that telehealth provides timely and cost-effective support for individuals with motor neurone disease (MND). However, little is known about the subjective experience of using telehealth. This study was designed to examine the experiences of using telemonitoring in patients with MND on noninvasive ventilation (NIV). Methods: Semi-structured interviews were conducted with seven patients [five males; mean age = 63 yrs; median illness duration = 14 m], who used a telemonitoring device for 24 weeks. Caregivers were present at five of the interviews; they supported communications and provided their feedback. Interviews were audio recorded and transcribed verbatim. Thematic analysis was conducted to find overarching themes. Results: Five themes were identified: Benefits of Timely Intervention, Reducing the Unnecessary, Increased Self-Awareness, Taking Initiative, and Technical Challenges. Overall, timely interventions were observed as a result of regular monitoring, contributing to both physical and psychological well-being of the participants. The patient-caregiver dyads suggested that telemonitoring could reduce costs, save time and ameliorate hassles associated with attending hospital appointments. Participants articulated that telemonitoring enabled symptom awareness and interpretation; the device also enabled the participants to raise concerns and/or requests to the healthcare professionals via the messaging system. Participants confirmed that the telemonitoring device was easy to use, despite some technical issues. Conclusions: Telemonitoring was positively experienced. The findings suggest this approach is empowering and effective in promoting patients' well-being, while potentially reducing unnecessary clinical contact. Implications for Rehabilitation Care for people with MND demands a flexible approach to accommodate the diversity of clinical needs and relentless physical deterioration. Telehealth allows clinicians to provide person-centred care for everyone with MND through frequent monitoring. Holistic and rehabilitative service facilitated by

5 Ando H, Ashcroft-Kelso H, Halhead R et al Experience of telehealth in people with motor neurone disease using noninvasive ventilation [published online ahead of print, 2019 Sep 12]. *Disabil Rehabil Assist Technol.* 2019;1- 7. doi:10.1080/17483107.2019.1659864

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telehealth is generally acceptable and preferred to routine appointments among MND NIV patients. Telehealth promotes time efficient engagement with professionals that leads to symptom awareness and interpretation, while benefiting physical and psychological well-being of MND NIV patients

Ando, H et al (2019) [Incorporating Self-Reported Questions for Telemonitoring to Optimize Care of Patients With MND on Noninvasive Ventilation (MND OptNIVent)](#)[6]

Objective: Previous studies suggest a positive impact of telehealth in the care of people with motor neuron disease/amyotrophic lateral sclerosis (MND/ALS). This study reports the development of self-reported questions for telemonitoring, using a tablet-based device Careportal®, in the care of patients with MND on noninvasive ventilation (NIV) and its initial impact. Methods: The study consisted of a question development phase and an evaluation phase of the use of Careportal®. The development phase employed a modified Delphi process. The evaluation phase involved a 24-week pilot study with 13 patients [median age = 66; median illness duration = 14 m], who were using NIV. The participants completed overnight oximetry and self-report questions via Careportal® each week, generating interventions where required. Patient-ventilator interaction (PVI) data were monitored and the revised ALS functional rating scale (ALSFRS-R) was completed. Results: Telemonitoring encompassing the newly developed 26-item symptom questions showed good feasibility and validity. During the evaluation phase, 61 interventions were made for 10 patients, including seven patients who had routine clinic appointments during the trial to optimize care. ALSFRS-R showed significant illness deteriorations. Blood oxygen saturation (SpO2) levels were maintained, time ventilated and inspiratory pressures increased during the trial. Conclusions: The MND OptNIVent question set together with weekly ventilator and oximetry monitoring facilitated the maintenance of ventilation and SpO2 levels despite illness progression. The use of the question set, and devices, such as Careportal®, facilitate care and may further enable a single point of contact for patients from which clinicians may offer proactive interventions to optimize care.

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[6] Ando H, Ashcroft-Kelso H, Halhead R et al Incorporating self-reported questions for telemonitoring to optimize care of patients with MND on noninvasive ventilation (MND OptNIVent). *Amyotroph Lateral Scler Frontotemporal Degener.* 2019;20(5-6):336– 347. doi:10.1080/21678421.2019.1587630

Geronimo, A, Simmons, Z (2019) Evaluation of Remote Pulmonary Function Testing in Motor Neuron Disease[7]
Introduction: Motor neuron disease (MND) causes respiratory insufficiency, which is managed in part through use of noninvasive ventilation (NIV). Guidelines for the initiation of NIV are based on pulmonary function tests (PFTs), usually performed once every three months. In the setting of MND telemedicine, remote monitoring of respiratory health may permit earlier intervention, but proof of equivalence to conventional PFTs is lacking. Methods: We implemented delivery of remote PFTs (rPFTs), based on our institution's telemedicine platform, with the goals of validating measurement equivalence to conventional forced vital capacity (FVC) and maximal inspiratory pressure (MIP) assessments, and assessing process acceptability from both patients and therapists. Results: When remotely guided by a respiratory therapist, 40 patient/caregiver teams produced respiratory parameters that were tightly correlated with those acquired through the standard evaluation. Both patients and therapists generally rated the setup and use of the devices positively, with patient ratings higher than those of the therapists. Discussion: This study suggests that rPFTs are accurate and acceptable, and thus may be incorporated into MND telemedicine for clinical and research use.

Hobson, EV et al (2019) The TiM System: Developing a Novel Telehealth Service to Improve Access to Specialist Care in Motor Neurone Disease Using User-Centered Design[8]
Objectives: Attendance at a specialist multidisciplinary motor neurone disease (MND) clinic is associated with improved survival and may also improve quality of life and reduce hospital admissions. However, patients struggle to travel to clinic and may experience difficulties between clinic visits that may not be addressed in a timely manner. We wanted to explore how we could improve access to specialist MND care.
Methods: We adopted an iterative, user-centered co-design approach, collaborating with those with experience of providing and receiving MND care including patients, carers, clinicians, and technology developers. We explored the unmet needs of those living with MND, how they might be met

[7] Geronimo A, Simmons Z. Evaluation of remote pulmonary function testing in motor neuron disease. *Amyotroph Lateral Scler Frontotemporal Degener.* 2019;20(5–6):348–355. doi:10.1080/21678421.2019.1587633
[8] Hobson EV, Baird WO, Partridge R et al The TiM system: developing a novel telehealth service to improve access to specialist care in motor neurone disease using user-centered design. *Amyotroph Lateral Scler Frontotemporal Degener.* 2018;19(5–6):351–361. doi:10.1080/21678421.2018.1440408

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through service redesign and through the use of digital technologies. We developed a new digital solution and performed initial testing with potential users including clinicians, patients, and carers.

Results: We used these findings to develop a telehealth system (TiM) using an Android app into which patients and carers answer a series of questions about their condition on a weekly basis. The questions aim to capture all the physical, emotional, and social difficulties associated with MND. This information is immediately uploaded to the Internet for review by the MND team. The data undergoes analysis in order to alert clinicians to any changes in a patient or carer's condition.

Conclusions: We describe the benefits of developing a novel digitally enabled service underpinned by participatory design. Future trials must evaluate the feasibility and acceptability of the TiM system within a clinical environment.

Hobson, EV et al (2019) [Mixed-Methods Pilot and Feasibilty Study] Using Telehealth in Motor Neuron Disease to Increase Access to Specialist Multidisciplinary Care: A UK-based Pilot and Feasibility Study[9]

Objectives: Care of patients with motor neuron disease (MND) in a specialist, multidisciplinary clinic is associated with improved survival, but access is not universal. We wanted to pilot and establish the feasibility of a definitive trial of a novel telehealth system (Telehealth in Motor neuron disease, TiM) in patients with MND.

Design: An 18-month, single-centre, mixed-methods, randomised, controlled pilot and feasibility study.

Intervention: TiM telehealth plus usual care versus usual care.

Setting: A specialist MND care centre in the UK.

Participants: Patients with MND and their primary informal carers.

Primary and Secondary Outcome Measures: Recruitment, retention and data collection rates, clinical outcomes including participant quality of life and anxiety and depression.

Results: Recruitment achieved the target of 40 patients and 37 carers. Participant characteristics reflected those attending the specialist clinic and included those with severe disability and those with limited experience of technology. Retention and data collection was good. Eighty per cent of patients and 82% of carer participants reported outcome measures were completed at 6 months. Using a longitudinal analysis with repeated

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[9] Hobson EV, Baird WO, Bradburn M et al Using telehealth in motor neuron disease to increase access to specialist multidisciplinary care: a UK-based pilot and feasibility study. *BMJ Open*. 2019;9(10):e028525. Published 2019 Oct 22. doi:10.1136/bmjopen-2018-028525

measures of quality of life (QoL), a sample size of 131 per arm is recommended in a definitive trial. The methods and intervention were acceptable to participants who were highly motivated to participate to research. The low burden of participation and accessibility of the intervention meant barriers to participation were minimal. However, the study highlighted difficulties assessing the associated costs of the intervention, the challenge of recruitment in such a rare disease and the difficulties of producing rigorous evidence of impact in such a complex intervention.

Conclusion: A definitive trial of TiM is feasible but challenging. The complexity of the intervention and heterogeneity of the patient population means that a randomised controlled trial may not be the best way to evaluate the further development and implementation of the TiM.

Murray, D et al (2019) [Conference Abstract] A survey of healthcare professionals on the measurement of physical functioning in amyotrophic lateral sclerosis (ALS)/motor neurone disease (MND) and attitudes to development of technology based measurement and monitoring solutions[10]

Background: Specialised multidisciplinary clinics are recommended for people with ALS/MND, however, disadvantages including burden of travel have been identified. Innovative service models utilising telemedicine have been reported 1., but with limitations in patient assessment. Novel assessment methods are required to maximize tele-medicine service delivery and priorities for clinically meaningful assessment need identification. Furthermore, the attitudes of healthcare professionals to developments in telemedicine for ALS/MND care requires investigation. Objectives: The aim of the project was to survey healthcare professionals regarding: 1. the use of and attitudes towards current outcome measurement tools; 2. their attitudes towards technology based measurement tools, remote monitoring and telemedicine. Methods: An online survey for healthcare professionals was designed. Demographics and service descriptors were sought. Information was collected regarding physical functioning assessment methods used and the attitudes of the respondents to these tools. The perspectives of respondents regarding the

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[10] Murray, D., Meldrum, D., Hayden, C., Hardiman, O. A survey of healthcare professionals on the measurement of physical functioning in amyotrophic lateral sclerosis (ALS)/motor neurone disease (MND) and attitudes to development of technology based measurement and monitoring solutions *Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration* 2019 20(Suppl 1) 330-1 [Accessed 13 May 2020]
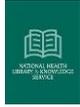
potential for development of technology based assessment methods was sought. Finally, a questionnaire designed to evaluate the acceptance of healthcare professionals to incorporation of telemedicine was completed. The survey was disseminated via email invitation, Twitter and Facebook between May and August 2019. Results: Forty-five respondents from six countries included neurologists, nurses and therapists working in hospital and community based settings, 50% of whom described themselves as expert clinicians. Only 9.7% reported that ALS/MND specific telemedicine infrastructure was used, while 51.6% indicated that this was not available but they would prefer to use it. Video conferencing was used by 45%, 16% reported using remote monitoring while 38.7% indicated that they would prefer it use it if available. The most commonly used assessment method were subjective symptoms (89.7%), weight (79.3%) and the ALSFRS-R (67.9%). 65.5% agreed that current measurement tools are clinically meaningful, while only 38% agreed that they are used consistently across sites. Health professionals identified a wide variety of constructs as the most important variables to measure in their patients. Discussion and Conclusion: A minority of clinicians report using telemedicine in ALS/MND clinical care, while a significant percentage indicate that they would prefer to use it if available. There is concern about a lack of consistency in outcome measure use across sites. New measurement tools providing consistent and valid data regarding physical status and progression are required in ALS/MND.

Sivaramakrishnan, A et al (2019) [Remotely Supervised Transcranial Direct Current Stimulation: A Feasibility Study for Amyotrophic Lateral Sclerosis](#)[11]
Background: Transcranial direct current stimulation (tDCS) has been investigated as a therapeutic neuromodulation tool in several neurological disorders. However, evidence supporting its efficacy in disorders such as amyotrophic lateral sclerosis (ALS) is limited possibly due to limited patient accessibility for research, particularly for individuals with advanced disease progression. Telerehabilitation using home-based protocols allows for remote supervision of tDCS over longer durations, thereby increasing participation, compliance and adherence. In this study, we explored the safety, feasibility and preliminary effects of a remotely supervised tDCS (RS-tDCS) protocol in ALS.

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[11] Sivaramakrishnan A, Datta A, Bikson M, Madhavan S. Remotely supervised transcranial direct current stimulation: A feasibility study for amyotrophic lateral sclerosis. *NeuroRehabilitation*. 2019;453.:369- 378. doi:10.3233/NRE-192851
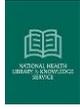
Material and Methods: In this pre-post case series study, two individuals with ALS completed 24 remotely supervised anodal tDCS sessions (20 minutes, 2 mA). Outcomes included adherence, compliance, disease progression, walking speed, risk of fall, endurance, fatigue and depression.

Results: Both participants successfully completed the study without any major adverse effects. Minor side effects included mild sensations of itching and throbbing under the electrodes during stimulation. Clinical outcomes showed minimal to no change for any of the measures.

Conclusions: Preliminary findings suggest that the RS-tDCS protocol is safe and feasible in individuals with ALS. Our protocol serves as a model for future long-term studies to evaluate the clinical and neurophysiological effects of tDCS using a telerehabilitation protocol in ALS.

Geronimo, A et al (2017) [Feasibility Study] Incorporation of Telehealth Into a Multidisciplinary ALS Clinic: Feasibility and Acceptability[12]

Objective: The practice of telehealth in the care of patients with ALS has received little attention, but has the potential to change the multidisciplinary care model. This study was carried out to assess the feasibility and acceptability of telehealth for ALS care via real-time videoconferencing from the clinic to patients' homes.

Methods: Patients and caregivers engaged in live telehealth videoconferencing from their homes with members of a multidisciplinary ALS care team who were located in an ALS clinic, in place of their usual in-person visit to the clinic. Participating patients, their caregivers, and health care providers (HCPs) completed surveys assessing satisfaction with the visit, quality of care, and confidence with the interface. Mixed methods analysis was used for survey responses.

Results: Surveys from 11 patients, 12 caregivers, and 15 HCPs were completed. All patients and caregivers, and most HCPs, agreed that the system allowed for good communication, description of concerns, and provision of care recommendations. The most common sentiment conveyed by each group was that telehealth removed the burdens of travel, resulting in lower stress and more comfortable interactions. Caregivers and HCPs expressed more concerns than patients about the ways in which telehealth fell short of in-person care.

[12] Geronimo A, Wright C, Morris A, Walsh S, Snyder B, Simmons Z. Incorporation of telehealth into a multidisciplinary ALS Clinic: feasibility and acceptability. *Amyotroph Lateral Scler Frontotemporal Degener.* 2017;18(7-8):555-561. doi:10.1080/21678421.2017.1338298

Conclusions: Telehealth was generally viewed favourably by ALS patients, caregivers, and multidisciplinary team members. Improvements in technology and in methods to provide satisfactory remote care without person-to-person contact should be explored.

Selkirk, S et al (2017) Delivering Tertiary Centre Specialty Care to ALS Patients via Telemedicine: A Retrospective Cohort Analysis[13]

Objective: This study was undertaken to determine if ALS patients evaluated via telemedicine received the same quality of care as patients evaluated by traditional face-to-face encounters.

Methods: A retrospective cohort study design was used. Participants were patients diagnosed with ALS that received multidisciplinary care at the tertiary Cleveland VA ALS Centre between 1 March 2008- and 31 anuary 2015. Participants were not randomised, but chose telemedicine based on preference, disability level or distance from the clinic. Telemedicine in this study consisted of a video conferencing platform enabling remote rather than face-to-face encounters with participants.

Results: There was no significant association between receiving quality ALS care and the mode of care. There was a trend for telemedicine patients to utilise home health care less often than those that received clinic care (AOR 0.50; 95% CI 0.16-1.59). There was no significant difference in survival time between the two groups (log-rank test χ^2 = 3.62, df = 1, p = 0.05). Patients receiving telemedicine had a higher probability of remaining stable or having <30% decrease in ALSFRS-R over time (log-rank test χ^2 = 4.46, df = 1, p = 0.03). There was a significantly lower risk of disease progression for patients receiving telemedicine (HR = 0.39, 95% CI = 0.16-0.93).

Conclusions: Patients managed by telemedicine received the same quality of care and had similar outcomes to those patients seen via traditional face-to-face encounters. Telemedicine is an effective platform for delivering high quality tertiary ALS care.

[13] Selkirk SM, Washington MO, McClellan F, Flynn B, Seton JM, Strozewski R. Delivering tertiary centre specialty care to ALS patients via telemedicine: a retrospective cohort analysis. *Amyotroph Lateral Scler Frontotemporal Degener*. 2017;18(5-6):324- 332. doi:10.1080/21678421.2017.1313867

Ashcroft, H et al (2016) [Conference Abstract] S57 Qualitative assessment of the experience of telemonitoring in ventilated patients with motor neurone disease[14]

Background: The National Institute for Health and care Excellence (NICE) has recently issued recommendations on the care of people with motor neurone disease (MND), promoting tailored care for each patient. Previous studies suggest remote monitoring offers a facility to regularly monitor and interact with patients, providing timely interventions so it may facilitate delivery of the recommendations. The efficacy of this approach is dependent upon acceptability of telemonitoring to patients.

Aim: To understand the experiences of using telemonitoring in ventilated patients with MND.

Methods: Semi-structured interviews were conducted with seven patients (male = 5; mean age = 63 yrs). The median illness duration was 14 m (range = 7 m–13 yrs 7 m) and the median non-invasive ventilation (NIV) usage was 12 m (range = 0 m–3 yrs). Participants used a telemonitoring device (Docobo CAREPORTAL®) for six months, completed weekly nocturnal pulse oximetry and symptom-related questions. Five caregivers were present at the interviews and provided their feedback. Interviews were audio recorded and transcribed verbatim. Thematic analysis was conducted to find overarching themes. The interpretation was reviewed and supported by a multidisciplinary team examination.

Findings: Five themes were identified: Technical Challenges, Increased Self-Awareness, Taking Initiative, Benefits of Timely Intervention, and Reducing the Unnecessary. Whilst participants expressed general ease of Careportal® use, technical issues included; messaging system challenges, oximetry transmission, device fault, mobile signal loss. No other negative experience of using Careportal® was reported. Overall, participants expressed how telemonitoring enabled symptom awareness and interpretation. The device also enabled the participants to raise their concerns and/or requests to the healthcare professionals via the messaging system, and this was depicted as a sharp contrast to current communication with hospitals. Timely interventions were observed as a result of regular monitoring, contributing to both physical and psychological well-being of the participants. It was also suggested that using Careportal® could reduce unnecessary cost/time and hassles created by attending hospital appointments.

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[14] Ashcroft, H, Ando, H, Halhead, R et al S57 Qualitative assessment of the experience of telemonitoring in ventilated patients with motor neurone disease *Thorax* 2016;71:A34.[Accessed 13 May 2020]

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Conclusions: Telemonitoring enabled participants to be actively involved in their care and they felt that the interventions were timely delivered to meet their needs. The findings suggest potential benefits of utilising Careportal ® in routine care as a contact point to accommodate different individual's needs.

Ashcroft, H et al (2016) [Conference Abstract] Telemonitoring to optimise care in motor neurone disease: A pilot study[15]

Background: Advances in telemedicine may benefit patients with motor neurone disease/ amyotrophic lateral sclerosis (MND/ALS). Aims: This study aimed to improve care through telemonitoring utilising standardised symptom monitoring, clinical measurements and assessment non-invasive ventilation (NIV) parameters. It was hypothesised that telemonitoring allows proactive intervention allowing symptom management and optimised ventilation indicated by adequate nocturnal SpO2 levels and minute ventilation (MV). Methods: 13 ventilated patients [mean age=62yrs; median illness duration=14m; median NIV usage= 8m] were recruited. Previously developed questions monitored symptoms and NIV-related issues, generating alerts and interventions where required. Nocturnal pulse oximetry and the patient-ventilator interaction (PVI) data were collected weekly. A revised ALS functional rating scale (ALSFRS-R) was completed three-monthly. Friedman's ANOVA and Spearman's correlation coefficient were used for analysis at the baseline, at 3 month, and at 6 month. Results: In total, 137 alerts led to 62 interventions [direct review 13, treatment adjustment 14, equipment provision 20, referral 15]. Inspiratory positive airway pressure levels were increased median 16.8 and 21.9cmsH20 (Wk1 and 22), NIV adherence also increased over time (both $p<.01$). No change was observed with nocturnal SpO2 levels. ALSFRS-R scores showed illness deteriorations. No consistent correlations were found between the variables. Conclusions: This pilot study found telemonitoring to be beneficial in maintaining ventilation MND despite the illness deterioration.

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CHAPTER 13
Telemedicine and Multiple Sclerosis

Systematic Reviews

Di Tella, Sonia et al (2019) [Systematic Review and Meta-Analysis]
Integrated telerehabilitation approach in multiple sclerosis: A systematic review and meta-analysis[1]

Introduction: Multiple sclerosis (MS) is a chronic immune-mediated disease of the central nervous system and a major cause of disability in young adults. Recently, there has been a growing interest in the development of innovative ways to deliver rehabilitation care outside of a hospital setting. The aim was to conduct a systematic review and a meta-analysis of the efficacy of an integrated telerehabilitation approach (ITA) on motor, cognitive and participation outcomes delivered to people with MS (pwMS). Methods: We systematically searched for original manuscripts regarding ITA in pwMS. Efficacy on motor, cognitive and participation outcomes was measured as the standardized mean difference [Hedges' g] of pre and post training. Results: Nine studies encompassing 716 pwMS diagnosis were included. The overall effect of ITA was: large for motor outcomes (g = 1.05; p = 0.013); small for cognitive performance outcomes (g = 0.16; p = 0.237); and small for participation outcomes (g = 0.15; p = 0.259). Domain-specific results showed that the effect on motor disability was large (g = 1.18), while on gait and balance was medium (g = 0.32 and g = 0.48, respectively). Moreover, all effects on single cognitive domains were small. Finally, among the single participation outcomes considered (depression, fatigue, daily functioning, quality of life and self-efficacy), only depression showed a nearly medium effect (g = 0.30). Conclusions: PwMS can benefit from ITA in the treatment of motor symptoms according to the current model of continuity of care. However, the low efficacy of ITA on cognition and participation domains

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[1] Di Tella S, Pagliari C, Blasi V, Mendozzi L, Rovaris M, Baglio F. Integrated telerehabilitation approach in multiple sclerosis: A systematic review and meta-analysis [published online ahead of print, 2019 May 27]. *J Telemed Telecare*. 2019;1357633X19850381. doi:10.1177/1357633X19850381

suggests the necessity to develop intervention models that include a broader spectrum of needs and objectives.

Randomised Controlled Trials

Charvet, Leigh E et al (2017) [Randomised Controlled Trial] Cognitive Function in Multiple Sclerosis Improves With Telerehabilitation: Results From a Randomized Controlled Trial[2]

Cognitive impairment affects more than half of all individuals living with multiple sclerosis (MS). We hypothesized that training at home with an adaptive online cognitive training program would have greater cognitive benefit than ordinary computer games in cognitively-impaired adults with MS. This was a double-blind, randomized, active-placebo-controlled trial. Participants with MS were recruited through Stony Brook Medicine and randomly assigned to either the adaptive cognitive remediation (ACR) program or active control of ordinary computer games for 60 hours over 12 weeks. Training was remotely-supervised and delivered through a study-provided laptop computer. A computer generated, blocked stratification table prepared by statistician provided the randomization schedule and condition was assigned by a study technician. The primary outcome, administered by study psychometrician, was measured by change in a neuropsychological composite measure from baseline to study end. An intent-to-treat analysis was employed and missing primary outcome values were imputed via Markov Chain Monte Carlo method. Participants in the ACR (n = 74) vs. active control (n = 61) training program had significantly greater improvement in the primary outcome of cognitive functioning (mean change in composite z score±SD: 0·25±0·45 vs. 0·09±0·37, p = 0·03, estimated difference = 0·16 with 95% CI: 0·02-0·30), despite greater training time in the active control condition (mean±SD:56·9 ± 34·6 vs. 37·7 ±23 ·8 hours played, p = 0·006). This study provides Class I evidence that adaptive, computer-based cognitive remediation accessed from home can improve cognitive functioning in MS. This telerehabilitation approach allowed for rapid recruitment and high compliance, and can be readily applied to other

[2] Charvet LE, Yang J, Shaw MT et al Cognitive function in multiple sclerosis improves with telerehabilitation: Results from a randomized controlled trial [published correction appears in PLoS One. 2018 Jan 30;131.:e0192317]. *PLoS One*. 2017;125.:e0177177. Published 2017 May 11.

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neurological conditions associated with cognitive dysfunction. Trial registration: Clinicaltrials.gov NCT02141386.

Guijarro-Castro, C. et al (2017) [Randomised Controlled Trial] Face-to-Face or Telematic Cognitive Stimulation in Patients With Multiple Sclerosis and Cognitive Impairment: Why Not Both?[3]

Introduction: Cognitive impairment (CI) affects 40-65% of patients with multiple sclerosis (MS). Few studies address telematic cognitive stimulation (TCS) in MS. The objective of this study is to evaluate the efficacy and impact of telestimulation or distance cognitive stimulation (TCS), with and without the support of face-to-face cognitive stimulation (FCS) in cognitive impairment in MS. Methods: Multicentre, prospective, randomised, controlled study. We will include 98 MS patients with EDSS ≤ 6, symbol digit modality test (SDMT) ≤ Pc 25, and Multiple Sclerosis Neuropsychological Screening Questionnaire (MSNQ) > 26 points. Patients will be randomised into 3 groups, a TCS group, a mixed TCS/FCS group, and a control group. CS is performed 3 days a week for 3 months. Processing speed, memory, attention, and executive functions will be rehabilitated. FCS will include ecological exercises and strategies. EDSS and a cognitive evaluation (SDMT, CTMT, PASAT, and TAVEC), MSNQ, psychological impact scales (MSIS), and depression (BDI) will be carried out, baseline, postrehabilitation, and also 6 and 12 months later, to evaluate the effect of CS in the longer term. Conclusion: This study could help to establish the usefulness of TCS or, in its absence, TCS with face-to-face help for CI in MS. The interest lies in the clear benefits of remote rehabilitation in the daily life of patients.

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[3] Guijarro-Castro C, Aladro-Benito Y, Sánchez-Musulim A et al Face-to-Face or Telematic Cognitive Stimulation in Patients with Multiple Sclerosis and Cognitive Impairment: Why Not Both?. *Behav Neurol.* 2017;2017:5713934. doi:10.1155/2017/5713934

Creagh, Andrew et al (2020) [Review] Smartphone-based remote assessment of upper extremity function for multiple sclerosis using the FLOODLIGHT draw a shape test[4]

Objective: Smartphone devices may enable out-of-clinic assessments in chronic neurological diseases. We describe the FLOODLIGHT Draw a Shape (DaS) Test, a smartphone-based and remotely administered test of Upper Extremity (UE) function developed for people with multiple sclerosis (PwMS). This work introduces DaS-related features that characterise UE function and impairment, and aims to demonstrate how multivariate modelling of these metrics can reliably predict the 9-Hole Peg Test (9HPT), a clinician-administered UE assessment in PwMS. Approach: The FLOODLIGHT DaS test instructed PwMS and healthy controls (HC) to trace predefined shapes on a smartphone screen. A total of 93 subjects (HC, n=22; PwMS, n=71) contributed both dominant and non-dominant handed DaS tests. PwMS subjects were characterised as those with normal (nPwMS, n=50) and abnormal UE function (aPwMS, n=21) with respect to their average 9HPT time ($\leq$ or >22.7 [s], respectively). L1-regularization techniques, combined with linear least squares (OLS, IRLS), or non-linear Support Vector (SVR) or Random Forest (RFR) regression were investigated as functions to map relevant DaS features to 9HPT times. Main results: It was observed that average non-dominant handed 9HPT times were more accurately predicted by DaS features ($r^2=0.41$, $P<0.05$; MAE: 2.08 ± 0.34 [s]) than average dominant handed 9HPTs ($r^2=0.39$, $P<0.05$; MAE: 2.32 ± 0.43 [s]), using simple linear IRLS ($P<0.01$). Moreover, it was found that the Mean absolute error (MAE) in predicted 9HPTs was comparable to the variability of actual 9HPT times within HC, nPwMS and aPwMS groups respectively. The 9HPT however exhibited large heteroscedasticity resulting in less stable predictions of longer 9HPT times. Significance: This study demonstrates the potential of the smartphone-based DaS Test to reliably predict 9HPT times and remotely monitor UE function in PwMS.

Matthews, Paul M et al (2020) [Review] E-health and Multiple Sclerosis[5]
Purpose: To outline recent applications of e-health data and digital tools for improving the care and management of healthcare for people with multiple sclerosis. Recent Findings: The digitization of most clinical data, along with developments in communication technologies, miniaturization of sensors and computational advances are enabling aggregation and clinically meaningful analyses of real-world data from patient registries, digital patient-reported outcomes and electronic health records (EHR). These data are allowing more confident descriptions of prognoses for multiple sclerosis patients and the long-term relative benefits and safety of disease-modifying treatments (DMT). Registries allow detailed, multiple sclerosis-specific data to be shared between clinicians more easily, provide data needed to improve the impact of DMT and, with EHR, characterize clinically relevant interactions between multiple sclerosis and other diseases. Wearable sensors provide continuous, long-term measures of performance dynamics in relevant ecological settings. In conjunction with telemedicine and online apps, they promise a major expansion of the scope for patients to manage aspects of their own care. Advances in disease understanding, decision support and self-management using these Big Data are being accelerated by machine learning and artificial intelligence. Summary: Both health professionals and patients can employ e-health approaches and tools for development of a more patient-centred learning health system.

Remy, Caroline et al (2020) [Cross-Sectional Study] Telecommunication and rehabilitation for patients with multiple sclerosis. Access and willingness to use: a cross-sectional study[6]
Background: Telerehabilitation is a promising approach for patients with multiple sclerosis (MS), but uncertainties regarding patients' access and preferences remain. Aim: To investigate the access to telecommunication technologies and rehabilitation services of patients with MS, and their willingness to use these technologies for rehabilitation. Design: Cross-sectional survey.
Setting: Outpatient neurological facility. Population: Patients with MS. Methods: Patients with MS attending consultations in the Neurology department were asked to fill in a paper questionnaire. This anonymous

[5] Matthews PM, Block VJ, Leocani L. E-health and multiple sclerosis. *Curr Opin Neurol.* 2020;333.:271–276. doi:10.1097/WCO.0000000000000823
[6] Remy C, Valet M, Stoquart G et al Telecommunication and rehabilitation for patients with multiple sclerosis. Access and willingness to use: a cross-sectional study [published online ahead of print, 2020 Apr 15]. *Eur J Phys Rehabil Med.* 2020;10.23736/S1973-9087.20.06061-X. doi:10.23736/S1973-9087.20.06061-X

questionnaire was designed to gain information about needs and access to rehabilitation and telecommunication technologies, as well as interests and perspectives of telerehabilitation among these patients. Descriptive statistics, chi- squared tests and logistic regressions were used to describe the sample and survey answers. Results: Two hundred patients completed the questionnaire. Mean age was 44.41(±12.52) years. Seventy-one percent were women, and 49% were unemployed. Ninety-one percent of the patients regularly used Internet and 73% used apps. Most patients were interested in using telecommunication technologies to receive a program of physical exercises (62%), for information and personalized advice about physical activity and MS (69%), and to communicate with caregivers (75%). Patients with EDSS>4 were less interested than patients with EDSS≤4 in communicating with the caregivers via apps (33%vs52%,Δ19%[CI-36%;-2%],p=0.04) but expressed greater interest in receiving information and personal advice about physical activity and MS via the Internet (70%vs51%,Δ19%[CI+2%;+36%],p=0.03). One third of the patients was not interested in receiving telerehabilitation interventions (32%), notably patients with EDSS>4 and non-workers.

Conclusions: Patients with MS are mainly interested in using telecommunication technologies for rehabilitation services, and most of these patients have access to the required technology. Being mildly disabled and having a professional activity are associated with a greater interest in telerehabilitation. In contrary, patients with moderate-to-severe disability and non-workers have reportedly less access and ease in using the required technologies. Clinical rehabilitation impact: Telerehabilitation is feasible and wished by patients with MS, specifically in patients with low EDSS scores and workers. Given the strong need for rehabilitation in more disabled patients, the barriers to its access, the lower access and ease of use of telecommunication technologies, a special effort is needed to facilitate their use in these patients.

Amatya, Bhasker et al (2019) [Overview] Rehabilitation for people with multiple sclerosis: an overview of Cochrane Reviews[7]
Background: Multiple sclerosis (MS) is a major cause of chronic, neurological disability, with a significant long-term disability burden, often requiring comprehensive rehabilitation. Objectives: To systematically evaluate

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[7] Amatya B, Khan F, Galea M. Rehabilitation for people with multiple sclerosis: an overview of Cochrane Reviews. *Cochrane Database Syst Rev*. 2019;11.:CD012732. Published 2019 Jan 14. doi:10.1002/14651858.CD012732.pub2

evidence from published Cochrane Reviews of clinical trials to summarise the evidence regarding the effectiveness and safety of rehabilitation interventions for people with MS (pwMS), to improve patient outcomes, and to highlight current gaps in knowledge.

Methods: We searched the Cochrane Database of Systematic Reviews up to December 2017, to identify Cochrane Reviews that assessed the effectiveness of organised rehabilitation interventions for pwMS. Two reviewers independently assessed the quality of included reviews, using the Revised Assessment of Multiple Systematic Reviews (R-AMSTAR) tool, and the quality of the evidence for reported outcomes, using the GRADE framework. Main results: Overall, we included 15 reviews published in the Cochrane Library, comprising 164 randomised controlled trials (RCTs) and four controlled clinical trials, with a total of 10,396 participants. The included reviews evaluated a wide range of rehabilitation interventions, including: physical activity and exercise therapy, hyperbaric oxygen therapy (HBOT), whole-body vibration, occupational therapy, cognitive and psychological interventions, nutritional and dietary supplements, vocational rehabilitation, information provision, telerehabilitation, and interventions for the management of spasticity. We assessed all reviews to be of high to moderate methodological quality, based on R-AMSTAR criteria. Moderate-quality evidence suggested that physical therapeutic modalities improved functional outcomes, reduced impairment, and improved participation. Moderate-quality evidence suggested that inpatient or outpatient multidisciplinary rehabilitation programmes led to longer-term gains at the levels of activity and participation, and interventions that provided information improved patient knowledge. Low-qualitty evidence suggested that neuropsychological interventions, symptom-management programmes, whole body vibration, and telerehabilitation improved some patient outcomes. Evidence for other rehabilitation modalities was inconclusive, due to lack of robust studies. Authors' Conclusions: The evidence suggests that regular specialist evaluation and follow-up to assess the needs of patients with all types of MS for appropriate rehabilitation interventions may be of benefit, although the certainty of evidence varies across the different types of interventions evaluated by the reviews. Structured, multidisciplinary rehabilitation programmes and physical therapy can improve functional outcomes [mobility, muscle strength, aerobic capacity], and quality of life. Overall, the evidence for many rehabilitation interventions should be interpreted cautiously, as the majority of included reviews did not include data from current studies. More studies, with

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appropriate design, which report the type and intensity of modalities and their cost-effectiveness are needed to address the current gaps in knowledge. The authors acknowledge that four included reviews were conducted by the present authors' team (Amatya 2013; Khan 2007b; Khan 2009; Khan 2015), and one author (FK) was involved in another review (Kopke 2014).

Block, Valerie J et al (2019) [Observational Study] [Association of Continuous Assessment of Step Count by Remote Monitoring With Disability Progression Among Adults With Multiple Sclerosis[8]](#)

Importance: Disability measures in multiple sclerosis (MS) fail to capture potentially important variability in walking behavior. More sensitive and ecologically valid outcome measures are needed to advance MS research. Objectives: To assess continuous step count activity remotely among individuals with MS for 1 year and determine how average daily step count is associated with other measures of MS disability. Design, Setting, and Participants: In a prospective longitudinal observational cohort study, 95 adults with relapsing or progressive MS who were able to walk more than 2 minutes with or without an assistive device were recruited between June 15, 2015, and August 8, 2016, and remotely monitored in their natural environment for 1 year. Patients were excluded if they had a clinical relapse within 30 days or comorbidity contributing to ambulatory impairment. Longitudinal analysis was performed from October 2017 to March 2018. Revised analysis was performed in December 2018. Intervention: Activity monitoring of step count using a wrist-worn accelerometer.
Main Outcomes and Measures: Average daily step count compared with in-clinic assessments and patient-reported outcomes. Results: of the 95 participants recruited (59 women and 36 men; mean [SD] age, 49.6 [13.6] years [range, 22.0-74.0 years]), 35 (37%) had progressive MS, and the median baseline Expanded Disability Status Scale score was 4.0 (range, 0-6.5). At 1 year, 79 participants completed follow-up (83% retention). There was a modest reduction in accelerometer use during the 1 year of the study. A decreasing average daily step count during the study was associated with worsening of clinic-based outcomes (Timed 25-Foot Walk, β = -13.09; P < .001; Timed-Up-and-Go, β = -9.25; P < .001) and patient-reported outcomes (12-item Multiple Sclerosis Walking Scale, β = -17.96; P < .001). A decreasing

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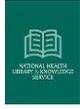
average daily step count occurred even when the Expanded Disability Status Scale score remained stable, and 12 of 25 participants (48%) with a significant decrease in average daily step count during the study did not have a reduction on other standard clinic-based metrics. Participants with a baseline average daily step count below 4766 (cohort median) had higher odds of clinically meaningful disability (Expanded Disability Status Scale score) worsening at 1 year, adjusting for age, sex, and disease duration (odds ratio, 4.01; 95% CI, 1.17-13.78; P = .03). Conclusions and Relevance: Continuous remote activity monitoring of individuals with MS for 1 year appears to be feasible. In this study, a decreasing average daily step count during a 1-year period was associated with worsening of standard ambulatory measures but could also occur even when traditional disability measures remained stable. These results appear to support the prospect of using the average daily step count as a sensitive longitudinal outcome measure in MS and as a clinically relevant metric for targeted intervention. Conflict of Interest Disclosures: Dr Bove reported receiving personal fees from Novartis, Roche-Genentech, and Genzyme-Sanofi; and receiving grants from Akili Interactive outside the submitted work. Dr Graves reported receiving personal fees from Novartis outside the submitted work. Dr Romeo reported receiving grants from the National Multiple Sclerosis Society outside the submitted work. Dr Green reported serving on scientific advisory boards or trial execution committees for MedImmune (VielaBio), Novartis, Inception 5 Sciences, Pipeline, and Bionure; holding a patent for remyelination molecules and pathways; receiving research support from Novartis, Inception Sciences, the National Institute of Neurological Disorders and Stroke, the National Institute on Aging, the National Institutes of Health, National Multiple Sclerosis Society, Sherak Foundation, and Hilton Foundation; and serving as an expert witness in Mylan Pharmaceuticals v Teva Pharmaceuticals. Dr Olgin reported receiving grants from Zoll; and personal fees from Novartis and from Vivalink outside the submitted work. Dr Marcus reported receiving grants from Jawbone Health during the conduct of the study. Dr Cree reported receiving personal consulting fees from AbbVie Akili, Biogen, EMD Serono, GeNeuro, and Novartis outside the submitted work. Dr Gelfand reported receiving grants to University of California, San Francisco from Genentech; receiving service contract support to University of California, San Francisco from MedDay; receiving personal fees from Alexion and from Biogen outside the submitted work; and receiving personal compensation for medical legal consulting and serving as an expert witness outside the submitted work. No other disclosures were reported.

Block, Valerie J et al (2019) [Review] Validation of a consumer-grade activity monitor for continuous daily activity monitoring in individuals with multiple sclerosis[9]

Background: Technological advancements of remote-monitoring used in clinical-care and research require validation of model updates. Objectives: To compare the output of a newer consumer-grade accelerometer to a previous model in people with multiple sclerosis (MS) and to the ActiGraph, a waist-worn device widely used in MS research. Methods: Thirty-one individuals with MS participated in a 7-day validation by the Fitbit Flex (Flex), Fitbit Flex-2 (Flex2) and ActiGraph GT3X. Primary outcome was step count. Valid epochs of 5-min block increments, where there was overlap of ≥1 step/min for both devices were compared and summed to give a daily total for analysis. Results: Bland-Altman plots showed no systematic difference between the Flex and Flex2; mean step-count difference of 25 more steps-per-day more recorded by Flex2 (95% confidence intervals (CI) = 2, 48; p = 0.04), interclass correlation coefficient (ICC) = 1.00. Compared to the ActiGraph, Flex2 (and Flex) tended to record more steps (808 steps-per-day more than the ActiGraph (95% CI= -2380, 765; p < 0.01), although the ICC was high (0.98) indicating that the devices were likely measuring the same kind of activity. Conclusions: Steps from Flex and Flex2 can be used interchangeably. Differences in total step count between ActiGraph and Flex devices can make cross-device comparisons of numerical step-counts challenging particularly for faster walkers.

Bove, Riley et al (2019) [Proof-of-Principle Study] Toward a low-cost, in-home, telemedicine-enabled assessment of disability in multiple sclerosis[10]

Background: Remote assessment of neurological disability in people with multiple sclerosis (MS) could improve access to clinical care and efficiency of clinical research. Objective: To develop and validate a telemedicine-based MS disability examination that does not require an in-home examiner. Methods: Adults with MS were recruited after a standardized in-person Expanded Disability Status Scale (EDSS) evaluation, and within 1 week

[9] Block VJ, Zhao C, Hollenbach JA et al Validation of a consumer-grade activity monitor for continuous daily activity monitoring in individuals with multiple sclerosis. *Mult Scler J Exp Transl Clin.* 2019;54.:2055217319888660. Published 2019 Nov 21. doi:10.1177/2055217319888660

[10] Bove R, Bevan C, Crabtree E et al Toward a low-cost, in-home, telemedicine-enabled assessment of disability in multiple sclerosis. *Mult Scler.* 2019;25(11):1526-1534. doi:10.1177/1352458518793527

underwent a blinded televideo-enabled EDSS examination with a different clinician. EDSS and tele-EDSS scores were compared. Results: Overall, 41 adults participated (mean (standard deviation (SD)) age: 47.0 years (11.6); median EDSS: 2 (range: 0-7)); 37 required no in-home assistance for the tele-EDSS evaluation (eg help positioning camera). Mean difference between EDSS and tele-EDSS was 0.34 (95% confidence interval (CI): 0.07-0.61). For 88% of evaluations, tele-EDSS and EDSS scores were within 1 point (similar to reported in-person inter-rater differences). Unweighted kappa for agreement within 0.5 point was 0.72. Correlation for individual functional systems (FS) ranged from modest (vision: 0.37) to high (bowel/bladder: 0.79). Overall correlation between EDSS and tele-EDSS was 0.89 (p < 0.0001); and 0.98 (p < 0.0001) at EDSS range: 4-7. Conclusion: In this proof of principle study, disability evaluation in mild to moderate MS is feasible using telemedicine without an aide at the patient's location.

Gil-S et al (2019) [Pilot Study] Pilot study of telemedicine in multiple sclerosis to evaluate the effectiveness of a telecommunication system for the detection of the clinical activity of the disease in the number of relapses with respect to the standard clinical practice[11]
Objectives: The aim of this study was to measure the ability of telemedicine to detect relapses in patients with multiple sclerosis (MS); also to observe the difference between patients with cognitive impairment and cognitive preservation. Methodology: 130 patients under treatment with firstline drugs for MS who had the computer skills to access a web platform created by this study were recruited. The patients had to answer surveys about their clinical status and were randomized in two groups: survey [intervention] and non-survey [control]. Also, three visits were made during the study: the basal visit, visit 6 and visit 12 months. All patients fulfilled questionnaires of mood, health, satisfaction with health services and adherence to treatment. They performed the Multiple Sclerosis Functional Composite (MSFC), and the Expanded Disability Status Scale (EDSS). The cognitive status was estimated using two tests for cognitive ability measurement: the Symbol Digit Modalities Test (SDMT) and the Paced Auditory Serial Addition Test (PASAT) and a subsequent classification was made: cognitive impairment/suspected impairment/cognitive preservation. Results and Conclusions: The sensitivity

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[11] Gil, S et al. Pilot Study of Telemedicine in multiple sclerosis to evaluate the effectiveness of a telecommunication system for the detection of the clinical activity of the disease in the number of relapses with respect to the standard clinical practice. TELEM https://onlinelibrary.ectrims-congress.eu/ectrims/2018/ectrims-2018/229242/anna.gil.pilot.study.of.telemedicine.in.multiple.sclerosis.to.evaluate.the.html.

of the platform survey was 100% and the specificity 96.5%. Both groups were equal in all the analyzed features, with the exception of the EDSS, which was significantly higher in the intervention group than in the control group (mean 0 vs. 1). There were no more relapses in the survey/intervention group (average 0 vs. 0). Patients with cognitive impairment had a worse mood at the beginning of the study and were less satisfied with the health services received than the cognitively preserved, but they showed the same adherence as them. Telemedicine is a useful tool in detecting relapses in MS patients and cognition is an important factor in the health and mood of patients with multiple sclerosis.

Shaw, M et al (2019) [Conference Abstract] Telemedicine reaches MS patients living with disabilities: at-home telerehabilitation with remotely-supervised transcranial direct current stimulation (RS-tDCS)[12]
Introduction: Travel to clinic can be difficult due to barriers of time and cost and becomes even more burdensome for MS patients living with disabilities. Telemedicine platforms present a solution by providing supervised treatment and rehabilitation at home. Without barriers to access, patients may be more compliant and adherent to daily rehabilitation exercises. We have a large telerehabilitation research program in MS that pairs rehabilitation with transcranial direct current stimulation (tDCS), an emerging non-invasive brain stimulation technique used to improve outcomes. We provide real-time treatment administration and supervision via HIPAA compliant videoconference, termed remotely supervised tDCS or RS-tDCS. Objectives: To characterize the advantages of telemedicine for patients with MS in an urban setting. Aims: To measure barriers to access for participants in our RS-tDCS telerehabilitation program, as well as compliance and adherence to a remotely supervised intervention. Methods: Participants with MS were recruited to complete a trial of cognitive remediation paired with RS-tDCS at-home. Participants were surveyed following completion of the intervention and asked to rate their difficulty in attending the clinic as well as the typical cost of attending clinic. Descriptive statistics and ordinal logistic regression models were used to evaluate the factors driving difficulty of travel. Results: Participants (n=44) reported that round trip travel to the clinic requires an average of 2.3±2.3 hours of time and $27.04±38.13. Participants rated the difficulty associated with attending

[12] Shaw M, Best P et al Telemedicine reaches MS patients living with disabilities: at-home telerehabilitation with remotely-supervised transcranial direct current stimulation (RS-tDCS). *Mult Scler.* 2019;252.:352. http://dx.doi.org/10.1177/1352458519868078

clinic as being moderate to significant (2.5±1.3). Regression analyses that included disease features produced better models and accounted for greater variance in difficulty attending the clinic, (p< 0.001, McFadden pseudo R2 = .515), as compared with socioeconomic variables alone (p< 0.001, McFadden pseudo R2 = .140). The RS-tDCS protocol was successful in providing treatment (95% compliance to treatment) and 93% of participants reported satisfaction with the treatment and remote protocols. Conclusions: Participants with MS face considerable difficulty reaching the clinic, largely due to increasing neurologic disability. Telemedicine techniques such as RS-tDCS can increase treatment access, reduce physical and financial burden of travel and maintain high rates of treatment adherence. Disclosure: This pilot study was funded by the National Multiple Sclerosis Society.

Wallin, Mitchell T et al (2019) [Review] Telemedicine and Multiple Sclerosis: A Comprehensive Literature Review[13]
Introduction: Patients with multiple sclerosis (pwMS) face barriers accessing specialty care for evaluation and treatment. Telemedicine, the practice of clinical care at a distance with the aid of technology, may be a potential bridge to close the access gap for pwMS separated by distance or disability. The objective of this review was to investigate the types of telemedicine being utilized and overall outcomes for pwMS and their providers. Methods: A Boolean search of the medical literature was conducted between January 2000 and January 31, 2018. PubMed, EMBASE, PsycINFO and the Cochrane databases, were used to identify all relevant citations. Two reviewers independently appraised the articles for meeting study criteria and for study quality using the CASP system. Financial costs of the telemedicine applications were assessed. Results: A total of 28 studies involving 3252 participants met criteria for inclusion. Telemedicine interventions were classified, and outcomes were assessed systematically by the following categories: general MS care; rehabilitation and exercise; and neuropsychology/mental health. Studies showed a range of outcomes with variable quality. Overall, remote clinical examinations, long-term telemedicine management interventions and telerehabilitation were shown to be beneficial, cost-effective and satisfactory for patients and providers. Discussion: Telemedicine is a viable platform for delivering specialty MS care. Remote neurological assessments and several forms of therapy have

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[13] Wallin M et al Telemedicine and Multiple Sclerosis: A Comprehensive Literature Review. *Journal of Telemedicine and Telecare*. 2019;92(15) https://doi.org/10.1177/1357633X19840097

been shown to be technically feasible. Optimal implementation and barriers to the use of telemedicine in the current healthcare system should be explored.

Cohen, M. (2018) [Review] Connected health and multiple sclerosis[14]
There is as yet no consensual definition of connected health. In general, the term refers to the growing use of technology and, in particular, mobile technology in medicine. Over the past 10 years, there have been an increasing number of published reports on the wide-ranging and heterogeneous fields involving the application of technology in medicine, ranging from telemedicine to tools to improve patients' evaluation and monitoring by physicians, as well as a multitude of patient-centered applications. They also represent promising tools in the field of clinical research. This report is a review of the importance of using this technology in the management of multiple sclerosis patients.

Howard, Ileana M, Kaufman, Marla S (2018) [Narrative Review] Telehealth applications for outpatients with neuromuscular or musculoskeletal disorders[15]
Telehealth describes the provision of medical services remotely through technology, and may enhance patient access to specialty care services. Although teleneurology has expanded widely since the introduction of telestroke in 1999, telehealth services for outpatients with neuromuscular or musculoskeletal disorders are less widespread. In this narrative review, we will describe the current technology, applications, outcomes, and limitations of this dynamically growing field. Evidence for telehealth applications related to neuromuscular diseases, palliative care, specialized multidisciplinary services, and musculoskeletal care are reviewed. With growing demand for specialized services and finite resources, telehealth provides a promising avenue to promote access to high-quality care, decrease the cost and burden of travel for patients, and with the expansion of software to personal computing and mobile devices, offer flexible, low-overhead practice opportunities for clinicians. Providers embarking on careers in telehealth should be aware of current legal restrictions impacting care to minimize risk and avoid liability.

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[14] Cohen M. Connected health and multiple sclerosis. *Rev Neurol (Paris)*. 2018;1746.:480- 485. doi:10.1016/j.neurol.2018.03.008
[15] Howard IM, Kaufman MS. Telehealth applications for outpatients with neuromuscular or musculoskeletal disorders. *Muscle Nerve*. 2018;584.:475- 485. doi:10.1002/mus.26115

Lavorgna, L et al (2018) [Review] e-Health and multiple sclerosis: An update[16]

e-Health is becoming increasingly relevant in multiple sclerosis (MS) clinical management. We aim to review and discuss current status and future perspective of e-health in people with multiple sclerosis (pwMS). The first part of this review describes how information on MS can be conveyed through the Web and digital media. The second part illustrates recent advances in digital technology that can improve clinical management and in motor and cognitive rehabilitation of pwMS. Finally, this review advocates future development of the digital case manager as a new figure to coordinate clinical management and care of pwMS. The digital revolution is changing the medical approach to MS in terms of information conveying and sharing, rehabilitation, and healthcare management.

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CHAPTER 14
Telemedicine and Care of Older Persons

Systematic Reviews

Sapci, AH, Sapci, HA (2019) [Systematic Review] Innovative Assisted Living Tools, Remote Monitoring Technologies, Artificial Intelligence-Driven Solutions, and Robotic Systems for Aging Societies: Systematic Review[1]

Background: The increase in life expectancy and recent advancements in technology and medical science have changed the way we deliver health services to the aging societies. Evidence suggests that home telemonitoring can significantly decrease the number of readmissions, and continuous monitoring of older adults' daily activities and health-related issues might prevent medical emergencies.

Objective: The primary objective of this review was to identify advances in assistive technology devices for seniors and aging-in-place technology and to determine the level of evidence for research on remote patient monitoring, smart homes, telecare, and artificially intelligent monitoring systems.

Methods: A literature review was conducted using Cumulative Index to Nursing and Allied Health Literature Plus, MEDLINE, EMBASE, Institute of Electrical and Electronics Engineers Xplore, ProQuest Central, Scopus, and Science Direct. Publications related to older people's care, independent living, and novel assistive technologies were included in the study.

Results: A total of 91 publications met the inclusion criteria. In total, four themes emerged from the data: technology acceptance and readiness, novel patient monitoring and smart home technologies, intelligent algorithm and software engineering, and robotics technologies. The results revealed that most studies had poor reference standards without an explicit critical appraisal.

Conclusions: The use of ubiquitous in-home monitoring and smart technologies for aged people's care will increase their independence and the health care services available to them as well as improve frail elderly people's health care outcomes. This review identified four different themes that require different conceptual approaches to solution development. Although the engineering teams were focused on prototype and algorithm development, the medical science teams were concentrated on outcome research. We also identified the need to develop custom technology solutions for different aging societies. The convergence of medicine and informatics could lead to the development of new interdisciplinary research models and new assistive products for the care of older adults.

Peretz, D et al (2018) [Systematic Review] Determining the Cost of Implementing and Operating a Remote Patient Monitoring Programme for the Elderly With Chronic Conditions: A Systematic Review of Economic Evaluations[2]

Introduction: Remote patient monitoring (RPM) in conjunction with home nursing visits is becoming increasingly popular for the follow-up of patients with chronic conditions and evidence exists that it improves patients' health outcomes. Current cost data is reported inconsistently and often gathered from studies of poor methodological quality, making it difficult for decision-makers who consider implementing this service in their organizations. This study reviewed the cost of RPM programmes targeting elderly patients with chronic conditions. Methods: After evaluation against the inclusion and exclusion criteria and appraisal against two criteria which are important for economic evaluations, data from selected studies were extracted and grouped into meaningful cost categories, then adjusted to reflect November 2015 US dollars. Results: In the 13 selected studies, the newly-created cost category 'combined intervention cost' (reflecting equipment purchasing, servicing and monitoring cost) for the various RPM programmes ranged from US$275-US$7963 per patient per year. The three main findings are: 1. RPM programme costs have decreased since 2004 due to cheaper technology; 2. monitoring a single vital sign is likely to be less costly than monitoring multiple vital signs; and 3. programmes targeting hypertension or congestive heart failure are less costly than those targeting respiratory diseases or multiple conditions. Conclusions: This review recommends that

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[2] Peretz D, Arnaert A, Ponzoni NN. Determining the cost of implementing and operating a remote patient monitoring programme for the elderly with chronic conditions: A systematic review of economic evaluations. *J Telemed Telecare*. 2018;241.:13- 21. doi:10.1177/1357633X16669239

future studies present their cost data with more granularity, that grouping of costs should be minimized and that any assumptions, such as amortization, should be made explicit. In addition, studies should compare programmes with similar characteristics in terms of type of conditions, number of vital signs monitored, etc. for more generalizable results.

Karlsen, C et al (2017) [Systematic Review] Experiences of Community-Dwelling Older Adults With the Use of Telecare in Home Care Services: A Qualitative Systematic Review[3]

Background: The aging population will lead to a rise in the number of people with age-related diseases, and increasing demand for home care services. Telecare is seen as a solution to this challenge by promoting aging in place. Nevertheless, there is still a poor understanding of older adults' experiences with the actual use of telecare.

Objective: The aim of this review was to identify and synthesize the best available qualitative evidence of community-dwelling older adults' experience with the use of telecare in home care services.

Inclusion Criteria: This review considered studies that focused on qualitative data, examining older adults' experiences with the use of active and passive technology devices, such as personal alarms and sensor technology, in the context of home care services.

Search Strategy: This review systematically searched the databases Scopus, CINAHL, PsycINFO, and SveMed+ to find both published and unpublished studies in English, Norwegian, Swedish and Danish, from 2005 to 2017.

Methodological Quality: Methodological quality of the included studies was assessed independently by two reviewers using the Joanna Briggs Institute Qualitative Assessment and Review Instrument.

Data Synthesis: Qualitative research findings were pooled using the Joanna Briggs Institute Qualitative Assessment and Review Instrument, and involved aggregation and synthesis of findings.

Results: A total of 118 findings from 11 studies were aggregated into 20 categories. The categories generated seven synthesized findings: 1. Aging in place is desired; however, it may also be related to feeling isolated and lonely. 2. Telecare contributes to safety, security, and aging in place. 3. Privacy is not seen as a problem by most older adults because the technology is intended to help them live safely in their own home. 4. Some

[3] Karlsen C, Ludvigsen MS, Moe CE, Haraldstad K, Thygesen E. Experiences of community-dwelling older adults with the use of telecare in home care services: a qualitative systematic review. *JBI Database System Rev Implement Rep.* 2017;15(12):2913-2980. doi:10.11124/JBISRIR-2017-003345

telecare devices have side effects, especially new technology. Some devices do not work outside the home, thus limiting active aging. 5. Some older adults experience a misfit between technology and needs. They must see the value of a telecare device to use it. 6. Telecare may enforce an identity with negative connotations on older adults, as frail and helpless people. Autonomy is considered important. 7. Lack of understanding can hamper the correct use of telecare. Specific strategies may be needed.

Conclusions: The experiences with the use of telecare are diverse. Findings indicate telecare systems can promote safety and security to age in place that is a wish of many older adults. However, "one size does not fit all"- Telecare systems must fit individual needs, and be supported by service providers to accommodate sustainable use over time.

Miscellaneous

Fudickar, S et al (2020) [Clinical Trial] Validation of the Ambient TUG Chair With Light Barriers and Force Sensors in a Clinical Trial[4]

To initiate appropriate interventions and avoid physical decline, comprehensive measurements are needed to detect functional changes in elderly people at the earliest possible stage. The established Timed UpandGo (TUG) test takes little time and, due to its standardized and easy procedure, can be conducted by elderly people in their own homes without clinical guidance. Therefore, cheap light barriers (LBs) and force sensors (FSs) are well suited ambient sensors that could easily be attached to existing (arm)chairs to measure and report TUG times in order to identify functional decline. We validated the sensitivity of these sensors in a clinical trial with 100 elderlies aged 58-92 years with a mean of 74 (±6.78) years by comparing the sensor-based results with standard TUG measurements using a stopwatch. We further evaluated the accuracy enhancement when calibrating the algorithm via a mixed linear model. With calibration, the LBs achieved a root mean square error (RMSE) of 0.83 s, compared to 1.90 s without, and the FSs achieved 0.90 s compared to 2.12 s without. The suitability of measuring accurate TUG times with each of the ambient sensors and of measuring TUG regularly in the homes of elderly people could be confirmed.

[4] Fudickar S, Kiselev J, Frenken T et al Validation of the ambient TUG chair with light barriers and force sensors in a clinical trial. *Assist Technol.* 2020;321.:1- 8. doi:10.1080/10400435.2018.1446195
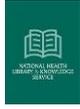
Macis, S et al (2020) [Design and Usability Assessment of a Multi-Device SOA-Based Telecare Framework for the Elderly](#)[5]

Telemonitoring is a branch of telehealth that aims at remotely monitoring vital signs, which is important for chronically ill patients and the elderly living alone. The available standalone devices and applications for the self-monitoring of health parameters largely suffer from interoperability problems; meanwhile, telemonitoring medical devices are expensive, self-contained, and are not integrated into user-friendly technological platforms for the end user. This paper presents the technical aspects and usability assessment of the telemonitoring features of the HEREiAM platform, which supports heterogeneous information technology systems. By exploiting a service-oriented architecture, the measured parameters collected by off-the-shelf Bluetooth medical devices are sent as XML documents to a private cloud that implements an interoperable health service infrastructure, which is compliant with the most recent healthcare standards and security protocols. This Android-based system is designed to be accessible both via TV and portable devices, and includes other utilities designed to support the elderly living alone. Four usability assessment sessions with quality-validated questionnaires were performed to accurately understand the ease of use, usefulness, acceptance, and quality of the proposed system. The results reveal that our system achieved very high usability scores even at its first use, and the scores did not significantly change over time during a field trial that lasted for four months, reinforcing the idea of an intuitive design. At the end of such a trial, the user-experience questionnaire achieved excellent scores in all aspects with respect to the benchmark. Good results were also reported by general practitioners who assessed the quality of their remote interfaces for telemonitoring.

Tun, SYY et al (2020) [Review] [Internet of Things (IoT) Applications for Elderly Care: A Reflective Review](#)[6]

Increasing in elderly population put extra pressure on healthcare systems globally in terms of operational costs and resources. To minimize this pressure and provide efficient healthcare services, the application of the Internet of Things (IoT) and wearable technology could be promising. These

[5] Macis S, Loi D, Ulgheri A et al Design and Usability Assessment of a Multi-Device SOA-Based Telecare Framework for the Elderly. *IEEE J Biomed Health Inform*. 2020;241.:268- 279. doi:10.1109/JBHI.2019.2894552

[6] Tun SYY, Madanian S, Mirza F. Internet of things (IoT) applications for elderly care: a reflective review [published online ahead of print, 2020 Apr 10]. *Aging Clin Exp Res*. 2020;10.1007/s40520-020-01545-9. doi:10.1007/s40520-020-01545-9
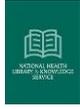
technologies have the potential to improve the quality of life of the elderly population while reducing strain on healthcare systems and minimizing their operational cost. Although IoT and wearable applications for elderly healthcare purposes were reviewed previously, there is a further need to summarize their current applications in this fast-developing area. This paper provides a comprehensive overview of IoT and wearable technologies' applications including the types of data collected and the types of devices for elderly healthcare. This paper provides insights into existing areas of IoT/wearable applications while presenting new research opportunities in emerging areas of applications, such as robotic technology and integrated applications. The analysis in this paper could be useful to healthcare solution designers and developers in defining technology supported futuristic healthcare strategies to serve elderly people and increasing their quality of life.

Ben Hassen, H et al (2019) An E-health System for Monitoring Elderly Health Based on Internet of Things and Fog Computing[7]
With the significant increase in the number of elderly in the world and the resulting health problems of these increasing, finding technical solutions to address this problem has become a pressing necessity, particularly in the field of health care. This paper proposes an e-health system for monitoring elderly health based on the Internet of Things (IoT) and Fog computing. The system was developed using Mysignals HW V2 platform and an Android app that plays the role of Fog server, which enables the collection of physiological parameters and general health parameters from elderly periodically. This Android app enables also the elderly and their families to follow their health, and they can also communicate with health care providers and receive recommendations, notifications and alerts. By evaluating this system, we find the most users they consider useful, easy to use and learn, suggesting that our proposal can improve the quality of health care for elderly.

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[7] Ben Hassen H, Dghais W, Hamdi B. An E-health system for monitoring elderly health based on Internet of Things and Fog computing. *Health Inf Sci Syst*. 2019;71.:24. Published 2019 Oct 24. doi:10.1007/s13755-019-0087-z

Bleda, AL et al (2019) **Enabling Heart Self-Monitoring for All and for AAL-Portable Device Within a Complete Telemedicine System**[8]
During the last decades there has been a rapidly growing elderly population and the number of patients with chronic heart-related diseases has exploded. Many of them (such as those with congestive heart failure or some types of arrhythmias) require close medical supervision, thus imposing a big burden on healthcare costs in most western economies. Specifically, continuous or frequent Arterial Blood Pressure (ABP) and electrocardiogram (ECG) monitoring are important tools in the follow-up of many of these patients. In this work, we present a novel remote non-ambulatory and clinically validated heart self-monitoring system, which allows ABP and ECG monitoring to effectively identify clinically relevant arrhythmias. The system integrates digital transmission of the ECG and tensiometer measurements, within a patient-comfortable support, easy to recharge and with a multi-function software, all of them aiming to adapt for elderly people. The main novelty is that both physiological variables (ABP and ECG) are simultaneously measured in an ambulatory environment, which to our best knowledge is not readily available in the clinical market. Different processing techniques were implemented to analyze the heart rhythm, including pause detection, rhythm alterations and atrial fibrillation, hence allowing early detection of these diseases. Our results achieved clinical quality both for in-lab hardware testing and for ambulatory scenario validations. The proposed active assisted living (AAL) Sensor-based system is an end-to-end multidisciplinary system, fully connected to a platform and tested by the clinical team from beginning to end.

Chkeir, A et al (2019) **In-home Physical Frailty Monitoring: Relevance With Respect to Clinical Tests**[9]
Background: Frailty detection and remote monitoring are of major importance for slowing down, and/or even stopping the frailty process in home-dwelling older people. Taking the Fried's criteria as a reference, this work aims to compare the results produced by a technological set (ARPEGE Pack) with those obtained by usual clinical tests, as well as to discuss the ability of the Pack to be used for long-run frailty remote monitoring.

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[8] Bleda AL, Melgarejo-Meseguer FM, Gimeno-Blanes FJ et al Enabling Heart Self-Monitoring for All and for AAL-Portable Device within a Complete Telemedicine System. *Sensors (Basel)*. 2019;19(18):3969. Published 2019 Sep 14. doi:10.3390/s19183969

[9] Chkeir A, Novella JL, Dramé M, Bera D, Collart M, Duchêne J. In-home physical frailty monitoring: relevance with respect to clinical tests. *BMC Geriatr*. 2019;191.:34. Published 2019 Feb 4. doi:10.1186/s12877-019-1048-8

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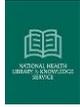
Methods: 194 participants were given a number of geriatric tests and asked to make use of the ARPEGE technological tools as well as reference clinical tools to feed Fried's indicators. Spearman or Pearson's correlation coefficients were used to compare the ARPEGE results to the reference ones, depending on data statistical characteristics.

Results: Good correlations were obtained for measurements of weight (0.99), grip strength (0.89) and walking speed (0.79). Results are much less satisfactory for evaluation of physical activity and exhaustion (Spearman correlation coefficients 0.25 and 0.41, respectively).

Conclusion: Correlations regarding weight, grip strength and walking speed confirm the validity of the data produced by the ARPEGE Pack to feed Fried's criteria. Assessing activity level and exhaustion from an abbreviated questionnaire is still questionable. However, for long-run monitoring other methods of evaluation can be explored. Beyond the quantitative results, the ARPEGE Pack has been proved to be acceptable and motivating in such a long-term frailty monitoring.

Majumder, S, Deen, MJ (2019) [Review] Smartphone Sensors for Health Monitoring and Diagnosis[10]

Over the past few decades, we have witnessed a dramatic rise in life expectancy owing to significant advances in medical science and technology, medicine as well as increased awareness about nutrition, education, and environmental and personal hygiene. Consequently, the elderly population in many countries are expected to rise rapidly in the coming years. A rapidly rising elderly demographics is expected to adversely affect the socioeconomic systems of many nations in terms of costs associated with their healthcare and wellbeing. In addition, diseases related to the cardiovascular system, eye, respiratory system, skin and mental health are widespread globally. However, most of these diseases can be avoided and/or properly managed through continuous monitoring. In order to enable continuous health monitoring as well as to serve growing healthcare needs; affordable, non-invasive and easy-to-use healthcare solutions are critical. The ever-increasing penetration of smartphones, coupled with embedded sensors and modern communication technologies, make it an attractive technology for enabling continuous and remote monitoring of an individual's health and wellbeing with negligible additional costs. In this paper, we present a comprehensive review of the state-of-the-art research and

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[10] Majumder S, Deen MJ. Smartphone Sensors for Health Monitoring and Diagnosis. *Sensors (Basel)*. 2019;19(9):2164. Published 2019 May 9. doi:10.3390/s19092164

developments in smartphone-sensor based healthcare technologies. A discussion on regulatory policies for medical devices and their implications in smartphone-based healthcare systems is presented. Finally, some future research perspectives and concerns regarding smartphone-based healthcare systems are described.

Mardini, MT et al (2019) [Review] A Survey of Healthcare Monitoring Systems for Chronically Ill Patients and Elderly[11]
The demand of healthcare systems for chronically ill patients and elderly has increased in the last few years. This demand is derived by the necessity to allow patients and elderly to be independent in their homes without the help of their relatives or caregivers. The prosperity of the information technology plays an essential role in healthcare by providing continuous monitoring and alerting mechanisms. In this paper, we survey the most recent applications in healthcare monitoring. We organize the applications into categories and present their common architecture. Moreover, we explain the standards used and challenges faced in this field. Finally, we make a comparison between the presented applications and discuss the possible future research paths.

Mulasso, A et al (2019) [Comparative Study] A Comparison Between an ICT Tool and a Traditional Physical Measure for Frailty Evaluation in Older Adults[12]
Background: Frailty is a clinical condition among older adults defined as the loss of resources in one or more domains (ie, physical, psychological and social domains) of individual functioning. In frail subjects, emergency situations and mobility levels need to be carefully monitored. This study aimed to: 1. evaluate differences in the mobility index (MI) provided by ADAMO system, an innovative remote monitoring device for older adults; 2. compare the association of the MI and a traditional physical measure with frailty.
Methods: Twenty-five community-dwelling older adults (71 ± 6 years; 60% women) wore ADAMO continuously for a week. The time percentage spent in Low, Moderate and Vigorous Activities was assessed using ADAMO system.

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[11] Mardini MT, Iraqi Y, Agoulmine N. A Survey of Healthcare Monitoring Systems for Chronically Ill Patients and Elderly. *J Med Syst*. 2019;433.:50. Published 2019 Jan 24. doi:10.1007/s10916-019-1165-0
[12] Mulasso A, Brustio PR, Rainoldi A et al A comparison between an ICT tool and a traditional physical measure for frailty evaluation in older adults. *BMC Geriatr*. 2019;191.:88. Published 2019 Mar 21. doi:10.1186/s12877-019-1089-z

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Walking ability and frailty were measured using the 400 m walk test and the Tilburg Frailty Indicator, respectively.

Results: Controlling for age and gender, the ANCOVA showed that frail and robust participants were different for Low (frail = 58.8%, robust = 42.0%, p < 0.001), Moderate (frail = 25.5%, robust = 33.8%, p = 0.008), and Vigorous Activity (frail = 15.7%, robust = 24.2%, p = 0.035). Using cluster analysis, participants were divided into two groups, one with higher and one with lower mobility. Controlling for age and gender, linear regression showed that the MI clusters were associated with total (β = 0.571, p = 0.002), physical (β = 0.381, p = 0.031) and social (β = 0.652, p < 0.001) frailty; and the 400 m walk test was just associated with total (β = 0.404, p = 0.043) and physical frailty (β = 0.668, p = 0.002).

Conclusion: ADAMO system seems to be a suitable time tracking that allows to measure mobility levels in a non-intrusive way providing wider information on individual health status and specifically on frailty. For the frail individuals with an important loss of resources in physical domain, this innovative device may represent a considerable help in preventing physical consequences and in monitoring functional status.

Zhou, H. et al (2019) [Instrumented Trail-Making Task: Application of Wearable Sensor to Determine Physical Frailty Phenotypes](#)[13]

Background: The physical frailty assessment tools that are currently available are often time consuming to use with limited feasibility.

Objective: To address these limitations, an instrumented trail-making task (iTMT) platform was developed using wearable technology to automate quantification of frailty phenotypes without the need of a frailty walking test.

Methods: Sixty-one older adults (age = 72.8 ± 9.9 years, body mass index [BMI] = 27.4 ± 4.9 kg/m2) were recruited. According to the Fried Frailty Criteria, 39% of participants were determined as robust and 61% as non-robust (pre-frail or frail). In addition, 17 young subjects (age = 29.0 ± 7.2 years, BMI = 26.2 ± 4.6 kg/m2) were recruited to determine the healthy benchmark. The iTMT included reaching 5 indexed circles (including numbers 1-to-3 and letters A and B placed in random orders), which virtually appeared on a computer-screen, by rotating one's ankle-joint while standing. By using an ankle-worn inertial sensor, 3D ankle-rotation was estimated and mapped into navigation of a computer-cursor in real-time (100 Hz), allowing subjects

[13] Zhou H, Razjouyan J, Halder D, Naik AD, Kunik ME, Najafi B. Instrumented Trail-Making Task: Application of Wearable Sensor to Determine Physical Frailty Phenotypes. *Gerontology*. 2019;652.:186- 197. doi:10.1159/000493263

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to navigate the computer-cursor to perform the iTMT. The ankle-sensor was also used for quantifying ankle-rotation velocity (representing slowness), its decline during the test (representing exhaustion), and ankle-velocity variability (representing movement inefficiency), as well as the power (representing weakness) generated during the test. Comparative assessments included Fried frailty phenotypes and gait assessment. Results: All subjects were able to complete the iTMT, with an average completion time of 125 ± 85 s. The iTMT-derived parameters were able to identify the presence and absence of slowness, exhaustion, weakness, and inactivity phenotypes (Cohen's d effect size = 0.90-1.40). The iTMT Velocity was significantly different between groups (d = 0.62-1.47). Significant correlation was observed between the iTMT Velocity and gait speed (r = 0.684 p < 0.001). The iTMT-derived parameters and age together enabled significant distinguishing of non-robust cases with area under curve of 0.834, sensitivity of 83%, and specificity of 67%.
Conclusion: This study demonstrated a non-gait-based wearable platform to objectively quantify frailty phenotypes and determine physical frailty, using a quick and practical test. This platform may address the hurdles of conventional physical frailty phenotypes methods by replacing the conventional frailty walking test with an automated and objective process that reduces the time of assessment and is more practical for those with mobility limitations.

Armstrong, D et al (2018) [Review] Potential Applications of Smart Multifunctional Wearable Materials to Gerontology[14]
Smart multifunctional materials can play a constructive role in addressing some very important aging-related issues. Aging affects the ability of older adults to continue to live safely and economically in their own residences for as long as possible. Thus, there will be a greater need for preventive, acute, rehabilitative, and long-term health care services for older adults as well as a need for tools to enable them to function independently during daily activities. The objective of this paper is, thus, to present a comprehensive review of some potential smart materials and their areas of applications to gerontology. Thus, brief descriptions of various currently available multifunctional smart materials and their possible applications to aging-related problems are presented. It is concluded that some of the most

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[14] Armstrong DG, Najafi B, Shahinpoor M. Potential Applications of Smart Multifunctional Wearable Materials to Gerontology. *Gerontology.* 2017;633.:287- 298. doi:10.1159/000455011

important applications to geriatrics may be in various sensing scenarios to collect health-related feedback or information and provide personalized care. Further described are the applications of wearable technologies to aging-related needs, including devices for home rehabilitation, remote monitoring, social well-being, frailty monitoring, monitoring of diabetes and wound healing and fall detection or prediction. It is also concluded that wearable technologies, when combined with an appropriate application and with appropriate feedback, may help improve activities and functions of older patients with chronic diseases. Finally, it is noted that methods developed to measure what one collectively manages in this population may provide a foundation to establish new definitions of quality of life.

Gokalp, H et al (2018) [Integrated Telehealth and Telecare for Monitoring Frail Elderly With Chronic Disease](#)[15]
Objective: To investigate the potential of an integrated care system that acquires vital clinical signs and habits data to support independent living for elderly people with chronic disease. Materials and Methods: We developed an IEEE 11073 standards-based telemonitoring platform for monitoring vital signs and activity data of elderly living alone in their home. The platform has important features for monitoring the elderly: unobtrusive, simple, elderly-friendly, plug and play interoperable, and self-integration of sensors. Thirty-six (36) patients in a primary care practice in the UK (mean [standard deviation] age, 82 [10] years) with congestive heart failure (CHF) or chronic obstructive pulmonary disease (COPD) were provided with clinical sensors to measure the vital signs for their disease (blood pressure [BP] and weight for CHF, and oxygen saturation for COPD) and one passive infrared (PIR) motion sensor and/or a chair/bed sensor were installed in a patient's home to obtain their activity data. The patients were asked to take one measurement each day of their vital signs in the morning before breakfast. All data were automatically transmitted wirelessly to the remote server and displayed on a clinical portal for clinicians to monitor each patient. An alert algorithm detected outliers in the data and indicated alerts on the portal. Patient data have been analyzed retrospectively following hospital admission, emergency room visit or death, to determine whether the data could predict the event. Results: Data of patients who were monitored for a long period and had interventions were analyzed to identify useful parameters and develop algorithms to define alert rules. Twenty of the 36 participants had a

[15] Gokalp H, de Folter J, Verma V, Fursse J, Jones R, Clarke M. Integrated Telehealth and Telecare for Monitoring Frail Elderly with Chronic Disease. *Telemed J E Health*. 2018;24(12):940-957. doi:10.1089/tmj.2017.0322

clinical referral during the time of monitoring; 16 of them received some type of intervention. The most common reason for intervention was due to low oxygen levels for patients with COPD and high BP levels for CHF. Activity data were found to contain information on the well-being of patients, in particular for those with COPD. During exacerbation the activity level from PIR sensors increased slightly, and there was a decrease in bed occupancy. One subject with CHF who felt unwell spent most of the day in the bedroom. Conclusions: Our results suggest that integrated care monitoring technologies have a potential for providing improved care and can have positive impact on well-being of the elderly by enabling timely intervention. Long-term BP and pulse oximetry data could indicate exacerbation and lead to effective intervention; physical activity data provided important information on the well-being of patients. However, there remains a need for better understanding of long-term variations in vital signs and activity data to establish intervention protocols for improved disease management.

Lhotska, L et al (2018) [Cast Study] Personalized Monitoring and Assistive Systems: Case Study of Efficient Home Solutions[16]

The rapid emergence and proliferation of connected medical devices and their application in healthcare are already part of the Healthcare Internet of Things (IoT) - as this area started to be named. Their true impact on patient care and other aspects of healthcare remains to be seen and is highly dependent on the quality and relevancy of the data acquired. There is also the trend of application of IoT in telemedicine and home care environment. Currently many research groups focus on design and development of various solutions that can assist elderly and handicapped people in their home environment. However, many of these solutions are sophisticated and require advanced users that are able to control the device, handle error states and exceptions. They are frequently using expensive technologies that are good for laboratory environment but they are not affordable for many elderly or handicapped persons. In the paper we will analyze the current situation, present identified needs of elderly population and propose potential solutions. On a case study of efficient home solution of a personalized and assistive system we will show possibilities of technologically simple solutions using off-the-shelf devices and elements.

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[16] Lhotska L, Doležal J, Adolf J, Potůček J, Křížek M, Chbani B. Personalized Monitoring and Assistive Systems: Case Study of Efficient Home Solutions. *Stud Health Technol Inform.* 2018;249:19- 28.

Mukherjee, R et al (2018) [Clinical Trial] A Universal Noninvasive Continuous Blood Pressure Measurement System for Remote Healthcare Monitoring[17]

Background: The effectiveness of any remote healthcare monitoring system depends on how much accurate, patient-friendly, versatile, and cost-effective measurement it is delivering. There has always been a huge demand for such a long-term noninvasive remote blood pressure (BP) measurement system, which could be used worldwide in the remote healthcare industry. Thus, noninvasive continuous BP measurement and remote monitoring have become an emerging area in the remote healthcare industry.

Introduction: Photoplethysmography-based (PPG) BP measurement is a continuous, unobtrusive, patient-friendly, and cost-effective solution. However, BP measurements through PPG sensors are not much reliable and accurate due to some major limitations such as pressure disturbance, motion artifacts, and variations in human skin tone.

Materials and Methods: A novel reflective PPG sensor has been developed to eliminate the abovementioned pressure disturbance and motion artifacts during the BP measurement. Considering the variations of the human skin tone across demography, a novel algorithm has been developed to make the BP measurement accurate and reliable. The training dataset captured 186 subjects' data and the trial dataset captured another new 102 subjects' data.

Results and Discussion: The overall accuracy achieved by using the proposed method is nearly 98%. Thus, demonstrating the efficacy of the proposed method.

Conclusions: The developed BP monitoring system is quite accurate, reliable, cost-effective, handy, and user friendly. It is also expected that this system would be quite useful to monitor the BP of infants, elderly people, patients having wounds, burn injury, or in the intensive care unit environment.

Razjouyan, J et al (2018) [Cohort Study] Wearable Sensors and the Assessment of Frailty Among Vulnerable Older Adults: An Observational Cohort Study[18]

Background: The geriatric syndrome of frailty is one of the greatest challenges facing the U.S. aging population. Frailty in older adults is

[17] Mukherjee R, Ghosh S, Gupta B, Chakravarty T. A Universal Noninvasive Continuous Blood Pressure Measurement System for Remote Healthcare Monitoring. *Telemed J E Health*. 2018;24(10):803- 810. doi:10.1089/tmj.2017.0257

[18] Razjouyan J, Naik AD, Horstman MJ et al Wearable Sensors and the Assessment of Frailty among Vulnerable Older Adults: An Observational Cohort Study. *Sensors (Basel)*. 2018;185.:1336. Published 2018 Apr 26. doi:10.3390/s18051336
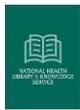
associated with higher adverse outcomes, such as mortality and hospitalization. Identifying precise early indicators of pre-frailty and measures of specific frailty components are of key importance to enable targeted interventions and remediation. We hypothesize that sensor-derived parameters, measured by a pendant accelerometer device in the home setting, are sensitive to identifying pre-frailty. Methods: Using the Fried frailty phenotype criteria, 153 community-dwelling, ambulatory older adults were classified as pre-frail (51%), frail (22%), or non-frail (27%). A pendant sensor was used to monitor the at home physical activity, using a chest acceleration over 48 h. An algorithm was developed to quantify physical activity pattern (PAP), physical activity behavior (PAB), and sleep quality parameters. Statistically significant parameters were selected to discriminate the pre-frail from frail and non-frail adults. Results: The stepping parameters, walking parameters, PAB parameters (sedentary and moderate-to-vigorous activity), and the combined parameters reached and area under the curve of 0.87, 0.85, 0.85, and 0.88, respectively, for identifying pre-frail adults. No sleep parameters discriminated the pre-frail from the rest of the adults. Conclusions: This study demonstrates that a pendant sensor can identify pre-frailty via daily home monitoring. These findings may open new opportunities in order to remotely measure and track frailty via telehealth technologies.

Zhong, R et al (2018) [Application of Smart Bracelet to Monitor Frailty-Related Gait Parameters of Older Chinese Adults: A Preliminary Study](#)[19]
Aim: Smart bracelets are popular today. Based on their built-in motion sensors, they can serve as a cost-effective method of gait assessment in home-based care. Few studies have applied smart bracelets in the gait assessment of older Chinese adults. The present study aimed to: 1. establish reference gait parameters of older Chinese adults using smart bracelets under single and dual task; and 2. explore the differences in gait parameters among non-frail and pre-frail Chinese older adults.
Methods: A total of 50 community-dwelling older Chinese adults aged ≥50 years wore a smart bracelet sensor in the L3 region of the back and underwent a 10-m walking test under single- and dual-task conditions. Participants were preliminarily classified into non-frail and pre-frail groups based on the Fatigue, Resistance, Ambulation, Illnesses and Loss of Weight scale. Gait parameters including average walking speed, step frequency, root

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[19] Zhong R, Rau PP, Yan X. Application of smart bracelet to monitor frailty-related gait parameters of older Chinese adults: A preliminary study. *Geriatr Gerontol Int.* 2018;18(9):1366–1371. doi:10.1111/ggi.13492

mean square (RMS), acceleration amplitude variability, step variability, step regularity and step symmetry were calculated based on the data exported from the bracelet.

Results: Multivariate analysis of covariance (mancova) analysis showed that older adults had significantly decreased speed and step frequency (P < 0.05) under the dual cognitive task condition. Pre-frail older adults showed significantly decreased speed, mediolateral RMS, vertical RMS, anteroposterior RMS, vertical amplitude variability and vertical step regularity compared with non-frail older adults (P < 0.05).

Conclusions: The present study suggested that the decline in gait parameters as a result of frailty could be detected by the smart bracelet sensor.

Deng, YY et al (2017) Internet of Things (IoT) Based Design of a Secure and Lightweight Body Area Network (BAN) Healthcare System[20]

As sensor networks and cloud computation technologies have rapidly developed over recent years, many services and applications integrating these technologies into daily life have come together as an Internet of Things (IoT). At the same time, aging populations have increased the need for expanded and more efficient elderly care services. Fortunately, elderly people can now wear sensing devices which relay data to a personal wireless device, forming a body area network (BAN). These personal wireless devices collect and integrate patients' personal physiological data, and then transmit the data to the backend of the network for related diagnostics. However, a great deal of the information transmitted by such systems is sensitive data, and must therefore be subject to stringent security protocols. Protecting this data from unauthorized access is thus an important issue in IoT-related research. In regard to a cloud healthcare environment, scholars have proposed a secure mechanism to protect sensitive patient information. Their schemes provide a general architecture; however, these previous schemes still have some vulnerability, and thus cannot guarantee complete security. This paper proposes a secure and lightweight body-sensor network based on the Internet of Things for cloud healthcare environments, in order to address the vulnerabilities discovered in previous schemes. The proposed authentication mechanism is applied to a medical reader to provide a more comprehensive architecture while also

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[20] Deng YY, Chen CL, Tsaur WJ, Tang YW, Chen JH. Internet of Things (IoT) Based Design of a Secure and Lightweight Body Area Network (BAN) Healthcare System. *Sensors (Basel)*. 2017;17(12):2919. Published 2017 Dec 15. doi:10.3390/s17122919

providing mutual authentication, and guaranteeing data integrity, user untraceability, and forward and backward secrecy, in addition to being resistant to replay attack.

Diraco, G et al (2017) **A Radar-Based Smart Sensor for Unobtrusive Elderly Monitoring in Ambient Assisted Living Applications**[21]
Continuous in-home monitoring of older adults living alone aims to improve their quality of life and independence, by detecting early signs of illness and functional decline or emergency conditions. To meet requirements for technology acceptance by seniors (unobtrusiveness, non-intrusiveness, and privacy-preservation), this study presents and discusses a new smart sensor system for the detection of abnormalities during daily activities, based on ultra-wideband radar providing rich, not privacy-sensitive, information useful for sensing both cardiorespiratory and body movements, regardless of ambient lighting conditions and physical obstructions (through-wall sensing). The radar sensing is a very promising technology, enabling the measurement of vital signs and body movements at a distance, and thus meeting both requirements of unobtrusiveness and accuracy. In particular, impulse-radio ultra-wideband radar has attracted considerable attention in recent years thanks to many properties that make it useful for assisted living purposes. The proposed sensing system, evaluated in meaningful assisted living scenarios by involving 30 participants, exhibited the ability to detect vital signs, to discriminate among dangerous situations and activities of daily living, and to accommodate individual physical characteristics and habits. The reported results show that vital signs can be detected also while carrying out daily activities or after a fall event (post-fall phase), with accuracy varying according to the level of movements, reaching up to 95% and 91% in detecting respiration and heart rates, respectively. Similarly, good results were achieved in fall detection by using the micro-motion signature and unsupervised learning, with sensitivity and specificity greater than 97% and 90%, respectively.

[21] Diraco G, Leone A, Siciliano P. A Radar-Based Smart Sensor for Unobtrusive Elderly Monitoring in Ambient Assisted Living Applications. *Biosensors (Basel).* 2017;74.:55. Published 2017 Nov 24. doi:10.3390/bios7040055

Haghi, M et al (2017) [Review] Wearable Devices in Medical Internet of Things: Scientific Research and Commercially Available Devices[22]

Objectives: Wearable devices are currently at the heart of just about every discussion related to the Internet of Things. The requirement for self-health monitoring and preventive medicine is increasing due to the projected dramatic increase in the number of elderly people until 2020. Developed technologies are truly able to reduce the overall costs for prevention and monitoring. This is possible by constantly monitoring health indicators in various areas, and in particular, wearable devices are considered to carry this task out. These wearable devices and mobile apps now have been integrated with telemedicine and telehealth efficiently, to structure the medical Internet of Things. This paper reviews wearable health care devices both in scientific papers and commercial efforts.

Methods: MIoT is demonstrated through a defined architecture design, including hardware and software dealing with wearable devices, sensors, smart phones, medical application, and medical station analyzers for further diagnosis and data storage.

Results: Wearables, with the help of improved technology have been developed greatly and are considered reliable tools for long-term health monitoring systems. These are applied in the observation of a large variety of health monitoring indicators in the environment, vital signs, and fitness.

Conclusions: Wearable devices are now used for a wide range of healthcare observation. One of the most important elements essential in data collection is the sensor. During recent years with improvement in semiconductor technology, sensors have made investigation of a full range of parameters closer to realization.

Kumari, P et al (2017) [Review] Increasing Trend of Wearables and Multimodal Interface for Human Activity Monitoring: A Review[23]

Activity recognition technology is one of the most important technologies for life-logging and for the care of elderly persons. Elderly people prefer to live in their own houses, within their own locality. If, they are capable to do so, several benefits can follow in terms of society and economy. However, living alone may have high risks. Wearable sensors have been developed to overcome these risks and these sensors are supposed to be ready for medical uses. It can help in monitoring the wellness of elderly persons living

[22] Haghi M, Thurow K, Stoll R. Wearable Devices in Medical Internet of Things: Scientific Research and Commercially Available Devices. *Healthc Inform Res*. 2017;231.:4-15. doi:10.4258/hir.2017.23.1.4

[23] Kumari P, Mathew L, Syal P. Increasing trend of wearables and multimodal interface for human activity monitoring: A review. *Biosens Bioelectron*. 2017;90:298-307. doi:10.1016/j.bios.2016.12.001

alone by unobtrusively monitoring their daily activities. The study aims to review the increasing trends of wearable devices and need of multimodal recognition for continuous or discontinuous monitoring of human activity, biological signals such as Electroencephalogram (EEG), Electrooculogram (EOG), Electromyogram (EMG), Electrocardiogram (ECG) and parameters along with other symptoms. This can provide necessary assistance in times of ominous need, which is crucial for the advancement of disease-diagnosis and treatment. Shared control architecture with multimodal interface can be used for application in more complex environment where more number of commands is to be used to control with better results in terms of controlling.

Majumder, S et al (2017) [Review] Smart Homes for Elderly Healthcare-Recent Advances and Research Challenges[24]

Advancements in medical science and technology, medicine and public health coupled with increased consciousness about nutrition and environmental and personal hygiene have paved the way for the dramatic increase in life expectancy globally in the past several decades. However, increased life expectancy has given rise to an increasing aging population, thus jeopardizing the socio-economic structure of many countries in terms of costs associated with elderly healthcare and wellbeing. In order to cope with the growing need for elderly healthcare services, it is essential to develop affordable, unobtrusive and easy-to-use healthcare solutions. Smart homes, which incorporate environmental and wearable medical sensors, actuators, and modern communication and information technologies, can enable continuous and remote monitoring of elderly health and wellbeing at a low cost. Smart homes may allow the elderly to stay in their comfortable home environments instead of expensive and limited healthcare facilities. Healthcare personnel can also keep track of the overall health condition of the elderly in real-time and provide feedback and support from distant facilities. In this paper, we have presented a comprehensive review on the state-of-the-art research and development in smart home based remote healthcare technologies.

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[24] Majumder S, Aghayi E, Noferesti M et al Smart Homes for Elderly Healthcare-Recent Advances and Research Challenges. *Sensors (Basel).* 2017;17(11):2496. Published 2017 Oct 31. doi:10.3390/s17112496

Majumder, S et al (2017) Wearable Sensors for Remote Health Monitoring[25]

Life expectancy in most countries has been increasing continually over the several few decades thanks to significant improvements in medicine, public health, as well as personal and environmental hygiene. However, increased life expectancy combined with falling birth rates are expected to engender a large aging demographic in the near future that would impose significant burdens on the socio-economic structure of these countries. Therefore, it is essential to develop cost-effective, easy-to-use systems for the sake of elderly healthcare and well-being. Remote health monitoring, based on non-invasive and wearable sensors, actuators and modern communication and information technologies offers an efficient and cost-effective solution that allows the elderly to continue to live in their comfortable home environment instead of expensive healthcare facilities. These systems will also allow healthcare personnel to monitor important physiological signs of their patients in real time, assess health conditions and provide feedback from distant facilities. In this paper, we have presented and compared several low-cost and non-invasive health and activity monitoring systems that were reported in recent years. A survey on textile-based sensors that can potentially be used in wearable systems is also presented. Finally, compatibility of several communication technologies as well as future perspectives and research challenges in remote monitoring systems will be discussed.

Parvaneh, S et al (2017) Postural Transitions During Activities of Daily Living Could Identify Frailty Status: Application of Wearable Technology to Identify Frailty During Unsupervised Condition[26]

Background: Impairment of physical function is a major indicator of frailty. Functional performance tests have been shown to be useful for identification of frailty in older adults. However, these tests are often not translatable into unsupervised and remote monitoring of frailty status at home and/or community settings.

Objective: In this study, we explored daily postural transition quantified using a chest-worn wearable technology to identify frailty in community-dwelling older adults.

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[25] Majumder S, Mondal T, Deen MJ. Wearable Sensors for Remote Health Monitoring. *Sensors (Basel)*. 2017;171.:130. Published 2017 Jan 12. doi:10.3390/s17010130

[26] Parvaneh S, Mohler J, Toosizadeh N, Grewal GS, Najafi B. Postural Transitions during Activities of Daily Living Could Identify Frailty Status: Application of Wearable Technology to Identify Frailty during Unsupervised Condition. *Gerontology*. 2017;635.:479- 487. doi:10.1159/000460292

Methods: Spontaneous daily physical activity was monitored over 24 h in 120 community-dwelling elderly (age: 78 ± 8 years) using an unobtrusive wearable sensor (PAMSys™, BioSensics LLC, Watertown, MA, USA). Participants were classified as non-frail and pre-frail/frail using Fried's criteria. A validated software package was used to identify body postures and postural transition between each independent postural activity such as sit-to-stand, stand-to-sit, stand-to-walk, and walk-to-stand. The transition from walking to sitting was further classified as quick sitting and cautious sitting based on presence/absence of a standing posture pause between sitting and walking. A general linear model univariate test was used for between-group comparison. Pearson's correlation was used to determine the association between sensor-derived parameters and age. Logistic regression model was used to identify independent predictors of frailty. Results: According to Fried's criteria, 63% of participants were pre-frail/frail. The total number of postural transitions, stand-to-walk, and walk-to-stand were, respectively, 25.2, 30.2, and 30.6% lower in the pre-frail/frail group when compared to the non-frail group (p < 0.05, Cohen's d = 0.73-0.79). Furthermore, the ratio of cautious sitting was significantly higher by 6.2% in pre-frail/frail compared to non-frail (p = 0.025, Cohen's d = 0.22). Total number of postural transitions and the ratio of cautious sitting also showed significant negative and positive correlations with age, respectively (r = -0.51 and 0.29, p < 0.05). After applying a logistic regression model, among tested parameters, walk-to-stand (odds ratio [OR] = 0.997 p = 0.013), quick sitting (OR = 1.036, p = 0.05), and age (OR = 1.073, p = 0.016) were recognized as independent variables to identify frailty status.

Conclusions: This study demonstrated that daily number of specific postural transitions such as walk-to-stand and quick sitting could be used for monitoring frailty status by unsupervised monitoring of daily physical activity. Further study is warranted to explore whether tracking the daily number of specific postural transitions is also sensitive to track change in the status of frailty over time.

Lai, YL et al (2015) An Intelligent Health Monitoring System Using Radio-Frequency Identification Technology[27]
Long-term care (LTC) for the elderly has become extremely important in recent years. It is necessary for the different physiological monitoring

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[27] Lai YL, Chen CL, Chang CH et al An intelligent health monitoring system using radio-frequency identification technology. *Technol Health Care*. 2015;24 Suppl 1:S421- S431. doi:10.3233/THC-151109

systems to be integrated on the same interface to help oversee and manage the elderly's needs. This paper presents a novel health monitoring system for LTC services using radio-frequency identification (RFID) technology. Dual-band RFID protocols were included in the system, in which the high-frequency (HF) band of 13.56 MHz was used to identify individuals and the microwave band of 2.45 GHz was used to monitor physiological information. Distinct physiological data, including oxyhemoglobin saturation by pulse oximetry (SpO2), blood pressure, blood sugar, electrocardiogram (ECG) readings, body temperature, and respiration rate, were monitored by various biosensors. The intelligent RFID health monitoring system provided the features of the real-time acquisition of biomedical signals and the identification of personal information pertaining to the elderly and patients in nursing homes.

Peetom, KK et al (2015) [Review] Literature Review on Monitoring Technologies and Their Outcomes in Independently Living Elderly People[28]

Purpose: To obtain insight into what kind of monitoring technologies exist to monitor activity in-home, what the characteristics and aims of applying these technologies are, what kind of research has been conducted on their effects and what kind of outcomes are reported.

Methods: A systematic document search was conducted within the scientific databases Pubmed, Embase, Cochrane, PsycINFO and Cinahl, complemented by Google Scholar. Documents were included in this review if they reported on monitoring technologies that detect activities of daily living (ADL) or significant events, eg falls, of elderly people in-home, with the aim of prolonging independent living.

Results: Five main types of monitoring technologies were identified: PIR motion sensors, body-worn sensors, pressure sensors, video monitoring and sound recognition. In addition, multicomponent technologies and smart home technologies were identified. Research into the use of monitoring technologies is widespread, but in its infancy, consisting mainly of small-scale studies and including few longitudinal studies.

Conclusions: Monitoring technology is a promising field, with applications to the long-term care of elderly persons. However, monitoring technologies have to be brought to the next level, with longitudinal studies that evaluate

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[28] Peetoom KK, Lexis MA, Joore M, Dirksen CD, De Witte LP. Literature review on monitoring technologies and their outcomes in independently living elderly people. *Disabil Rehabil Assist Technol*. 2015;104.:271- 294. doi:10.3109/17483107.2014.961179

their (cost-)effectiveness to demonstrate the potential to prolong independent living of elderly persons.

CHAPTER 15
Telemedicine and Ophthalmology

Systematic Reviews

Islam, Md Mohaimenul et al (2020) [Systematic Review and Meta-Analysis] **Deep learning algorithms for detection of diabetic retinopathy in retinal fundus photographs: A systematic review and meta-analysis[1]**
Background: Diabetic retinopathy (DR) is one of the leading causes of blindness globally. Earlier detection and timely treatment of DR are desirable to reduce the incidence and progression of vision loss. Currently, deep learning (DL) approaches have offered better performance in detecting DR from retinal fundus images. We, therefore, performed a systematic review with a meta-analysis of relevant studies to quantify the performance of DL algorithms for detecting DR. Methods: A systematic literature search on EMBASE, PubMed, Google Scholar, Scopus was performed between January 1, 2000, and March 31, 2019. The search strategy was based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guidelines, and DL-based study design was mandatory for articles inclusion. Two independent authors screened abstracts and titles against inclusion and exclusion criteria. Data were extracted by two authors independently using a standard form and the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool was used for the risk of bias and applicability assessment. Results: Twenty-three studies were included in the systematic review; 20 studies met inclusion criteria for the meta-analysis. The pooled area under the receiving operating curve (AUROC) of DR was 0.97 (95%CI: 0.95-0.98), sensitivity was 0.83 (95%CI: 0.83-0.83), and specificity was 0.92 (95%CI: 0.92-0.92). The positive- and negative-likelihood ratio were 14.11 (95%CI: 9.91-20.07), and 0.10 (95%CI: 0.07-0.16), respectively. Moreover, the diagnostic odds ratio for DL models was 136.83 (95%CI: 79.03-236.93). All the studies provided a DR-grading scale, a human grader eg

trained caregivers, ophthalmologists as a reference standard. Conclusion: The findings of our study showed that DL algorithms had high sensitivity and specificity for detecting referable DR from retinal fundus photographs. Applying a DL-based automated tool of assessing DR from color fundus images could provide an alternative solution to reduce misdiagnosis and improve workflow. A DL-based automated tool offers substantial benefits to reduce screening costs, accessibility to healthcare and ameliorate earlier treatments.

Tan, Choon Han et al (2020) [Literature Review and Meta-Analysis] Use of Smartphones to Detect Diabetic Retinopathy: Scoping Review and Meta-Analysis of Diagnostic Test Accuracy Studies[2]
Background: Diabetic retinopathy (DR), a common complication of diabetes mellitus, is the leading cause of impaired vision in adults worldwide. Smartphone ophthalmoscopy involves using a smartphone camera for digital retinal imaging. Utilizing smartphones to detect DR is potentially more affordable, accessible, and easier to use than conventional methods. Objective: This study aimed to determine the diagnostic accuracy of various smartphone ophthalmoscopy approaches for detecting DR in diabetic patients. Methods: We performed an electronic search for literature published from January 2000 to November 2018. We included studies involving diabetic patients, which compared the diagnostic accuracy of smartphone ophthalmoscopy for detecting DR to an accurate or commonly employed reference standard, such as indirect ophthalmoscopy, slit-lamp biomicroscopy, and tabletop fundus photography. Two reviewers independently screened studies against the inclusion criteria, extracted data, and assessed the quality of included studies using the Quality Assessment of Diagnostic Accuracy Studies-2 tool, with disagreements resolved via consensus. Sensitivity and specificity were pooled using the random effects model. A summary receiver operating characteristic (SROC) curve was constructed. This review is reported in line with the Preferred Reporting Items for a Systematic Review and Meta-analysis of Diagnostic Test Accuracy Studies guidelines. Results: In all, nine studies involving 1430 participants were included. Most studies were of high quality, except one study with limited applicability because of its reference standard. The pooled sensitivity and specificity for detecting any DR was 87% (95% CI 74%-94%)

[2] Tan CH, Kyaw BM, Smith H, Tan CS, Tudor Car L. Use of Smartphones to Detect Diabetic Retinopathy: Scoping Review and Meta-Analysis of Diagnostic Test Accuracy Studies. *J Med Internet Res*. 2020;22.5.:e16658. Published 2020 May 15. doi:10.2196/16658

and 94% (95% CI 81%-98%); mild nonproliferative DR (NPDR) was 39% (95% CI 10%-79%) and 95% (95% CI 91%-98%); moderate NPDR was 71% (95% CI 57%-81%) and 95% (95% CI 88%-98%); severe NPDR was 80% (95% CI 49%-94%) and 97% (95% CI 88%-99%); proliferative DR (PDR) was 92% (95% CI 79%-97%) and 99% (95% CI 96%-99%); diabetic macular edema was 79% (95% CI 63%-89%) and 93% (95% CI 82%-97%); and referral-warranted DR was 91% (95% CI 86%-94%) and 89% (95% CI 56%-98%). The area under SROC curve ranged from 0.879 to 0.979. The diagnostic odds ratio ranged from 11.3 to 1225. Conclusions: We found heterogeneous evidence showing that smartphone ophthalmoscopy performs well in detecting DR. The diagnostic accuracy for PDR was highest. Future studies should standardize reference criteria and classification criteria and evaluate other available forms of smartphone ophthalmoscopy in primary care settings.

Kawaguchi, Atsushi et al (2018) [Systematic Review and Meta-Analysis]
Tele-Ophthalmology for Age-Related Macular Degeneration and Diabetic Retinopathy Screening: A Systematic Review and Meta-Analysis[3]
Background: To synthesize high-quality evidence to compare traditional in-person screening and tele-ophthalmology screening. Methods: Only randomized controlled trials (RCTs) were included in this systematic review and meta-analysis. The intervention of interest was any type of tele-ophthalmology, including screening of diseases using remote devices. Studies involved patients receiving care from any trained provider via tele-ophthalmology, compared with those receiving equivalent face-to-face care. A search was executed on the following databases: Medline, EMBASE, EBM Reviews, Global Health, EBSCO-CINAHL, SCOPUS, ProQuest Dissertations and Theses Global, OCLC Papers First, and Web of Science Core Collection. Six outcomes of care for age-related macular degeneration (AMD), diabetic retinopathy (DR), or glaucoma were measured and analyzed. Results: Two hundred thirty-seven records were assessed at the full-text level; six RCTs fulfilled inclusion criteria and were included in this review. Four studies involved participants with diabetes mellitus, and two studies examined choroidal neovascularization in AMD. Only data of detection of disease and participation in the screening program were used for the meta-analysis. Tele-ophthalmology had a 14% higher odds to detect disease than traditional examination; however, the result was not statistically significant

[3] Kawaguchi A, Sharafeldin N, Sundaram A et al Tele-Ophthalmology for Age-Related Macular Degeneration and Diabetic Retinopathy Screening: A Systematic Review and Meta-Analysis. *Telemed J E Health*. 2018;244.:301- 308. doi:10.1089/tmj.2017.0100

(n = 2,012, odds ratio: 1.14, 95% confidence interval (CI): 0.52-2.53, p = 0.74). Meta-analysis results show that odds of having DR screening in the tele-ophthalmology group was 13.15 (95% CI: 8.01-21.61; p < 0.001) compared to the traditional screening program. Conclusions: The current evidence suggests that tele-ophthalmology for DR and age-related macular degeneration is as effective as in-person examination and potentially increases patient participation in screening.

Tan, Irene J et al (2017) [Systematic Review] Real-time teleophthalmology versus face-to-face consultation: A systematic review[4]
Advances in imaging capabilities and the evolution of real-time teleophthalmology have the potential to provide increased coverage to areas with limited ophthalmology services. However, there is limited research assessing the diagnostic accuracy of face-to-face teleophthalmology consultation. This systematic review aims to determine if real-time teleophthalmology provides comparable accuracy to face-to-face consultation for the diagnosis of common eye health conditions. A search of PubMed, Embase, Medline and Cochrane databases and manual citation review was conducted on 6 February and 7 April 2016. Included studies involved real-time telemedicine in the field of ophthalmology or optometry, and assessed diagnostic accuracy against gold-standard face-to-face consultation. The revised quality assessment of diagnostic accuracy studies (QUADAS-2) tool assessed risk of bias. Results Twelve studies were included, with participants ranging from four to 89 years old. A broad number of conditions were assessed and include corneal and retinal pathologies, strabismus, oculoplastics and post-operative review. Quality assessment identified a high or unclear risk of bias in patient selection (75%) due to an undisclosed recruitment processes. The index test showed high risk of bias in the included studies, due to the varied interpretation and conduct of real-time teleophthalmology methods. Reference standard risk was overall low (75%), as was the risk due to flow and timing (75%). Conclusion In terms of diagnostic accuracy, real-time teleophthalmology was considered superior to face-to-face consultation in one study and comparable in six studies. Store-and-forward image transmission coupled with real-time videoconferencing is a suitable alternative to overcome poor Internet transmission speeds.

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[4] Tan IJ, Dobson LP, Bartnik S, Muir J, Turner AW. Real-time teleophthalmology versus face-to-face consultation: A systematic review. *J Telemed Telecare*. 2017;237.:629- 638. doi:10.1177/1357633X16660640

Athikarisamy, Sam E et al (2015) [Systematic Review] Screening for retinopathy of prematurity (ROP) using wide-angle digital retinal photography by non-ophthalmologists: a systematic review[5]

Retinopathy of prematurity (ROP) is one of the leading and preventable causes of blindness. The investigation of choice for diagnosing ROP is binocular indirect ophthalmoscope (BIO) done by ophthalmologists. Since the number of ophthalmologists available to do BIO examination is limited, especially in developing countries, there is a need for an alternate, cheap, reliable and feasible test. Telemedicine imaging with Digital Retinal Photography (DRP) is one such alternate diagnostic test which can be performed easily by non-ophthalmologists, with adequate training. Our objective was to conduct a systematic review to evaluate the accuracy of DRP performed by trained personnel [non-ophthalmologists] in diagnosing clinically significant ROP. Medline, EMBASE, CINAHL and Cochrane databases were searched independently by two authors. Eligible studies were assessed using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS)-2, an evidence-based tool for the assessment of quality in systematic reviews of diagnostic accuracy studies. Six were included in the review (three prospective; N=120, three retrospective; N=579). Studies had methodological limitations on QUADAS-2. Because of the heterogeneity of studies, data could not be pooled to derive single-effect size estimates for sensitivity and specificity. The included studies reported sensitivity of 45.5-100% with the majority being more than 90%; specificity 61.7-99.8% with the majority being more than 90%, positive predictive value 61.5-96.6% and negative predictive value of 76.9-100% for diagnosing clinically significant ROP. We conclude that diagnostic accuracy of DRP must be established in prospective studies with adequate sample size where DRP is compared against the simultaneously performed BIO examination.

[5] Athikarisamy SE, Patole S, Lam GC, Dunstan C, Rao S. Screening for retinopathy of prematurity (ROP) using wide-angle digital retinal photography by non-ophthalmologists: a systematic review. *Br J Ophthalmol.* 2015;993.:281- 288. doi:10.1136/bjophthalmol-2014-304984

Shi, Lili et al (2015) [Systematic Review and Meta-Analysis] Telemedicine for detecting diabetic retinopathy: a systematic review and meta-analysis[6]

Objective: To determine the diagnostic accuracy of telemedicine in various clinical levels of diabetic retinopathy (DR) and diabetic macular oedema (DME). Methods: PubMed, EMBASE and Cochrane databases were searched for telemedicine and DR. The methodological quality of included studies was evaluated using the Quality Assessment for Diagnostic Accuracy Studies (QUADAS-2). Measures of sensitivity, specificity and other variables were pooled using a random effects model. Summary receiver operating characteristic curves were used to estimate overall test performance. Meta-regression and subgroup analyses were used to identify sources of heterogeneity. Publication bias was evaluated using Stata V.12.0. Results: Twenty articles involving 1960 participants were included. Pooled sensitivity of telemedicine exceeded 80% in detecting the absence of DR, low- or high-risk proliferative diabetic retinopathy (PDR), it exceeded 70% in detecting mild or moderate non-proliferative diabetic retinopathy (NPDR), DME and clinically significant macular oedema (CSME) and was 53% (95% CI 45% to 62%) in detecting severe NPDR. Pooled specificity of telemedicine exceeded 90%, except in the detection of mild NPDR which reached 89% (95% CI 88% to 91%). Diagnostic accuracy was higher with digital
images obtained through mydriasis than through non-mydriasis, and was highest when a wide angle (100-200°) was used compared with a narrower angle (45-60°, 30° or 35°) in detecting the absence of DR and the presence of mild NPDR. No potential publication bias was detected. Conclusions: The diagnostic accuracy of telemedicine using digital imaging in DR is overall high. It can be used widely for DR screening. Telemedicine based on the digital imaging technique that combines mydriasis with a wide angle field (100-200°) is the best choice in detecting the absence of DR and the presence of mild NPDR.

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[6] Shi L, Wu H, Dong J, Jiang K, Lu X, Shi J. Telemedicine for detecting diabetic retinopathy: a systematic review and meta-analysis. *Br J Ophthalmol.* 2015;996.:823- 831. doi:10.1136/bjophthalmol-2014-305631

Miscellaneous

Abràmoff, Michael D et al (2020) [Literature Review] Automated and Computer-Assisted Detection, Classification, and Diagnosis of Diabetic Retinopathy[7]

Background: The introduction of artificial intelligence (AI) in medicine has raised significant ethical, economic, and scientific controversies. Introduction: Because an explicit goal of AI is to perform processes previously reserved for human clinicians and other health care personnel, there is justified concern about the impact on patient safety, efficacy, equity, and liability. Discussion: Systems for computer-assisted and fully automated detection, triage, and diagnosis of diabetic retinopathy (DR) from retinal images show great variation in design, level of autonomy, and intended use. Moreover, the degree to which these systems have been evaluated and validated is heterogeneous. We use the term DR AI system as a general term for any system that interprets retinal images with at least some degree of autonomy from a human grader. We put forth these standardized descriptors to form a means to categorize systems for computer-assisted and fully automated detection, triage, and diagnosis of DR. The components of the categorization system include level of device autonomy, intended use, level of evidence for diagnostic accuracy, and system design. Conclusion: There is currently minimal empirical basis to assert that certain combinations of autonomy, accuracy, or intended use are better or more appropriate than any other. Therefore, at the current stage of development of this document, we have been descriptive rather than prescriptive, and we treat the different categorizations as independent and organized along multiple axes.

Bilong, Yannick et al (2020) [Pilot Study] Smartphone-Assisted Glaucoma Screening in Patients With Type 2 Diabetes: a Pilot Study[8]

We aimed to determine true and false positives of glaucoma screening, relying solely on photos of the retina, taken with a smartphone. We performed a descriptive and analytical study on patients with type 2 diabetes at the National Obesity Centre, Yaoundé, Cameroon. Participating patients had retinal photography sessions using an iPhone 5s (iOS 10.3.3; Apple, Cupertino, CA) coupled to the Make in India Retinal Camera (MIIRetCam; MIIRetCam Inc., Coimbatore, TN, India). Obtained pictures of the retina were stored and transferred via the Internet to an ophthalmologist to assess glaucoma. Selected patients were then invited to undergo a conventional ophthalmological examination to confirm the diagnosis. A total of 395 patients were screened, 39 (including 20 women) were diagnosed with suspicion of glaucoma based on retinal photos, a prevalence rate of 9.87%. The following signs were found; Cup/Disc ratio (C/D) ≥0.5 in 64.1% (25/39), asymmetric C/D >0.2 in 35.9% (14/39), papillary haemorrhage in 10.2% (4/39) and retinal nerve fibre deficiency in 2.5% (1/39). Only 14 of 39 patients with suspicion of glaucoma were examined, giving a lost-to-follow-up rate of 64.1%. Chronic open-angle glaucoma was confirmed in 8 patients [true positives] and absent in 6 patients [false positives]. The prevalence of smartphone-detected glaucoma and lost-to-follow-up rates were high. So we need to improve this type of screening, with additional tests such as transpalpebral applanation tonometer and the smartphone Frequency Doubling Technique visual field combined with better education of patients to increase their adherence to follow-up.

Brady, Christopher J et al (2020) [Literature Review] Telemedicine for Age-Related Macular Degeneration[9]

Background: As the leading cause of vision loss in the United States, age-related macular degeneration (AMD) would seem to be amenable to interventions that increase access to screening and management services for patients. AMD poses several unique challenges for telemedicine, however. The disease lacks clinical consensus on the effectiveness and cost-effectiveness of screening the general population, and more complex imaging modalities may be required than for what has traditionally been

[8] Bilong Y, Domngang CN, Nwanlih Gimma G et al Smartphone-Assisted Glaucoma Screening in Patients With Type 2 Diabetes: a Pilot Study. *Med Hypothesis Discov Innov Ophthalmol.* 2020;91.:61-65.

[9] Brady CJ, Garg S. Telemedicine for Age-Related Macular Degeneration. *Telemed J E Health.* 2020;26(4):565-568. doi:10.1089/tmj.2020.0011

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used for diabetic retinopathy telehealth systems. Methods: The current literature was reviewed to find clinical trials and expert consensus documents on the state-of-the-art of telemedicine for AMD. Results: A range of feasibility studies have reported success with telemedicine strategies for AMD. Several investigators have reported experience with AMD screening and remote-monitoring systems as well as artificial intelligence applications. Conclusions: There are currently no large-scale telemedicine programs for either screening or managing AMD, but new approaches to screening and managing the condition may allow for expansion of high-quality convenient care for an increasing patient population.

Brady, Christopher J et al (2020) [Literature Review] Telemedicine for Retinopathy of Prematurity[10]

Background: Retinopathy of prematurity (ROP) is a disease of the retinal vasculature that remains a leading cause of childhood blindness worldwide despite improvements in the systemic care of premature newborns. Screening for ROP is effective and cost-effective, but in many areas, access to skilled examiners to conduct dilated examinations is poor. Remote screening with retinal photography is an alternative strategy that may allow for improved ROP care. Methods: The current literature was reviewed to find clinical trials and expert consensus documents on the state-of-the-art of telemedicine for ROP. Results: Several studies have confirmed the utility of telemedicine for ROP. In addition, several clinical studies have reported favorable long-term results. Many investigators have reinforced the need for detailed protocols on image acquisition and image interpretation. Conclusions: Telemedicine for ROP appears to be a viable alternative to live ophthalmoscopic examinations in many circumstances. Standardization and documentation afforded by telemedicine may provide additional benefits to providers and their patients. With continued improvements in image quality and affordability of imaging systems as well as improved automated image interpretation tools anticipated in the near future, telemedicine for ROP is expected to play an expanding role for a uniquely vulnerable patient population.

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[10] Brady CJ, D'Amico S, Campbell JP. Telemedicine for Retinopathy of Prematurity. *Telemed J E Health*. 2020;264.:556- 564. doi:10.1089/tmj.2020.0010

Cai, Sophie et al (2020) [Literature Review] Recent developments in pediatric retina[11]

Purpose: Pediatric retina is an exciting, but also challenging field, where patient age and cooperation can limit ease of diagnosis of a broad range of congenital and acquired diseases, inherited retinal degenerations are mostly untreatable and surgical outcomes can be quite different from those for adults. This review aims to highlight some recent advances and trends that are improving our ability to care for children with retinal conditions. Recent Findings: Studies have demonstrated the feasibility of multimodal imaging even in nonsedated infants, with portable optical coherence tomography (OCT) and OCT angiography in particular offering structural insights into diverse pediatric retinal conditions. Encouraging long-term outcomes of subretinal voretigene neparvovec-rzyl injection for RPE65 mutation-associated Leber congenital amaurosis have inspired research on the optimization of subretinal gene delivery and gene therapy for other inherited retinal degenerations. In retinopathy of prematurity, machine learning and smartphone-based imaging can facilitate screening, and studies have highlighted favorable outcomes from intravitreal anti-vascular endothelial growth factor [anti-VEGF] injections. A nomogram for pediatric pars plana sclerotomy site placement may improve safety in complex surgeries. Summary: Multimodal imaging, gene therapy, machine learning and surgical innovation have been and will continue to be important to advances in pediatric retina.

Cao, Yingpin et al (2020) [Pilot Study] An effectiveness study of a wearable device (Clouclip) intervention in unhealthy visual behaviors among school-age children: A pilot study[12]

Introduction: The study aimed to determine the effectiveness of an intervention for unhealthy visual behaviors of school-age children using a wearable device (Clouclip). Method: The design was a self-controlled prospective study. Clouclip, with the vibration alert disabled, was first applied to measure baseline near-work behaviors in the first week. The vibration alert was then enabled to signal unhealthy visual behaviors (near-work distance < 30 cm and >5 seconds, or near-work distance <60 cm for >45 minutes) for 3 weeks. Near-work behaviors were measured again at the first

[11] Cai S, Therattil A, Vajzovic L. Recent developments in pediatric retina. *Curr Opin Ophthalmol.* 2020;313.:155–160. doi:10.1097/ICU.0000000000000650

[12] Cao Y, Lan W, Wen L et al An effectiveness study of a wearable device (Clouclip) intervention in unhealthy visual behaviors among school-age children: A pilot study. *Medicine (Baltimore).* 2020;992.:e17992. doi:10.1097/MD.0000000000017992

week and the first month after intervention, respectively. The changes in behaviors between the baseline and the first week and the first month after intervention were analyzed. Results: Sixty-seven subjects were eligible for this experiment (the mean age 10.45 ± 0.50 years, 34 boys). Children who logged sufficient wearing time (12.30 ± 0.18 hours on weekdays and 12.16 ± 0.23 hours on weekends) were included for analysis. The average daily near-work distance was significantly increased after the vibration intervention. The time ratio of near-work activity <30 cm to the total <60 cm and the frequency of continuous near-work (distance <60 cm and continuous time >30 minutes) were significantly decreased after the intervention. Although some of the effects were reversed with time following the intervention, some were observed to be maintained until the end of the observation period, and the improvement of the behaviors was more prominent in children who had a shorter near-work distance (<30 cm) at baseline. Conclusions: In conclusion, Clouclip can significantly modify near-work behaviors in school-age children and it can last a certain period of time. If these behaviors are causes of myopia development and progression, Clouclip might provide a strategy for managing myopia.

Chun, Jaehyeong et al (2020) [Validation Study] Deep Learning-Based Prediction of Refractive Error Using Photorefraction Images Captured by a Smartphone: Model Development and Validation Study[13]
Background: Accurately predicting refractive error in children is crucial for detecting amblyopia, which can lead to permanent visual impairment, but is potentially curable if detected early. Various tools have been adopted to more easily screen a large number of patients for amblyopia risk. Objective: For efficient screening, easy access to screening tools and an accurate prediction algorithm are the most important factors. In this study, we developed an automated deep learning-based system to predict the range of refractive error in children (mean age 4.32 years, SD 1.87 years) using 305 eccentric photorefraction images captured with a smartphone. Methods: Photorefraction images were divided into seven classes according to their spherical values as measured by cycloplegic refraction. Results: The trained deep learning model had an overall accuracy of 81.6%, with the following accuracies for each refractive error class: 80.0% for ≤-5.0 diopters (D), 77.8% for >-5.0 D and ≤-3.0 D, 82.0% for >-3.0 D and ≤-0.5 D, 83.3% for >-0.5 D and

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[13] Chun J, Kim Y, Shin KY et al Deep Learning-Based Prediction of Refractive Error Using Photorefraction Images Captured by a Smartphone: Model Development and Validation Study. *JMIR Med Inform*. 2020;85.:e16225. Published 2020 May 5. doi:10.2196/16225
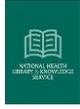
<+0.5 D, 82.8% for ≥+0.5 D and <+3.0 D, 79.3% for ≥+3.0 D and <+5.0 D, and 75.0% for ≥+5.0 D. These results indicate that our deep learning-based system performed sufficiently accurately. Conclusions: This study demonstrated the potential of precise smartphone-based prediction systems for refractive error using deep learning and further yielded a robust collection of pediatric photorefraction images.

Fatehi, F et al (2020) [Literature Review] Teleophthalmology for the elderly population: A review of the literature[14]
Background: Ophthalmology is one of the most requested medical speciality services in the elderly population. Although numerous studies have shown the potentials of telemedicine for the provision of ophthalmology services, the extent of its usability in older adults and the aged population is not clear. The aim of this study was to investigate the characteristics and usability features of teleophthalmology for the elderly population. Method: We searched PubMed, Embase, Scopus and CINAHL for relevant studies since 2008. Forty-five papers met the eligibility criteria and included in this review. We used a multifaceted model to extract the data and analyze findings by cross-tabulation. Results: The majority of the reviewed papers included participants of 65 years of age or older. Most of the studies were conducted in the USA (38 %). Diabetic retinopathy, glaucoma, age-related macular degeneration and cataract were the most researched eye diseases, and among the imaging technologies, retinal photography had been used the most (72 %). The studies showed teleophthalmology can improve access to specialty care, reduce the number of unnecessary visits, alleviate overloads on treatment centers, and provide more comprehensive exams. It also made services cost-saving for stakeholders and cost-effective in rural areas. However, teleophthalmology was not cost-effective for patients above 80 and low-density population areas. Conclusion: Evidence is lacking for the usability and effectiveness of teleophthalmology for the elderly population. The findings suggest that primary care providers in collaboration with ophthalmologists could provide more effective eye care to elderly population. Appropriate training is also necessary for primary care doctors to manage and refer older patients in a timely manner. Diagnostic value and cost-effective imaging modalities which are the core of the teleophthalmology, can be enhanced by image processing techniques and artificial intelligence.

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[14] Fatehi F, Jahedi F, Tay-Kearney ML, Kanagasingam Y. Teleophthalmology for the elderly population: A review of the literature. *Int J Med Inform*. 2020;136:104089. doi:10.1016/j.ijmedinf.2020.104089

Gan, Kenman et al (2020) [Recommendations] Telemedicine for Glaucoma: Guidelines and Recommendations[15]

Background: Glaucoma is the leading cause of irreversible blindness worldwide. Access to glaucoma specialists is challenging and likely to become more difficult as the population ages. Introduction: Using telemedicine for glaucoma has the potential to increase access to glaucoma care by improving efficiency and decreasing the need for long-distance travel for patients. Results: Teleglaucoma programs can be used for screening, diagnostic consultation, and long-term treatment monitoring. Key components of teleglaucoma programs include patient history, equipment, intraocular pressure measurement, pachymetry, anterior chamber imaging/gonioscopy, fundus photography, retinal nerve fiber layer imaging, medical record and imaging software, and skilled personnel. Discussion: Teleglaucoma has tremendous potential to improve patient access to high-quality cost-effective glaucoma care. Conclusions: We have reviewed some special considerations needed to address the complexity of providing guideline-concordant glaucoma care.

Greenwald, Miles F et al (2020) [Evaluation Study] Evaluation of artificial intelligence-based telemedicine screening for retinopathy of prematurity[16]

Retrospective evaluation of a deep learning-derived retinopathy of prematurity (ROP) vascular severity score in an operational ROP screening program demonstrated high diagnostic performance for detection of type 2 or worse ROP. To our knowledge, this is the first report in the literature that evaluated the use of artificial intelligence for ROP screening and represents a proof of concept. With further prospective validation, this technology might improve the accuracy, efficiency, and objectivity of diagnosis and facilitate earlier detection of disease progression in patients with potentially blinding ROP.

[15] Gan K, Liu Y, Stagg B, Rathi S, Pasquale LR, Damji K. Telemedicine for Glaucoma: Guidelines and Recommendations. *Telemed J E Health*. 2020;264.:551- 555. doi:10.1089/tmj.2020.0009

[16] Greenwald MF, Danford ID, Shahrawat M et al Evaluation of artificial intelligence-based telemedicine screening for retinopathy of prematurity [published online ahead of print, 2020 Apr 11]. *J AAPOS*. 2020;S1091-8531(20)30067-7. doi:10.1016/j.jaapos.2020.01.014

Hogarty, Daniel T et al (2020) [Literature Review] Smartphone use in ophthalmology: What is their place in clinical practice?[17]

Smartphones are an increasingly common and rapidly developing tool in clinical practice. Numerous applications or "apps" are available for use on smartphones that aim to help clinicians perform a variety of tasks at the point of care. A large number of ophthalmology-related medical apps that can perform a variety of clinically relevant functions are now available in virtual stores such as the Google Play™ Store or the Apple App Store®. On the ophthalmic front, these include measures of visual acuity, tools to assist in the assessment and treatment of conditions such as amblyopia and glaucoma, as well as add-on devices that allow visualization and photography of the anterior and posterior segments of the eye. Despite the large number of available programs, the evidence supporting their use is unclear, with issues concerning professional input in development, regulation, validation, and security of information. We present the various uses of smartphones in ophthalmology and summarize the current literature.

Horton, Mark B et al (2020) [Practice Guidelines] Practice Guidelines for Ocular Telehealth-Diabetic Retinopathy, Third Edition[18]

Contributors The following document and appendices represent the third edition of the Practice Guidelines for Ocular Telehealth-Diabetic Retinopathy. These guidelines were developed by the Diabetic Retinopathy Telehealth Practice Guidelines Working Group. This working group consisted of a large number of subject matter experts in clinical applications for telehealth in ophthalmology.

Kern, Christoph et al (2020) [Feasibility Study] Implementation of a cloud-based referral platform in ophthalmology: making telemedicine services a reality in eye care[19]

Background: Hospital Eye Services (HES) in the UK face an increasing number of optometric referrals driven by progress in retinal imaging. The National Health Service (NHS) published a 10-year strategy (NHS Long-Term Plan) to transform services to meet this challenge. In this study, we implemented a

[17] Hogarty DT, Hogarty JP, Hewitt AW. Smartphone use in ophthalmology: What is their place in clinical practice?. *Surv Ophthalmol*. 2020;652.:250–262. doi:10.1016/j.survophthal.2019.09.001

[18] Horton MB, Brady CJ, Cavallerano J et al Practice Guidelines for Ocular Telehealth-Diabetic Retinopathy, Third Edition. *Telemed J E Health*. 2020;264.:495–543. doi:10.1089/tmj.2020.0006

[19] Kern C, Fu DJ, Kortuem K et al Implementation of a cloud-based referral platform in ophthalmology: making telemedicine services a reality in eye care. *Br J Ophthalmol*. 2020;1043.:312–317. doi:10.1136/bjophthalmol-2019-314161

cloud-based referral platform to improve communication between optometrists and ophthalmologists. Methods: Retrospective cohort study conducted at Moorfields Eye Hospital, Croydon (NHS Foundation Trust, London, UK). Patients classified into the HES referral pathway by contributing optometrists have been included into this study. Main outcome measures was the reduction of unnecessary referrals. Results: After reviewing the patient's data in a web-based interface 54 (52%) out of 103 attending patients initially classified into the referral pathway did not need a specialist referral. Fourteen (14%) patients needing urgent treatment were identified. Usability was measured in duration for data input and reviewing which was an average of 9.2 min (median: 5.4; IQR: 3.4-8.7) for optometrists and 3.0 min (median: 3.0; IQR: 1.7-3.9) min for ophthalmologists. A variety of diagnosis was covered by this tool with dry age-related macular degeneration (n=34) being most common. Conclusion: After implementation more than half of the HES referrals have been avoided. This platform offers a digital-first solution that enables rapid-access eye care for patients in community optometrists, facilitates communication between healthcare providers and may serve as a foundation for implementation of artificial intelligence.

Keskinbora, Kadircan et al (2020) [Literature Review] Artificial Intelligence and Ophthalmology[20]

Artificial intelligence is advancing rapidly and making its way into all areas of our lives. This review discusses developments and potential practices regarding the use of artificial intelligence in the field of ophthalmology, and the related topic of medical ethics. Various artificial intelligence applications related to the diagnosis of eye diseases were researched in books, journals, search engines, print and social media. Resources were cross-checked to verify the information. Artificial intelligence algorithms, some of which were approved by the US Food and Drug Administration, have been adopted in the field of ophthalmology, especially in diagnostic studies. Studies are being conducted that prove that artificial intelligence algorithms can be used in the field of ophthalmology, especially in diabetic retinopathy, age-related macular degeneration, and retinopathy of prematurity. Some of these algorithms have come to the approval stage. The current point in artificial intelligence studies shows that this technology has advanced considerably and shows promise for future work. It is believed that artificial intelligence

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[20] Keskinbora K, Güven F. Artificial Intelligence and Ophthalmology. *Turk J Ophthalmol.* 2020;501.:37- 43. doi:10.4274/tjo.galenos.2020.78989

applications will be effective in identifying patients with preventable vision loss and directing them to physicians, especially in developing countries where there are fewer trained professionals and physicians are difficult to reach. When we consider the possibility that some future artificial intelligence systems may be candidates for moral/ethical status, certain ethical issues arise. Questions about moral/ethical status are important in some areas of applied ethics. Although it is accepted that current intelligence systems do not have moral/ethical status, it has yet to be determined what the exact the characteristics that confer moral/ethical status are or will be.

Kim, Tyson N et al (2020) [Feasibility Study] [Comparison of automated and expert human grading of diabetic retinopathy using smartphone-based retinal photography](21)

Purpose: The aim of this study is to investigate the efficacy of a mobile platform that combines smartphone-based retinal imaging with automated grading for determining the presence of referral-warranted diabetic retinopathy (RWDR). Methods: A smartphone-based camera (RetinaScope) was used by non-ophthalmic personnel to image the retina of patients with diabetes. Images were analyzed with the Eyenuk EyeArt® system, which generated referral recommendations based on presence of diabetic retinopathy (DR) and/or markers for clinically significant macular oedema. Images were independently evaluated by two masked readers and categorized as refer/no refer. The accuracies of the graders and automated interpretation were determined by comparing results to gold standard clinical diagnoses. Results: A total of 119 eyes from 69 patients were included. RWDR was present in 88 eyes (73.9%) and in 54 patients (78.3%). At the patient-level, automated interpretation had a sensitivity of 87.0% and specificity of 78.6%; grader 1 had a sensitivity of 96.3% and specificity of 42.9%; grader 2 had a sensitivity of 92.5% and specificity of 50.0%. At the eye-level, automated interpretation had a sensitivity of 77.8% and specificity of 71.5%; grader 1 had a sensitivity of 94.0% and specificity of 52.2%; grader 2 had a sensitivity of 89.5% and specificity of 66.9%. Discussion: Retinal photography with RetinaScope combined with automated interpretation by EyeArt achieved a lower sensitivity but higher specificity than trained expert graders. Feasibility testing was performed using non-ophthalmic personnel

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[21] Kim TN, Aaberg MT, Li P et al Comparison of automated and expert human grading of diabetic retinopathy using smartphone-based retinal photography [published online ahead of print, 2020 Apr 27]. *Eye (Lond)*. 2020;10.1038/s41433-020-0849-5. doi:10.1038/s41433-020-0849-5

in a retina clinic with high disease burden. Additional studies are needed to assess efficacy of screening diabetic patients from general population.

Koh, Joel En Wie et al (2020) [Pilot Study] A novel hybrid approach for automated detection of retinal detachment using ultrasound images[22]
Retinal detachment (RD) is an ocular emergency, which needs quick intervention to preclude permanent vision loss. In general, ocular ultrasound is used by ophthalmologists to enhance their judgment in detecting RD in eyes with media opacities which precludes the retinal evaluation. However, the quality of ultrasound (US) images may be degraded due to the presence of noise, and other retinal conditions may cause membranous echoes. All these can influence the accuracy of diagnosis. Hence, to overcome the above, we are proposing an automated system to detect RD using texton, higher order spectral (HOS) cumulants and locality sensitive discriminant analysis (LSDA) techniques. Our developed method is able to classify the posterior vitreous detachment and RD using support vector machine classifier with highest accuracy of 99.13%. Our system is ready to be tested with more diverse ultrasound images and aid ophthalmologists to arrive at a more accurate diagnosis.

Lam, Alexander et al (2020) Use of Virtual Reality Simulation to Identify Vision-Related Disability in Patients With Glaucoma[23]
Importance: Clinical assessment of vision-related disability is hampered by the lack of instruments to assess visual performance in real-world situations. Interactive virtual reality (VR) environments displayed in a binocular stereoscopic VR headset have been designed, presumably simulating day-to-day activities to evaluate vision-related disability. Objective: To investigate the application of VR to identify vision-related disability in patients with glaucoma. Design, Setting, and Participants: In a cross-sectional study, 98 patients with glaucoma and 50 healthy individuals were consecutively recruited from a university eye clinic; all participants were Chinese. The study was conducted between August 30, 2016, and July 31, 2017; data analysis was performed from December 1, 2017, to October 30, 2018. Exposures: Measurements of visual acuity, contrast sensitivity, visual field (VF), National Eye Institute 25-item Visual Function Questionnaire Rasch

[22] Koh JEW, Raghavendra U, Gudigar A et al A novel hybrid approach for automated detection of retinal detachment using ultrasound images. *Comput Biol Med.* 2020;120:103704. doi:10.1016/j.compbiomed.2020.103704
[23] Lam AKN, To E, Weinreb RN et al Use of Virtual Reality Simulation to Identify Vision-Related Disability in Patients With Glaucoma [published online ahead of print, 2020 Mar 19]. *JAMA Ophthalmol.* 2020;1385.:490- 498. doi:10.1001/jamaophthalmol.2020.0392
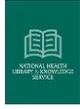
score, and VR disability scores determined from 5 VR simulations: supermarket shopping, stair and city navigations in daytime, and stair and city navigations in nighttime. Duration required to complete the simulation, number of items incorrectly identified, and number of collisions were measured to compute task-specific and overall VR disability scores. Vision-related disability was identified when the VR disability score was outside the normal age-adjusted 95% confidence region. Main Outcomes and Measures: Virtual reality disability score. Results: In the 98 patients with glaucoma, mean (SD) age was 49.8 (11.6) years and 60 were men (61.2%); in the 50 healthy individuals, mean (SD) age was 48.3 (14.8) years and 16 were men (32.0%). The patients with glaucoma had different degrees of VF loss (122 eyes [62.2%] had moderate or advanced VF defects). The time required to complete the activities by patients with glaucoma vs healthy individuals was longer by 15.2 seconds (95% CI, 5.5-24.9 seconds) or 34.1% (95% CI, 12.4%-55.7%) for the shopping simulation, 72.8 seconds (95% CI, 23.0-122.6 seconds) or 33.8% (95% CI, 10.7%-56.9%) for the nighttime stair navigation, and 38.1 seconds (95% CI, 10.9-65.2 seconds) or 30.8% (95% CI, 8.8%-52.8%) for the nighttime city navigation. The mean (SD) duration was not significantly different between the glaucoma and healthy groups in daytime stair (203.7 [93.7] vs 192.9 [89.1] seconds, $P = .52$) and city (118.7 [41.5] vs 117.0 [52.3] seconds, $P = .85$) navigation. For each decibel decrease in binocular VF sensitivity, the risk of collision increased by 15% in nighttime stair (hazard ratio [HR], 1.15; 95% CI, 1.08-1.22) and city (HR, 1.15; 95% CI, 1.08-1.23) navigations. Fifty-eight patients (59.1%) with glaucoma had vision-related disability in at least 1 simulated daily task; a higher proportion of patients had vision-related disability in nighttime city (27 of 88 [30.7%]) and stair (27 of 90 [30.0%]) navigation than in daytime city (7 of 88 [8.0%]) and stair (19 of 96 [19.8%]) navigation. The overall VR disability score was associated with the National Eye Institute 25-item Visual Function Questionnaire Rasch score (R2 = 0.207). Conclusions and Relevance: These findings suggest that vision-related disability is associated with lighting condition and task in patients with glaucoma. Virtual reality may allow eye care professionals to understand the patients' perspectives on how visual impairment imparts disability in daily living and provide a new paradigm to augment the assessment of vision-related disability.

Lanzetta, Paolo et al (2020) [Recommendations] Fundamental principles of an effective diabetic retinopathy screening program[24]

Background: Diabetic retinopathy (DR) is the leading cause of blindness among working-age adults worldwide. Early detection and treatment are necessary to forestall vision loss from DR. Methods: A working group of ophthalmic and diabetes experts was established to develop a consensus on the key principles of an effective DR screening program. Recommendations are based on analysis of a structured literature review. Results: The recommendations for implementing an effective DR screening program are: 1. examination methods must be suitable for the screening region, and DR classification/grading systems must be systematic and uniformly applied. Two-field retinal imaging is sufficient for DR screening and is preferable to seven-field imaging, and referable DR should be well defined and reliably identifiable by qualified screening staff; 2. in many countries/regions, screening can and should take place outside the ophthalmology clinic; 3. screening staff should be accredited and show evidence of ongoing training; 4. screening programs should adhere to relevant national quality assurance standards; 5. studies that use uniform definitions of risk to determine optimum risk-based screening intervals are required; 6. technology infrastructure should be in place to ensure that high-quality images can be stored securely to protect patient information; 7. although screening for diabetic macular edema (DME) in conjunction with DR evaluations may have merit, there is currently insufficient evidence to support implementation of programs solely for DME screening. Conclusion: Use of these recommendations may yield more effective DR screening programs that reduce the risk of vision loss worldwide.

Maa, April Y et al (2020) [Evaluation Study] Diagnostic Accuracy of Technology-based Eye Care Services: The Technology-based Eye Care Services Compare Trial Part I[25]

Purpose: Ophthalmologic telemedicine has the ability to provide eye care for patients remotely, and many countries have used screening tele-

[24] Lanzetta P, Sarao V, Scanlon PH et al Fundamental principles of an effective diabetic retinopathy screening program [published online ahead of print, 2020 Mar 28] [published correction appears in Acta Diabetol. 2020 May 18;;]. *Acta Diabetol.* 2020;10.1007/s00592-020-01506-8. doi:10.1007/s00592-020-01506-8

[25] Maa AY, Medert CM, Lu X et al Diagnostic Accuracy of Technology-based Eye Care Services: The Technology-based Eye Care Services Compare Trial Part I. *Ophthalmology.* 2020;1271.:38- 44. doi:10.1016/j.ophtha.2019.07.026
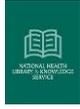
ophthalmology programs for several years. One such initiative at the Veterans Affairs (VA) Healthcare System is Technology-based Eye Care Services (TECS). The TECS services are located in primary care clinics and provide basic screening eye care, including vision, refraction, and retinal photography. Eye care providers ('readers') review the clinical data and recommend appropriate follow-up. One of the most common referrals from TECS has been for glaucoma, and this study was powered for glaucoma/glaucoma suspect detection. The current study was undertaken to identify aspects of the protocol that could be refined to enhance accuracy. Design: Prospective comparison between the standard TECS protocol versus a face-to-face (FTF) examination on 256 patients, all of whom had no known history of significant ocular disease. Participants: Patients with no known ocular disease who were scheduled for an in-person eye appointment at the Atlanta VA. Patients underwent screening through the TECS protocol and received an FTF examination on the same day [gold standard]. The TECS readers were masked to the results of the FTF examination. Main Outcome Measures: Percent agreement, kappa, sensitivity, and specificity were calculated for the TECS readers' interpretations versus the FTF examination. Results: The TECS readers showed substantial agreement for cataract ($\kappa \geq 0.71$) and diabetic retinopathy ($\kappa \geq 0.61$) and moderate to substantial agreement for glaucoma/glaucoma suspect ($\kappa \geq 0.52$) compared with an FTF examination. Age-related macular degeneration (AMD) showed moderate agreement ($\kappa \geq 0.34$). Percent agreement with the TECS protocol was high (84.3%-98.4%) for each of the disease categories. Overall sensitivity and specificity were $\geq 75\%$ and $\geq 55\%$, respectively, for any diagnosis resulting in referral. Inter-reader and intra-reader agreement was substantial for most diagnoses ($\kappa > 0.61$) with percent agreements ranging from 66% to 99%. Conclusions: Our results indicate that the standard TECS protocol is accurate when compared with an FTF examination for the detection of common eye diseases. The inclusion of additional testing such as OCT could further enhance diagnostic capability.

Maa, April Y et al (2020) [Evaluation Study] The Impact of OCT on Diagnostic Accuracy of the Technology-Based Eye Care Services Protocol: Part II of the Technology-Based Eye Care Services Compare Trial[26]

Purpose: Ophthalmologic telemedicine programs help to address the growing demand for eye care and lessen healthcare disparities for patients. One example is Technology-Based Eye Care Services (TECS), implemented in the Veteran Affairs Healthcare System in 2015. Accuracy and quality data for TECS both have been reported, and data suggest that although the TECS examination is comparable with an in-person examination, sensitivity for glaucoma and glaucoma suspect detection is less than that for other diseases, such as macular degeneration. Several articles suggest that OCT can improve disease detection for glaucoma. Therefore, this study was undertaken to test the impact of OCT on the accuracy of the TECS protocol. This article reports the data from part II of the TECS Compare trial; results from part I are discussed in a previous article. Design: Prospective comparison between the TECS protocol with OCT versus a face-to-face (FTF) examination for 256 patients. Participants: An eligible patient was defined as a patient with no known ocular disease who desired a routine eye examination. Methods: Patient underwent the TECS protocol workup and OCT nerve, OCT macula, and FTF examination on the same day. Main Outcome Measures: Percent agreement, κ values, sensitivity, and specificity were calculated for nonexpert readers after OCT interpretation of the TECS protocol using the FTF examination as the clinical gold standard. Results: OCT did not improve the diagnostic accuracy of the TECS protocol when compared with an FTF examination. In most cases, OCT had no impact, and in the case of reader 2, OCT actually reduced the κ value from moderate agreement to agreement equal to chance while lowering the percent agreement by 10%. OCT also did not impact inter- or intrareader variability parameters. Conclusions: In this study, OCT did not seem to improve the accuracy of glaucoma or retinal disease detection when added to the standard TECS protocol. In one case, OCT worsened the agreement of the reader compared with the FTF. Further study is necessary to confirm these findings, and results may change if the readers are glaucoma or retina specialists instead of nonexpert OCT readers, comprehensive and anterior segment specialists.

[26] Maa AY, McCord S, Lu X et al The Impact of OCT on Diagnostic Accuracy of the Technology-Based Eye Care Services Protocol: Part II of the Technology-Based Eye Care Services Compare Trial. *Ophthalmology*. 2020;1274.:544– 549. doi:10.1016/j.ophtha.2019.10.025

Odden, Jamie L et al (2020) [Evaluation Study] Telemedicine in long-term care of glaucoma patients[27]

Introduction This manuscript describes data from an original study, simulating a tele-glaucoma programme in an established clinic practice with an interdisciplinary team. This is a 'real life' trial of a telemedicine approach to see a follow-up patient. The goal is to evaluate the accuracy of such a programme to detect worsening and/or unstable disease. Such a programme is attractive since in-clinic time could be reduced for both the patient and provider. This study evaluates agreement between in-person and remote assessment of glaucoma progression. Methods A total of 200 adult glaucoma patients were enrolled at a single institution. The in-person assessment by an optometrist or glaucoma specialist at time of enrolment was used as the gold standard for defining progression. Collated clinical data were then reviewed by four masked providers who classified glaucoma as progression or non-progression in each eye by comparing data from enrolment visit to data from the visit immediately prior to enrolment. Agreement of glaucoma progression between the masked observer and the in-person assessment was determined using Kappa statistics. Intra-observer agreement was calculated using Kappa to compare in-person to remote assessment when both assessments were performed by the same provider (n = 279 eyes). Results A total of 399 eyes in 200 subjects were analysed. Agreement between in-person versus remote assessment for the determination of glaucoma progression was 63%, 62%, 69% and 68% for each reader 1–4 (kappa values = 0.19, 0.20, 0.35 and 0.33, respectively). For intra-observer agreement, reader 1 agreed with their own in-person assessment for 65% of visits (kappa = 0.18). Discussion Intra-observer agreement was similar to the agreement for each provider who did not see the patient in person. This similarity suggests that telemedicine may be equally effective at identifying glaucomatous disease progression, regardless of whether the same provider performed both in-clinic and remote assessments. However, fair agreement levels highlight a limitation of using only telemedicine data to determine progression compared with clinical detail available during in-patient assessment.

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[27] Odden JL, Khanna CL, Choo CM et al Telemedicine in long-term care of glaucoma patients. *J Telemed Telecare*. 2020;26(1-2):92- 99. doi:10.1177/1357633X18797175

Pueyo, Victoria et al (2020) [Evaluation Study] Development of a system based on artificial intelligence to identify visual problems in children: study protocol of the TrackAI project[28]

Introduction: Around 70% to 80% of the 19 million visually disabled children in the world are due to a preventable or curable disease, if detected early enough. Vision screening in childhood is an evidence-based and cost-effective way to detect visual disorders. However, current screening programmes face several limitations: training required to perform them efficiently, lack of accurate screening tools and poor collaboration from young children. Some of these limitations can be overcome by new digital tools. Implementing a system based on artificial intelligence systems avoid the challenge of interpreting visual outcomes. The objective of the TrackAI Project is to develop a system to identify children with visual disorders. The system will have two main components: a novel visual test implemented in a digital device, DIVE (Device for an Integral Visual Examination); and artificial intelligence algorithms that will run on a smartphone to analyse automatically the visual data gathered by DIVE. Methods and Analysis: This is a multicentre study, with at least five centres located in five geographically diverse study sites participating in the recruitment, covering Europe, USA and Asia.The study will include children aged between 6 months and 14 years, both with normal or abnormal visual development. The project will be divided in two consecutive phases: design and training of an artificial intelligence (AI) algorithm to identify visual problems, and system development and validation. The study protocol will consist of a comprehensive ophthalmological examination, performed by an experienced paediatric ophthalmologist, and an exam of the visual function using a DIVE.For the first part of the study, diagnostic labels will be given to each DIVE exam to train the neural network. For the validation, diagnosis provided by ophthalmologists will be compared with AI system outcomes. Ethics and Dissemination: The study will be conducted in accordance with the principles of Good Clinical Practice. This protocol was approved by the Clinical Research Ethics Committee of Aragón, CEICA, on January 2019 [Code PI18/346]. Results will be published in peer-reviewed journals and disseminated in scientific meetings.

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[28] Pueyo V, Pérez-Roche T, Prieto E et al Development of a system based on artificial intelligence to identify visual problems in children: study protocol of the TrackAI project. *BMJ Open*. 2020;102.:e033139. Published 2020 Feb 17. doi:10.1136/bmjopen-2019-033139

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Strul, Sasha et al (2020) [Evaluation Study] Pediatric diabetic retinopathy telescreening[29]

Purpose: To describe the role of telemedicine screening for pediatric diabetic retinopathy (DR) and to identify risk factors for pediatric DR. Methods: The medical records of a telemedicine program at a tertiary, academic medical center over 17 months were reviewed retrospectively. Patients visiting an academic pediatric endocrinology clinic who met guidelines underwent telescreening. Presence of pediatric DR and risk factors for retinopathy were evaluated. Results: The fundus photographs of 852 patients 10-23 years of age were reviewed. Diabetic retinopathy was noted in 51 (6%). Patients with an abnormal screening photograph were compared to patients with diabetes who had normal screening photographs (n = 64). Older age, longer diabetes duration, type 1 diabetes, and higher average glycated hemoglobin (HbA1c) from the year prior to the photograph were associated with increased risk of retinopathy. Of these, longer duration (P = 0.003) and higher average A1c (P = 0.02) were significant after adjusting for sex, race, and age. Conclusions: Our telemedicine program found a higher percentage of diabetic retinopathy screening non-mydriatic photographs than prior studies found through standard ophthalmic examinations. In this relatively small sample size, longer duration of disease and higher average A1c were associated with increased risk of having diabetic retinopathy in our study.

Tan, Nicholas Y. Q et al (2020) [Literature Review] Glaucoma screening: where are we and where do we need to go?[30]

Purpose: Current recommendations for glaucoma screening are decidedly neutral. No studies have yet documented improved long-term outcomes for individuals who undergo glaucoma screening versus those who do not. Given the long duration that would be required to detect a benefit, future studies that may answer this question definitively are unlikely. Nevertheless, advances in artificial intelligence and telemedicine will lead to more effective screening at lower cost. With these new technologies, additional research is needed to determine the costs and benefits of screening for glaucoma. Recent Findings: Using optic disc photographs and/or optical coherence tomography, deep learning systems appear capable of diagnosing glaucoma

[29] Strul S, Zheng Y, Gangaputra S et al Pediatric diabetic retinopathy telescreening. *JAAPOS*. 2020;241.:10.e1-10.e5. doi:10.1016/j.jaapos.2019.10.010

[30] Tan NYQ, Friedman DS, Stalmans I, Ahmed IIK, Sng CCA. Glaucoma screening: where are we and where do we need to go?. *Curr Opin Ophthalmol*. 2020;312.:91-100. doi:10.1097/ICU.0000000000000649

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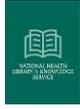
more accurately than human graders. Eliminating the need for expert graders along with better technologies for remote imaging of the ocular fundus will allow for less expensive screening, which could enable screening of individuals with otherwise limited healthcare access. In India and China, where most glaucoma remains undiagnosed, glaucoma screening was recently found to be cost-effective. Summary: Recent advances in artificial intelligence and telemedicine have the potential to increase the accuracy, reduce the costs, and extend the reach of screening. Further research into implementing these technologies in glaucoma screening is required.

Wang, Linyan et al (2020) [Evaluation Study] [Automated identification of malignancy in whole-slide pathological images: identification of eyelid malignant melanoma in gigapixel pathological slides using deep learning](#)[31]

Background/aims: To develop a deep learning system (DLS) that can automatically detect malignant melanoma (MM) in the eyelid from histopathological sections with colossal information density. Methods: Setting: Double institutional study. Study Population: We retrospectively reviewed 225 230 pathological patches [small section cut from pathologist-labelled area from an HandE image], cut from 155 HandE-stained whole-slide images (WSI). Observation Procedures: Labelled gigapixel pathological WSIs were used to train and test a model designed to assign patch-level classification. Using malignant probability from a convolutional neural network, the patches were embedded back into each WSI to generate a visualisation heatmap and leveraged a random forest model to establish a WSI-level diagnosis. Main Outcome Measure(s): For classification, the area under the receiver operating characteristic curve (AUC), accuracy, sensitivity and specificity were used to evaluate the efficacy of the DLS in detecting MM. Results: For patch diagnosis, the model achieved an AUC of 0.989 (95% CI 0.989 to 0.991), with an accuracy, sensitivity and specificity of 94.9%, 94.7% and 95.3%, respectively. We displayed the lesion area on the WSIs as graded by malignant potential. For WSI, the obtained sensitivity, specificity and accuracy were 100%, 96.5% and 98.2%, respectively, with an AUC of 0.998 (95% CI 0.994 to 1.000). Conclusion: Our DLS, which uses artificial intelligence, can automatically detect MM in histopathological slides and highlight the lesion area on WSIs using a probabilistic heatmap. In addition,

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[31] Wang L, Ding L, Liu Z et al Automated identification of malignancy in whole-slide pathological images: identification of eyelid malignant melanoma in gigapixel pathological slides using deep learning. *Br J Ophthalmol.* 2020;1043.:318- 323. doi:10.1136/bjophthalmol-2018-313706
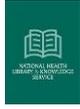
our approach has the potential to be applied to the histopathological sections of other tumour types.

Wang, Sophia Y et al (2020) [Feasibility Study] Automated extraction of ophthalmic surgery outcomes from the electronic health record[32]

Objective: Comprehensive analysis of ophthalmic surgical outcomes is often restricted by limited methodologies for efficiently and accurately extracting clinical information from electronic health record (EHR) systems because much is in free-text form. This study aims to utilize advanced methods to automate extraction of clinical concepts from the EHR free text to study visual acuity (VA), intraocular pressure (IOP), and medication outcomes of cataract and glaucoma surgeries. Methods: Patients who underwent cataract or glaucoma surgery at an academic medical center between 2009 and 2018 were identified by Current Procedural Terminology codes. Rule-based algorithms were developed and used on EHR clinical narrative text to extract intraocular lens (IOL) power and implant type, as well as to create a surgery laterality classifier. MedEx [version 1.3.7] was used on free-text clinical notes to extract information on eye medications and compared to information from medication orders. Random samples of free-text notes were reviewed by two independent masked annotators to assess inter-annotator agreement on outcome variable classification and accuracy of classifiers. VA and IOP were available from semi-structured fields. Results: This study cohort included 6347 unique patients, with 8550 stand-alone cataract surgeries, 451 combined cataract/glaucoma surgeries, and 961 glaucoma surgeries without concurrent cataract surgery. The rule-based laterality classifier achieved 100% accuracy compared to manual review of a sample of operative notes by independent masked annotators. For cataract surgery alone, glaucoma surgery alone, or combined cataract/glaucoma surgeries, our automated extraction algorithm achieved 99-100% accuracy compared to manual annotation of samples of notes from each group, including IOL model and IOL power for cataract surgeries, and glaucoma implant for glaucoma surgeries. For glaucoma medications, there was 90.7% inter-annotator agreement. After adjudication, 85.0% of medications identified by MedEx determined to be correct. Determination of surgical laterality enabled evaluation of pre- and postoperative VA and IOP for operative eyes. Conclusion: This text-processing pipeline can accurately capture surgical laterality and implant model usage from free-text operative

[32] Wang SY, Pershing S, Tran E, Hernandez-Boussard T. Automated extraction of ophthalmic surgery outcomes from the electronic health record. *Int J Med Inform*. 2020;133:104007. doi:10.1016/j.ijmedinf.2019.104007

notes of cataract and glaucoma surgeries, enabling extraction of clinical outcomes including visual acuities, intraocular pressure, and medications from the EHR system. Use of this approach with EHRs to assess ophthalmic surgical outcomes can benefit research groups interested in studying the safety and clinical efficacies of different surgical approaches.

Baxter, Sally L et al (2019) [Evaluation Study] Machine Learning-Based Predictive Modeling of Surgical Intervention in Glaucoma Using Systemic Data From Electronic Health Records[33]

Purpose: To predict the need for surgical intervention in patients with primary open-angle glaucoma (POAG) using systemic data in electronic health records (EHRs). Design: Development and evaluation of machine learning models. Methods: Structured EHR data of 385 POAG patients from a single academic institution were incorporated into models using multivariable logistic regression, random forests, and artificial neural networks. Leave-one-out cross-validation was performed. Mean area under the receiver operating characteristic curve (AUC), sensitivity, specificity, accuracy, and Youden index were calculated for each model to evaluate performance. Systemic variables driving predictions were identified and interpreted. Results: Multivariable logistic regression was most effective at discriminating patients with progressive disease requiring surgery, with an AUC of 0.67. Higher mean systolic blood pressure was associated with significantly increased odds of needing glaucoma surgery (odds ratio [OR] = 1.09, P < .001). Ophthalmic medications (OR = 0.28, P < .001), non-opioid analgesic medications (OR = 0.21, P = .002), anti-hyperlipidemic medications (OR = 0.39, P = .004), macrolide antibiotics (OR = 0.40, P = .03), and calcium blockers (OR = 0.43, P = .03) were associated with decreased odds of needing glaucoma surgery. Conclusions: Existing systemic data in the EHR has some predictive value in identifying POAG patients at risk of progression to surgical intervention, even in the absence of eye-specific data. Blood pressure-related metrics and certain medication classes emerged as predictors of glaucoma progression. This approach provides an opportunity for future development of automated risk prediction within the EHR based on systemic data to assist with clinical decision-making.

[33] Baxter SL, Marks C, Kuo TT, Ohno-Machado L, Weinreb RN. Machine Learning-Based Predictive Modeling of Surgical Intervention in Glaucoma Using Systemic Data From Electronic Health Records. *Am J Ophthalmol.* 2019;208:30- 40. doi:10.1016/j.ajo.2019.07.005

Bodnar, Zachary M et al (2019) [Conference Abstract and Literature Review] Evaluating New Ophthalmic Digital Devices for Safety and Effectiveness in the Context of Rapid Technological Development[34]

Importance: The US Food and Drug Administration's medical device regulatory pathway was initially conceived with hardware devices in mind. The emerging market for ophthalmic digital devices necessitates an evolution of this paradigm. Objectives: To facilitate innovation in ophthalmic digital health with attention to safety and effectiveness. Evidence Review: This article presents a summary of the presentations, discussions, and literature review that occurred during a joint Ophthalmic Digital Health workshop of the American Academy of Ophthalmology, the American Academy of Pediatrics, the American Association for Pediatric Ophthalmology and Strabismus, the American Society of Cataract and Refractive Surgery, the American Society of Retina Specialists, the Byers Eye Institute at Stanford and the US Food and Drug Administration. Findings: Criterion standards and expert graders are critically important in the evaluation of automated systems and telemedicine platforms. Training at all levels is important for the safe and effective operation of digital health devices. The risks associated with automation are substantially increased in rapidly progressive diseases. Cybersecurity and patient privacy warrant meticulous attention. Conclusions and Relevance: With appropriate attention to safety and effectiveness, digital health technology could improve screening and treatment of ophthalmic diseases and improve access to care.

Inomata, Takenori et al (2019) [Evaluation Study] Characteristics and Risk Factors Associated With Diagnosed and Undiagnosed Symptomatic Dry Eye Using a Smartphone Application[35]

Importance: The incidence of dry eye disease has increased; the potential for crowdsource data to help identify undiagnosed dry eye in symptomatic individuals remains unknown. Objective: To assess the characteristics and risk factors associated with diagnosed and undiagnosed symptomatic dry eye using the smartphone app DryEyeRhythm. Design, Setting, and Participants: A cross-sectional study using crowdsourced data was conducted including individuals in Japan who downloaded DryEyeRhythm

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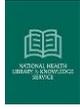
and completed the entire questionnaire; duplicate users were excluded. DryEyeRhythm was released on November 2, 2016; the study was conducted from November 2, 2016, to January 12, 2018. Exposures: DryEyeRhythm data were collected on demographics, medical history, lifestyle, subjective symptoms, and disease-specific symptoms, using the Ocular Surface Disease Index (100-point scale; scores 0-12 indicate normal, healthy eyes; 13-22, mild dry eye; 23-32, moderate dry eye; 33-100, severe dry eye symptoms), and the Zung Self-Rating Depression Scale (total of 20 items, total score ranging from 20-80, with ≥40 highly suggestive of depression). Main Outcomes and Measures: Multivariate-adjusted logistic regression analysis was used to identify risk factors for symptomatic dry eye and to identify risk factors for undiagnosed symptomatic dry eye. Results: A total of 21 394 records were identified in our database; 4454 users, included 899 participants (27.3%) with diagnosed and 2395 participants (72.7%) with undiagnosed symptomatic dry eye, completed all questionnaires and their data were analyzed. A total of 2972 participants (66.7%) were women; mean (SD) age was 27.9 (12.6) years. The identified risk factors for symptomatic vs no symptomatic dry eye included younger age (odds ratio [OR], 0.99; 95% CI, 0.987-0.999, P = .02), female sex (OR, 1.99; 95% CI, 1.61-2.46; P < .001), pollinosis (termed hay fever on the questionnaire) (OR, 1.35; 95% CI, 1.18-1.55; P < .001), depression (OR, 1.78; 95% CI, 1.18-2.69; P = .006), mental illnesses other than depression or schizophrenia (OR, 1.87; 95% CI, 1.24-2.82; P = .003), current contact lens use (OR, 1.27; 95% CI, 1.09-1.48; P = .002), extended screen exposure (OR, 1.55; 95% CI, 1.25-1.91; P < .001), and smoking (OR, 1.65; 95% CI, 1.37-1.98; P < .001). The risk factors for undiagnosed vs diagnosed symptomatic dry eye included younger age (OR, 0.96; 95% CI, 0.95-0.97; P < .001), male sex (OR, 0.55; 95% CI, 0.42-0.72; P < .001), as well as absence of collagen disease (OR, 95% CI, 0.23; 0.09-0.60; P = .003), mental illnesses other than depression or schizophrenia (OR, 0.50; 95% CI, 0.36-0.69; P < .001), ophthalmic surgery other than cataract surgery and laser-assisted in situ keratomileusis (OR, 0.41; 95% CI, 0.27-0.64; P < .001), and current (OR, 0.64; 95% CI, 0.54-0.77; P < .001) or past (OR, 0.45; 95% CI, 0.34-0.58; P < .001) contact lens use. Conclusions and Relevance: This study's findings suggest that crowdsourced research identified individuals with diagnosed and undiagnosed symptomatic dry eye and the associated risk factors. These findings could play a role in earlier prevention or more effective interventions for dry eye disease.

Moss, Heather E et al (2019) [Feasibility Study] Big Data Research in Neuro-Ophthalmology: Promises and Pitfalls[36]

Background: Big data clinical research involves application of large data sets to the study of disease. It is of interest to neuro-ophthalmologists but also may be a challenge because of the relative rarity of many of the diseases treated. Evidence Acquisition: Evidence for this review was gathered from the authors' experiences performing analysis of large data sets and review of the literature. Results: Big data sets are heterogeneous, and include prospective surveys, medical administrative and claims data and registries compiled from medical records. High-quality studies must pay careful attention to aspects of data set selection, including potential bias, and data management issues, such as missing data, variable definition, and statistical modeling to generate appropriate conclusions. There are many studies of neuro-ophthalmic diseases that use big data approaches. Conclusions: Big data clinical research studies complement other research methodologies to advance our understanding of human disease. A rigorous and careful approach to data set selection, data management, data analysis, and data interpretation characterizes high-quality studies.

Patel, Tapan P et al (2019) [Feasibility Study] Smartphone-based fundus photography for screening of plus-disease retinopathy of prematurity[37]

Background: Inadequate screening of treatment-warranted retinopathy of prematurity (ROP) can lead to devastating visual outcomes. Especially in resource-poor communities, the use of an affordable, portable, and easy to use smartphone-based non-contact fundus photography device may prove useful for screening for high-risk ROP. This study evaluates the feasibility of screening for high-risk ROP using a novel smartphone-based fundus photography device, RetinaScope. Methods: Retinal images were obtained using RetinaScope on a cohort of prematurely born infants during routine examinations for ROP. Images were reviewed by two masked graders who determined the image quality, the presence or absence of plus disease, and whether there was retinopathy that met predefined criteria for referral. The agreement between image-based assessments was compared to the gold standard indirect ophthalmoscopic assessment. Results: Fifty-four eyes of 27 infants were included. A wide-field fundus photograph was obtained

[36] Moss HE, Joslin CE, Rubin DS, Roth S. Big Data Research in Neuro-Ophthalmology: Promises and Pitfalls. *J Neuroophthalmol.* 2019;394.:480-486. doi:10.1097/WNO.0000000000000751

[37] Patel TP, Aaberg MT, Paulus YM et al Smartphone-based fundus photography for screening of plus-disease retinopathy of prematurity. *Graefes Arch Clin Exp Ophthalmol.* 2019;257(11):2579-2585. doi:10.1007/s00417-019-04470-4

using RetinaScope. Image quality was acceptable or excellent in 98% and 95% of cases. There was substantial agreement between the gold standard and photographic assessment of presence or absence of plus disease (Cohen's κ = 0.85). Intergrader agreement on the presence of any retinopathy in photographs was also high (κ = 0.92). Conclusions: RetinaScope can capture digital retinal photographs of prematurely born infants with good image quality for grading of plus disease.

Simkin, Samantha K et al (2019) [Evaluation Study] Auckland regional telemedicine retinopathy of prematurity screening network: A 10-year review[38]

Importance: Retinopathy of prematurity (ROP) is a potentially blinding condition affecting the retinae of premature infants. Effective screening is necessary for timely treatment. Background: The Auckland Regional Telemedicine ROP (ART-ROP) network, utilizes wide-field digital imaging for ROP screening. This study reviews the ART-ROP network. Design: Retrospective analysis of the ART-ROP database. Participants: Files of infants in ART-ROP from 2006 to 2015. Methods: Data on infant demographics, ROP stage, treatment and outcome was collected. Main Outcome Measures: The efficacy of ART-ROP in the management of ROP. Results: A review of 1181 infants across three neonatal intensive care units, was completed. Infants had a mean of four screening sessions with no infants who met ROP screening criteria being missed. Type 1 ROP was present in 83 infants, who had significantly lower average birth weight 786 ± 191 g compared to 1077 ± 285 g (P < .001), and gestational age 25.3 ± 1.7 weeks compared to 27.8 ± 2.2 weeks (P < .001) than the screened cohort. The number of infants requiring screening increased (R^2 = .7993), yet treatment rates decreased (R^2 = .9205) across the time period. Out-patient clinic follow-up was attended by 75.10% of infants screened and there was no missed ROP in those infants seen. Conclusions and Relevance: ART-ROP solely uses wide-field digital imaging for ROP diagnosis, and management, including discharge, of infants. This detailed review of ART-ROP indicates an increase in screening demand, but a decrease in the rate of type 1 ROP. The ART-ROP telemedicine model demonstrates real potential to address workforce shortage in ROP screening.

[38] Simkin SK, Misra SL, Han JV, McGhee CNJ, Dai S. Auckland regional telemedicine retinopathy of prematurity screening network: A 10-year review. *Clin Exp Ophthalmol.* 2019;47(9):1122-1130. doi:10.1111/ceo.13593

Starr, Matthew R et al (2019) [Evaluation Study] Telemedicine in the Management of Exudative Age-Related Macular Degeneration within an Integrated health care System[39]

Purpose: To investigate the outcomes of patients with exudative age-related macular degeneration (AMD) treated with intravitreal antivascular endothelial growth factors (VEGF) using a telemedicine system. Design: Interventional case series. Methods: This study examined all patients with exudative AMD who were receiving intravitreal anti-VEGF injections from September 1, 2015, through August 31, 2017, using electronic consultations at a single academic center and health system. Patients were managed initially by a retinal specialist and then allowed to receive further care with their local ophthalmologist. There were 200 electronic consultations placed during this time period for 83 eyes of 59 patients. Data collected included the retina specialist's recommendations: intravitreal agent, interval between injections, number of injections, and when the patient was to follow-up. All occurrences of recommendations that were not completed were reported. Results: The mean age of the patients at the time of electronic consultations was 82.3 ± 7.3 years with a mean follow-up time of 2.4 ± 0.81 years. The mean distance from the home of the patient to the retina specialist was 70 ± 44 miles. There were 14 consultations (7.1%) that did not comply with the recommendations of the retina specialist. Most of these were due to other medical comorbidities leading to missed appointments or scheduling errors. Conclusions: In an integrated health care setting, 59 patients with exudative AMD were identified who were able to be effectively managed using a telemedicine system. In the appropriate setting, telemedicine may be able to assist in the management of patients with wet AMD.

Ting, Darren Shu Jeng et al (2019) [Feasibility Study] Artificial intelligence-assisted telemedicine platform for cataract screening and management: a potential model of care for global eye health[40]

In their editorial, Ting et al discuss how in ophthalmology, many studies showed comparable, if not better, diagnostic performance in using artificial intelligence to screen, diagnose, predict and monitor various eye conditions on fundus photographs and optical coherence tomography, including

[39] Starr MR, Barkmeier AJ, Engman SJ, Kitzmann A, Bakri SJ. Telemedicine in the Management of Exudative Age-Related Macular Degeneration within an Integrated health care System. *Am J Ophthalmol.* 2019;208:206- 210. doi:10.1016/j.ajo.2019.03.021

[40] Ting DSJ, Ang M, Mehta JS, Ting DSW. Artificial intelligence-assisted telemedicine platform for cataract screening and management: a potential model of care for global eye health. *Br J Ophthalmol.* 2019;103(11):1537- 1538. doi:10.1136/bjophthalmol-2019-315025

diabetic retinopathy, age-related macular degeneration, glaucoma and retinopathy of prematurity.

Wu, Yue et al (2019) [Feasibility Study] Development and validation of a machine learning, smartphone-based tonometer[41]

Background/Aims: To compare intraocular pressure (IOP) measurements using a prototype smartphone tonometer with other tonometers used in clinical practice. Methods: Patients from an academic glaucoma practice were recruited. The smartphone tonometer uses fixed force applanation and in conjunction with a machine-learning computer algorithm is able to calculate the IOP. IOP was also measured using Goldmann applanation tonometry (GAT) in all subjects. A subset of patients were also measured using ICare, pneumotonometry [upright and supine positions] and Tono-Pen [upright and supine positions] and the results were compared. Results: 92 eyes of 81 subjects were successfully measured. The mean difference (in mm Hg) for IOP measurements of the smartphone tonometer versus other devices was +0.24 mm Hg for GAT, -1.39 mm Hg for ICare, -3.71 mm Hg for pneumotonometry and -1.30 mm Hg for Tono-Pen. The 95% limits of agreement for the smartphone tonometer versus other devices was -4.35 to 4.83 mm Hg for GAT, -6.48 to 3.70 mm Hg for ICare, -7.66 to -0.15 mm Hg for pneumotonometry and -5.72 to 3.12 mm Hg for Tono-Pen. Overall, the smartphone tonometer results correlated best with GAT (R^2=0.67, p<0.001). Of the 92 videos, 90 (97.8%) were within ±5 mm Hg of GAT and 58 (63.0%) were within ±2 mm Hg of GAT. Conclusions: Preliminary IOP measurements using a prototype smartphone-based tonometer was grossly equivalent to the reference standard.

[41] Wu Y, Luttrell I, Feng S et al Development and validation of a machine learning, smartphone-based tonometer [published online ahead of print, 2019 Dec 23]. *Br J Ophthalmol*. 2019;bjophthalmol-2019-315446. doi:10.1136/bjophthalmol-2019-315446

▶ **Contents**

CHAPTER 16
Telemedicine and Palliative Care

Systematic Reviews

Hancock, S et al (2019) [Systematic Review] Telehealth in Palliative Care Is Being Described but Not Evaluated: A Systematic Review[1]
Telehealth is growing and its application in palliative care is seen as a solution to pressures on palliative care services. A 2010 UK review reported growing awareness of telehealth in palliative care but a lack of evidence-based research to support its use. The primary aim of this review was to describe the current use of telehealth in palliative care in the UK and evaluate telehealth initiatives against a digital service standard. The secondary aim was to explore whether telehealth results in a reduction in emergency care access. The authors conclude that although there is growth of telehealth services, there remains a lack of evaluation and robust study design meaning conclusions regarding the clinical application of telehealth in palliative care cannot be drawn. There is insufficient evidence to appreciate any benefit of telehealth on access to emergency care. Future work is needed to evaluate the use of telehealth in palliative care and improve telehealth design in line with digital service standards.

Head, BA et al (2018) [Systematic Review] Telehealth in Palliative Care[2]
A systematic review was conducted to explore published quantitative and qualitative research describing patient-reported outcomes of palliative telehealth intervention studies. Multiple databases were searched for articles published between January 2006 and May 2016, which met study criteria. Methodological quality was assessed using Cochrane Collaboration's tool for assessing risk of bias for quantitative articles. For studies reporting qualitative outcomes, a checklist was used to evaluate trustworthiness of the methodology. Of the 6 studies reporting quantitative

[1] Hancock S, Preston N, Jones H, Gadoud A. Telehealth in palliative care is being described but not evaluated: a systematic review. *BMC Palliat Care*. 2019;181.:114. Published 2019 Dec 13. doi:10.1186/s12904-019-0495-5 [Accessed 1 May 2020]
[2] Head BA, Schapmire TJ, Yongqiang Zheng. Telehealth in Palliative Care. *Journal of Hospice and Palliative Nursing*. 2017;192.:130-139. doi:10.1097/NJH.0000000000000319. [Accessed 1 May 2020]

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outcomes, 3 studies were rated as having moderate study quality, and 3 studies were rated as having low study quality. Of the 6 studies reporting qualitative outcomes, 3 reported 5 different methods for ensuring trustworthiness, whereas 1 article reported 4methods, 1 reported 3, and 1 article reported 2methods. Studies were notably diverse in terms of patient population, technology used, outcomes measures, and methodology. Results across studies were also variable. Methodological factors were major limitations. Recruitment problems, participant attrition, and lack of standardized outcomes measures impacted outcome assessment. Overall, research support for positive patient outcomes in palliative telehealth interventions was weak. However, all studies but one found positive results to support the intervention.

Rogante, M et al (2016) [Systematic Review] Telemedicine in Palliative Care: A Review of Systematic Reviews[3]

An evaluation of the quality of systematic reviews on telemedicine applications in palliative care. The authors conclude that the results of this first attempt to appraise the evidence in the field of telemedicine applications in palliative care highlighted that there is still limited evidence related to this approach. Strengths and weaknesses that impact on the general quality of the reviews were identified and relevant points to be taken into account for future research were suggested.

Zhen, Y et al (2016) [Systematic Review] A Systematic Review of Telehealth in Palliative Care: Caregiver Outcomes[4]

Telehealth interventions have proven efficacy in healthcare, but little is known about the results of such interventions in palliative care. We conducted a systematic review to evaluate caregiver outcomes related to palliative telehealth interventions. This systematic review suggests there is evidence of overall satisfaction in caregivers who undergo a telehealth intervention, but outcomes reported were often not substantial. Methodological flaws and small sample sizes negatively affected study quality. More rigorous research to test and evaluate such palliative interventions is needed.

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[3] Rogante M, Giacomozzi C, Grigioni M, Kairy D. Telemedicine in palliative care: a review of systematic reviews. *Ann Ist Super Sanita*. 2016;523.:434- 442. doi:10.4415/ANN_16_03_16 [Accessed 1 May 2020]
[4] Zheng Y, Head BA, Schapmire TJ. A Systematic Review of Telehealth in Palliative Care: Caregiver Outcomes. *Telemed J E Health*. 2016;224.:288- 294. doi:10.1089/tmj.2015.0090 [Accessed 1 May 2020]

Jain, A et al (2015) [Systematic Review] Video Decision Aids to Assist With Advance Care Planning: A Systematic Review and Meta-Analysis[5]

The objective of this systematic review was to evaluate the impact of video decision aids on patients' preferences regarding life-sustaining treatments. The authors conclude that video decision aids may improve some ACP-related outcomes. Before recommending their use in clinical practice, more evidence is needed to confirm these findings and to evaluate the impact of video decision aids when integrated into patient care.

Randomised Controlled Trials

Dionne-Odom, JN et al (2020) [Randomised Controlled trial] Effects of a Telehealth Early Palliative Care Intervention for Family Caregivers of Persons With Advanced Heart Failure: The ENABLE CHF-PC Randomized Clinical Trial[6]

Family caregivers of persons with advanced heart failure perform numerous daily tasks to assist their relatives and are at high risk for distress and poor quality of life. The aim of this study was to determine the effect of a nurse-led palliative care telehealth intervention Educate, Nurture, Advise, Before Life Ends Comprehensive Heart Failure for Patients and Caregivers (ENABLE CHF-PC)) on quality of life and mood of family caregivers of persons with New York Heart Association Class III/IV heart failure over 16 weeks. This 2-site randomized clinical trial of a telehealth intervention for family caregivers of patients with advanced heart failure, more than half of whom were African American and most of whom were not distressed at baseline, did not demonstrate clinically better quality of life, mood, or burden compared with usual care over 16 weeks. Future interventions should target distressed caregivers and assess caregiver effects on patient outcomes.

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5 Jain A, Corriveau S, Quinn K, Gardhouse A, Vegas DB, You JJ. Video decision aids to assist with advance care planning: a systematic review and meta-analysis. *BMJ Open*. 2015;56.:e007491. Published 2015 Jun 24. doi:10.1136/bmjopen-2014-007491 [Accessed 1 May 2020]
6 Dionne-Odom JN, Ejem DB, Wells R et al Effects of a Telehealth Early Palliative Care Intervention for Family Caregivers of Persons With Advanced Heart Failure: The ENABLE CHF-PC Randomized Clinical Trial. *JAMA Netw Open*. 2020;34.:e202583. Published 2020 Apr 1. doi:10.1001/jamanetworkopen.2020.2583 [Accessed 1 May 2020]

Gustafson, DH et al (2018) [Randomised Controlled Trial] Reducing Symptom Distress in Patients With Advanced Cancer Using an e-Alert System for Caregivers: Pooled Analysis of Two Randomized Clinical Trials[7]
The aim of this paper was to assess the effects on cancer patient symptom distress of an eHealth system that alerts clinicians to significant changes in the patient's symptoms, as reported by a family caregiver. A pooled analysis from two randomized clinical trials compared outcomes at 12 months for two unblinded groups: a control group (Comprehensive Health Enhancement Support System [CHESS]-Only) that gave caregivers access to CHESS, an online support system, and an experimental group (CHESS+CR [Clinician Report]), which also had CHESS but with a CR that automatically alerted clinicians if symptoms exceeded a predetermined threshold of severity. Participants were dyads (n=235) of patients with advanced lung, breast, or prostate cancer and their respective family caregivers from 5 oncology clinics in the United States of America. The proportion of improved patient threshold symptoms was compared between groups using area-under-the-curve analysis and binomial proportion tests. The proportion of threshold symptoms out of all reported symptoms was also examined. This study suggests that an eHealth system designed for caregivers that alerts clinicians to worrisome changes in patient health status may lead to reduced patient distress.

Hoek, PD et al (2017) [Randomised Controlled Trial] The Effect of Weekly Specialist Palliative Care Teleconsultations in Patients With Advanced Cancer -A Randomized Clinical Trial[8]
Teleconsultation seems to be a promising intervention for providing palliative care to home-dwelling patients; however, its effect on clinically relevant outcome measures remains largely unexplored. Therefore, the purpose of this study was to determine whether weekly teleconsultations from a hospital-based specialist palliative care consultation team (SPCT) improved patient-experienced symptom burden compared to "care as usual". Secondary objectives were to determine the effects of these teleconsultations on unmet palliative care needs, continuity of care, hospital

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[7] Gustafson DH, DuBenske LL, Atwood AK et al Reducing Symptom Distress in Patients With Advanced Cancer Using an e-Alert System for Caregivers: Pooled Analysis of Two Randomized Clinical Trials. *J Med Internet Res*. 2017;19(11):e354. doi:10.2196/jmir.7466 [Accessed 1 May 2020]

[8] Hoek PD, Schers HJ, Bronkhorst EM, Vissers KCP, Hasselaar JGJ. The effect of weekly specialist palliative care teleconsultations in patients with advanced cancer -a randomized clinical trial. *BMC Med*. 2017;151.:119. Published 2017 Jun 19. doi:10.1186/s12916-017-0866-9 [Accessed 1 May 2020]

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admissions, satisfaction with teleconsultations, and the burden experienced by informal caregivers. Seventy-four home-dwelling patients diagnosed with advanced cancer were recruited from outpatient clinics of a tertiary university hospital and from regional home care organizations between May 2011 and January 2015. Participants were randomized to receive weekly, prescheduled teleconsultations with an SPCT-member [intervention group], or to receive "care as usual" [control group], for a period of 12 weeks. The primary outcome of this study was: patient-experienced symptom burden indicated by the following: 1. Total Distress Score, defined as the sum of all nine subscales of the Edmonton Symptom Assessment System; and 2. the Hospital Anxiety and Depression Scale. Mixed models were used to test for differences between the two groups. Adding weekly teleconsultations to usual palliative care leads to worse reported symptom scores among home-dwelling patients with advanced cancer. Possible explanations for these findings include excess attention on symptoms and potential suffering, the supply-driven care model for teleconsultations used in this trial, and the already high level of specialist palliative care provided to the control group in this study.

Miscellaneous

Carlton, B et al (2020) [Comment] Telemedicine in the Time of Coronavirus[9]
COVID-19 has transformed our practice of palliative care and clinical medicine as we know it. Telemedicine has emerged as a critical technology to bring medical care to patients while attempting to reduce the transmission of COVID-19 among patients, families, and clinicians. It is also increasingly necessary to preserve scarce resources such as personal protective equipment. In this article, we share just-in-time tips to support palliative care clinicians and program leaders in providing the best care possible by telemedicine. These quick, practical tips cover telemedicine setup, patient considerations, and clinician considerations. Next steps include ensuring equitable access to affordable telemedicine technology for

[9] Calton B, Abedini N, Fratkin M. Telemedicine in the Time of Coronavirus [published online ahead of print, 2020 Mar 31]. *J Pain Symptom Manage*. 2020;S0885-3924(20)30170-6. doi:10.1016/j.jpainsymman.2020.03.019 [Accessed 1 May 2020]

vulnerable populations through creative solutions and financing, and dedicated attention to telemedicine evaluation and quality improvement.

Dickman Portz, J et al (2020) "We're Taking Something So Human and Trying to Digitize": Provider Recommendations for mHealth in Palliative Care[10]

Background: Mobile health is a promising tool for improving health outcomes. However, the benefits of using mHealth in palliative care are under studied. This research explored provider perspectives regarding the utility of mHealth in palliative care. Results: Thematic analysis resulted in five provider recommendations regarding the utility and design of palliative care-specific mHealth, including: 1. thoughtfulness to language, context, and delivery when assessing palliative care needs; 2. include tools for prognosis and advance care planning; 3. tailor health and quality-of-life goals; 4. emphasize supports for family and caregivers; and 5. consider technology abilities of older adults. Conclusions: Palliative care providers are enthusiastic about the use of mHealth to improve care coordination, facilitate communication, enhance symptom monitoring, and improve patient-family support. However, providers have reservations about mobile functionality and depersonalized assessment and care. Providers stress the utility of mHealth to facilitate palliative care rather than replace important multidisciplinary services

Guzman, D. (2020) [Retrospective Chart Review] Enhancing Palliative Care Patient Access to Psychological Counselling Through Outreach Telehealth Services[11]

Palliative care encompasses an interdisciplinary team, including mental health care professionals, to address psychological distress of cancer patients. An outreach counselling program via videoconferencing or telephone was implemented to patients receiving care in an outpatient palliative care clinic and to compare patients using this service to those who only received psychological counselling in our outpatient clinic. A retrospective chart review was carried out and the authors conclude that outreach telehealth counselling services enhance palliative care patient

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[10] Dickman Portz J, Ford K, Bekelman DB et al "We're Taking Something So Human and Trying to Digitize": Provider Recommendations for mHealth in Palliative Care. *J Palliat Med.* 2020;232.:240- 247. doi:10.1089/jpm.2019.0216 [Accessed 1 May 2020]

[11] Guzman D, Ann-Yi S, Bruera E et al Enhancing palliative care patient access to psychological counseling through outreach telehealth services. *Psychooncology.* 2020;291.:132- 138. doi:10.1002/pon.5270 [Accessed 1 May 2020]

access to psychological counselling. These services represent an additional modality for providing continuous psychological care.

Humphreys, J et al (2020) [Comment] Rapid Implementation of Inpatient Telepalliative Medicine Consultations During COVID-19 Pandemic[12]

As coronavirus disease 2019 cases increase throughout the country and health care systems grapple with the need to decrease provider exposure and minimize personal protective equipment use while maintaining high-quality patient care, our specialty is called on to consider new methods of delivering inpatient palliative care (PC). Telepalliative medicine has been used to great effect in outpatient and home-based PC but has had fewer applications in the inpatient setting. As we plan for decreased provider availability because of quarantine and redeployment and seek to reach increasingly isolated hospitalized patients in the face of coronavirus disease 2019, the need for telepalliative medicine in the inpatient setting is now clear. We describe our rapid and ongoing implementation of telepalliative medicine consultation for our inpatient PC teams and discuss lessons learned and recommendations for programs considering similar care models.

Slavin-Stewart, C et al (2020) [Feasibility Study] A Feasibility Study of Home-Based Palliative Care Telemedicine in Rural Nova Scotia[13]

This study evaluated the use of the FaceTime application on an Apple iPad to improve timely access to physician consultation for home-based palliative care patients living in rural Nova Scotia. Patients enrolled with the Hants Community Palliative Care Program who consented to participate (n = 15) received regular home-based visits from a palliative care nurse who used the FaceTime application to connect with the palliative care physician in Halifax. Participants were then asked to complete a questionnaire evaluating their experience. Results indicated that using FaceTime through cellular data networks is feasible in rural areas of Nova Scotia. All participants reported that both the audio and visual quality allowed them to communicate easily with the doctor, and no consultations were terminated due to network instability. Patients also found the FaceTime encounter highly acceptable with 86% reporting they were satisfied or very satisfied; 100% stated that their medical concerns were addressed and 100% were willing to use

[12] Humphreys J, Schoenherr L, Elia G et al Rapid Implementation of Inpatient Telepalliative Medicine Consultations During COVID-19 Pandemic [published online ahead of print, 2020 Apr 10]. *J Pain Symptom Manage*. 2020;S0885-3924(20)30195-0. doi:10.1016/j.jpainsymman.2020.04.001 [Accessed 1 May 2020]

[13] Slavin-Stewart C, Phillips A, Horton R. A Feasibility Study of Home-Based Palliative Care Telemedicine in Rural Nova Scotia. *J Palliat Med*. 2020;234.:548– 551. doi:10.1089/jpm.2019.0173 [Accessed 1 May 2020]

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FaceTime again. The results add to the limited literature exploring the application of telehealth in palliative care and demonstrating the utility of low-cost commonly used technology to improve access to palliative care in underserviced areas.

Calton, B. et al (2019) [Review] Top Ten Tips Palliative Care Clinicians Should Know About Telepalliative Care[14]

The field of telehealth is rapidly growing and evolving across medical specialties and health care settings. While additional data are needed, telepalliative care, the application of telehealth technologies to palliative care, may help address important challenges inherent to our specialty, such as geography and clinician staffing; the burden of traveling to brick-and-mortar clinics for patients who are symptomatic and/or functionally limited; and the timely assessment and management of symptoms. Telepalliative care can take many forms, including, but not limited to, video visits between clinicians and patients, smartphone applications to promote caregiver well-being, and remote patient symptom-monitoring programs. This article, created by experts in telehealth and palliative care, provides a review of the current evidence for telepalliative care and potential applications and practical tips for using the technology.

Doolittle, GC et al (2019) [Case Study] TeleHospice: A Community-Engaged Model for Utilizing Mobile Tablets to Enhance Rural Hospice Care[15]

In rural communities, providing hospice care can be a challenge. Hospice personnel sometimes travel great distances to reach patients, resulting in difficulty maintaining access, quality, cost-effectiveness, and safety. In 1998, the University of Kansas Medical Center piloted the country's first TeleHospice (TH) service. At that time, challenges with broad adoption due to cost and attitudes regarding technology were noted. A second TH project was launched in early 2017 using newer technology; this article updates that ongoing implementation. From August 2017 through January 2018, 218 TH videoconferencing encounters including 917 attendees occurred. Calls were made for direct patient care, family support, and administrative purposes. These TH calls have been shown to save HSI money, and initial reports suggest they may strengthen the communication and relationships between

[14] Calton BA, Rabow MW, Branagan L et al Top Ten Tips Palliative Care Clinicians Should Know About Telepalliative Care. *J Palliat Med.* 2019;228.:981- 985. doi:10.1089/jpm.2019.0278 [Accessed 1 May 2020]

[15] Doolittle GC, Nelson EL, Spaulding AO et al TeleHospice: A Community-Engaged Model for Utilizing Mobile Tablets to Enhance Rural Hospice Care. *Am J Hosp Palliat Care.* 2019;36(9):795- 800. doi:10.1177/1049909119829458 [Accessed 1 May 2020]

staff, patients, and the patient's family. Finding innovative, cost-effective, and community-driven approaches such as TH are needed to continually advance hospice care. TeleHospice's potential to supplement and improve hospice services while reducing costs is significant, but continued research is needed to understand best fit within frontier hospices, to inform future urban applications, and to address reimbursement.

Funderskov, KF et al (2019) Telemedicine in Specialised Palliative Care: Healthcare Professionals' and Their Perspectives on Video consultations-A Qualitative Study[16]

The aim of this study was to explore the advantages and disadvantages of using video consultations, as experienced by specialised palliative care healthcare professionals, who are involved in palliative care at home. The study carried out in Denmark involved eight participants (n = 8); five community nurses; and three specialised palliative care team members-a head physician, a physiotherapist and a nurse-participated in the study. The healthcare professionals' knowledge was based on n = 82 video consultations with 11 patients. The range of video consultations was 3-18 per patient. The use of tablets in video consultations facilitated direct palliative care and led the community nurses and the specialised palliative care team nurse to co-operate. Potential barriers against using video consultations are the discussions about personal, and private issues regarding the illness, while family members are present. The authors conclusions are that video consultations in specialised palliative home care are feasible, and the technology can facilitate multidisciplinary participation and co-operation among healthcare professionals. The continuous use of video consultations over time may increase the quality of specialised palliative home care.

Funderskov, KF et al (2019) Experiences With Video Consultations in Specialized Palliative Home-Care: Qualitative Study of Patient and Relative Perspectives[17]

The work of specialized palliative care (SPC) teams is often challenged by substantial amounts of time spent driving to and from patients' homes and long distances between the patients and the hospitals. Video consultations

[16] Funderskov KF, Boe Danbjørg D, Jess M, Munk L, Olsen Zwisler AD, Dieperink KB. Telemedicine in specialised palliative care: Healthcare professionals' and their perspectives on video consultations-A qualitative study. *J Clin Nurs*. 2019;28(21-22):3966-3976. doi:10.1111/jocn.15004 [Accessed 1 May 2019]

[17] Funderskov KF, Raunkiær M, Danbjørg DB et al Experiences With Video Consultations in Specialized Palliative Home-Care: Qualitative Study of Patient and Relative Perspectives. *J Med Internet Res*. 2019;213.:e10208. Published 2019 Mar 21. doi:10.2196/10208 [Accessed 1 May 2020]

may be a solution for real-time SPC at home. The aim of this study was to explore the use of video consultations, experienced by patients and their relatives, as part of SPC at home. This explorative and qualitative study included palliative care patients in different stages and relatives to use video consultations as a part of their SPC between October 2016 and March 2017. Data collection took place in the patients' homes and consisted of participant observations followed by semistructured interviews. Inclusion criteria consisted of patients with the need for SPC, aged more than 18 years, who agreed to participate, and relatives wanting to participate in the video consultations. Data were analyzed with Giorgi's descriptive phenomenological methodology. The authors conclude that Video consultations in SPC for home-based patients are feasible and facilitate a strengthened involvement and communication between patients, relatives, and SPC team members.

Middlton-Green, L et al (2019) **'A Friend in the Corner': Supporting People at Home in the Last Year of Life via Telephone and Video Consultation-An Evaluation**[18]

An evaluation of a 24/7, nurse-led telephone and video-consultation support service for patients thought to be in the last year of life in Bradford, Airedale, Wharfedale and Craven. Data on the time and nature of all calls between 1 April 2014 and 30 March 2015 were obtained from the patient Electronic Records. Interviews with 13 participants captured patients and carers perspectives. The authors conclude that a nurse-led, 24/7 telephone and video consultation service can provide valuable support for patients identified to be in the last year of life and for their carers. The line enabled them to feel supported and remain in their place of residence, hence reducing the pressure for avoidable hospital admissions and use of other services. Providing this service may encourage healthcare professionals to identify more patients approaching the last year of life, widening support offered to this group of patients beyond those known to specialist palliative care services.

[18] Middleton-Green L, Gadoud A, Norris B et al 'A Friend in the Corner': supporting people at home in the last year of life via telephone and video consultation-an evaluation. *BMJ Support Palliat Care*. 2019;94.:e26. doi:10.1136/bmjspcare-2015-001016 [Accessed 1 May 2020]

Read Paul, L et al (2019) Web-Based Videoconferencing for Rural Palliative Care Consultation With Elderly Patients at Home[19]

Providing specialized palliative care support to elderly patients in rural areas can be challenging. The purpose of this study was to gain a preliminary understanding of the experience of using mobile web-based videoconferencing (WBVC) for conducting in-home palliative care consults with elderly rural patients with life-limiting illness. This was a descriptive, exploratory, proof-of-concept study with a convenience sample of 10 WBVC visits. A palliative care clinical nurse specialist (PC-CNS), in the home with the patient/family and home care nurse (HC-N), used a laptop computer with webcam and speakerphone to connect to a distant palliative care physician consultant (PC-MD) over a secure Internet connection. Data was collected using questionnaires, interviews, and focus groups. Using WBVC for in-home palliative care consults could be an acceptable, effective, feasible, and efficient way to provide timely support to elderly rural patients and their families. Having a health care provider in the home during the WBVC is beneficial. WBVC visits have advantages over telephone calls, but limitations compared to in-person visits, suggesting they be an alternative but not replacement for in-person consultations.

Schoppee, TM et al (2019) Patients and Caregivers Rate the PAINReportIt Wireless Internet-Enabled Tablet as a Method for Reporting Pain During End-of-Life Cancer Care[20]

In several studies, investigators have successfully used an Internet-enabled PAINReportIt tablet to allow patients to report their pain to clinicians in real-time, but it is unknown how acceptable this technology is to patients and caregivers when used in their homes. The aims of this study were to examine computer use acceptability scores of patients with end-stage cancer in hospice and their caregivers and to compare the scores for differences by age, gender, race, and computer use experience. Immediately after using the tablet, 234 hospice patients and 231 caregivers independently completed the Computer Acceptability Scale. This technology was highly acceptable to patients and caregivers for reporting pain in real time to their hospice nurses. Findings provide encouraging results that are worthy of serious consideration for patients who are in end stages of illness, including older

[19] Read Paul L, Salmon C, Sinnarajah A, Spice R. web-based videoconferencing for rural palliative care consultation with elderly patients at home. *Support Care Cancer*. 2019;27(9):3321- 3330. doi:10.1007/s00520-018-4580-8 [Accessed 1 May 2020]

[20] Schoppee TM, Dyal BW, Scarton L et al Patients and Caregivers Rate the PAINReportIt Wireless Internet-Enabled Tablet as a Method for Reporting Pain During End-of-Life Cancer Care [published online ahead of print, 2019 Sep 27]. *Cancer Nurs*. 2019;10.1097/NCC.0000000000000743. doi:10.1097/NCC.0000000000000743 [Accessed 1 May 2020]

persons and those with minimal computer experience. Increasing availability of technology can provide innovative methods for improving care provided to patients facing significant cancer-related pain even at the end of life.

Tasneem, S et al (2019) Telemedicine Video Visits for Patients Receiving Palliative Care: A Qualitative Study[21]
In this needs assessment, gathered patient perceptions on how telemedicine video visits might influence their care. Patients in this study (n = 13) were all diagnosed with end-stage cancer and were receiving palliative care at an urban academic medical center. Interview themes addressed: 1. impact on patient's health management; 2. user experience; 3. technical issues; and 4. cost and time. Ultimately, despite concerns over truncated physical exams and prescription limits, the majority of patients favored having the opportunity for telemedicine video visits, felt that the doctor-patient relationship would not suffer, had confidence in their or their surrogate's technical abilities to navigate the video visit, had privacy concerns on par with other technologies, had few cost concerns, and believed a video alternative to an in-person visit might increase access, save time as well as increase comfort and safety by avoiding a trip to the office. These results suggest potential for acceptance of video-based telemedicine by an urban population of oncology patients receiving palliative care.

Vitacca, M et al (2019) [Feasibility Study] Tele-Assisted Palliative Homecare for Advanced Chronic Obstructive Pulmonary Disease: A Feasibility Study[22]
Despite real needs, very few chronic obstructive pulmonary disease (COPD) patients with life-limiting disease receive a well-organized support for palliative care (PC). To test the feasibility of, and patient satisfaction with, an advanced care plan for severe COPD patients followed by tele-assistance at home for six months that focused on monitoring patient's palliative topics through a dedicated checklist. Ten hospitalized patients with severe COPD [<1-year life expectancy] received a 60 minutes PC talk by a specialist to define an advanced care plan in the case of very severe respiratory insufficiency, based on three options: 1. endotracheal intubation (EI); 2. noninvasive ventilation; or 3. no mechanical aid, oxygen and drugs. After the

[21] Tasneem S, Kim A, Bagheri A, Lebret J. Telemedicine Video Visits for patients receiving palliative care: A qualitative study. *Am J Hosp Palliat Care.* 2019;36(9):789-794. doi:10.1177/1049909119846843 [Accessed 1 May 2020]

[22] Vitacca M, Comini L, Tabaglio E, Platto B, Gazzi L. Tele-Assisted Palliative Homecare for Advanced Chronic Obstructive Pulmonary Disease: A Feasibility Study. *J Palliat Med.* 2019;222.:173-178. doi:10.1089/jpm.2018.0321 [Accessed 1 May 2020]

talk, patients expressed their personal choice. Following discharge home, patients received structured monthly telephone monitoring from specialized tutor nurses for six months on palliative topics. Patient's anxiety before and after talk, depression, quality of life, specialist's quality of communication, and customer satisfaction were evaluated. Tele-assisted PC is feasible and well accepted. According to these observations, a suitable supportive program can be the goal of a future study.

Bonsignore, L et al (2018) [Feasibility Study] [Evaluating the Feasibility and Acceptability of a Telehealth Program in a Rural Palliative Care Population: TapCloud for Palliative Care](#)[23]
The impact of telehealth and remote patient monitoring has not been well established in palliative care populations in rural communities. The objectives of this study were to: 1. describe a telehealth palliative care program using the TapCloud remote patient monitoring application and videoconferencing; 2. evaluate the feasibility, usability, and acceptability of a telehealth system in palliative care; and 3. use a quality data assessment collection tool in addition to TapCloud ratings of symptom burden and hospice transitions. A mixed-methods approach was used to assess feasibility, usability, and acceptability. Quantitative assessments included patient symptom burden and improvement, hospice transitions, and advanced directives. Qualitative semistructured interviews on a subpopulation of telehealth patients, caregivers, and providers were performed to learn about their experiences using TapCloud. The authors describe a telehealth palliative care program and demonstrate acceptability, feasibility, and usability as well as describe symptom outcomes and hospice transitions.

Phongtankeul, V et al (2018) [Mobile Health Technology Is Here-But Are Hospice Informal Caregivers Receptive?](#)[24]
In home hospice, informal caregivers play an essential role in attending to the day-to-day needs of their terminally ill loved ones. Using mHealth apps by caregivers in this setting could potentially improve the support provided to both patients and caregivers at the end of life (EoL). The objectives of this study was to explore informal caregivers' receptivity and concerns in using

[23] Bonsignore L, Bloom N, Steinhauser K et al Evaluating the Feasibility and Acceptability of a Telehealth Program in a Rural Palliative Care Population: TapCloud for Palliative Care. *J Pain Symptom Manage.* 2018;561.:7-14. doi:10.1016/j.jpainsymman.2018.03.013 [Accessed 1 May 2020]
[24] Phongtankuel V, Shalev A, Adelman RD et al Mobile Health Technology Is Here-But Are Hospice Informal Caregivers Receptive?. *Am J Hosp Palliat Care.* 2018;35(12):1547-1552. doi:10.1177/1049909118779018 [Accessed 1 May 2020]

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mHealth apps along with app features, caregivers perceived to be most useful in home hospice care. Eighty semistructured phone interviews were conducted with informal caregivers who received care from a nonprofit hospice organization. Study data were analyzed using content analysis, coding for themes of receptivity and interest. A substantial majority of informal caregivers voiced receptivity to using mHealth apps and expressed interest in features that enhance communication and provide information to improve patient care. Although more research is needed to examine how to incorporate this technology into existing home hospice care, our study suggests that informal caregivers are likely to use this technology they feel will help enhance home-based EoL care delivery.

Phongtankeul, V et al (2018) [Comment] Mobile Health Technology and Home Hospice Care: Promise and Pitfalls[25]

With the increasing use of mobile devices in our everyday lives, people have the ability to communicate and share information faster than ever before. This has led to the development of promising applications aimed at improving health and healthcare delivery for those with limited access. Hospice care, which is commonly provided at home, may particularly benefit from the use of this technology platform. This commentary outlines several potential benefits and pitfalls of incorporating mobile health applications into existing home hospice care while highlighting some of the relevant telemedicine work being done in the palliative and End-of-Life care fields.

Pinto, S et al (2017) [Literature Review] e-Health in Palliative Care: Review of Literature, Google Play and App Store[26]

Literature review to analyse the use of e-Health technologies and mobile apps in palliative care (PC). Twenty-five papers and forty mobile apps were analysed. Teleconsultation is the principal e-Health technology. Mobile apps focus on communication, drugs, tools/clinical guidelines, hospice, symptom management and PC information. e-Health is an emergent topic in PC. Teleconsultation enhances communication among patients, families and PC teams, reinforces partnership and decreases the burden on families and use of the emergency services.

[25] Phongtankuel V, Adelman RD, Reid MC. Mobile health technology and home hospice care: promise and pitfalls. *Prog Palliat Care*. 2018;263.:137- 141. doi:10.1080/09699260.2018.1467109 [Accessed 1 May 2020]

[26] Pinto S, Caldeira S, Martins JC. e-Health in palliative care: review of literature, Google Play and App Store. *Int J Palliat Nurs*. 2017;238.:394- 401. doi:10.12968/ijpn.2017.23.8.394 [Accessed 1 May 2020]
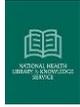
Taylor, S et al (2017) Identifying Professionals' Needs in Integrating Electronic Pain Monitoring in Community Palliative Care Services: An Interview Study[27]

The aim of this study was to inform the development and implementation strategy of an electronic pain monitoring system, PainCheck, by understanding palliative care professionals' needs when integrating PainCheck into routine clinical practice. Health professionals have reservations about how PainCheck would work in practice. For optimal use, PainCheck needs embedding within existing electronic health records. Electronic pain monitoring systems have the potential to enable professionals to support patients' pain management more effectively but only when barriers to implementation are appropriately identified and addressed.

Worster, B, Swartz, K (2017) [Review] Telemedicine and Palliative Care: An Increasing Role in Supportive Oncology[28]

This review looks at the use of telemedicine to expand access to palliative care as well as provide better care for patients and families where travel is difficult, if not impossible. When telemedicine has been used, often in Europe, for palliative care, the results show improvements in symptom management, comfort with care as well as patient and family satisfaction. One barrier to use of telemedicine is the concerns with technology and technology-related complications in population that is often elderly, frail and not always comfortable with non-face-to-face physician care. There remain significant opportunities to explore this intersection of supportive care and telemedicine.

Collier, A et al (2016) Implementation of a Pilot Telehealth Programme in Community Palliative Care: A Qualitative Study of Clinicians' Perspectives[29]

The objectives of the study were to explore clinicians' perspectives on and experiences of the utilisation of a pilot telehealth model and its integration into a specialist community palliative care programme. The study was

[27] Taylor S, Allsop MJ, Bekker HL, Bennett MI, Bewick BM. Identifying professionals' needs in integrating electronic pain monitoring in community palliative care services: An interview study. *Palliat Med*. 2017;317.:661- 670. doi:10.1177/0269216316677470 [Accessed 1 May 2020]

[28] Worster B, Swartz K. Telemedicine and Palliative Care: an Increasing Role in Supportive Oncology. *Curr Oncol Rep*. 2017;196.:37. doi:10.1007/s11912-017-0600-y [Accessed 1 May 2020]

[29] Collier A, Morgan DD, Swetenham K, To TH, Currow DC, Tieman JJ. Implementation of a pilot telehealth programme in community palliative care: A qualitative study of clinicians' perspectives. *Palliat Med*. 2016;304.:409- 417. doi:10.1177/0269216315600113 [Accessed 1 May 2020]

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conducted in a metropolitan specialist palliative care service in South Australia. Participants (n = 10) were clinicians involved in the delivery of community specialist palliative care and the piloting of a telehealth programme. Implementation of a pilot telehealth programme in a specialist palliative community team needs to involve clinical staff in service redesign from the outset. Reliable IT infrastructure and technical support is critical for telehealth models to be effective and will aid uptake.

Tieman, JL et al (2016) [Prospective Cohort Study] Using Telehealth to Support End of Life Care in the Community: A Feasibility Study[30]

Telehealth is being used increasingly in providing care to patients in the community setting. Telehealth enhanced service delivery could offer new ways of managing load and care prioritisation for palliative care patients living in the community. The study assesses the feasibility of a telehealth-based model of service provision for community based palliative care patients, carers and clinicians. This study was a prospective cohort study of a telehealth-based intervention for community based patients of a specialist palliative care service living in Southern Adelaide, South Australia. Participants were 43 community living patients enrolled in the Southern Adelaide Palliative Service. To be eligible patients needed to be over 18 years and have an Australian modified Karnofksy Performance Score > 40. Exclusion criteria included a demonstrated inability to manage the hardware or technology (unless living with a carer who could manage the technology) or non-English speaking without a suitable carer/proxy. Participants received video-based conferences between service staff and the patient/carer; virtual case conferences with the patient/carer, service staff and patient's general practitioner (GP); self-report assessment tools for patient and carer; and remote activity monitoring. The trial showed that patients and carers could manage the technology and provide data that would otherwise not have been available to the palliative care service.

Van Gurp, J et al (2016) Teleconsultation for Integrated Palliative Care at Home: A Qualitative Study[31]

Interprofessional consultation contributes to symptom control for home-based palliative care patients and improves advance care planning. Distance

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[30] Tieman JJ, Swetenham K, Morgan DD, To TH, Currow DC. Using telehealth to support end of life care in the community: a feasibility study. *BMC Palliat Care*. 2016;151.:94. Published 2016 Nov 17. doi:10.1186/s12904-016-0167-7 [Accessed 1 May 2020]

[31] van Gurp J, van Selm M, van Leeuwen E, Vissers K, Hasselaar J. Teleconsultation for integrated palliative care at home: A qualitative study. *Palliat Med*. 2016;303.:257–269. doi:10.1177/0269216315598068 [Accessed 1 May 2020]

and travel time, however, complicate the integration of primary care and specialist palliative care. Expert online audiovisual teleconsultations could be a method for integrating palliative care services. This study aims to describe: 1. whether and how teleconsultation supports the integration of primary care, specialist palliative care, and patient perspectives and services; and 2. how patients and (in)formal caregivers experience collaboration in a teleconsultation approach. Specialist palliative care team teleconsultation with home-based patients leads to collaboration between primary care physicians and hospital-based palliative care specialists. Due to cultural reasons, most collaboration was of a multidisciplinary character, strongly relying on organized backstage work. Interdisciplinary teleconsultations with real-time contact between patient and both professionals were less common but stimulated patient-centered care dialogues.

Hennemann-Krause, L et al (2015) [The Assessment of Telemedicine to Support Outpatient Palliative Care in Advanced Cancer](#)[32]
This study examined telemedicine as a form of home and additional support for traditional outpatient care as a way to remotely monitor and manage the symptoms of patients with advanced cancer. In total, 12 patients were monitored through monthly consultations with a multidisciplinary healthcare team and weekly web conferences. To evaluate and treat pain and other symptoms, the Edmonton Symptom Assessment System (ESAS) was applied during all remote or in-person interviews. Telemedicine allowed greater access to the healthcare system, reduced the need to employ emergency services, improved assessment/control of symptoms, and provided greater orientation and confidence in the care given by family members through early and proactive interventions. Web conferencing proved to be a good adjuvant to home monitoring of symptoms, complementing in-person assistance.

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[32] Hennemann-Krause L, Lopes AJ, Araújo JA, Petersen EM, Nunes RA. The assessment of telemedicine to support outpatient palliative care in advanced cancer. *Palliat Support Care.* 2015;134.:1025- 1030. doi:10.1017/S147895151400100X [Accessed 1 May 2020]

Van Gurp, J et al (2015) [How Outpatient Palliative Care Teleconsultation Facilitates Empathic Patient-Professional Relationships: A Qualitative Study](33)

The problems and needs of advanced cancer patients and proxies normally increase as the disease progresses. Home-based advanced cancer patients and their proxies benefit from collaborations between primary care physicians and hospital-based palliative care specialists when confronted with complex problems in the last phase of life. Telemedicine might facilitate direct, patient-centered communication between patients and proxies, primary care physicians, and specialist palliative care teams (SPCTs). This study focuses on the impact of teleconsultation technologies on the relationships between home-based palliative care patients and hospital-based palliative care specialists. This work consists of a qualitative study among patients, family members, and caregivers that utilizes long-term direct observations, semi-structured interviews, and open interviews following the observations. Teleconsultation fits the practice of home-based palliative care. Teleconsultation can, if well applied, facilitate computer-mediated but empathic patient-palliative care specialist relationships, which enable professional care attuned to the patient's context as well as patient involvement. This article proposes a teleconsultation implementation guide for optimal use of teleconsultation in daily palliative care practice.

33 van Gurp J, van Selm M, Vissers K, van Leeuwen E, Hasselaar J. How outpatient palliative care teleconsultation facilitates empathic patient-professional relationships: a qualitative study. *PLoS One*. 2015;104.:e0124387. Published 2015 Apr 22. doi:10.1371/journal.pone.0124387 [Accessed 1 May 2020]

CHAPTER 17
Telemedicine and Progressive Supranuclear Palsy

Systematic Reviews

Theodoros, Deborah et al (2019) [Systematic Review] Technology-enabled management of communication and swallowing disorders in Parkinson's disease: a systematic scoping review[1]

Background: Communication and swallowing disorders are highly prevalent in people with Parkinson's disease (PD). Maintenance of functional communication and swallowing over time is challenging for the person with PD and their families and may lead to social isolation and reduced quality of life if not addressed. Speech and language therapists (SLTs) face the conundrum of providing sustainable and flexible services to meet the changing needs of people with PD. Motor, cognitive and psychological issues associated with PD, medication regimens and dependency on others often impede attendance at a centre-based service. The access difficulties experienced by people with PD require a disruptive service approach to meet their needs. Technology-enabled management using information and telecommunications technologies to provide services at a distance has the potential to improve access, and enhance the quality of SLT services to people with PD. Aims: To report the status and scope of the evidence for the use of technology in the management of the communication and swallowing disorders associated with PD. Methods and Procedures: Studies were retrieved from four major databases: PubMed, CINAHL, EMBASE and Medline via Web of Science. Data relating to the types of studies, level of evidence, context, nature of the management undertaken, participant perspectives and the types of technologies involved were extracted for the review. Main Contribution: A total of 17 studies were included in the review, 15 of which related to the management of communication and swallowing disorders in

PD with two studies devoted to participant perspectives. The majority of the studies reported on the treatment of the speech disorder in PD using Lee Silverman Voice Treatment (LSVT LOUD®). Synchronous and asynchronous technologies were used in the studies with a predominance of the former. There was a paucity of research in the management of cognitive-communication and swallowing disorders. Conclusions and Implications: Research evidence supporting technology-enabled management of the communication and swallowing disorders in PD is limited and predominantly low in quality. The treatment of the speech disorder online is the most developed aspect of the technology-enabled management pathway. Future research needs to address technology-enabled management of cognitive-communication and swallowing disorders and the use of a more diverse range of technologies and management approaches to optimize SLT service delivery to people with PD.

Miscellaneous

De Vos, Maarten et al (2020) [Discriminating progressive supranuclear palsy from Parkinson's disease using wearable technology and machine learning](#)[2]

Background: Progressive supranuclear palsy (PSP), a neurodegenerative conditions may be difficult to discriminate clinically from idiopathic Parkinson's disease (PD). It is critical that we are able to do this accurately and as early as possible in order that future disease modifying therapies for PSP may be deployed at a stage when they are likely to have maximal benefit. Analysis of gait and related tasks is one possible means of discrimination. Research Question: Here we investigate a wearable sensor array coupled with machine learning approaches as a means of disease classification. Methods: 21 participants with PSP, 20 with PD, and 39 healthy control (HC) subjects performed a two-minute walk, static sway test, and timed up-and-go task, while wearing an array of six inertial measurement units. The data were analysed to determine what features discriminated PSP from PD and PSP from HC. Two machine learning algorithms were applied, Logistic Regression (LR) and Random Forest (RF). Results: 17 features were identified in the combined dataset that contained independent information.

[2] De Vos M, Prince J, Buchanan T, FitzGerald JJ, Antoniades CA. Discriminating progressive supranuclear palsy from Parkinson's disease using wearable technology and machine learning. *Gait Posture*. 2020;77:257-263. doi:10.1016/j.gaitpost.2020.02.007

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The RF classifier outperformed the LR classifier, and allowed discrimination of PSP from PD with 86 % sensitivity and 90 % specificity, and PSP from HC with 90 % sensitivity and 97 % specificity. Using data from the single lumbar sensor only resulted in only a modest reduction in classification accuracy, which could be restored using 3 sensors: lumbar, right arm and foot. However, for maximum specificity the full six sensor array was needed. Significance: A wearable sensor array coupled with machine learning methods can accurately discriminate PSP from PD. Choice of array complexity depends on context; for diagnostic purposes a high specificity is needed suggesting the more complete array is advantageous, while for subsequent disease tracking a simpler system may suffice.

Nigro, Salvatore et al (2020) [Cohort Study] Automated MRI Classification in Progressive Supranuclear Palsy: a Large International Cohort Study[3]
Background: The Magnetic Resonance Parkinsonism Index is listed as one of the most reliable imaging morphometric markers for diagnosis of progressive supranuclear palsy (PSP). However, the use of this index in diagnostic workup has been limited until now by the low generalizability of published results because of small monocentric patient cohorts, the lack of data validation in independent patient series, and manual measurements used for index calculation. The objectives of this study were to investigate the generalizability of Magnetic Resonance Parkinsonism Index performance validating previously established cutoff values in a large international cohort of PSP patients subclassified into PSP-Richardson's syndrome and PSP-parkinsonism and to standardize the use of the automated Magnetic Resonance Parkinsonism Index by providing a web-based platform to obtain homogenous measures around the world. Methods: In a retrospective international multicenter study, a total of 173 PSP patients and 483 non-PSP participants were enrolled. A web-based platform was used to calculate automated Magnetic Resonance Parkinsonism Index values. Results: Magnetic Resonance Parkinsonism Index values showed optimal performance in differentiating PSP-Richardson's syndrome and PSP-parkinsonism patients from non-PSP participants (93.6% and 86.5% of accuracy, respectively). The Magnetic Resonance Parkinsonism Index was also able to differentiate PSP-Richardson's syndrome and PSP-parkinsonism patients in an early stage of the disease from non-PSP participants (90.1%

[3] Nigro S, Antonini A, Vaillancourt DE et al Automated MRI Classification in Progressive Supranuclear Palsy: a Large International Cohort Study [published online ahead of print, 2020 Feb 24]. *Mov Disord.* 2020;10.1002/mds.28007. doi:10.1002/mds.28007

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and 85.9%, respectively). The web-based platform provided the automated Magnetic Resonance Parkinsonism Index calculation in 94% of cases. Conclusions: Our study provides the first evidence on the generalizability of automated Magnetic Resonance Parkinsonism Index measures in a large international cohort of PSP-Richardson's syndrome and PSP-parkinsonism patients. The web-based platform enables widespread applicability of the automated Magnetic Resonance Parkinsonism Index to different clinical and research settings.

Nordio, S et al (2018) [Review] Effect of lee silverman voice treatment (LSVT LOUD) on dysphagia in patients with parkinsonism (progressive supranuclear palsy and multiple system atrophy)[4]
Telerehabilitation is the use of telecommunications technology for rehabilitation. Recently, some studies have shown positive effects of telerehabilitation of swallowing disorders, yet there are no systematic reviews verifying the evidence. The aim of this review is to assess the effects of telerehabilitation in the field of dysphagia as an alternative to face-to-face patient care, considering swallowing recovery and/or quality of life in different patient populations. We searched the Cochrane Library, MEDLINE, EMBASE, Google Scholar, Google Search and the grey literature from inception until December 2016 for publications written in English (keywords: telerehabilitation, telemedicine, dysphagia, swallowing disorders), which resulted in 330 records. Abstract screening and data extraction was carried out independently by two reviewers. Four papers were selected to read in full, and the methodological quality of the studies included was evaluated using Cochrane Collaboration's tool for assessing risk of bias. One study met our inclusion criteria which showed that telerehabilitation improves adherence to treatment compared to patient-directed intervention. Although adherence is an important factor that influences the treatment outcome, clinical outcomes have to be examined in randomised controlled trials in order to reach evidence in this field. Lastly, this systematic review did not demonstrate the efficacy of telerehabilitation compared with face-to face therapy.

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[4] Nordio S, Innocenti T, Agostini M, Meneghello F, Battel I. The efficacy of telerehabilitation in dysphagic patients: a systematic review. *Acta Otorhinolaryngol Ital.* 2018;382.:79- 85. doi:10.14639/0392-100X-1816

Clerici, Ilaria et al (2017) [Clinical Trial] Rehabilitation in Progressive Supranuclear Palsy: Effectiveness of Two Multidisciplinary Treatments[5]
Background: to date, there are no medical or surgical treatments for progressive supranuclear palsy (PSP). It is possible to speculate that patients with PSP could benefit from rehabilitative treatments designed for Parkinson's disease, including the use of robot-assisted walking training. Objective: to evaluate whether the use of the robotic device Lokomat® is superior in PSP patients to the use of treadmill with visual cues and auditory feedbacks [treadmill-plus] in the context of an aerobic, multidisciplinary, intensive, motor-cognitive and goal-based rehabilitation treatment (MIRT) conceived for Parkinsonian patients. Methods: we enrolled twenty-four PSP patients. Twelve subjects underwent a 4-week MIRT exploiting the use of the treadmill-plus (MIRT group). Twelve subjects underwent the same treatment, but replacing the treadmill-plus with Lokomat® (MIRT-Lokomat group). Subjects were evaluated with clinical and functional scales at admission and discharge. The primary outcomes were the total PSP Rating Scale (PSPRS) score and its limb and gait sub-scores. Secondary outcomes were Berg Balance Scale (BBS), Six Minutes Walking test (6MWT) and the number of falls. Results: total PSPRS, PSPRS-gait sub-score, BBS, 6MWT and number of falls improved significantly in both groups (p ≤ 0.003 all, except 6MWT, p = 0.032 and p = 0.018 in MIRT-Lokomat and MIRT group respectively). The PSPRS-limb sub-score improved significantly only in the MIRT group (p = 0.002). A significant difference between groups was observed only for total PSPRS, indicating a slightly better improvement for patients in the MIRT group (p = 0.047). No differences between groups were revealed for the other outcomes, indicating that the effect of rehabilitation was similar in both groups. Conclusions: Lokomat® training, in comparison with treadmill-plus training, does not provide further benefits in PSP patients undergoing MIRT. Our findings suggest the usefulness of an aerobic, multidisciplinary, intensive, motor-cognitive and goal-based approach for the rehabilitation of patients suffering from such a complex disease as PSP. Trial registration: This trial was registered on ClinicalTrials.gov, NCT02109393.

[5] Clerici I, Ferrazzoli D, Maestri R et al Rehabilitation in progressive supranuclear palsy: Effectiveness of two multidisciplinary treatments. *PLoS One*. 2017;122.:e0170927. Published 2017 Feb 3. doi:10.1371/journal.pone.0170927

Dunlop, Susan Rebecca et al (2016) **The Cure PSP Care Guide: A Telephonic Nursing Intervention for Individuals and Families Living With Progressive Supranuclear Palsy**[6]

Progressive supranuclear palsy (PSP) is a rare, progressive, and terminal neurodegenerative disease characterized by problems with ambulation, balance, mobility, vision, speech, swallowing, and behavior during the 7- to 10-year course of the illness. Substantial evidence in the nursing literature supports the benefits of patient education, self-management, chronic disease management, telehealth, and nurse navigation programs, which enhance patient and caregiver knowledge, improve day-to-day management by developing an awareness of resources, decrease dependence on services, and address caregiver needs. The Cure PSP Care Guide is a targeted telehealth nursing intervention aimed at providing knowledge, guidance, and resources to the vulnerable individuals and families living with PSP; identifying local resources; and building community. During the course of two telephone calls, individuals and their caregivers are assessed to develop a Cure PSP Care Guide designed to provide guidance along the trajectory. A knowledge assessment, self-efficacy scale, and Caregiver Strain Index are administered before and after the intervention to determine the program intervention effect. Caregiver knowledge assessments improved after the intervention, whereas strain scores were static. Qualitative data show the ability of the intervention to address caregiver needs for knowledge and support, daily management tips, and resource identification. The preliminary quantitative and qualitative data collected on this pilot project justify further exploration of the use of telehealth to remotely deliver nurse case management to the vulnerable individuals and families living with PSP.

[6] Dunlop SR, Kent VP, Lashley M, Caruana T. The Cure PSP Care Guide: A Telephonic Nursing Intervention for Individuals and Families Living With Progressive Supranuclear Palsy. *J Neurosci Nurs*. 2016;482.:105- 106. doi:10.1097/JNN.0000000000000194

▸ **Contents**

CHAPTER 18
Telemedicine and Stroke Rehabilitation

Systematic Reviews

Laver, KE et al (2020) [Cochrane Systematic Review] Telerehabilitation Services for Stroke[1]

Authors' Conclusions: While there is now an increasing number of RCTs testing the efficacy of telerehabilitation, it is hard to draw conclusions about the effects as interventions and comparators varied greatly across studies. In addition, there were few adequately powered studies and several studies included in this review were at risk of bias. At this point, there is only low or moderate-level evidence testing whether telerehabilitation is a more effective or similarly effective way to provide rehabilitation. Short-term post-hospital discharge telerehabilitation programmes have not been shown to reduce depressive symptoms, improve quality of life, or improve independence in activities of daily living when compared with usual care. Studies comparing telerehabilitation and in-person therapy have also not found significantly different outcomes between groups, suggesting that telerehabilitation is not inferior. Some studies reported that telerehabilitation was less expensive to provide but information was lacking about cost-effectiveness. Only two trials reported on whether or not any adverse events had occurred; these trials found no serious adverse events were related to telerehabilitation. The field is still emerging and more studies are needed to draw more definitive conclusions. In addition, while this review examined the efficacy of telerehabilitation when tested in randomised trials, studies that use mixed methods to evaluate the acceptability and feasibility of telehealth interventions are incredibly valuable in measuring outcomes.

[1] Laver KE, Adey-Wakeling Z, Crotty M, Lannin NA, George S, Sherrington C. Telerehabilitation services for stroke. *Cochrane Database Syst Rev*. 2020;11.:CD010255. Published 2020 Jan 31. doi:10.1002/14651858.CD010255.pub3

Appleby, E et al (2019) [Systematic Review] Effectiveness of Telerehabilitation in the Management of Adults With Stroke: A Systematic Review[2]

Discussion: Telerehabilitation, as an alternate form of rehabilitation for people with stroke, shows potential. However, due to methodological and practical concerns, an unequivocal recommendation cannot be made. Findings from this review may inform future policies and practices regarding the use of telerehabilitation for stroke patients.

Chen, Yu et al (2019) [Systematic Review] Home-based Technologies for Stroke Rehabilitation: A Systematic Review[3]

Results: The search yielded 832 potentially relevant articles, leading to 31 articles that were included for in-depth analysis. The types of technology of reviewed articles included games, telerehabilitation, robotic devices, virtual reality devices, sensors, and tablets. We present the merits and limitations of each type of technology. We then derive two main human factors in designing home-based technologies for stroke rehabilitation: designing for engagement, including external and internal motivation, and designing for the home environment, including understanding the social context, practical challenges, and technical proficiency. Conclusion: This systematic review presents an overview of key technologies and human factors for designing home-based technologies for stroke rehabilitation.

Lee, HS et al (2019) [Systematic Review and Meta-Analysis] The Effects of Virtual Reality Training on Function in Chronic Stroke Patients: A Systematic Review and Meta-Analysis[4]

The aim of this study was to perform a meta-analysis to examine whether virtual reality (VR) training is effective for lower limb function as well as upper limb and overall function in chronic stroke patients. Three databases, OVID, PubMed, and EMBASE, were used to collect articles. The search terms used were "cerebrovascular accident (CVA)," "stroke", and "virtual reality".

[2] Appleby E, Gill ST, Hayes LK, Walker TL, Walsh M, Kumar S. Effectiveness of telerehabilitation in the management of adults with stroke: A systematic review. *PLoS One*. 2019;14(11):e0225150. Published 2019 Nov 12. doi:10.1371/journal.pone.0225150

[3] Chen Y, Abel KT, Janecek JT, Chen Y, Zheng K, Cramer SC. Home-based technologies for stroke rehabilitation: A systematic review. *Int J Med Inform*. 2019;123:11–22. doi:10.1016/j.ijmedinf.2018.12.001

[4] Lee HS, Park YJ, Park SW. The Effects of Virtual Reality Training on Function in Chronic Stroke Patients: A Systematic Review and Meta-Analysis. *Biomed Res Int*. 2019;2019:7595639. Published 2019 Jun 18. doi:10.1155/2019/7595639

Consequently, twenty-one studies were selected in the second screening of meta-analyses. The PEDro scale was used to assess the quality of the selected studies. The total effect size for VR rehabilitation programs was 0.440. The effect size for upper limb function was 0.431, for lower limb function it was 0.424, and for overall function it was 0.545. The effects of VR programs on specific outcomes were most effective for improving muscle tension, followed by muscle strength, activities of daily living (ADL), joint range of motion, gait, balance, and kinematics. The VR training was effective in improving the function in chronic stroke patients, corresponding to a moderate effect size. Moreover, VR training showed a similar effect for improving lower limb function as it did for upper limb function.

Maier, M et al (2019) [Meta-Analysis] Effect of Specific Over Nonspecific VR-Based Rehabilitation on Poststroke Motor Recovery: A Systematic Meta-Analysis[5]
Maier et al evaluated the efficacy of specific VR (SVR) and nonspecific VR (NSVR) systems for rehabilitating upper-limb function and activity after stroke. They conducted a systematic search for randomised controlled trials with adult stroke patients to analyse the effect of SVR or NSVR systems versus conventional therapy (CT). They identified 30 studies including 1473 patients. SVR showed a significant impact on body function (standardised mean difference [SMD] = 0.23; 95% CI = 0.10 to 0.36; P = .0007) versus CT, whereas NSVR did not (SMD = 0.16; 95% CI = -0.14 to 0.47; P = .30). This result was replicated in activity measures. Their results suggest that SVR systems are more beneficial than CT for upper-limb recovery, whereas NSVR systems are not. Additionally, they identified six principles of neurorehabilitation that are shared across SVR systems and are possibly responsible for their positive effect. These findings may disambiguate the contradictory results found in the current literature.

[5] Maier M, Rubio Ballester B, Duff A, Duarte Oller E, Verschure PFMJ. Effect of Specific Over Nonspecific VR-Based Rehabilitation on Poststroke Motor Recovery: A Systematic Meta-analysis. *Neurorehabil Neural Repair.* 2019;332.:112- 129. doi:10.1177/1545968318820169

Moral-Munoz, J.A. et al (2019) [Systematic Review] Smartphone-based Systems for Physical Rehabilitation Applications: A Systematic Review[6]

This paper presents a systematic review of the literature on smartphone-based systems designed for remote facilitation of physical rehabilitation. A total of 74 documents from Web of Science search results were reviewed. Systems were classified based on target medical conditions, and a taxonomy of technology was created along with identification of monitored activities. Beyond monitoring, some systems also provide patient-caregiver communication and progress management functions. The review identifies major research interests in stroke, cardiac disease, balance impairment and joint/limb rehabilitation; however, there is a lack of attention to other diseases. There are also few systems that have computerized existing clinical tests. On the basis of the review, design recommendations are formulated to encourage implementation of advanced functionalities, usability considerations, and system validation based on clinical evidence. Results of this study may help researchers and companies to design functions and interactions of smartphone-based rehabilitation systems or to select technology.

Piran, P et al (2019) [Systematic Review] Medical Mobile Applications for Stroke Survivors and Caregivers[7]

Objective: To identify apps 1. designed for stroke survivors/caregivers; 2. dealing with a modifiable stroke risk factor (SRF); or 3. that were developed for other purposes but could potentially be used by stroke survivors/caregivers. Methods: A systematic review of the medical apps in the US Apple iTunes store was conducted between August 2013 and January 2016 using 18 predefined inclusion/exclusion criteria. SRFs considered were: diabetes, hypertension, smoking, obesity, atrial fibrillation, and dyslipidemia. Conclusions: Over 70 medical apps exist to specifically support stroke survivors/caregivers and primarily targeted language and communication difficulties. Apps encompassing most stroke survivor/caregiver needs could be developed and tested to ensure the issues faced by these populations are being adequately addressed.

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[6] Moral-Munoz JA PhD, Zhang W PhD, Cobo MJ PhD, Herrera-Viedma E PhD, Kaber DB PhD. Smartphone-based systems for physical rehabilitation applications: A systematic review [published online ahead of print, 2019 May 21]. *Assist Technol.* 2019;1-14. doi:10.1080/10400435.2019.1611676

[7] Piran P, Thomas J, Kunnakkat S et al Medical Mobile Applications for Stroke Survivors and Caregivers. *J Stroke Cerebrovasc Dis.* 2019;28(11):104318. doi:10.1016/j.jstrokecerebrovasdis.2019.104318

Rintala, A et al (2019) [Systematic Review and Meta-Analysis]

Effectiveness of Technology-Based Distance Physical Rehabilitation Interventions for Improving Physical Functioning in Stroke: A Systematic Review and Meta-analysis of Randomized Controlled Trials[8]

Objective: To study the effectiveness of technology-based distance physical rehabilitation interventions on physical functioning in stroke. Conclusions: The findings suggest that the effectiveness of technology-based distance physical rehabilitation interventions on physical functioning might be similar compared to traditional treatments in stroke. Further research should be performed to confirm the effectiveness of technology-based distance physical rehabilitation interventions for improving physical functioning of persons with stroke.

Schroder, Jonas et al (2019) [Systematic Review] Combining the Benefits of Tele-Rehabilitation and Virtual Reality-Based Balance Training: A Systematic Review on Feasibility and Effectiveness[9]

This review aims to investigate whether it is feasible to combine virtual reality (VR) which allows exercising in game-like environments with tele-rehabilitation in a community-dwelling stroke population. Conclusions: Tele-rehabilitation could be a promising tool to overcome burdens that restrict accessibility to rehabilitation in the future. VR can increase motivation allowing longer and more training sessions in community-dwelling stroke survivors. Therefore, combining the benefits of both approaches seems convenient. Although evidence is still sparse, functional improvements seem to be equal compared to a similar intervention with therapist-supervision in the clinic, suggesting that for cost-efficient rehabilitation parts of therapy can be transferred to the homes. Implications for rehabilitation The use of tele-rehabilitation could be a promising tool to overcome burdens that restrict the access of stroke survivors to long-term rehabilitative care. VR-based interventions are game-like and therefore seem to provide a motivational environment which allows longer exercise sessions and greater adherence to therapy.

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[8] Rintala A, Päivärinne V, Hakala S et al Effectiveness of Technology-Based Distance Physical Rehabilitation Interventions for Improving Physical Functioning in Stroke: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Arch Phys Med Rehabil.* 2019;1007.:1339-1358. doi:10.1016/j.apmr.2018.11.007

[9] Schröder J, van Criekinge T, Embrechts E et al Combining the benefits of tele-rehabilitation and virtual reality-based balance training: a systematic review on feasibility and effectiveness. *Disabil Rehabil Assist Technol.* 2019;141.:2-11. doi:10.1080/17483107.2018.1503738

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Bonnechere, Bruno et al (2016) [Systematic Review] The use of commercial video games in rehabilitation: a systematic review[10]

The aim of this paper was to investigate the effect of commercial video games (VGs) in physical rehabilitation of motor functions. Several databases were screened using combinations of the following free-text terms: commercial games, video games, exergames, serious gaming, rehabilitation games, PlayStation, Nintendo, Wii, Wii Fit, Xbox, and Kinect. The search was limited to peer-reviewed English journals. The beginning of the search time frame was not restricted and the end of the search time frame was 31 December 2015. Only randomized controlled trial, cohort, and observational studies evaluating the effect of VGs on physical rehabilitation were included in the review. A total of 4728 abstracts were screened, 275 were fully reviewed, and 126 papers were eventually included. The following information was extracted from the selected studies: device type, number and type of patients, intervention, and main outcomes. The integration of VGs into physical rehabilitation has been tested for various pathological conditions, including stroke, cerebral palsy, Parkinson's disease, balance training, weight loss, and aging. There was large variability in the protocols used (eg number of sessions, intervention duration, outcome measures, and sample size). The results of this review show that in most cases, the introduction of VG training in physical rehabilitation offered similar results as conventional therapy. Therefore, VGs could be added as an adjunct treatment in rehabilitation for various pathologies to stimulate patient motivation. VGs could also be used at home to maintain rehabilitation benefits.

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[10] Bonnechère B, Jansen B, Omelina L, Van Sint Jan S. The use of commercial video games in rehabilitation: a systematic review. *Int J Rehabil Res.* 2016;394.:277- 290. doi:10.1097/MRR.0000000000000190

Cho, Deng-Rae et al (2019) [Randomised Controlled Trial] Effects of Virtual Reality Immersive Training With Computerized Cognitive Training on Cognitive Function and Activities of Daily Living Performance in Patients With Acute Stage Stroke: A Preliminary Randomized Controlled Trial[11]

The purpose of this study was to investigate the impact of virtual reality immersive training with computerized cognitive training on the cognitive function and activity of daily living in patients with acute stroke. Cho and Lee included 42 patients with acute stage stroke from C hospital in Sungnam from May 2017 to September 2017. The patients were randomly selected and divided into the experimental (n = 21) and control (n = 21) group. The experimental group performed virtual reality training, including Head Mount Display with computerized cognitive therapy, and the control group performed computerized cognitive therapy. Both groups trained for 30 minutes a day 5 times a week; the intervention lasted 4 weeks. To evaluate the improvement in each group, pre-post-test evaluation was conducted using the Loewenstein Occupational Therapy Cognitive Assessment and Computerized Neurocognitive Function Test for cognitive function, and Functional Independent Measure for activities of daily living. Attention and memory in cognitive function and activity of daily living performance were improved in the both groups. Virtual reality immersive training might be an affordable approach for cognitive function and activity of daily living performance recovery for patients with acute stroke.

Maresca, G et al (2019) Toward Improving Poststroke Aphasia: A Pilot Study on the Growing Use of Telerehabilitation for the Continuity of Care[12]

Background: Aphasia is a quite common and very disabling symptom following stroke, negatively affecting patient's quality of life. The aim of this

[11] Cho DR, Lee SH. Effects of virtual reality immersive training with computerized cognitive training on cognitive function and activities of daily living performance in patients with acute stage stroke: A preliminary randomized controlled trial. *Medicine (Baltimore).* 2019;98(11):e14752. doi:10.1097/MD.0000000000014752

[12] Maresca G, Maggio MG, Latella D et al Toward Improving Poststroke Aphasia: A Pilot Study on the Growing Use of Telerehabilitation for the Continuity of Care. *J Stroke Cerebrovasc Dis.* 2019;28(10):104303. doi:10.1016/j.jstrokecerebrovasdis.2019.104303

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study is to evaluate the effectiveness of rehabilitation training for aphasia that employ a touch-screen tablet using a virtual reality rehabilitation system (VRRS-Tablet). Thirty patients with aphasia due to ischemic or haemorrhagic stroke were randomised into either the control or the experimental group and assessed by means of a specific neuropsychological evaluation. The study lasted 6 months and included 2 phases. During the former, the experimental group underwent an experimental linguistic treatment performed using the VRRS-Tablet, while the control group was trained with a traditional linguistic treatment. In the latter, the control groups were delivered to territorial services, while the experimental group was provided with the VRRS-Tablet. The experimental group improves in all the investigated areas, except for writing, while the control group only improves in comprehension, depression, and quality of life. The study has demonstrated the effectiveness of a home-based telerehabilitation program specific for poststroke aphasia. The use of telerehabilitation by means of VRRS-Tablet could be one of the best solutions to treat aphasic patients after their discharge, promoting continuity of care by monitoring functional outcomes, maintaining preserved abilities, reducing depression, and improving linguistic functions, besides the psychological well-being.

Torrisi, M et al (2019) [Randomised Controlled Trial] [Using telerehabilitation to improve cognitive function in post-stroke survivors: is this the time for the continuity of care?](#)[13]

The aim of our study is to evaluate the efficacy of a virtual reality rehabilitation system in improving cognitive function in stroke survivors. Forty patients affected by stroke were enrolled in this study and randomized into either the control or the experimental groups in order of recruitment. The study lasted 6 months, and included two phases: 1. during the first phase the experimental group underwent cognitive rehabilitation training using the Virtual Reality Rehabilitation System-Evo, whereas the control group was submitted to standard cognitive training; 2. in the second phase after discharge, the experimental group was treated by means of virtual reality rehabilitation system Home Tablet [three sessions per week, each session lasting about 50 minutes], and the control group continued the traditional training, with the same amount of treatment. The patients underwent a neuropsychological evaluation before and at the end of the treatment. Linear

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[13] Torrisi M, Maresca G, De Cola MC et al Using telerehabilitation to improve cognitive function in post-stroke survivors: is this the time for the continuity of care?. *Int J Rehabil Res*. 2019;424.:344- 351. doi:10.1097/MRR.0000000000000369

mixed-effects analysis results showed that the scores of Montreal overall cognitive assessment, attentive matrices, Trail Making Test B, Phonemic Fluency, Semantic Fluency, Rey Auditory Verbal Learning Test I, Hamilton Rating Scale-Anxiety and Hamilton Rating Scale-Depression were affected by the type of the rehabilitative treatment. Our data show the effectiveness of telerehabilitation for the treatment of cognitive disorders following stroke.

Yacoby, Anat et al (2019) [Randomised Controlled Trial] Feasibility of, Adherence to, and Satisfaction With Video Game Versus Traditional Self-Training of the Upper Extremity in People With Chronic Stroke: A Pilot Randomized Controlled Trial[14]

Yacoby et al compared the feasibility of, adherence to, and satisfaction with a newly developed upper extremity (UE) self-training protocol using commercial video games with a traditional self-training programme for people with chronic stroke. 24 participants with mild to moderate UE weakness were randomised to a video game (n = 13) or a traditional (n = 11) self-training programme. Participants were requested to train 60 min/day, 6×/wk. During the 5-wk self-training programme and 4-wk follow-up, participants documented their self-training time and rated their perceived enjoyment and exertion. 11 participants completed video game training; 9 completed traditional self-training. During the follow-up period, 8 participants (72.7%) continued the video game training, and 4 (44.4%) continued traditional training. Perceived enjoyment, satisfaction, and benefit for UE improvement were relatively high. Participants demonstrated high adherence to and satisfaction with both self-training programmes. More participants continued to play video games after the intervention, indicating its potential to maintain ongoing activity.

Laver, KE et al (2017) [Cochrane Systematic Review - update] Virtual Reality for Stroke Rehabilitation[15]

This is an update of a Cochrane Review published first in 2011 and then again in 2015. Objectives: Primary Objective: to determine the efficacy of virtual reality compared with an alternative intervention or no intervention on upper

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[14] Yacoby A, Zeilig G, Weingarden H, Weiss R, Rand D. Feasibility of, Adherence to, and Satisfaction With Video Game Versus Traditional Self-Training of the Upper Extremity in People With Chronic Stroke: A Pilot Randomized Controlled Trial. *Am J Occup Ther.* 2019;731.:7301205080p1- 7301205080p14.

[15] Laver KE, Lange B, George S, Deutsch JE, Saposnik G, Crotty M. Virtual reality for stroke rehabilitation. *Cochrane Database Syst Rev.* 2017;11(11):CD008349. Published 2017 Nov 20. doi:10.1002/14651858.CD008349.pub4

limb function and activity. Secondary Objectives: to determine the efficacy of virtual reality compared with an alternative intervention or no intervention on: gait and balance, global motor function, cognitive function, activity limitation, participation restriction, quality of life, and adverse events. Primary outcome: results were not statistically significant for upper limb function (standardised mean difference (SMD) 0.07, 95% confidence intervals (CI) -0.05 to 0.20, 22 studies, 1038 participants, low-quality evidence) when comparing virtual reality to conventional therapy. However, when virtual reality was used in addition to usual care, providing a higher dose of therapy for those in the intervention group, there was a statistically significant difference between groups (SMD 0.49, 0.21 to 0.77, 10 studies, 210 participants, low-quality evidence). Secondary outcomes: when compared to conventional therapy approaches there were no statistically significant effects for gait speed or balance. Results were statistically significant for the activities of daily living (ADL) outcome (SMD 0.25, 95% CI 0.06 to 0.43, 10 studies, 466 participants, moderate-quality evidence); however, we were unable to pool results for cognitive function, participation restriction, or quality of life. Twenty-three studies reported that they monitored for adverse events; across these studies there were few adverse events and those reported were relatively mild. Authors' Conclusions: We found evidence that the use of virtual reality and interactive video gaming was not more beneficial than conventional therapy approaches in improving upper limb function. Virtual reality may be beneficial in improving upper limb function and activities of daily living function when used as an adjunct to usual care to increase overall therapy time. There was insufficient evidence to reach conclusions about the effect of virtual reality and interactive video gaming on gait speed, balance, participation, or quality of life. This review found that time since onset of stroke, severity of impairment, and the type of device [commercial or customised] were not strong influencers of outcome. There was a trend suggesting that higher dose of more than 15 hours of total intervention was preferable as were customised virtual reality programs; however, these findings were not statistically significant.

Miscellaneous

Chen, Yu et al (2020) [A Qualitative Study on User Acceptance of a Home-Based Stroke Telerehabilitation System](#)[16]
This paper reports a qualitative study of a home-based stroke telerehabilitation system. The telerehabilitation system delivers treatment sessions in the form of daily guided rehabilitation games, exercises, and stroke education in the patient's home. The aims of the current report are to investigate patient perceived benefits of and barriers to using the telerehabilitation system at home. Conclusion: Telerehabilitation systems can be used as an efficient and user-friendly tool to deliver home-based stroke rehabilitation that enhance patients' physical recovery and mental and social-emotional wellbeing. Such systems need to be designed to offer engaging experience, display of recovery progress, and flexibility of schedule and location, with consideration of facilitating and social factors.

Hyakutake, K et al (2019) [Pilot Study] [Effects of Home-Based Robotic Therapy Involving the Single-Joint Hybrid Assistive Limb Robotic Suit in the Chronic Phase of Stroke: A Pilot Study](#)[17]
This study aimed to investigate paretic upper limb activity and function with home-based robotic therapy involving a single-joint hybrid assistive limb (HAL-SJ) in stroke patients. A home-based robotic therapy programme involving a HAL-SJ was performed for 30 min per session followed by standard therapy for 30 min per session, 2 times a week, for 4 weeks (i.e., completion of all 8 sessions involved 8 h of rehabilitation), at home. After the intervention, patients were followed up by telephone and home visits for 8 weeks. The paretic upper limb activity and function were assessed using the Motor Activity Log (MAL; amount of use (AOU)), arm triaxial accelerometry (laterality index (LI)), the Fugl-Meyer assessment (FMA), and the action research arm test (ARAT), at baseline and week 4 and week 12 after the start of training. The AOU scores and LI significantly improved at week 4 after the

[16] Chen Y, Chen Y, Zheng K et al A qualitative study on user acceptance of a home-based stroke telerehabilitation system. *Top Stroke Rehabil.* 2020;272.:81- 92. doi:10.1080/10749357.2019.1683792
[17] Hyakutake K, Morishita T, Saita K et al Effects of Home-Based Robotic Therapy Involving the Single-Joint Hybrid Assistive Limb Robotic Suit in the Chronic Phase of Stroke: A Pilot Study. *Biomed Res Int.* 2019;2019:5462694. Published 2019 Mar 18. doi:10.1155/2019/5462694

start of training (p<0.05). However, no significant changes were observed in the LI at week 12 (p=0.161) and the FMA scores at both week 4 and week 12 (p=0.059 and p=0.083, respectively). The ARAT scores significantly improved at both week 4 and week 12 (p<0.05). Home-based robotic therapy combined with conventional therapy could be a valuable approach for increasing paretic upper limb activity and maintaining paretic upper limb function in the chronic phase of stroke.

Norouzi-Gheidari, N et al (2019) [Clinical Trial] Feasibility, Safety and Efficacy of a Virtual Reality Exergame System to Supplement Upper Extremity Rehabilitation Post-Stroke: A Pilot Randomized Clinical Trial and Proof of Principle[18]

Rehabilitation-based virtual reality exergame systems, such as Jintronix, can be offered to stroke survivors as an adjunct to traditional therapy. The goal of this study was to examine the safety and feasibility of providing additional therapy using an exergame system and assess its preliminary clinical efficacy. The efficacy measures showed statistically meaningful improvements in the activities of daily living measures ▯ ie MAL-QOM and both mobility and physical domains of the SIS with mean difference of 1.0%, 5.5%, and 6.7% between the intervention and control group, respectively ▯ at post-intervention. Conclusion: Using virtual reality exergaming technology as an adjunct to traditional therapy is feasible and safe in post-stroke rehabilitation and may be beneficial to upper extremity functional recovery.

Seo, Na Jin et al (2019) Capturing Upper Limb Gross Motor Categories Using the Kinect® Sensor[19]

Seo et al examined the feasibility of using the Kinect sensor in an objective, computerised clinical assessment of upper limb motor categories. They developed a computerised Mallet classification using the Kinect sensor. Accuracy of computer scoring was assessed based on reference scores determined collaboratively by multiple evaluators from reviewing video recording of movements. In addition, using the reference score, they assessed the accuracy of the typical clinical procedure in which scores were determined immediately based on visual observation. The accuracy of the

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[18] Norouzi-Gheidari N, Hernandez A, Archambault PS, Higgins J, Poissant L, Kairy D. Feasibility, Safety and Efficacy of a Virtual Reality Exergame System to Supplement Upper Extremity Rehabilitation Post-Stroke: A Pilot Randomized Clinical Trial and Proof of Principle. *Int J Environ Res Public Health*. 2019;171.:113. Published 2019 Dec 23. doi:10.3390/ijerph17010113

[19] Seo NJ, Crocher V, Spaho E et al Capturing Upper Limb Gross Motor Categories Using the Kinect® Sensor. *Am J Occup Ther*. 2019;734.:7304205090p1- 7304205090p10. doi:10.5014/ajot.2019.031682

computer scores was compared with that of the typical clinical procedure. Seven patients with stroke and 10 healthy adults participated in the laboratory-based study. Healthy participants intentionally achieved predetermined scores. The outcomes and measures were the accuracy of the computer scores in comparison with accuracy of the typical clinical procedure (immediate visual assessment). The computerised assessment placed participants' upper limb movements in motor categories as accurately as did typical clinical procedures. Computerised clinical assessment using the Kinect sensor promises to facilitate tele-evaluation and complement telehealth applications.

Zanona, A et al (2019) Use of Virtual Rehabilitation to Improve the Symmetry of Body Temperature, Balance, and Functionality of Patients with Stroke Sequelae[20]
Purpose: The objective of this study was to evaluate the acute effect of an occupational therapy protocol associated with virtual reality (VR) on the symmetry of body temperature (BTP), balance, and functionality of patients with stroke sequelae. Conclusion: VR associated with occupational therapeutic planning can amplify and potentiate neurological recovery following stroke.

Carregosa, AA et al (2018) Virtual Rehabilitation Through Nintendo Wii in Poststroke Patients: Follow-Up[21]
The objective of this study was to evaluate the follow-up of the sensory-motor recovery and quality of life patients two months after completion of the Nintendo Wii console intervention and determine whether learning retention was obtained through the technique. Five hemiplegics patients participated in the study, of whom 3 were male with an average age of 54.8 years (SD = 4.6). Everyone practiced Nintendo Wii therapy for 2 months (50 minutes/day, 2 times/week, during 16 sessions). Each session lasting 60 minutes, under a protocol in which only the games played were changed, plus 10 minutes of stretching. In the first session, tennis and hula hoop games were used; in the second session, football (soccer) and boxing were used. For the evaluation, the Fulg-Meyer and Short Form Health Survey 36

[20] Zanona AF, de Souza RF, Aidar FJ et al Use of Virtual Rehabilitation to Improve the Symmetry of Body Temperature, Balance, and Functionality of Patients with Stroke Sequelae. *Ann Neurosci.* 2019;253.:166-173. doi:10.1159/000488581
[21] Carregosa AA, Aguiar Dos Santos LR, Masruha MR et al Virtual Rehabilitation through Nintendo Wii in Poststroke Patients: Follow-Up. *J Stroke Cerebrovasc Dis.* 2018;272.:494-498. doi:10.1016/j.jstrokecerebrovasdis.2017.09.029

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(SF-36) scales were utilized. The patients were immediately evaluated upon the conclusion of the intervention and 2 months after the second evaluation (follow-up). Values for the upper limb motor function sub-items and total score in the Fugl-Meyer scale evaluation and functional capacity in the SF-36 questionnaire were sustained, indicating a possible maintenance of the therapeutic effects. The results suggest that after Nintendo Wii therapy, patients had motor learning retention, achieving a sustained benefit through the technique.

Ding, WL et al (2018) [Case Study] Kinect-based virtual rehabilitation and evaluation system for upper limb disorders: A case study[22]
Objective: To help patients with disabilities of the arm and shoulder recover the accuracy and stability of movements, a novel and simple virtual rehabilitation and evaluation system called the Kine-VRES system was developed using Microsoft Kinect. Methods: First, several movements and virtual tasks were designed to increase the coordination, control and speed of the arm movements. The movements of the patients were then captured using the Kinect sensor, and kinematics-based interaction and real-time feedback were integrated into the system to enhance the motivation and self-confidence of the patient. Finally, a quantitative evaluation method of upper limb movements was provided using the recorded kinematics during hand-to-hand movement. Results: A preliminary study of this rehabilitation system indicates that the shoulder movements of two participants with ataxia became smoother after three weeks of training (one hour per day). Conclusion: This case study demonstrated the effectiveness of the designed system, which could be promising for the rehabilitation of patients with upper limb disorders.

Givon Schaham, N et al (2018) Game analysis and clinical use of the Xbox-Kinect for stroke rehabilitation[23]
Whole-body movement is required to interact with Microsoft Xbox with the 3D Kinect sensor (Xbox-Kinect) and, therefore, may be suitable for encouraging and practicing movements as part of stroke rehabilitation. We aimed to describe: 1. game analysis; 2. clinical use; and 3. the Xbox-Kinect game experience with individuals with chronic stroke. Four therapists played

[22] Ding WL, Zheng YZ, Su YP, Li XL. Kinect-based virtual rehabilitation and evaluation system for upper limb disorders: A case study. *J Back Musculoskelet Rehabil.* 2018;314.:611- 621. doi:10.3233/BMR-140203
[23] Givon Schaham N, Zeilig G, Weingarden H, Rand D. Game analysis and clinical use of the Xbox-Kinect for stroke rehabilitation. *Int J Rehabil Res.* 2018;414.:323- 330. doi:10.1097/MRR.0000000000000302

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the Xbox-Kinect games and then carried out a games analysis on the basis of the categories suggested by Deutsch. Eleven participants aged 29-69 years with chronic stroke and varying motor deficits played Xbox-Kinect games for 4-22 sessions as part of a video-game group intervention and the clinical use was documented. The game experience was characterized by self-report questionnaires. Detailed tables of game analysis are provided. The clinical use of the console with the participants is presented. Participants reported high enjoyment and 'somewhat-high' perceived exertion after playing the two games and stated that overall the console suited their therapeutic goals. This information can assist clinicians with their clinical reasoning and decision-making for incorporating the Xbox-Kinect into stroke rehabilitation. Potentially, the Xbox-Kinect could be used as an on-going tool to facilitate whole-body movement and physical activity of individuals with chronic stroke.

Held, JP et al (2018) [Autonomous rehabilitation at stroke patients home for balance and gait: safety, usability and compliance of a virtual reality system](24)

Aim: To study the safety, usability and patient acceptance of an autonomous telerehabilitation system for balance and gait [the REWIRE platform] in the patient's home. Methods: Autonomous rehabilitation based on virtual rehabilitation was provided at the participants' home for twelve weeks. The primary outcome was compliance (the ratio between days of actual and scheduled training), analyzed with the two-tailed Wilcoxon Mann-Whitney test. Furthermore safety is defined by adverse events. The secondary endpoint was the acceptance of the system measured with the Technology Acceptance Model (TAM). Additionally, the cumulative duration of weekly training was analyzed. Results: During the study there were no adverse events related to the therapy. Patients performed on average 71% (range 39 to 92%) of the scheduled sessions. The TAM Questionnaire showed excellent values for stroke patients after the training. The average training duration per week was 99±53min. Conclusions: Autonomous telerehabilitation for balance and gait training with the REWIRE-system is safe, feasible and can help to intensive rehabilitative therapy at home.

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[24] Held JP, Ferrer B, Mainetti R et al Autonomous rehabilitation at stroke patients home for balance and gait: safety, usability and compliance of a virtual reality system. *Eur J Phys Rehabil Med*. 2018;544.:545- 553. doi:10.23736/S1973-9087.17.04802-X

Triandafilou, KM et al (2018) [Development of a 3D, networked multi-user virtual reality environment for home therapy after stroke](#)[25]

Methods: We developed a 3D, networked multi-user Virtual Environment for Rehabilitative Gaming Exercises (VERGE) system for home therapy. Within this environment, stroke survivors can interact with therapists and/or fellow stroke survivors in the same virtual space even though they may be physically remote. Each user's own movement controls an avatar through kinematic measurements made with a low-cost, Kinect™ device. The system was explicitly designed to train movements important to rehabilitation and to provide real-time feedback of performance to users and clinicians. To obtain user feedback about the system, 15 stroke survivors with chronic upper extremity hemiparesis participated in a multisession pilot evaluation study, consisting of a three-week intervention in a laboratory setting. For each week, the participant performed three one-hour training sessions with one of three modalities: 1. VERGE system; 2. an existing virtual reality environment based on Alice in Wonderland (AWVR); or 3. a home exercise program (HEP). Results: Over 85% of the subjects found the VERGE system to be an effective means of promoting repetitive practice of arm movement. Arm displacement averaged 350 m for each VERGE training session. Arm displacement was not significantly less when using VERGE than when using AWVR or HEP. Participants were split on preference for VERGE, AWVR or HEP. Importantly, almost all subjects indicated a willingness to perform the training for at least 2-3 days per week at home. Conclusions: Multi-user VR environments hold promise for home therapy, although the importance of reducing complexity of operation for the user in the VR system must be emphasized. A modified version of the VERGE system is currently being used in a home therapy study.

Dobkin, Bruce (2017) [A Rehabilitation-Internet-of-Things in the Home to Augment Motor Skills and Exercise Training](#)[26]

Although motor learning theory has led to evidence-based practices, few trials have revealed the superiority of one theory-based therapy over another after stroke. Nor have improvements in skills been as clinically robust as one might hope. We review some possible explanations, then

[25] Triandafilou KM, Tsoupikova D, Barry AJ, Thielbar KN, Stoykov N, Kamper DG. Development of a 3D, networked multi-user virtual reality environment for home therapy after stroke. *J Neuroeng Rehabil.* 2018;151.:88. Published 2018 Oct 5. doi:10.1186/s12984-018-0429-0

[26] Dobkin BH. A Rehabilitation-Internet-of-Things in the Home to Augment Motor Skills and Exercise Training. *Neurorehabil Neural Repair.* 2017;313.:217- 227. doi:10.1177/1545968316680490

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potential technology-enabled solutions. Over the Internet, the type, quantity, and quality of practice and exercise in the home and community can be monitored remotely and feedback provided to optimize training frequency, intensity, and progression at home. A theory-driven foundation of synergistic interventions for walking, reaching and grasping, strengthening, and fitness could be provided by a bundle of home-based Rehabilitation Internet-of-Things (RIoT) devices. A RIoT might include wearable, activity-recognition sensors and instrumented rehabilitation devices with radio transmission to a smartphone or tablet to continuously measure repetitions, speed, accuracy, forces, and temporal spatial features of movement. Using telerehabilitation resources, a therapist would interpret the data and provide behavioral training for self-management via goal setting and instruction to increase compliance and long-term carryover. On top of this user-friendly, safe, and conceptually sound foundation to support more opportunity for practice, experimental interventions could be tested or additions and replacements made, perhaps drawing from virtual reality and gaming programs or robots. RIoT devices continuously measure the actual amount of quality practice; improvements and plateaus over time in strength, fitness, and skills; and activity and participation in home and community settings. Investigators may gain more control over some of the confounders of their trials and patients will have access to inexpensive therapies.

Dodakian, Lucy et al (2017) A Home-Based Telerehabilitation Program for Patients With Stroke[27]

We designed, then evaluated a home-based telerehabilitation system in patients with chronic hemiparetic stroke. Methods: Patients were 3 to 24 months poststroke with stable arm motor deficits. Each received 28 days of telerehabilitation using a system delivered to their home. Each day consisted of 1 structured hour focused on individualized exercises and games, stroke education, and an hour of free play. Conclusions: This home-based system was effective in providing telerehabilitation, education, and secondary stroke prevention to participants. Use of a computer-based interface offers many opportunities to monitor and improve the health of patients after stroke.

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[27] Dodakian L, McKenzie AL, Le V et al A Home-Based Telerehabilitation Program for Patients With Stroke. *Neurorehabil Neural Repair*. 2017;31(10-11):923- 933. doi:10.1177/1545968317733818

Minge, M et al (2017) [BeMobil: Developing a User-Friendly and Motivating Telerehabilitation System for Motor Relearning After Stroke](#)[28]

Motor relearning after stroke is a lengthy process which should be continued after patients get discharged from the clinic. This project aims at developing a system for telerehabilitation which enables stroke patients to exercise at home autonomously or under supervision of a therapist. The system includes haptic therapy devices which are more promising and beneficial for stroke rehabilitation than non-haptic approaches. In this paper, we present the results of two initial studies investigating specific design solutions for the patient's user interface. In the first study, we developed four interactive prototypes illustrating different navigation concepts. A usability test was conducted to identify the best suitable concept. In the second study we followed a participatory design approach to create a set of design solutions for a motivating instant visual feedback for exercising with the haptic devices. The current project status and next steps are described.

Simpson, Lisa A et al (2017) [H-GRASP: the feasibility of an upper limb home exercise program monitored by phone for individuals post stroke](#)[29]

Purpose: To investigate the feasibility of a phone-monitored home exercise program for the upper limb following stroke.

Methods: A pre-post double baseline repeated measures design was used. Participants completed an 8-week home exercise program that included behavioural strategies to promote greater use of the affected upper limb. Participants were monitored weekly by therapists over the phone. The following feasibility outcomes were collected: process [eg recruitment rate]; resources [eg exercise adherence rate]; management [eg therapist monitoring] and scientific [eg safety, effect sizes]. Clinical outcomes included: The Chedoke Arm and Hand Inventory, Motor Activity Log, grip strength and the Canadian Occupational Performance Measure. Conclusions: Community dwelling individuals with stroke may benefit from a phone-monitored upper limb home exercise program that includes behavioural strategies that promote transfer of exercise gains into daily upper limb use. Implications for Rehabilitation A repetitive, task-oriented home exercise program that utilizes telephone supervision may be an effective method for

[28] Minge M, Ivanova E, Lorenz K, Joost G, Thuring M, Kruger J. BeMobil: Developing a user-friendly and motivating telerehabilitation system for motor relearning after stroke. *IEEE Int Conf Rehabil Robot.* 2017;2017:870- 875. doi:10.1109/ICORR.2017.8009358

[29] Simpson LA, Eng JJ, Chan M. H-GRASP: the feasibility of an upper limb home exercise program monitored by phone for individuals post stroke. *Disabil Rehabil.* 2017;39(9):874- 882. doi:10.3109/09638288.2016.1162853

the treatment of the upper limb following stroke This program is best suited for individuals with mild to moderate level impairment and experience a sufficient level of challenge from the exercises An exercise program that includes behavioural strategies may promote transfer of exercise gains into greater use of the affected upper limb during daily activities.

Buick, Alison R et al (2016) Tele-Supervised FES-Assisted Exercise for Hemiplegic Upper Limb[30]

Stroke survivors often have upper limb hemiparesis, limiting their ability to perform activities of daily life. Intensive, task-oriented exercise therapy can improve UL function, but motivation to perform sufficient ET is difficult to maintain. Here, we report on a trial in which a workstation was deployed in the homes of chronic stroke survivors to enable tele-coaching of ET in the guise of computer games. Participants performed six weeks of 1 h/day, five days/week ET. Hand opening and grasp were assisted with functional electrical stimulation. The primary outcome measure was the Action Research Arm Test. Secondary outcome measures included a quantitative test of UL function performed on the workstation, grasp force measurements and transcranial magnetic stimulation. Improvements were seen in the functional tests, but surprisingly, not in the TMS responses. An important finding was that participants commencing with intermediate functional scores improved the most. Conclusions: 1. daily, tele-supervised FES-ET in chronic stroke survivors is feasible with commercially-available technology; 2. the intervention can significantly improve UL function, particularly in people who start with an intermediate level of function; 3. significant improvements in UL function can occur in the absence of changes in TMS responses.

Paul, Lorna et al (2016) [Pilot Study] Increasing physical activity in stroke survivors using STARFISH, an interactive mobile phone application: a pilot study[31]

We developed STARFISH, a mobile phone app-based intervention, which incorporates evidence-based behavior change techniques [feedback, self-monitoring and social support], in which users' physical activity is visualized by fish swimming. Objective: To evaluate the potential effectiveness of

[30] Buick AR, Kowalczewski J, Carson RG, Prochazka A. Tele-Supervised FES-Assisted Exercise for Hemiplegic Upper Limb. *IEEE Trans Neural Syst Rehabil Eng.* 2016;241.:79- 87. doi:10.1109/TNSRE.2015.2408453

[31] Paul L, Wyke S, Brewster S et al Increasing physical activity in stroke survivors using STARFISH, an interactive mobile phone application: a pilot study. *Top Stroke Rehabil.* 2016;233.:170- 177. doi:10.1080/10749357.2015.1122266

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STARFISH in stroke survivors. Method: Twenty-three people with stroke (12 women; age: 56.0 ± 10.0 years, time since stroke: 4.2 ± 4.0 years) from support groups in Glasgow completed the study. Participants were sequentially allocated in a 2:1 ratio to intervention (n = 15) or control (n = 8) groups. The intervention group followed the STARFISH program for six weeks; the control group received usual care. Outcome measures included physical activity, sedentary time, heart rate, blood pressure, body mass index, Fatigue Severity Scale, Instrumental Activity of Daily Living Scale, Ten-Meter Walk Test, Stroke Specific Quality of Life Scale, and Psychological General Well-Being Index. Results: The average daily step count increased by 39.3% (4158 to 5791 steps/day) in the intervention group and reduced by 20.2% (3694 to 2947 steps/day) in the control group (p = 0.005 for group-time interaction). Similar patterns of data and group-time interaction were seen for walking time (p = 0.002) and fatigue (p = 0.003). There were no significant group-time interactions for other outcome measures. Conclusion: Use of STARFISH has the potential to improve physical activity and health outcomes in people after stroke and longer term intervention trials are warranted.

Staszuk, Arleta et al (2016) Telerehabilitation approach for patients with hand impairment[32]

The professional and advanced systems for telerehabilitation are presented in papers, however, there is still lack of development of minor systems which provide therapeutic values and are more accessible to people. Therefore, we focus on a solution for hand telerehabilitation of poststroke patients, based solely on a personal computer and camera. Methods: We focused on the manipulative hand [fingers, metacarpus, wrist] movements trainings for patients with cerebral palsy. The contact between patient and physiotherapist is provided by using web cameras and web service. Additionally, the camera can be used to monitor the effectiveness of performed exercises. Computer vision system keeps track of the patient's hand movement. The digital image processing is used to detect if the patient performs exercises correctly. Results: We created web service and software application TeleReh that provides therapeutic values for the hand impaired people. The system created was evaluated by three physiotherapists, one doctor and a cerebral palsy patient. Conclusions: Our solution applies to all

[32] Staszuk A, Wiatrak B, Tadeusiewicz R, Karuga-Kuźniewska E, Rybak Z. Telerehabilitation approach for patients with hand impairment. *Acta Bioeng Biomech*. 2016;184.:55- 62.

patients who have undergone basic rehabilitation in hospital and need to continue hand rehabilitation at home. The main advantages are: easy adaptation to the individual needs and abilities, monitoring the progress by using automatically generated reports after each training session. It is worth noticing that discussion between IT specialists, rehabilitants and patients was necessary to achieve good results.

Ehn, Maria et al (2015) Users perspectives on interactive distance technology enabling home-based motor training for stroke patients[33]

The aim of this work has been to develop a technical support enabling home-based motor training after stroke. The basis for the work plan has been to develop an interactive technical solution supporting three different groups of stroke patients: 1. patients with stroke discharged from hospital with support from neuro team; 2. patients with stroke whose support from neuro team will be phased out and 3. patients living with impaired motor functions long-term. The technology has been developed in close collaboration with end-users using a method earlier evaluated and described. This paper describes the main functions of the developed technology. Further, results from early user-tests with end-users, performed to identify needs for improvements to be carried out during further technical development. The developed technology will be tested further in a pilot study of the safety and, usefulness of the technology when applied as a support for motor training in three different phases of the post-stroke rehabilitation process.

Jagos, Harald et al (2015) Tele-monitoring of the Rehabilitation Progress in Stroke Patients[34]

Preservation of mobility in conjunction with an independent lifestyle is one of the major goals of rehabilitation after stroke. The Rehab@Home framework shall support the continuation of rehabilitation in the domestic area. The framework consists of instrumented insoles, wireless linked to a tablet PC, a server and a web-interface for medical experts. The rehabilitation progress is estimated via automated analysis of movement data from standardized assessment tests which are executed via the tablet PC application designed according to the needs of stroke patients. Initial evaluation of the analysis algorithms shows reproducible results for the

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[33] Ehn M, Hansson P, Sjölinder M et al Users perspectives on interactive distance technology enabling home-based motor training for stroke patients. *Stud Health Technol Inform.* 2015;211:145- 152.

[34] Jagos H, David V, Reichel M et al Tele-monitoring of the rehabilitation progress in stroke patients. *Stud Health Technol Inform.* 2015;211:311- 313.

overall time of the Timed Up and Go Test. Therefore, it is assumed that the Rehab@Home framework is applicable as monitoring tool for the gait rehabilitation progress in stroke patients.

Zhang, Songyuan et al (2015) [Design of a Novel Telerehabilitation System With a Force-Sensing Mechanism](#)[35]

Many stroke patients are expected to rehabilitate at home, which limits their access to proper rehabilitation equipment, treatment, or assessment by therapists. We have developed a novel telerehabilitation system that incorporates a human-upper-limb-like device and an exoskeleton device. The system is designed to provide the feeling of real therapist-patient contact via telerehabilitation. We applied the principle of a series elastic actuator to both the master and slave devices. On the master side, the therapist can operate the device in a rehabilitation center. When performing passive training, the master device can detect the therapist's motion while controlling the deflection of elastic elements to near-zero, and the patient can receive the motion via the exoskeleton device. When performing active training, the design of the force-sensing mechanism in the master device can detect the assisting force added by the therapist. The force-sensing mechanism also allows force detection with an angle sensor. Patients' safety is guaranteed by monitoring the motor's current from the exoskeleton device. To compensate for any possible time delay or data loss, a torque-limiter mechanism was also designed in the exoskeleton device for patients' safety. Finally, we successfully performed a system performance test for passive training with transmission control protocol/Internet protocol communication.

[35] Zhang S, Guo S, Gao B, Hirata H, Ishihara H. Design of a novel telerehabilitation system with a force-sensing mechanism. *Sensors (Basel)*. 2015;155.:11511- 11527. Published 2015 May 19. doi:10.3390/s150511511

CHAPTER 19
Telemedicine and Suicide Prevention

Systematic Reviews

Arshad, U et al (2020) [Systematic Review] A Systematic Review of the Evidence Supporting Mobile- And Internet-Based Psychological Interventions For Self-Harm[1]

Objectives: Internet- and mobile phone-based psychological interventions have the potential to overcome many of the barriers associated with accessing traditional face-to-face therapy. Self-injurious thoughts and behaviors (STB) are prevalent global health problems that may benefit from Internet- and mobile-based interventions. We provide a systematic review and meta-analysis of studies evaluating mobile- and Internet-based interventions for STB, including nonsuicidal self-injury (NSSI).

Methods: Online databases were searched up to March 2019 for single-arm and controlled trials of Internet- or mobile-based interventions for STB. The potential for bias was assessed using the Cochrane risk of bias tool.

Results: Twenty-two eligible trials were identified. The research was limited by a lack of controlled designs and small samples. Evidence supports the acceptability of interventions. There is preliminary evidence that these interventions are associated with a decline in STB. A meta-analysis suggested a positive treatment effect on suicidal ideation when compared to treatment as usual, but not when trials with active controls were also considered.

Conclusions: Overall, Internet- and mobile-based interventions show promise and further controlled trials are warranted, focusing on behavioral outcomes: NSSI; suicidal behavior.

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Buscher, R et al (2020) [Systematic Review] Internet-Based Cognitive Behavioral Therapy to Reduce Suicidal Ideation: A Systematic Review and Meta-analysis[2]

Importance: Suicidal ideation is a widespread phenomenon. However, many individuals at risk for suicide do not seek treatment, which might be addressed by providing low-threshold, Internet-based self-help interventions.

Objective: To investigate whether Internet-based self-help interventions directly targeting suicidal ideation or behavior are associated with reductions in suicidal ideation.

Data Sources: A systematic search of PsycINFO, MEDLINE, Cochrane Central Register of Controlled Trials (CENTRAL), and the Centre for Research Excellence of Suicide Prevention (CRESP) databases for trials from inception to April 6, 2019, was performed, supplemented by reference searches. Search strings consisted of various search terms related to the concepts of Internet, suicide, and randomized clinical trials.

Study Selection: Two independent researchers reviewed titles, abstracts, and full texts. Randomized clinical trials evaluating the effectiveness of Internet-based self-help interventions to reduce suicidal ideation were included. Interventions were eligible if they were based on psychotherapeutic elements. Trials had to report a quantitative measure of a suicide-specific outcome. Mobile-based and gatekeeper interventions were excluded; no further restrictions were placed on participant characteristics or date of publication.

Data Extraction and Synthesis: This study followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guidelines. Risk of bias was evaluated using the Cochrane Risk of Bias Tool. Standardized mean differences were calculated using a random-effects model.

Main Outcomes and Measures: Suicidal ideation was the a priori primary outcome.

Results: Six unique eligible trials (1567 unique participants; 1046 [66.8%] female; pooled mean [SD] age, 36.2 [12.5] years) were included in the systematic review and meta-analysis. All identified interventions were

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[2] Büscher R, Torok M, Terhorst Y, Sander L. Internet-Based Cognitive Behavioral Therapy to Reduce Suicidal Ideation: A Systematic Review and Meta-analysis. *JAMA Netw Open*. 2020;34.:e203933. Published 2020 Apr 1. doi:10.1001/jamanetworkopen.2020.3933

Internet-based cognitive behavioral therapy (iCBT). Participants assigned to the iCBT condition experienced a significantly reduced suicidal ideation compared with controls following intervention in all 6 trials (standardized mean difference, -0.29; 95% CI, -0.40 to -0.19; P < .001). Heterogeneity was low (I2 = 0%). The effect appeared to be maintained at follow-up in 4 trials (standardized mean difference, -0.18; 95% CI, -0.34 to -0.02; P = .03; I2 = 36%). Studies did not report sufficient data on completed suicides and suicide attempts to assess potential associations.

Conclusions and Relevance: These results show that iCBT interventions are associated with significant reductions in suicidal ideation compared with control conditions. Considering their high scalability, iCBT interventions have the potential to reduce suicide mortality. Future research should assess the effect of these digital health interventions on suicidal behavior and identify moderators and mediators to advance understanding of the mechanisms of effectiveness of these interventions.

Melia, R et al (2020) [Systematic Review] Mobile Health Technology Interventions for Suicide Prevention: Systematic Review[3]

Background: Digital interventions are proposed as one way by which effective treatments for self-harm and suicidal ideation may be improved and their scalability enhanced. Mobile devices offer a potentially powerful medium to deliver evidence-based interventions with greater specificity to the individual when the intervention is needed. The recent proliferation of publicly available mobile apps designed for suicide prevention underlines the need for robust evidence to promote safe practice.

Objective: This review aimed to examine the effectiveness of currently available mobile health technology tools in reducing suicide-specific outcomes.

Methods: The following databases were searched: Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, PsycINFO, and relevant sources of gray literature. All published and unpublished randomized controlled trials, pseudo-RCTs, and pre-post observational studies that evaluated the effectiveness of mHealth technology in suicide prevention delivered via mobile computing and communication technology were included. Studies were included if they measured at least one suicide outcome variable: ie suicidal ideation, suicidal intent, nonsuicidal self-injurious behavior, and suicidal behavior. A total of 2 review authors

[3] Melia R, Francis K, Hickey E et al Mobile Health Technology Interventions for Suicide Prevention: Systematic Review. *JMIR Mhealth Uhealth*. 2020;81.:e12516. Published 2020 Jan 15. doi:10.2196/12516

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independently extracted data and assessed study suitability, in accordance with the Cochrane Collaboration Risk of Bias Tool, on July 31, 2018. Owing to the heterogeneity of outcomes found across studies, results were not amenable for pooled synthesis, and a meta-analysis was not performed. A narrative synthesis of the available research is presented here.

Results: A total of 7 studies met criteria for inclusion . Four published articles that reported on the effectiveness of the following mobile phone apps were included: iBobbly, Virtual Hope Box, BlueIce, and Therapeutic Evaluative Conditioning. Results demonstrated some positive impacts for individuals at elevated risk of suicide or self-harm, including reductions in depression, psychological distress, and self-harm and increases in coping self-efficacy. None of the apps evaluated demonstrated the ability to significantly decrease suicidal ideation compared with a control condition. In addition, 3 unpublished and recently completed trials also met criteria for inclusion in the review.

Conclusions: Further research is needed to evaluate the efficacy of stand-alone mHealth technology-based interventions in suicide prevention. The small number of studies reported in this review tentatively indicate that such tools may have a positive impact on suicide-specific outcomes. Future mHealth intervention evaluations would benefit from addressing the following 3 main methodological limitations : 1. heterogeneity of outcomes: a lack of standardized measurement of suicide outcomes across studies; 2. ecological validity: the tendency to exclude potential participants because of the elevated suicide risk may reduce generalizability within clinical settings; and 3. app regulation and definition: the lack of a standardized classification system for mHealth intervention type points to the need for better definition of the scope of such technologies to promote safe practice

Berrouiguet, S et al (2017) [Systematic Review] Fundamentals for Future Mobile-Health (mHealth): A Systematic Review of Mobile Phone and Web-Based Text Messaging in Mental Health[4]

Background: Mobile phone text messages are used pervasively as a form of communication. Almost 100% of the population uses text messaging worldwide and this technology is being suggested as a promising tool in psychiatry. Text messages can be sent either from a classic mobile phone or

[4] Berrouiguet S, Baca-García E, Brandt S, Walter M, Courtet P. Fundamentals for Future Mobile-Health (mHealth): A Systematic Review of Mobile Phone and Web-Based Text Messaging in Mental Health. *J Med Internet Res*. 2016;186.:e135. Published 2016 Jun 10. doi:10.2196/jmir.5066

a web-based application. Reviews are needed to better understand how text messaging can be used in mental health care and other fields of medicine. Objective: The objective of the study was to review the literature regarding the use of mobile phone text messaging in mental health care.

Methods: We conducted a thorough literature review of studies involving text messaging in health care management. Searches included PubMed, PsycINFO, Cochrane, Scopus, Embase and Web of Science databases on May 25, 2015. Studies reporting the use of text messaging as a tool in managing patients with mental health disorders were included. Given the heterogeneity of studies, this review was summarized using a descriptive approach.

Results: From 677 initial citations, 36 studies were included in the review. Text messaging was used in a wide range of mental health situations, notably substance abuse (31%), schizophrenia (22%), and affective disorders (17%). We identified four ways in which text messages were used: reminders (14%), information (17%), supportive messages (42%), and self-monitoring procedures (42%). Applications were sometimes combined. Conclusions: We report growing interest in text messaging since 2006. Text messages have been proposed as a health care tool in a wide spectrum of psychiatric disorders including substance abuse, schizophrenia, affective disorders, and suicide prevention. Most papers described pilot studies, while some randomized clinical trials were also reported. Overall, a positive attitude toward text messages was reported. RCTs reported improved treatment adherence and symptom surveillance. Other positive points included an increase in appointment attendance and in satisfaction with management and health care services. Insight into message content, preventative strategies, and innovative approaches derived from the mental health field may be applicable in other medical specialties.

Kreuze, E et al (2017) [Systematic Review] Technology-enhanced Suicide Prevention Interventions: A Systematic Review[5]

Objective: Suicide prevention is a high priority. Scalable and sustainable interventions for suicide prevention are needed to set the stage for population-level impact. This systematic review explores how technology-enhanced interventions target suicide risk and protective factors, using the Centers for Disease Control and Prevention (CDC, 2015) Risk and Protective Factors Ecological Model. Methods: Information databases (PsycINFO,

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[5] Kreuze E, Jenkins C, Gregoski M et al Technology-enhanced suicide prevention interventions: A systematic review. *J Telemed Telecare*. 2017;236.:605- 617. doi:10.1177/1357633X16657928

PubMed and CINAHL) were systematically searched and records including technology-enhanced interventions for suicide prevention (n = 3764) were reviewed. Records with varying technologies and diverse methodologies were integrated into the search. Results: Review of the records resulted in the inclusion of 16 studies that utilized technology-enhanced interventions to address determinants of suicidal behaviour. This includes the use of standalone or, in most cases, adjunct technology-enhanced interventions for suicide prevention delivered by mobile phone application, text message, telephone, computer, web, CD-ROM and video. Conclusion: Intervention effectiveness was variable, but several technology-enhanced interventions have demonstrated effectiveness in reducing suicidal ideation and mental health co-morbidities. Large-scale research and evaluation initiatives are needed to evaluate the costs and long-term population-level impact of these interventions.

Leavey, K, Hawkins, R (2017) [Systematic Review and Meta-Analysis] Is Cognitive Behavioural Therapy Effective in Reducing Suicidal Ideation and Behaviour When Delivered Face-To-Face or via E-Health? A Systematic Review and Meta-Analysis[6]

Cognitive Behavioural Therapy (CBT) is a widely used psychotherapeutic intervention for suicide prevention despite its efficacy for suicide prevention in adults remaining ambiguous. Reluctance or inability to access face-to-face help suggests that e-health delivery may be a valuable resource for suicidal people. The aim of this study was to systematically review and conduct meta-analysis on research assessing the efficacy of CBT delivered via face-to-face and e-health for suicidal ideation and behaviour. A comprehensive literature search of MEDLINE, PsycINFO, Scopus, PubMed and the Cochrane Central Register of Controlled Trials was conducted. From 764 identified articles, 26 met the inclusion criteria for investigating CBT for suicidal ideation and behaviours in adult populations. Data were extracted on study characteristics and meta-analysis was performed where possible. There was a statistically significant, small to medium effect for face-to-face delivered CBT in reducing suicidal ideation and behaviour although there was significant heterogeneity between the included studies. CBT delivered via e-health was not found to be efficacious for reducing suicidal ideation and behaviour in adults though the number of studies reviewed was small.

[6] Leavey K, Hawkins R. Is cognitive behavioural therapy effective in reducing suicidal ideation and behaviour when delivered face-to-face or via e-health? A systematic review and meta-analysis. *Cogn Behav Ther.* 2017;465.:353- 374. doi:10.1080/16506073.2017.1332095
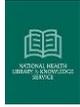
Witt, K et al (2017) [Systematic Review and Meta-Analysis] Effectiveness of Online and Mobile Telephone Applications ('Apps') for the Self-Management of Suicidal Ideation and Self-Harm: A Systematic Review and Meta-Analysis[7]

Background: Online and mobile telephone applications have the potential to improve the scalability of effective interventions for suicidal ideation and self-harm. The aim of this review was therefore to investigate the effectiveness of digital interventions for the self-management of suicidal ideation or self-harm.

Methods: Seven databases [Applied Science and Technology; CENTRAL; CRESP; Embase; Global Health; PsycARTICLES; PsycINFO; Medline] were searched to 31 March, 2017. Studies that examined the effectiveness of digital interventions for suicidal ideation and/or self-harm, or which reported outcome data for suicidal ideation and/or self-harm, within a randomised controlled trial, pseudo-RCT, or observational pre-test/post-test design were included in the review.

Results: Fourteen non-overlapping studies were included, reporting data from a total of 3,356 participants. Overall, digital interventions were associated with reductions for suicidal ideation scores at post-intervention. There was no evidence of a treatment effect for self-harm or attempted suicide.

Conclusions: Most studies were biased in relation to at least one aspect of study design, and particularly the domains of participant, clinical personnel, and outcome assessor blinding. Performance and detection bias therefore cannot be ruled out. Digital interventions for suicidal ideation and self-harm may be more effective than waitlist control. It is unclear whether these reductions would be clinically meaningful at present. Further evidence, particularly with regards to the potential mechanisms of action of these interventions, as well as safety, is required before these interventions could recommended.

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[7] Witt K, Spittal MJ, Carter G et al Effectiveness of online and mobile telephone applications ('apps') for the self-management of suicidal ideation and self-harm: a systematic review and meta-analysis. *BMC Psychiatry*. 2017;171.:297. Published 2017 Aug 15. doi:10.1186/s12888-017-1458-0

Noh, D et al (2016) [Systematic Review] Effectiveness of Telephone-Delivered Interventions Following Suicide Attempts: A Systematic Review[8]

Aim: To evaluate efficacy of telephone-delivered interventions following suicide attempts.

Methods: Systematic review, meta-analysis, and narrative synthesis.

Results: Five papers evaluating telephone interventions were included. Three studies provided suicide attempters with telephone contact intervention, and two studies provided deliberate self-harm patients with crisis cards to help after discharge. Meta-analyses showed that telephone contact intervention did not significantly reduce further suicide attempts and completed suicides, and the crisis card did not significantly reduce further deliberate self-harm.

Conclusion: Telephone-delivered interventions have been suggested as an alternative to face-to-face psychotherapy, but their effectiveness in reducing the recurrence of suicide attempts is not supported.

Randomised Controlled Trials

O'Toole, MS et al (2019) [Randomised Controlled Trial] Testing an App-Assisted Treatment for Suicide Prevention in a Randomized Controlled Trial: Effects on Suicide Risk and Depression[9]

Suicide is a global public health problem and effective psychological interventions are needed. The objective of the present study was to evaluate the effect of an app-assisted suicide prevention treatment on suicide risk and depression. One hundred twenty-nine participants were randomized to treatment as usual (TAU), consisting of psychotherapy adhering to the framework of Collaborative Assessment and Management of Suicidality (CAMS), with (TAU+APP, N = 60) or without (TAU, N = 69) access to a mobile application (ie LifeApp'tite). Suicide risk and symptoms of depression were assessed pre- and posttherapy, and at 4-month follow-up. The TAU+APP group showed a smaller decrease on self-reported suicide risk at the end of treatment, corresponding to a medium between-group effect size (p = .008,

[8] Noh D, Park YS, Oh EG. Effectiveness of Telephone-Delivered Interventions Following Suicide Attempts: A Systematic Review. *Arch Psychiatr Nurs.* 2016;301.:114–119. doi:10.1016/j.apnu.2015.10.012

[9] O'Toole MS, Arendt MB, Pedersen CM. Testing an App-Assisted Treatment for Suicide Prevention in a Randomized Controlled Trial: Effects on Suicide Risk and Depression. *Behav Ther.* 2019;502.:421–429. doi:10.1016/j.beth.2018.07.007
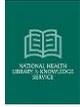
d = 0.46). At the 4-month follow-up this was the case only at the trend level, where the effect size was also of a smaller magnitude (p = .057, d = 0.30). No differences between the treatment groups were observed on self-reported depressive symptoms, either immediately following treatment (p = .732, d = 0.05) or at follow-up (p = .467, d = 0.11). The unexpected negative effect concerning suicide risk points to crucial consideration of issues pertaining to timing, dosing, and content when adding new technology to existing treatments both in this and other populations.

Berrouiguet, S et al (2018) [Case Series] Toward mHealth Brief Contact Interventions in Suicide Prevention: Case Series From the Suicide Intervention Assisted by Messages (SIAM) Randomized Controlled Trial[10]

Background: Research indicates that maintaining contact either via letter or postcard with at-risk adults following discharge from care services after a suicide attempt (SA) can reduce reattempt risk. Pilot studies have demonstrated that interventions using mobile health (mHealth) technologies are feasible in a suicide prevention setting.

Objective: The aim of this study was to report three cases of patients recruited in the Suicide Intervention Assisted by Messages (SIAM) study to describe how a mobile intervention may influence follow-up.

Methods: SIAM is a 2-year, multicenter randomized controlled trial conducted by the Brest University Hospital, France. Participants in the intervention group receive SIAM text messages 48 hours after discharge, then at day 8 and day 15, and months 1, 2, 3, 4, 5, and 6. The study includes participants aged 18 years or older, who have attended a participating hospital for an SA, and have been discharged from the emergency department (ED) or a psychiatric unit (PU) for a stay of less than 7 days. Eligible participants are randomized between the SIAM intervention messages and a control group. In this study, we present three cases from the ongoing SIAM study that demonstrate the capability of a mobile-based brief contact intervention for triggering patient-initiated contact with a crisis support team at various time points throughout the mobile-based follow-up period.

Results: Out of the 244 patients recruited in the SIAM randomized controlled trial, three cases were selected to illustrate the impact of mHealth on suicide risk management. Participants initiated contact with the emergency crisis

[10] Berrouiguet S, Larsen ME, Mesmeur C et al Toward mHealth Brief Contact Interventions in Suicide Prevention: Case Series From the Suicide Intervention Assisted by Messages (SIAM) Randomized Controlled Trial. *JMIR Mhealth Uhealth*. 2018;61:e8. Published 2018 Jan 10. doi:10.2196/mhealth.7780

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support service after receiving text messages up to 6 months following discharge from the hospital. Contact was initiated immediately following receipt of a text message or up to 6 days following a message. Conclusions: This text message-based brief contact intervention has demonstrated the potential to reconnect suicidal individuals with crisis support services while they are experiencing suicidal ideation as well as in a period after receiving messages. As follow-up phone calls over an extended period of time may not be feasible, this intervention has the potential to offer simple technological support for individuals following discharge from the ED.

Wilks, CR et al (2018) [Randomised Controlled Trial] [A Randomized Controlled Trial of an Internet Delivered Dialectical Behavior Therapy Skills Training for Suicidal and Heavy Episodic Drinkers](11)
Background: Cognizant that alcohol misuse elevates risk of suicide death among ideators, the paucity of treatment outcome research for individuals presenting with both suicide ideation and problem drinking is particularly troubling. Dialectical behavior therapy (DBT) skills training, which effectively targets behaviors associated with emotion dysregulation including addictive and suicidal behaviors, provides a fitting model amenable to computerization. As stigma and scarcity stand as potential barriers to treatment, online dissemination platforms provide means for efficient treatment delivery that can augment the utility of suitable interventions. This pilot RCT sought to evaluate the feasibility, acceptability, and preliminary efficacy of an Internet-delivered DBT skills training intervention (iDBT-ST) for suicidal individuals who engage in heavy episodic drinking METHODS: Participants (n = 59) were randomized to receive iDBT-ST immediately or after an 8-week waiting period. Clinical outcomes were suicide ideation, alcohol use, and emotion dysregulation. Results: Participants on average saw a significant reduction in all outcomes over the four-month study period. Compared to waitlist controls, individuals who received iDBT-ST immediately showed faster reductions in alcohol consumption.
Conclusions: Preliminary results suggest that iDBT-ST may be a viable resource for the high-risk and underserved group represented in this study, and pathways for future development are suggested.

[11] Wilks CR, Lungu A, Ang SY, Matsumiya B, Yin Q, Linehan MM. A randomized controlled trial of an Internet delivered dialectical behavior therapy skills training for suicidal and heavy episodic drinkers. *J Affect Disord*. 2018;232:219-228. doi:10.1016/j.jad.2018.02.053

Tighe, J et al (2017) [Randomised Controlled Trial] [Ibobbly Mobile Health Intervention for Suicide Prevention in Australian Indigenous Youth: A Pilot Randomised Controlled Trial](#)[12]

Objectives: Rates of youth suicide in Australian Indigenous communities are 4 times the national youth average and demand innovative interventions. Historical and persistent disadvantage is coupled with multiple barriers to help seeking. Mobile phone applications offer the opportunity to deliver therapeutic interventions directly to individuals in remote communities. The pilot study aimed to evaluate the effectiveness of a self-help mobile app (ibobbly) targeting suicidal ideation, depression, psychological distress and impulsivity among Indigenous youth in remote Australia.

Setting: Remote and very remote communities in the Kimberley region of North Western Australia. Participants: Indigenous Australians aged 18-35 years.

Interventions: 61 participants were recruited and randomised to receive either an app (ibobbly) which delivered acceptance-based therapy over 6 weeks or were waitlisted for 6 weeks and then received the app for the following 6 weeks.

Primary and Secondary Outcome Measures: The primary outcome was the Depressive Symptom Inventory-Suicidality Subscale (DSI-SS) to identify the frequency and intensity of suicidal ideation in the previous weeks. Secondary outcomes were the Patient Health Questionnaire 9 (PHQ-9), The Kessler Psychological Distress Scale (K10) and the Barratt Impulsivity Scale (BIS-11).

Results: Although preintervention and postintervention changes on the (DSI-SS) were significant in the ibobbly arm (t=2.40; df=58.1; p=0.0195), these differences were not significant compared with the waitlist arm (t=1.05; df=57.8; p=0.2962). However, participants in the ibobbly group showed substantial and statistically significant reductions in PHQ-9 and K10 scores compared with waitlist. No differences were observed in impulsivity. Waitlist participants improved after 6 weeks of app use.

Conclusions: Apps for suicide prevention reduce distress and depression but do not show significant reductions on suicide ideation or impulsivity. A feasible and acceptable means of lowering symptoms for mental health disorders in remote communities is via appropriately designed self-help apps.

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[12] Tighe J, Shand F, Ridani R, Mackinnon A, De La Mata N, Christensen H. Ibobbly mobile health intervention for suicide prevention in Australian Indigenous youth: a pilot randomised controlled trial. *BMJ Open*. 2017;71.:e013518. Published 2017 Jan 27. doi:10.1136/bmjopen-2016-013518

Franklin, JC et al (2016) [Randomised Controlled Trial] A Brief Mobile App Reduces Nonsuicidal and Suicidal Self-Injury: Evidence From Three Randomized Controlled Trials[13]

Objective: Self-injurious thoughts and behaviors (SITBs) are a major public health problem that traditional interventions have been unable to address on a large scale. The goal of this series of studies was to take initial steps toward developing an effective SITB treatment that can be easily delivered on a very large scale.

Method: We created a brief (1-2 min), game app called Therapeutic Evaluative Conditioning (TEC), designed to increase aversion to SITBs and decrease aversion to the self. In 3 separate studies, we recruited participants with recent and severe histories of SITBs from web forums focused on self-injury and psychopathology (Ns = 114, 131, and 163) and randomly assigned them to receive access to the mobile treatment TEC app or a control app for 1 month. We tested the effect of TEC on the frequency of self-cutting, nonsuicidal self-injury more generally, suicide ideation, suicide plans, and suicidal behaviors.

Results: Analyses showed that, compared with the control app, TEC produced moderate reductions for all SITBs except suicide ideation. Across studies, the largest and most consistent reductions were for self-cutting episodes (32%–40%), suicide plans (21%-59%), and suicidal behaviors (33%-77%). Two of the 3 studies showed that TEC impacted its intended treatment targets and that greater change in these targets was associated with greater SITB reductions. TEC effects were not maintained at the 1-month posttreatment follow-up. Conclusions: Future versions of brief, mobile interventions may have the potential to reduce SITBs and related behaviors on a large scale.

King, CA et al (2015) [Randomised Controlled Trial] Online Suicide Risk Screening and Intervention With College Students: A Pilot Randomized Controlled Trial[14]

Objective: This pilot randomized controlled trial examined the effect of an online intervention for college students at risk for suicide, Electronic Bridge to Mental Health Services (eBridge), which included personalized feedback and optional online counseling delivered in accordance with motivational

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[13] Franklin JC, Fox KR, Franklin CR et al A brief mobile app reduces nonsuicidal and suicidal self-injury: Evidence from three randomized controlled trials. *J Consult Clin Psychol*. 2016;846.:544- 557. doi:10.1037/ccp0000093

[14] King CA, Eisenberg D, Zheng K et al Online suicide risk screening and intervention with college students: a pilot randomized controlled trial. *J Consult Clin Psychol*. 2015;833.:630- 636. doi:10.1037/a0038805
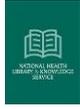
interviewing principles. Primary outcomes were readiness to seek information or talk with family and friends about mental health treatment, readiness to seek mental health treatment, and actual treatment linkage. Method: Participants were 76 college students (45 women, 31 men; mean age = 22.9 years, SD = 5.0 years) at a large public university who screened positive for suicide risk, defined by at least 2 of the following: suicidal thoughts, history of suicide attempt, depression, and alcohol abuse. Racial/ethnic self-identifications were primarily Caucasian (n = 54) and Asian (n = 21). Students were randomized to eBridge or the control condition (personalized feedback only, offered in plain report format). Outcomes were measured at 2-month follow-up. Results: Despite relatively modest engagement in online counseling (29% of students posted ≥1 message), students assigned to eBridge reported significantly higher readiness for help-seeking scores, especially readiness to talk to family, talk to friends, and see a mental health professional. Students assigned to eBridge also reported lower stigma levels and were more likely to link to mental health treatment.

Conclusions: Findings suggest that offering students personalized feedback and the option of online counseling, using motivational interviewing principles, has a positive impact on students' readiness to consider and engage in mental health treatment. Further research is warranted to determine the robustness of this effect, the mechanism by which improved readiness and treatment linkage occurs, and the longer term impact on student mental health outcomes.

Miscellaneous

Dimeff, LA et al (2020) [A Novel Engagement of Suicidality in the Emergency Department: Virtual Collaborative Assessment and Management of Suicidality](15)
Objective: A novel avatar system (Virtual Collaborative Assessment and Management of Suicidality System; V-CAMS) for suicidal patients and medical personnel in emergency departments was developed and evaluated. V-CAMS facilitates the delivery of CAMS and other evidence-

[15] Dimeff LA, Jobes DA, Chalker SA et al A novel engagement of suicidality in the emergency department: Virtual Collaborative Assessment and Management of Suicidality. *Gen Hosp Psychiatry*. 2020;63:119- 126. doi:10.1016/j.genhosppsych.2018.05.005

based interventions to reduce unnecessary hospitalization, readmissions, and suicide following an ED visit.

Method: Using iterative user-centered design with 24 suicidal patients, an avatar prototype, 'Dr. Dave' [based on Dr. Jobes] was created, along with other patient-facing tools; provider-facing tools, including a clinical decision support tool were also designed and tested to aid discharge disposition.

Results: Feasibility tests supported proof of concept. Suicidal patients affirmed the system's overall merit, positive Perception of Care, and acceptability; medical providers (n = 21) viewed the system as an efficient, effective, and safe method of improving care for suicidal ED patients and reducing unnecessary hospitalization.

Conclusions: Technology tools including a patient-facing avatar and e-caring contacts, along with provider-facing tools may offer a powerful method of facilitating best-practice suicide prevention interventions and point-of-care tools for suicidal patients seeking ED services and their medical providers. Future directions include full development of V-CAMS and integration into a health electronic medical record and a rigorous randomized controlled trial to study its effectiveness.

Castillo-Sanchez, G et al (2019) Suicide Prevention Mobile Apps: Descriptive Analysis of Apps From the Most Popular Virtual Stores[16]

Background: Provision of follow-up and care during treatment of people with suicidal intentions is a challenge for health professionals and experts in information and communications technology (ICT). Therefore, health professionals and ICT experts are making efforts to carry out these activities in collaboration by using obile apps as a technological resource.

Objective: This study aimed to descriptively analyze mobile apps aimed at suicide prevention and to determine relevant factors in their design and development. In addition, it sought to analyze their impact on the support of treatment for patients at risk for suicide.

Methods: We considered 20 apps previously listed in the article 'Mobile Apps for Suicide Prevention: Review of Virtual Stores and Literature' [de la Torre et al 2017]. To find the apps in this list, the most popular app stores Android and iOS were searched using the keyword suicide prevention. The research focused on publicly available app information: language, platform, and user ratings. The results obtained were statistically evaluated using 16

[16] Castillo-Sánchez G, Camargo-Henríquez I, Muñoz-Sánchez JL, Franco-Martín M, de la Torre-Díez I. Suicide Prevention Mobile Apps: Descriptive Analysis of Apps from the Most Popular Virtual Stores. *JMIR Mhealth Uhealth*. 2019;78.:e13885. Published 2019 Aug 13. doi:10.2196/13885
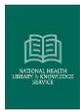
parameters that establish various factors that may affect the choice of the user, and the consequent support that the app can offer to a person at risk for suicide.

Results: Of the 20 mobile apps, 4 no longer appeared in the app stores and were therefore excluded. Analysis of the remaining 16 apps sampled showed the following: 1. a high percentage of the apps analyzed in the study (n=13, 82%) are provided in English language; 2. the sampled apps were last updated in 2017, when only 45% of them were updated, but the constant and progressive update of treatments should be reflected in the apps; and 3. the technical quality of these apps cannot be determined on the basis of the distribution of scores, because their popularity indices can be subjective according to the users. User preference for a particular operating system would require further, more specific research, including study of the differences in the technical and usability aspects between both platforms and the design of medical apps.

Conclusions: Although there are positive approaches to the use of apps for suicide prevention and follow-up, the technical and human aspects are yet to be explored and defined. For example, the design and development of apps that support suicide prevention should be strongly supported by health personnel to humanize these apps, so that the effectiveness of the treatments supported by them can be improved.

Gilmore, AK, Ward-Ciesielski, EF (2019) Perceived Risks and Use of Psychotherapy via Telemedicine for Patients at Risk for Suicide[17]

Introduction: Suicide is a major public health problem and its human, emotional, and economic costs are significant. Individuals in rural areas are at highest risk for suicide. However, telemedicine services are typically not rendered to individuals who are actively suicidal. The goals of the current study were to identify the risks of using telemedicine for mental healthcare from the perspective of licensed mental health providers and to determine factors associated with the use of telemedicine with patients who are at high risk for suicide. Methods: A total of 52 licensed mental health providers were recruited online through several professional organization listservs and targeted emails. Providers completed online questionnaires regarding demographics, caseload of suicidal patients, perceived risks for using telemedicine with patients at risk for suicide, attitudes towards telemedicine, and use of telemedicine with patients at risk for suicide.

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[17] Gilmore AK, Ward-Ciesielski EF. Perceived risks and use of psychotherapy via telemedicine for patients at risk for suicide. *J Telemed Telecare*. 2019;251.:59- 63. doi:10.1177/1357633X17735559

Results: Three key perceived risks associated with using telemedicine were identified, including assessment, lack of control over patient, and difficulties triaging patients if needed. It was also found that individuals who had more positive attitudes towards telemedicine, younger providers, and more experienced providers were more likely to use telemedicine with patients who are at high risk for suicide.

Discussion: To our knowledge, this is the first study to examine the perceived risks and use of telemedicine with patients at high risk for suicide. It is essential to continue this line of research to develop protocols for the provision of evidence-based therapy via telemedicine for this high-risk group.

Martinengo, L et al (2019) [Suicide Prevention and Depression Apps' Suicide Risk Assessment and Management: A Systematic Assessment of Adherence to Clinical Guidelines](#)[18]

Background: There are an estimated 800,000 suicides per year globally, and approximately 16,000,000 suicide attempts. Mobile apps may help address the unmet needs of people at risk. We assessed adherence of suicide prevention advice in depression management and suicide prevention apps to six evidence-based clinical guideline recommendations: mood and suicidal thought tracking, safety plan development, recommendation of activities to deter suicidal thoughts, information and education, access to support networks, and access to emergency counseling.

Methods: A systematic assessment of depression and suicide prevention apps available in Google Play and Apple's App Store was conducted. Apps were identified by searching 42matters in January 2019 for apps launched or updated since January 2017; general characteristics of apps, adherence with six suicide prevention strategies identified in evidence-based clinical guidelines using a 50-question checklist developed by the study team, and trustworthiness of the app based on HONcode principles were appraised and reported as a narrative review, using descriptive statistics.

Results: The initial search yielded 2690 potentially relevant apps. Sixty-nine apps met inclusion criteria and were systematically assessed. There were 20 depression management apps (29%), 3 (4%) depression management and suicide prevention apps, and 46 (67%) suicide prevention apps. Eight (12%) depression management apps were chatbots. Only 5/69 apps (7%)

[18] Martinengo L, Van Galen L, Lum E, Kowalski M, Subramaniam M, Car J. Suicide prevention and depression apps' suicide risk assessment and management: a systematic assessment of adherence to clinical guidelines. *BMC Med.* 2019;171.:231. Published 2019 Dec 19. doi:10.1186/s12916-019-1461-z

incorporated all six suicide prevention strategies. Six apps (6/69, 9%), including two apps available in both app stores and downloaded more than one million times each, provided an erroneous crisis helpline number. Most apps included emergency contact information (65/69 apps, 94%) and direct access to a crisis helpline through the app (46/69 apps, 67%). Conclusions: Non-existent or inaccurate suicide crisis helpline phone numbers were provided by mental health apps downloaded more than 2 million times. Only five out of 69 depression and suicide prevention apps offered all six evidence-based suicide prevention strategies. This demonstrates a failure of Apple and Google app stores, and the health app industry in self-governance, and quality and safety assurance. Governance levels should be stratified by the risks and benefits to users of the app, such as when suicide prevention advice is provided.

Martinez-Miranda, J et al (2019) Assessment of Users' Acceptability of a Mobile-Based Embodied Conversational Agent for the Prevention and Detection of Suicidal Behaviour[19]

The use of embodied conversational agents in mental health has increased in the last years. Several studies exist describing the benefits and advantages of this technology as a complement to psychotherapeutic interventions for the prevention and treatment of depression, anxiety, or post-traumatic stress disorder, to name a few. A small number of these works implement capabilities in the virtual agent focused on the detection and prevention of suicidality risks. The work presented in this paper describes the development of an embodied conversational agent used as the main interface in HelPath, a mobile-based application addressed to individuals detected with any of the suicidal behaviours: ideation, planning or attempt. The main objective of HelPath is to continuously collect user's information that, complemented with data from the electronic health record, supports the identification of risks associated with suicidality. Through the virtual agent, the users also receive information and suggestions based on cognitive behaviour therapy that would help them to maintain a healthy condition. The paper also presents the execution of an exploratory pilot to assess the acceptability, perception and adherence of users towards the virtual agent. The obtained results are presented and discussed, and some

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[19] Martínez-Miranda J, Martínez A, Ramos R et al Assessment of users' acceptability of a mobile-based embodied conversational agent for the prevention and detection of suicidal behaviour. *J Med Syst*. 2019;438.:246. Published 2019 Jun 25. doi:10.1007/s10916-019-1387-1
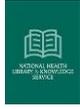
actions for further improvement of the embodied conversational agent are also identified.

Buus, N et al (2018) [Focus Group] Stakeholder Perspectives on Using and Developing the MYPLAN Suicide Prevention Mobile Phone Application: A Focus Group Study[20]
The objective of this study was to explore different stakeholder perspectives on the MYPLAN app for suicide prevention safety planning. The study was a comparative analysis of 4 focus groups with Danish MYPLAN stakeholders, young users, adult users, relatives, and clinicians. The focus groups were audio recorded, transcribed, and subjected to a thematic analysis. The analysis contextualized the participants' experiences of the benefits and limitations of MYPLAN. While participants believed that MYPLAN could potentially interrupt early stages of a suicidal process, clinicians' involvement in safety planning was considered important. MYPLAN could potentially give users a sense of increased personal control but learning how to effectively safety plan was not perceived to be simple and additional support should be considered for MYPLAN users.

Franco-Martin, MA et al (2018) [Literature Review] A Systematic Literature Review of Technologies for Suicidal Behavior Prevention[21]
Suicide is the second cause of death in young people. The use of technologies as tools facilitates the detection of individuals at risk of suicide thus allowing early intervention and efficacy. Suicide can be prevented in many cases. Technology can help people at risk of suicide and their families. It could prevent situations of risk of suicide with the technological evolution that is increasing. This work is a systematic review of research papers published in the last ten years on technology for suicide prevention. In September 2017, the consultation was carried out in the scientific databases PubMed, ScienceDirect, PsycINFO, The Cochrane Library and Google Scholar. A general search was conducted with the terms prevention AND suicide AND technology. More specific searches included technologies such as Web, mobile, social networks, and others terms related to technologies. The number of articles found following the methodology proposed was 90, but

[20] Buus N, Erlangsen A, River J et al Stakeholder Perspectives on Using and Developing the MYPLAN Suicide Prevention Mobile Phone Application: A Focus Group Study [published online ahead of print, 2018 Oct 8]. *Arch Suicide Res*. 2018;1-16. doi:10.1080/13811118.2018.1489319

[21] Franco-Martín MA, Muñoz-Sánchez JL, Sainz-de-Abajo B, Castillo-Sánchez G, Hamrioui S, de la Torre-Díez I. A Systematic Literature Review of Technologies for Suicidal Behavior Prevention. *J Med Syst*. 2018;424.:71. Published 2018 Mar 5. doi:10.1007/s10916-018-0926-5
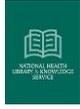
only 30 are focused on the objective of this work. Most of them were Web technologies (51.61%), mobile solutions (22.58%), social networks (12.90%), machine learning (3.23%) and other technologies (9.68%). According to the results obtained, although there are technological solutions that help the prevention of suicide, much remains to be done in this field. Collaboration among technologists, psychiatrists, patients, and family members is key to advancing the development of new technology-based solutions that can help save lives.

Munoz-Sanchez, JL et al (2018) **Facilitating Factors and Barriers to the Use of Emerging Technologies for Suicide Prevention in Europe: Multicountry Exploratory Study**[22]

Background: This study provides an analysis on the use of emerging technologies for the prevention of suicide in 8 different European countries.

Objective: The objective of this study was to analyze the potentiality of using emerging technologies in the area of suicide prevention based on the opinion of different professionals involved in suicide prevention.

Methods: Opinions of 3 groups of stakeholders (ie relevant professionals in suicide field) were gathered using a specifically designed questionnaire to explore dimensions underlying perceptions of facilitating factors and barriers in relation to the use of emerging technologies for suicide prevention.

Results: Objective 1 involved facilitating factors for the use of emerging technologies in suicide prevention. Northern European countries, except for Belgium, attach greater relevance to those that optimize implementation and benefits. On the other hand, Southern European countries attach greater importance to professionally oriented and user-centered facilitating factors. According to different stakeholders, the analysis of these facilitating factors suggest that professionals in the field of social work attach greater relevance to those that optimize implementation and benefits. However, professionals involved in the area of mental health, policy makers, and political decision makers give greater importance to professionally oriented and user-centered facilitating factors. Objective 2 was related to barriers to the usability of emerging technologies for suicide prevention. Both countries and stakeholders attach greater importance to barriers associated with resource constraints than to those centered on personal limitations. There

[22] Muñoz-Sánchez JL, Delgado C, Parra-Vidales E, Franco-Martín M. Facilitating Factors and Barriers to the Use of Emerging Technologies for Suicide Prevention in Europe: Multicountry Exploratory Study. *JMIR Ment Health*. 2018;51.:e7. Published 2018 Jan 24. doi:10.2196/mental.7784

are no differences between countries or between stakeholders. Nevertheless, there is a certain stakeholders-countries interaction that indicates that the opinions on resource constraints expressed by different stakeholders do not follow a uniform pattern in different countries, but they differ depending on the country.

Conclusions: Although all countries and stakeholders agree in identifying resource constraints as the main barrier to the use of emerging technologies, factors facilitating their use in suicide prevention differ among countries and among stakeholders.

Torus, J et al (2018) [Review] Smartphones, Sensors, and Machine Learning to Advance Real-Time Prediction and Interventions for Suicide Prevention: A Review of Current Progress and Next Steps[23]

Purpose: As rates of suicide continue to rise, there is urgent need for innovative approaches to better understand, predict, and care for those at high risk of suicide. Numerous mobile and sensor technology solutions have already been proposed, are in development, or are already available today. This review seeks to assess their clinical evidence and help the reader understand the current state of the field.

Recent Findings: Advances in smartphone sensing, machine learning methods, and mobile apps directed towards reducing suicide offer promising evidence; however, most of these innovative approaches are still nascent. Further replication and validation of preliminary results is needed. Whereas numerous promising mobile and sensor technology based solutions for real time understanding, predicting, and caring for those at highest risk of suicide are being studied today, their clinical utility remains largely unproven. However, given both the rapid pace and vast scale of current research efforts, we expect clinicians will soon see useful and impactful digital tools for this space within the next 2 to 5 years.

Boudreaux, ED et al (2017) Computer Administered Safety Planning for Individuals at Risk for Suicide: Development and Usability Testing[24]

Background: Safety planning is a brief intervention that has become an accepted practice in many clinical settings to help prevent suicide. Even

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[23] Torus J, Larsen ME, Depp C et al Smartphones, Sensors, and Machine Learning to Advance Real-Time Prediction and Interventions for Suicide Prevention: a Review of Current Progress and Next Steps. *Curr Psychiatry Rep.* 2018;207.:51. Published 2018 Jun 28. doi:10.1007/s11920-018-0914-y

[24] Boudreaux ED, Brown GK, Stanley B, Sadasivam RS, Camargo CA Jr, Miller IW. Computer Administered Safety Planning for Individuals at Risk for Suicide: Development and Usability Testing. *J Med Internet Res.* 2017;195.:e149. Published 2017 May 15. doi:10.2196/jmir.6816
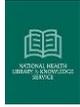
though it is quick compared to other approaches, it frequently requires 20 min or more to complete, which can impede adoption. A self-administered, web-based safety planning application could potentially reduce clinician time, help promote standardization and quality, and provide enhanced ability to share the created plan.

Objective: The aim of this study was to design, build, and test the usability of a web-based, self-administered safety planning application.

Methods: We employed a user-centered software design strategy led by a multidisciplinary team. The application was tested for usability with a target sample of suicidal patients. Detailed observations, structured usability ratings, and Think Aloud procedures were used. Suicidal ideation intensity and perceived ability to cope were assessed pre-post engagement with the Web application.

Results: A total of 30 participants were enrolled. Usability ratings were generally strong, and all patients successfully built a safety plan. However, the completeness of the safety plan varied. The mean number of steps completed was 5.5 (SD 0.9) out of 6, with 90% (27/30) of participants completing at least 5 steps and 67% (20/30) completing all 6 steps. Some safety planning steps were viewed as inapplicable to some individuals. Some confusion in instructions led to modifications to improve understandability of each step. Ratings of suicide intensity after completion of the application were significantly lower than preratings, pre: mean 5.11 (SD 2.9) versus post: mean 4.46 (SD 3.0), $t_{27}=2.49$, P=.02. Ratings of ability to cope with suicidal thoughts after completion of the application were higher than preratings, with the difference approaching statistical significance, pre: mean 5.93 (SD 2.9), post: mean 6.64 (SD 2.4), $t_{27}=-2.03$, P=.05.

Conclusions: We have taken the first step toward identifying the components needed to maximize usability of a self-administered, web-based safety planning application. Results support initial consideration of the application as an adjunct to clinical contact. This allows for the clinician or other personnel to provide clarification, when needed, to help the patient build the plan, and to help review and revise the draft.

Exbrayat, S et al (2017) [Controlled Study] Effect of Telephone Follow-Up on Repeated Suicide Attempt in Patients Discharged From an Emergency Psychiatry Department: A Controlled Study[25]

Background: Attempted suicide is a major public health problem, and the efficacies of current postvention protocols vary. We evaluated the effectiveness of telephone follow-up of patients referred to an emergency psychiatric unit for attempted suicide on any further attempt/s over the following year.

Method: In a single-center, controlled study with intent to treat, we evaluated the efficacy of a protocol of telephone follow-up of 436 patients at 8, 30, and 60 days after they were treated for attempted suicide. As controls for comparison, we evaluated patients with similar social and demographic characteristics referred to our emergency psychiatric unit in the year prior to the study who did not receive telephone follow-up after their initial hospitalization. Data were analyzed using logistic regression.

Results: Very early telephone follow-up of our patients effectively reduced recidivism and seemed to be the only protective factor against repeated suicide attempt.

Conclusions: Implementing a protocol of early telephone follow-up after attempted suicide could help prevent repeated attempt/s. More controlled studies are needed to assess optimal techniques to prevent such repetition.

Larsen, ME et al (2017) A Mobile Text Message Intervention to Reduce Repeat Suicidal Episodes: Design and Development of Reconnecting After a Suicide Attempt (RAFT)[26]

Background: Suicide is a leading cause of death, particularly among young people. Continuity of care following discharge from hospital is critical, yet this is a time when individuals often lose contact with health care services. Offline brief contact interventions following a suicide attempt can reduce the number of repeat attempts, and text message interventions are currently being evaluated. Objective: The aim of this study was to extend postattempt caring contacts by designing a brief web-based intervention targeting proximal risk factors and the needs of this population during the

[25] Exbrayat S, Coudrot C, Gourdon X et al Effect of telephone follow-up on repeated suicide attempt in patients discharged from an emergency psychiatry department: a controlled study. *BMC Psychiatry*. 2017;171.:96. Published 2017 Mar 20. doi:10.1186/s12888-017-1258-6

[26] Larsen ME, Shand F, Morley K et al A Mobile Text Message Intervention to Reduce Repeat Suicidal Episodes: Design and Development of Reconnecting After a Suicide Attempt (RAFT). *JMIR Ment Health*. 2017;44.:e56. Published 2017 Dec 13. doi:10.2196/mental.7500

postattempt period. This paper details the development process and describes the realized system.

Methods: To inform the design of the intervention, a lived experience design group was established. Participants were asked about their experiences of support following their suicide attempt, their needs during this time, and how these could be addressed in a brief contact eHealth intervention. The intervention design was also informed by consultation with lived experience panels external to the project and a clinical design group. Results: Prompt outreach following discharge, initial distraction activities with low cognitive demands, and ongoing support over an extended period were identified as structural requirements of the intervention. Key content areas identified included coping with distressing feelings, safety planning, emotional regulation and acceptance, coping with suicidal thoughts, connecting with others and interpersonal relationships, and managing alcohol consumption. Conclusions: The RAFT (Reconnecting AFTer a suicide attempt) text message brief contact intervention combines SMS contacts with additional web-based brief therapeutic content targeting key risk factors. It has the potential to reduce the number of repeat suicidal episodes and to provide accessible, acceptable, and cost-effective support for individuals who may not otherwise seek face-to-face treatment. A pilot study to test the feasibility and acceptability of the RAFT intervention is underway.

Martinez-Miranda, J (2017) [Literature Review] Embodied Conversational Agents for the Detection and Prevention of Suicidal Behaviour: Current Applications and Open Challenges[27]

Embodied conversational agents (ECAs) are advanced computational interactive interfaces designed with the aim to engage users in the continuous and long-term use of a background application. The advantages and benefits of these agents have been exploited in several e-health systems. One of the medical domains where ECAs are recently applied is to support the detection of symptoms, prevention and treatment of mental health disorders. As ECAs based applications are increasingly used in clinical psychology, and due that one fatal consequence of mental health problems is the commitment of suicide, it is necessary to analyse how current ECAs in this clinical domain support the early detection and prevention of risk situations associated with suicidality. The present work provides and overview of the main features implemented in the ECAs to detect and

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[27] Martínez-Miranda J. Embodied Conversational Agents for the Detection and Prevention of Suicidal Behaviour: Current Applications and Open Challenges. *J Med Syst*. 2017;41(9):135. doi:10.1007/s10916-017-0784-6

prevent suicidal behaviours through two scenarios: ECAs acting as virtual counsellors to offer immediate help to individuals in risk; and ECAs acting as virtual patients for learning/training in the identification of suicide behaviours. A literature review was performed to identify relevant studies in this domain during the last decade, describing the main characteristics of the implemented ECAs and how they have been evaluated. A total of six studies were included in the review fulfilling the defined search criteria. Most of the experimental studies indicate promising results, though these types of ECAs are not yet commonly used in routine practice. The identification of some open challenges for the further development of ECAs within this domain is also discussed.

Pauwels, K et al (2017) [Evaluation Study] BackUp: Development and Evaluation of a Smart-Phone Application for Coping With Suicidal Crises[28]
Background: Suicide is a major public health issue and has large impact on the lives of many people. Innovative technologies such as smartphones could create new possibilities for suicide prevention, such as helping to overcome the barriers and stigma on help seeking in case of suicidal ideation. Due to their omnipresence, smartphone apps can offer suicide prevention tools very fast, they are easily-accessible, low-threshold and can help overcome some of the help-seeking barriers suicidal people experience. This article describes the development, testing and implementation of a mobile application for coping with suicidal crisis: BackUp.
Methods: Based on the analysis of literature and existing suicide prevention apps several tools were identified as relevant to include in a suicide prevention app. The selected tools (a safety planning tool, a hope box, a coping cards module, and a module to reach out) are evidence based in a face to face context, and could be easily transferred into a mobile app. The testing of existing apps and the literature also revealed important guidelines for the technical development of the application.
Results: BackUp was developed and tested by an expert panel (n = 9) and a panel of end users (n = 21). Both groups rated BackUp as valuable for suicide prevention. Suicidal ideation of the end user group was measured using the Beck Scale for Suicidal Ideation before and after testing BackUp, and showed a small but non-significant decrease. The majority of the testers used

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[28] Pauwels K, Aerts S, Muijzers E, De Jaegere E, van Heeringen K, Portzky G. BackUp: Development and evaluation of a smart-phone application for coping with suicidal crises. *PLoS One*. 2017;126.:e0178144. Published 2017 Jun 21. doi:10.1371/journal.pone.0178144
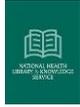
BackUp several times. All tools were evaluated as rather or very useable in times of suicidal crisis.

Conclusion: BackUp was positively evaluated and indicates that self-help tools can have a positive impact on suicidal ideation. Apps in particular create opportunities in approaching people that are not reached by traditional interventions; on the other hand, they can contribute to suicide prevention in addition to regular care. However, more research is needed on the impact and effect of suicide prevention apps.

Kasckow, J et al (2016) [Pilot Trial] Using Telehealth to Augment an Intensive Case Monitoring Program in Veterans With Schizophrenia and Suicidal Ideation: A Pilot Trial[29]

Veterans with schizophrenia admitted for suicidal ideation were recruited into a post-discharge program consisting of Intensive Case Monitoring (ICM) with daily monitoring with the Health Buddy (HB; experimental group) or ICM alone (control group). This study tested the feasibility of the telehealth monitoring intervention in this population. Secondly, we determined whether augmentation of ICM with our intervention for 3 months would result in a reduction in suicidal ideation. Twenty of 25 telehealth participants could set up the device. Monthly adherence for telehealth participants was > 80%. A qualitative analysis of endpoint surveys revealed that the majority of participants had positive responses. In both groups, there were improvements in Beck Scale for Suicidal Ideation (BSS) scores at endpoint relative to baseline. No group differences were present with survival analysis when using remission [ie BSS score = 0] as the outcome; however, in a subgroup with a history of suicide attempt, there was a trend (p = .093) for a higher rate of remission for those in the HB condition. In conclusion, telehealth monitoring for this population appears to be feasible for those who are able to start using the system. The pilot data obtained should help investigators design better telehealth interventions for this population.

Larsen, ME et al (2016) [Review] A Systematic Assessment of Smartphone Tools for Suicide Prevention[30]

Background: Suicide is a leading cause of death globally, and there has been a rapid growth in the use of new technologies such as mobile health

[29] Kasckow J, Zickmund S, Gurklis J et al Using telehealth to augment an intensive case monitoring program in veterans with schizophrenia and suicidal ideation: A pilot trial. *Psychiatry Res*. 2016;239:111- 116. doi:10.1016/j.psychres.2016.02.049
[30] Larsen ME, Nicholas J, Christensen H. A Systematic Assessment of Smartphone Tools for Suicide Prevention. *PLoS One*. 2016;114.:e0152285. Published 2016 Apr 13. doi:10.1371/journal.pone.0152285

applications to help identify and support those at risk. However, it is not known whether these apps are evidence-based, or indeed contain potentially harmful content. This review examines the concordance of features in publicly available apps with current scientific evidence of effective suicide prevention strategies.

Methods: Apps referring to suicide or deliberate self-harm (DSH) were identified on the Android and iOS app stores. Systematic review methodology was employed to screen and review app content. App features were labelled using a coding scheme that reflected the broad range of evidence-based medical and population-based suicide prevention interventions. Best-practice for suicide prevention was based upon a World Health Organization report and supplemented by other reviews of the literature.

Results: One hundred and twenty-three apps referring to suicide were identified and downloaded for full review, 49 of which were found to contain at least one interactive suicide prevention feature. Most apps focused on obtaining support from friends and family (n = 27) and safety planning (n = 14). Of the different suicide prevention strategies contained within the apps, the strongest evidence in the literature was found for facilitating access to crisis support (n = 13). All reviewed apps contained at least one strategy that was broadly consistent with the evidence base or best-practice guidelines. Apps tended to focus on a single suicide prevention strategy (mean = 1.1), although safety plan apps provided the opportunity to provide a greater number of techniques (mean = 3.9). Potentially harmful content, such as listing lethal access to means or encouraging risky behaviour in a crisis, was also identified.

Discussion: Many suicide prevention apps are available, some of which provide elements of best practice, but none that provide comprehensive evidence-based support. Apps with potentially harmful content were also identified. Despite the number of apps available, and their varied purposes, there is a clear need to develop useful, pragmatic, and multifaceted mobile resources for this population. Clinicians should be wary in recommending apps, especially as potentially harmful content can be presented as helpful. Currently safety plan apps are the most comprehensive and evidence-informed.

Rizvi, S et al (2016) [The DBT Coach Mobile Application as an Adjunct to Treatment for Suicidal and Self-Injuring Individuals With Borderline Personality Disorder: A Preliminary Evaluation and Challenges to Client Utilization](#)[31]

Acquisition and generalization of specific behavioral skills is a key component of dialectical behavior therapy (DBT) for individuals with borderline personality disorder (BPD). We examined the feasibility, acceptability, usability, and immediate effects of the DBT Coach, a mobile phone application designed specifically to augment skills generalization through interactive coaching in DBT skills. In this pilot study, we provided the DBT Coach installed on a mobile device as an adjunct to 6 months of standard DBT, among a sample of 16 individuals with BPD and a recent history of attempted suicide and/or nonsuicidal self-injury (NSSI). Results indicate good acceptability and usability of the DBT Coach with considerable between-person variability in the frequency of app use and a median use of only 11.5 times over the course of treatment and a 3-month follow-up period. Using a hierarchical linear modeling approach, analyses indicated the DBT Coach reduced subjective distress and urges to self-harm following app use. However, use of the DBT Coach was not related to any treatment outcomes, except for reductions in NSSI. This study is the first to examine the use of mobile technology as an adjunct in DBT and highlights some potential challenges in incorporating apps into treatment. Implications for future research and clinical utility are discussed.

Vahabzadeh, A et al (2016) [Review] [Digital Suicide Prevention: Can Technology Become a Game-changer?](#)[32]

Suicide continues to be a leading cause of death and has been recognized as a significant public health issue. Rapid advances in data science can provide us with useful tools for suicide prevention, and help to dynamically assess suicide risk in quantitative data-driven ways. In this article, the authors highlight the most current international research in digital suicide prevention, including the use of machine learning, smartphone applications, and wearable sensor driven systems. The authors also discuss future opportunities for digital suicide prevention, and propose a novel Sensor-driven Mental State Assessment System.

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[31] Rizvi SL, Hughes CD, Thomas MC. The DBT Coach mobile application as an adjunct to treatment for suicidal and self-injuring individuals with borderline personality disorder: A preliminary evaluation and challenges to client utilization. *Psychol Serv.* 2016;134.:380- 388. doi:10.1037/ser0000100

[32] Vahabzadeh A, Sahin N, Kalali A. Digital Suicide Prevention: Can Technology Become a Game-changer?. *Innov Clin Neurosci.* 2016;13(5-6):16- 20. Published 2016 Jun 1.

Bidargaddi, N et al (2015) Telephone-based Low Intensity Therapy After Crisis Presentations to the Emergency Department Is Associated With Improved Outcomes[33]

Introduction: In Australia there is an overwhelming need to provide effective treatment to patients presenting to the Emergency Department (ED) in mental health crisis. We adapted Improving Access to Psychological Therapies service model (IAPT) from the National Health Service (NHS) method for the large scale delivery of psychological therapies throughout the UK to an Australian ED setting. This telephone-based low intensity therapy was provided to people presenting in crisis to the EDs with combinations of anxiety, depression, substance use, and suicidal thinking. Methods: This uncontrolled study utilised session-by-session, before-and-after measures of anxiety and depression via Patient Health Questionnaire (PHQ-9) and Generalised Anxiety Disorder-7 (GAD-7). Results: Of 347 eligible post-crisis ED referred patients, 291 (83.9%) engaged with the IAPT team. Most patients (65%) had attended the ED previously on an average of 3.9 (SD = 6.0) occasions. Two hundred and forty-one patients received an average of 4.1 (SD = 2.3) contacts of low-intensity psychological therapies including 1.2 (SD = 1.7) community outreach visits between 20th Oct 2011 and 31st Dec 2012. Treated patients reported clinically significant improvements in anxiety, depression and suicidal ideation. Uncontrolled effect sizes were moderate for anxiety (0.6) and depression (0.6).

Discussion: The Australian ED IAPT program demonstrated that the UK IAPT program could be adapted for emergency mental health patients and be associated with similar clinical benefits as the original program.

Cebria, AI et al (2015) [Clinical Trial] Telephone Management Program for Patients Discharged From an Emergency Department After a Suicide Attempt: A 5-Year Follow-Up Study in a Spanish Population[34]

Aim: In a previous controlled study, the authors reported on the significant beneficial effects of a telephone intervention program for prevention of suicide attempts by patients for up to 1 year. This study reports the 5-year

[33] Bidargaddi N, Bastiampillai T, Allison S et al Telephone-based low intensity therapy after crisis presentations to the emergency department is associated with improved outcomes. *J Telemed Telecare*. 2015;217.:385- 391. doi:10.1177/1357633X15579785

[34] Cebria AI, Pérez-Bonaventura I, Cuijpers P et al Telephone Management Program for Patients Discharged From an Emergency Department After a Suicide Attempt: A 5-Year Follow-Up Study in a Spanish Population. *Crisis*. 2015;365.:345- 352. doi:10.1027/0227-5910/a000331

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follow-up data. Outcomes were number of recurrences and time to recurrence.

Method: The intervention was carried out on patients discharged from the emergency room following attempted suicide (Sabadell). It consisted of a systematic, 1-year telephone follow-up program: after 1 week, and thereafter at 1-, 3-, 6-, 9-, and 12-month intervals to assess the risk of suicide and encourage adherence to treatment. The population in the control group (Terrassa) received treatment as usual after discharge, without additional telephone contact.

Results: The effect of reattempt prevention observed in the first year was not maintained over the long term.

Conclusion: A telephone management program for patients discharged from an ER after attempted suicide could be considered a useful strategy in delaying further suicide attempts and reducing the rate of reattempts in the first year. However, results showed that the beneficial effects were not maintained at the 5-year follow-up.

CHAPTER 20
Telemedicine and Biotechnology

Systematic Reviews

Kristoffersson, Annica et al (2020) [Systematic Review] A Systematic Review on the Use of Wearable Body Sensors for Health Monitoring: A Qualitative Synthesis[1]

The use of wearable body sensors for health monitoring is a quickly growing field with the potential of offering a reliable means for clinical and remote health management. This includes both real-time monitoring and health trend monitoring with the aim to detect/predict health deterioration and also to act as a prevention tool. The aim of this systematic review was to provide a qualitative synthesis of studies using wearable body sensors for health monitoring. The synthesis and analysis have pointed out a number of shortcomings in prior research. Major shortcomings are demonstrated by the majority of the studies adopting an observational research design, too small sample sizes, poorly presented, and/or non-representative participant demographics: ie age, gender, patient/healthy. These aspects need to be considered in future research work.

Mohsin, AH et al (2020) [Systematic Review] Real-Time Remote Health Monitoring Systems Using Body Sensor Information and Finger Vein Biometric Verification: A Multi-Layer Systematic Review[2]

The development of wireless body area sensor networks is imperative for modern telemedicine. However, attackers and cybercriminals are gradually becoming aware in attacking telemedicine systems, and the black market value of protected health information has the highest price nowadays. Security remains a formidable challenge to be resolved. Intelligent home environments make up one of the major application areas of pervasive

[1] Kristoffersson A, Lindén M. A Systematic Review on the Use of Wearable Body Sensors for Health Monitoring: A Qualitative Synthesis. *Sensors (Basel).* 2020;205.:1502. Published 2020 Mar 9. doi:10.3390/s20051502

[2] Mohsin AH, Zaidan AA, Zaidan BB et al Real-Time Remote Health Monitoring Systems Using Body Sensor Information and Finger Vein Biometric Verification: A Multi-Layer Systematic Review. *J Med Syst.* 2018;42(12):238. Published 2018 Oct 16. doi:10.1007/s10916-018-1104-5

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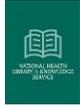
computing. Security and privacy are the two most important issues in the remote monitoring and control of intelligent home environments for clients and servers in telemedicine architecture. The personal authentication approach that uses the finger vein pattern is a newly investigated biometric technique. This type of biometric has many advantages over other types and is suitable for different human categories and ages. This study aims to establish a secure verification method for real-time monitoring systems to be used for the authentication of patients and other members who are working in telemedicine systems. The process begins with the sensor based on Tiers 1 and 2 [client side] in the telemedicine architecture and ends with patient verification in Tier 3 [server side] via finger vein biometric technology to ensure patient security on both sides. Multilayer taxonomy is conducted in this research to attain the study's goal. In the first layer, real-time remote monitoring studies based on the sensor technology used in telemedicine applications are reviewed and analysed to provide researchers a clear vision of security and privacy based on sensors in telemedicine. An extensive search is conducted to identify articles that deal with security and privacy issues, related applications are reviewed comprehensively and a coherent taxonomy of these articles is established. ScienceDirect, IEEE Xplore and Web of Science databases are checked for articles on mHealth in telemedicine based on sensors. A total of 3064 papers are collected from 2007 to 2017. The retrieved articles are filtered according to the security and privacy of telemedicine applications based on sensors. Nineteen articles are selected and classified into two categories. The first category, which accounts for 57.89% (n = 11/19), includes surveys on telemedicine articles and their applications. The second category, accounting for 42.1% (n = 8/19), includes articles on the three-tiered architecture of telemedicine. The collected studies reveal the essential need to construct another taxonomy layer and review studies on finger vein biometric verification systems. This map-matching for both taxonomies is developed for this study to go deeply into the sensor field and determine novel risks and benefits for patient security and privacy on client and server sides in telemedicine applications. In the second layer of our taxonomy, the literature on finger vein biometric verification systems is analysed and reviewed. In this layer, we obtain a final set of 65 articles classified into four categories. In the first category, 80% (n = 52/65) of the articles focus on development and design. In the second category, 12.30% (n = 8/65) includes evaluation and comparative articles. These articles are not intensively included in our literature analysis. In the third category, 4.61% (n = 3/65) includes articles about analytical studies. In
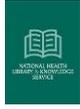
the fourth category, 3.07% (n = 2/65) comprises reviews and surveys. This study aims to provide researchers with an up-to-date overview of studies that have been conducted on user/patient authentication to enhance the security level in telemedicine or any information system. In the current study, taxonomy is presented by explaining previous studies. Moreover, this review highlights the motivations, challenges and recommendations related to finger vein biometric verification systems and determines the gaps in this research direction [protection of finger vein templates in real time], which represent a new research direction in this area.

Shuwandy, ML et al (2019) [Systematic Review] Sensor-Based mHealth Authentication for Real-Time Remote Healthcare Monitoring System: A Multilayer Systematic Review[3]
The new and groundbreaking real-time remote healthcare monitoring system on sensor-based mobile health authentication in telemedicine has considerably bounded and dispersed communication components. mHealth, an attractive part in telemedicine architecture, plays an imperative role in patient security and privacy and adapts different sensing technologies through many built-in sensors. This study aims to improve sensor-based defence and attack mechanisms to ensure patient privacy in client side when using mHealth. Thus, a multilayer taxonomy was conducted to attain the goal of this study. Within the first layer, real-time remote monitoring studies based on sensor technology for telemedicine application were reviewed and analysed to examine these technologies and provide researchers with a clear vision of security- and privacy-based sensors in the telemedicine area. An extensive search was conducted to find articles about security and privacy issues, review related applications comprehensively and establish the coherent taxonomy of these articles. ScienceDirect, IEEE Xplore and Web of Science databases were investigated for articles on mHealth in telemedicine-based sensor. A total of 3064 papers were collected from 2007 to 2017. The retrieved articles were filtered according to the security and privacy of sensor-based telemedicine applications. A total of 19 articles were selected and classified into two categories. The first category, 57.89% (n = 11/19), included survey on telemedicine articles and their applications. The second category, 42.1% (n = 8/19), included articles contributed to the three-tiered architecture of telemedicine. The collected studies improved the

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[3] Shuwandy ML, Zaidan BB, Zaidan AA, Albahri AS. Sensor-Based mHealth Authentication for Real-Time Remote Healthcare Monitoring System: A Multilayer Systematic Review. *J Med Syst*. 2019;432.:33. Published 2019 Jan 6. doi:10.1007/s10916-018-1149-5
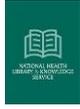
essential need to add another taxonomy layer and review the sensor-based smartphone authentication studies. This map matching for both taxonomies was developed for this study to investigate sensor field comprehensively and gain access to novel risks and benefits of the mHealth security in telemedicine application. The literature on sensor-based smartphones in the second layer of our taxonomy was analysed and reviewed. A total of 599 papers were collected from 2007 to 2017. In this layer, we obtained a final set of 81 articles classified into three categories. The first category of the articles [86.41% (n = 70/81)], where sensor-based smartphones were examined by utilising orientation sensors for user authentication, was used. The second category [7.40% (n = 6/81)] included attack articles, which were not intensively included in our literature analysis. The third category [8.64% (n = 7/81)] included 'other' articles. Factors were considered to understand fully the various contextual aspects of the field in published studies. The characteristics included the motivation and challenges related to sensor-based authentication of smartphones encountered by researchers and the recommendations to strengthen this critical area of research. Finally, many studies on the sensor-based smartphone in the second layer have focused on enhancing accurate authentication because sensor-based smartphones require sensors that could authentically secure mHealth.

Talal, Mohammed et al (2019) [Systematic Review] Smart Home-based IoT for Real-time and Secure Remote Health Monitoring of Triage and Priority System Using Body Sensors: Multi-driven Systematic Review[4]
The Internet of Things (IoT) has been identified in various applications across different domains, such as in the healthcare sector. IoT has also been recognised for its revolution in reshaping modern healthcare with aspiring wide range prospects, including economical, technological and social. This study aims to establish IoT-based smart home security solutions for real-time health monitoring technologies in telemedicine architecture. A multilayer taxonomy is driven and conducted in this study. In the first layer, a comprehensive analysis on telemedicine, which focuses on the client and server sides, shows that other studies associated with IoT-based smart home applications have several limitations that remain unaddressed. Particularly, remote patient monitoring in healthcare applications presents various facilities and benefits by adopting IoT-based smart home

[4] Talal M, Zaidan AA, Zaidan BB et al Smart Home-based IoT for Real-time and Secure Remote Health Monitoring of Triage and Priority System using Body Sensors: Multi-driven Systematic Review. *J Med Syst*. 2019;433.:42. Published 2019 Jan 15. doi:10.1007/s10916-019-1158-z
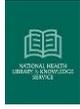
technologies without compromising the security requirements and potentially large number of risks. An extensive search is conducted to identify articles that handle these issues, related applications are comprehensively reviewed and a coherent taxonomy for these articles is established. A total number of (n = 3064) are gathered between 2007 and 2017 for most reliable databases, such as ScienceDirect, Web of Science and Institute of Electrical and Electronic Engineer Xplore databases. Then, the articles based on IoT studies that are associated with telemedicine applications are filtered. Nine articles are selected and classified into two categories. The first category, which accounts for 22.22% (n = 2/9), includes surveys on telemedicine articles and their applications. The second category, which accounts for 77.78% (n = 7/9), includes articles on the client and server sides of telemedicine architecture. The collected studies reveal the essential requirement in constructing another taxonomy layer and review IoT-based smart home security studies. Therefore, IoT-based smart home security features are introduced and analysed in the second layer. The security of smart home design based on IoT applications is an aspect that represents a crucial matter for general occupants of smart homes, in which studies are required to provide a better solution with patient security, privacy protection and security of users' entities from being stolen or compromised. Innovative technologies have dispersed limitations related to this matter. The existing gaps and trends in this area should be investigated to provide valuable visions for technical environments and researchers. Thus, 67 articles are obtained in the second layer of our taxonomy and are classified into six categories. In the first category, 25.37% (n = 17/67) of the articles focus on architecture design. In the second category, 17.91% (n = 12/67) includes security analysis articles that investigate the research status in the security area of IoT-based smart home applications. In the third category, 10.44% (n = 7/67) includes articles about security schemes. In the fourth category, 17.91% (n = 12/67) comprises security examination. In the fifth category, 13.43% (n = 9/67) analyses security protocols. In the final category, 14.92% (n = 10/67) analyses the security framework. Then, the identified basic characteristics of this emerging field are presented and provided in the following aspects. Open challenges experienced on the development of IoT-based smart home security are addressed to be adopted fully in telemedicine applications. Then, the requirements are provided to increase researcher's interest in this study area. On this basis, a number of recommendations for different parties are described to provide insights on the next steps that should be considered to enhance the security of smart homes based on IoT. A map matching for both

taxonomies is developed in this study to determine the novel risks and benefits of IoT-based smart home security for real-time remote health monitoring within client and server sides in telemedicine applications.

Sanyal, Chiranjeev et al (2018) [Systematic Review] [Economic Evaluations of eHealth Technologies: A Systematic Review](5)

Background: Innovations in eHealth technologies have the potential to help older adults live independently, maintain their quality of life, and to reduce their health system dependency and health care expenditure. The objective of this study was to systematically review and appraise the quality of cost-effectiveness or utility studies assessing eHealth technologies in study populations involving older adults. Methods: We systematically searched multiple databases (MEDLINE, EMBASE, CINAHL, NHS EED, and PsycINFO) for peer-reviewed studies published in English from 2000 to 2016 that examined cost-effectiveness or utility of eHealth technologies. The reporting quality of included studies was appraised using the Consolidated Health Economic Evaluation Reporting Standards statement. Results: Eleven full text articles met the inclusion criteria representing public and private health care systems. eHealth technologies evaluated by these studies includes computerized decision support system, a web-based physical activity intervention, Internet-delivered cognitive behavioral therapy, telecare, and telehealth. Overall, the reporting quality of the studies included in the review was varied. Most studies demonstrated efficacy and cost-effectiveness of an intervention using a randomized control trial and statistical modeling, respectively. This review found limited information on the feasibility of adopting these technologies based on economic and organizational factors. Conclusions: This review identified few economic evaluations of eHealth technologies that included older adults. The quality of the current evidence is limited and further research is warranted to clearly demonstrate the long-term cost-effectiveness of eHealth technologies from the health care system and societal perspectives.

5 Sanyal C, Stolee P, Juzwishin D, Husereau D. Economic evaluations of eHealth technologies: A systematic review. *PLoS One*. 2018;136.:e0198112. Published 2018 Jun 13. doi:10.1371/journal.pone.0198112

Randomised Controlled Trials
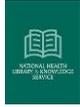
Steinberg, Christian et al (2020) A Novel Wearable Device for Continuous Ambulatory ECG Recording: Proof of Concept and Assessment of Signal Quality[6]

Diagnosis of arrhythmic disorders is challenging because of their short-lasting, intermittent character. Conventional technologies of noninvasive ambulatory rhythm monitoring are limited by modest sensitivity. We present a novel form of wearable electrocardiogram sensors providing an alternative tool for long-term rhythm monitoring with the potential of increased sensitivity to detect intermittent or subclinical arrhythmia. The objective was to assess the signal quality and R-R coverage of a wearable ECG sensor system compared to a standard 3-lead Holter. In this phase-1 trial, healthy individuals underwent 24-h simultaneous rhythm monitoring using the OMsignal system together with a 3-lead Holter recording. The OMsignal system consists of a garment [bra or shirt] with integrated sensors recording a single-lead ECG and an acquisition module for data storage and processing. Head-to-head signal quality was assessed regarding adequate P-QRS-T distinction and was performed by three electrophysiologists blinded to the recording technology. The accuracy of signal coverage was assessed using Bland-Altman analysis. Fifteen individuals underwent simultaneous 24-h recording. Signal quality and accuracy of the OMgaments was equivalent to Holter-monitoring (84% vs 93% electrophysiologists rating, p = 0.06). Signal coverage of R-R intervals showed a very close overlay between the OMsignal system and Holter signals, mean difference in heart rate of 2 5 bpm. The noise level of OMgarments was comparable to Holter recording. OMgarments provide high signal quality for adequate rhythm analysis, representing a promising novel technology for long-term non-invasive ECG monitoring.

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[6] Steinberg C, Philippon F, Sanchez M et al A Novel Wearable Device for Continuous Ambulatory ECG Recording: Proof of Concept and Assessment of Signal Quality. *Biosensors (Basel)*. 2019;91.:17. Published 2019 Jan 21. doi:10.3390/bios9010017

Miscellaneous

Alwashmi, Meshari F (2020) [Review] [The Use of Digital Health in the Detection and Management of COVID-19](7)

Digital health is uniquely positioned to enhance the way we detect and manage infectious diseases. This commentary explores the potential of implementing digital technologies that can be used at different stages of the COVID-19 outbreak, including data-driven disease surveillance, screening, triage, diagnosis, and monitoring. Methods that could potentially reduce the exposure of healthcare providers to the virus are also discussed.

Damen, Ida et al (2020) [Scoping Review] [A Scoping Review of Digital Tools to Reduce Sedentary Behavior or Increase Physical Activity in Knowledge Workers](8)

Background: There is increasing interest in the role that technology can play in improving the vitality of knowledge workers. A promising and widely adopted strategy to attain this goal is to reduce sedentary behavior (SB) and increase physical activity (PA). In this paper, we review the state-of-the-art SB and PA interventions using technology in the office environment. By scoping the existing landscape, we identified current gaps and underexplored possibilities. We discuss opportunities for future development and research on SB and PA interventions using technology. Methods: A systematic search was conducted in the Association for Computing Machinery digital library, the interdisciplinary library Scopus, and the Institute of Electrical and Electronics Engineers Xplore Digital Library to locate peer-reviewed scientific articles detailing SB and PA technology interventions in office environments between 2009 and 2019. Results: The initial search identified 1130 articles, of which 45 studies were included in the analysis. Our scoping review focused on the technologies supporting the interventions, which were coded using a grounded approach. Conclusion: Our findings showed that current SB and PA interventions using technology provide limited possibilities for physically active ways of working as opposed

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[7] Alwashmi MF. The Use of Digital Health in the Detection and Management of COVID-19. *Int J Environ Res Public Health*. 2020;178.:2906. Published 2020 Apr 23. doi:10.3390/ijerph17082906

[8] Damen I, Brombacher H, Lallemand C et al A Scoping Review of Digital Tools to Reduce Sedentary Behavior or Increase Physical Activity in Knowledge Workers. *Int J Environ Res Public Health*. 2020;172.:499. Published 2020 Jan 13. doi:10.3390/ijerph17020499

to the common strategy of prompting breaks. Interventions are also often offered as additional systems or services, rather than integrated into existing office infrastructures. With this work, we have mapped different types of interventions and provide an increased understanding of the opportunities for future multidisciplinary development and research of technologies to address sedentary behavior and physical activity in the office context.

Muzny, Miroslav et al (2020) [Review] [Wearable sensors with possibilities for data exchange: Analyzing status and needs of different actors in mobile health monitoring systems](#)[9]

Background: Wearable devices with an ability to collect various type of physiological data are increasingly becoming seamlessly integrated into everyday life of people. In the area of eHealth, many of these devices provide remote transfer of health data, as a result of the increasing need for ambulatory monitoring of patients. This has a potential to reduce the cost of care due to prevention and early detection. Objective: The objective of this study was to provide an overview of available wearable sensor systems with data exchange possibilities. Due to the heterogeneous capabilities these systems possess today, we aimed to systematize this in terms of usage, where there is a need of, or users benefit from, transferring self-collected data to health care actors. Methods: We searched for and reviewed relevant sensor systems [ie devices] and mapped these into 13 selected attributes related to data-exchange capabilities. We collected data from the Vandrico database of wearable devices, and complemented the information with an additional Internet search. We classified the following attributes of devices: type, communication interfaces, data protocols, smartphone/PC integration, connection to smartphone health platforms, 3rd party integration with health platforms, connection to health care system/middleware, type of gathered health data, integrated sensors, medical device certification, access to user data, developer-access to device, and market status. Devices from the same manufacturer with similar functionalities/characteristics were identified under the same device family. Furthermore, we classified the systems in three subgroups of relevance for different actors in mobile health monitoring systems: EHR providers, software developers, and patient users. Results: We identified 362 different mobile health monitoring devices

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belonging to 193 device families. Based on an analysis of these systems, we identified the following general challenges: Conclusions: Few of the identified mobile health monitoring systems use standardized, open communication protocols, which would allow the user to directly acquire sensor data. Use of open protocols can provide mobile health application developers an alternative to proprietary cloud services and communication tools, which are often closely integrated with the devices. Emerging new types of sensors, often intended for everyday use, have a potential to supplement health records systems with data that can enrich patient care.

Palanica, Adam et al (2020) [Review] [The Need for Artificial Intelligence in Digital Therapeutics](#)[10]

Digital therapeutics is a newly described concept in healthcare which is proposed to change patient behavior and treat medical conditions using a variety of digital technologies. However, the term is rarely defined with criteria that make it distinct from simply digitizedversions of traditional therapeutics. Our objective is to describe a more valuable characteristic of digital therapeutics, which is distinct from traditional medicine or therapy: that is, the utilization of artificial intelligence and machine learning systems to monitor and predict individual patient symptom data in an adaptive clinical feedback loop via digital biomarkers to provide a precision medicine approach to healthcare. Artificial intelligence platforms can learn and predict effective interventions for individuals using a multitude of personal variables to provide a customized and more tailored therapy regimen. Digital therapeutics coupled with artificial intelligence and machine learning also allows more effective clinical observations and management at the population level for various health conditions and cohorts. This vital differentiation of digital therapeutics compared to other forms of therapeutics enables a more personalized form of healthcare that actively adapts to patients' individual clinical needs, goals, and lifestyles. Importantly, these characteristics are what needs to be emphasized to patients, physicians, and policy makers to advance the entire field of digital healthcare.

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[10] Palanica A, Docktor MJ, Lieberman M, Fossat Y. The Need for Artificial Intelligence in Digital Therapeutics. *Digit Biomark*. 2020;41.:21-25. Published 2020 Apr 8. doi:10.1159/000506861

Sust, Pol Perez et al (2020) [Review] Turning the Crisis Into an Opportunity: Digital Health Strategies Deployed During the COVID-19 Outbreak[11]

Digital health technologies offer significant opportunities to reshape current health care systems. From the adoption of electronic medical records to mobile health apps and other disruptive technologies, digital health solutions have promised a better quality of care at a more sustainable cost. However, the widescale adoption of these solutions is lagging behind. The most adverse scenarios often provide an opportunity to develop and test the capacity of digital health technologies to increase the efficiency of health care systems. Catalonia is one of the most advanced regions in terms of digital health adoption across Europe. The region has a long tradition of health information exchange in the public health care sector and is currently implementing an ambitious digital health strategy. In this viewpoint, we discuss the crucial role digital health solutions play during the COVID-19 pandemic to support public health policies. We also report on the strategies currently deployed at scale during the outbreak in Catalonia. Conflicts of Interest: All authors are public servants involved in the deployment of the digital health strategies mentioned in this paper.

Tsai, Tsai-Hsuan et al (2020) [Review] Technology anxiety and resistance to change behavioral study of a wearable cardiac warming system using an extended TAM for older adults[12]

With advances in technology, wireless and sensor technologies represent a method for continuously recording people's biomedical signals, which may enhance the diagnosis and treatment of users' everyday health conditions. These technologies mostly target older adults. In this study, we examine a smart clothing system targeting clinically high-risk patients, including older adults with cardiovascular disease and older adults in general to obtain an understanding of the patients' perception of using wearable healthcare technologies. Cognizant that technology anxiety has been shown to affect users' resistance to using new technology and that perceived ubiquity is considered a characteristic of wearable devices and other mobile wireless technologies, we included three external variables: technology anxiety, perceived ubiquity, and resistance to change, in addition to the traditional

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[11] Pérez Sust P, Solans O, Fajardo JC et al Turning the Crisis Into an Opportunity: Digital Health Strategies Deployed During the COVID-19 Outbreak. *JMIR Public Health Surveill.* 2020;62.:e19106. Published 2020 May 4. doi:10.2196/19106

[12] Tsai TH, Lin WY, Chang YS, Chang PC, Lee MY. Technology anxiety and resistance to change behavioral study of a wearable cardiac warming system using an extended TAM for older adults. *PLoS One.* 2020;151.:e0227270. Published 2020 Jan 13. doi:10.1371/journal.pone.0227270

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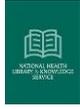
components of the technology acceptance model (TAM). The results of the hypothesized model showed that among older adults in general, technology anxiety had a negative effect on the perceived ease of use and perceived ubiquity. The perceived ubiquity construct affects both user groups' perceived ease of use and perceived usefulness of wearing smart clothes. Most relationships among the original constructs of the TAM were validated in older adults in general. Interestingly, we found that perceived usefulness had an indirect effect on behavioral intention through attitude. These results further confirm the validity of the extended TAM in determining older users' technology acceptance behavior.

Xin, Ming et al (2020) [Review] MXenes and Their Applications in Wearable Sensors[13]

MXenes, a kind of two-dimensional material of early transition metal carbides and carbonitrides, have emerged as a unique class of layered-structured metallic materials with attractive features, as good conductivity comparable to metals, enhanced ionic conductivity, hydrophilic property derived from their hydroxyl or oxygen-terminated surfaces, and mechanical flexibility. With tunable etching methods, the morphology of MXenes can be effectively controlled to form nanoparticles, single layer, or multi-layer nanosheets, which exhibit large specific surface areas and is favorable for enhancing the sensing performance of MXenes based sensors. Moreover, MXenes are available to form composites with other materials facilely. With structure design, MXenes or its composite show enhanced mechanical flexibility and stretchability, which enabled its wide application in the fields of wearable sensors, energy storage, and electromagnetic shielding. In this review, recent progress in MXenes is summarized, focusing on its application in wearable sensors including pressure/strain sensing, biochemical sensing, temperature, and gas sensing. Furthermore, the main challenges and future research are also discussed.

Calvaresi, Davide et al (2019) [Review] Real-time multi-agent systems for telerehabilitation scenarios[14]

Telerehabilitation in older adults is most needed in the patient environments, rather than in formal ambulatories or hospitals. Supporting such practices

[13] Xin M, Li J, Ma Z, Pan L, Shi Y. MXenes and Their Applications in Wearable Sensors. *Front Chem*. 2020;8:297. Published 2020 Apr 21. doi:10.3389/fchem.2020.00297

[14] Calvaresi D, Marinoni M, Dragoni AF, Hilfiker R, Schumacher M. Real-time multi-agent systems for telerehabilitation scenarios. *Artif Intell Med*. 2019;96:217- 231. doi:10.1016/j.artmed.2019.02.001

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brings significant advantages to patients, their family, formal and informal caregivers, clinicians, and researchers. This paper presents a focus group with experts in physiotherapy and telerehabilitation, debating on the requirements, current techniques and technologies developed to facilitate and enhance the effectiveness of telerehabilitation, and the still open challenges. Particular emphasis is given to 1. the body-parts requiring the most rehabilitation; 2. the typical environments, initial causes, and general conditions; 3. the values and parameters to be observed; 4. common errors and limitations of current practices and technological solutions; and 5. the envisioned and desired technological support. Consequently, it has been performed a systematic review of the state of the art, investigating what types of systems and support currently cope with telerehabilitation practices and possible matches with the outcomes of the focus group. Technological solutions based on video analysis, wearable devices, robotic support, distributed sensing, and gamified telerehabilitation are examined. Particular emphasis is given to solutions implementing agent-based approaches, analyzing and discussing strength, limitations, and future challenges. By doing so, it has been possible to relate functional requirements expressed by professional physiotherapists and researchers, with the need for extending multi-agent systems (MAS) peculiarities at the sensing level in wearable solutions establishing new research challenges. In particular, to be employed in safety-critical cyber-physical scenarios with user-sensor and sensor-sensor interactions, MAS are requested to handle timing constraints, scarcity of resources and new communication means, crucial to providing real-time feedback and coaching. Therefore, MAS pillars such as the negotiation protocol and the agent's internal scheduler have been investigated, proposing solutions to achieve the aforementioned real-time compliance.

Gu, Dongxiao et al (2019) [Review] Visualizing the intellectual structure and evolution of electronic health and telemedicine research[15]
Background: In recent years, the development and application of emerging information technologies, such as artificial intelligence, cloud computing, Internet of Things, and wearable devices, has expanded the content of e-health. Electronic health has become a research focus, but few studies have explored its knowledge structure from a global perspective. Methods: To detect the evolution track, knowledge base and research hotspots of e-

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[15] Gu D, Li T, Wang X, Yang X, Yu Z. Visualizing the intellectual structure and evolution of electronic health and telemedicine research. *Int J Med Inform.* 2019;130:103947. doi:10.1016/j.ijmedinf.2019.08.007

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health, we conducted a series of bibliometric analyses on the retrieved 3,085 papers from the Web of Science core database in 1992-2017. We used several bibliometric tools, such as HistCite, CiteSpace, NetDraw, and NEViewer, to describe the evolution process, time-and-space knowledge map, and hotspots in e-health. Results: The research results are as follows: 1. the number of publications has been obviously increasing after 2005 and according to the trend line it is expected to continue increase exponentially in the future; 2. countries/regions conducting e-health research have close cooperative relationship, among which European countries have the closest cooperation; 3. electronic health records, mobile health and health information technology are research hotspots in electronic health. Moreover, scholars also pay attention to the hot issues such as privacy, security, and quality improvement. Conclusions: Electronic health is a large and growing field with quite a number of research articles in medical journals. This study provides a comprehensive knowledge structure of electronic health for scholars in the healthcare informatics field, which can help them quickly grasp research hotspots and choose future research projects.

Guo, Jingjing et al (2019) [Review] [Soft and Stretchable Polymeric Optical Waveguide-Based Sensors for Wearable and Biomedical Applications](#)[16] The past decades have witnessed the rapid development in soft, stretchable, and biocompatible devices for applications in biomedical monitoring, personal healthcare, and human-machine interfaces. In particular, the design of soft devices in optics has attracted tremendous interests attributed to their distinct advantages such as inherent electrical safety, high stability in long-term operation, potential to be miniaturized, and free of electromagnetic interferences. As the alternatives to conventional rigid optical waveguides, considerable efforts have been made to develop light-guiding devices by using various transparent and elastic polymers, which offer desired physiomechanical properties and enable wearable/implantable applications in optical sensing, diagnostics, and therapy. Here, we review recent progress in soft and stretchable optical waveguides and sensors, including advanced structural design, fabrication strategies, and functionalities. Furthermore, the potential applications of those optical devices for various wearable and biomedical applications are discussed. It is expected that the newly emerged soft and stretchable optical technologies

[16] Guo J, Yang C, Dai Q, Kong L. Soft and Stretchable Polymeric Optical Waveguide-Based Sensors for Wearable and Biomedical Applications. *Sensors (Basel).* 2019;19(17):3771. Published 2019 Aug 30. doi:10.3390/s19173771

will provide a safe and reliable alternative to next-generation, smart wearables and healthcare devices.

Huzooree, Geshwaree et al (2019) [Review] Pervasive mobile healthcare systems for chronic disease monitoring[17]

Pervasive mobile healthcare system has the potential to improve healthcare and the quality of life of chronic disease patients through continuous monitoring. Recently, many articles related to pervasive mobile healthcare system focusing on health monitoring using wireless technologies have been published. The main aim of this review is to evaluate the state-of-the-art pervasive mobile healthcare systems to identify major technical requirements and design challenges associated with the realization of a pervasive mobile healthcare system. A systematic literature review was conducted over IEEE Xplore Digital Library to evaluate 20 pervasive mobile healthcare systems out of 683 articles from 2011 to 2016. The classification of the pervasive mobile healthcare systems and other important factors are discussed. Potential opportunities and challenges are pointed out for the further deployment of effective pervasive mobile healthcare systems. This article helps researchers in health informatics to have a holistic view toward understanding pervasive mobile healthcare systems and points out new technological trends and design challenges that researchers have to consider when designing such systems for better adoption, usability, and seamless integration.

Jeong, Yu Ra et al (2019) [Review] Stretchable, Skin-Attachable Electronics With Integrated Energy Storage Devices for Biosignal Monitoring[18]

The demand for novel electronics that can monitor human health, for example, the physical conditions of individuals, during daily life using different techniques from those used in traditional clinic diagnostic facilities is increasing. These novel electronics include stretchable sensor devices that allow various biosignals to be directly measured on human skin without restricting routine activity. The thin, skin-like characteristics of these devices enable stable operation under various deformations, such as stretching, pressing, and rubbing, experienced while attached to skin. The mechanically engineered design of these devices also minimizes the inconvenience caused

[17] Huzooree G, Kumar Khedo K, Joonas N. Pervasive mobile healthcare systems for chronic disease monitoring. *Health Informatics J.* 2019;252.:267- 291. doi:10.1177/1460458217704250

[18] Jeong YR, Lee G, Park H, Ha JS. Stretchable, Skin-Attachable Electronics with Integrated Energy Storage Devices for Biosignal Monitoring. *Acc Chem Res.* 2019;521.:91- 99. doi:10.1021/acs.accounts.8b00508

by long-term wear owing to conformal lamination on the skin. The final form of a skin-attachable device must be an integrated platform with an independent and complete system containing all components on a single, thin, lightweight, stretchable substrate. To fabricate fully integrated devices, various aspects, such as material design for deformable interconnection, fabrication of high-performance active devices, miniaturization, and dense arrangement of component devices, should be considered. In particular, a power supply system is critical and must be combined in an electromechanically stable and efficient manner with all devices, including sensors. Additionally, the biosignals obtained by these sensors should be wirelessly transmitted to external electronic devices for free daily activity. This Account covers recent progress in developing fully integrated, stretchable, skin-attachable devices by presenting our strategies to achieve this goal. First, we introduce several integration methods used in this field to build stretchable systems with a special focus on the utilization of liquid gallium alloy. The unique characteristics and patterning process of liquid metal are summarized. Second, various skin-attachable sensors, including strain, pressure, with enhanced sensitivity and mechanical properties are discussed along with their applications for biosignal monitoring. Dual mode sensors that simultaneously detect temperature and pressure signals without interference are also introduced. Third, we emphasize supercapacitors as promising, efficient energy storage devices for power management systems in wearable devices. Supercapacitors for skin-attachable applications should have a high performance, such as high operation voltage, high energy and power densities, cyclic and air stability and water resistance. For this, strategies to select novel materials for electrode, electrolyte, and encapsulation are suggested. Several approaches to fabricate stretchable supercapacitor systems are also presented. Finally, we introduce recent examples of skin-attachable, stretchable electronics that integrate sensors, power management devices, and wireless data transfer functions on a single elastomer substrate. Conventional wireless technologies, such as near-field communications (NFC) and Bluetooth, are incorporated in miniaturized features on the devices. To date, much research has been performed in this field, but there are still many technologies to develop. The performance of individual devices and mass fabrication techniques should be enhanced. We expect that future electronic devices with fully integrated functions will include advanced human-machine interaction capabilities and expand the overall abilities of the human body.

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Jeong, In Cheol et al (2019) [Review] Wearable Devices for Precision Medicine and Health State Monitoring[19]

Wearable technologies will play an important role in advancing precision medicine by enabling measurement of clinically-relevant parameters describing an individual's health state. The lifestyle and fitness markets have provided the driving force for the development of a broad range of wearable technologies that can be adapted for use in healthcare. Here we review existing technologies currently used for measurement of the four primary vital signs: temperature, heart rate, respiration rate, and blood pressure, along with physical activity, sweat, and emotion. We review the relevant physiology that defines the measurement needs and evaluate the different methods of signal transduction and measurement modalities for the use of wearables in healthcare.

Khan, Saleem et al (2019) [Review] Recent Developments in Printing Flexible and Wearable Sensing Electronics for Healthcare Applications[20]

Wearable biosensors attract significant interest for their capabilities in real-time monitoring of wearers' health status, as well as the surrounding environment. Sensor patches are embedded onto the human epidermis accompanied by data readout and signal conditioning circuits with wireless communication modules for transmitting data to the computing devices. Wearable sensors designed for recognition of various biomarkers in human epidermis fluids as well as physiological indicators have potential applications both in medical diagnostics and fitness monitoring. The rapid developments in solution-based nanomaterials offered a promising perspective to the field of wearable sensors by enabling their cost-efficient manufacturing through printing on a wide range of flexible polymeric substrates. This review highlights the latest key developments made in the field of wearable sensors involving advanced nanomaterials, manufacturing processes, substrates, sensor type, sensing mechanism, and readout circuits, and ends with challenges in the future scope of the field. Sensors are categorized as biological and fluidic, mounted directly on the human body, or physiological, integrated onto wearable substrates/gadgets separately for monitoring of human-body-related analytes, as well as external stimuli.

[19] Jeong IC, Bychkov D, Searson PC. Wearable Devices for Precision Medicine and Health State Monitoring. *IEEE Trans Biomed Eng.* 2019;665.:1242-1258. doi:10.1109/TBME.2018.2871638

[20] Khan S, Ali S, Bermak A. Recent Developments in Printing Flexible and Wearable Sensing Electronics for Healthcare Applications. *Sensors (Basel).* 2019;195.:1230. Published 2019 Mar 11. doi:10.3390/s19051230
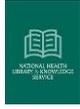
Special focus is given to printable materials and sensors, which are key enablers for wearable electronics.

Loncar-Turukalo, Tatjana et al (2019) [Review] **Literature on Wearable Technology for Connected Health: Scoping Review of Research Trends, Advances, and Barriers**[21]

Background: Wearable sensing and information and communication technologies are key enablers driving the transformation of health care delivery toward a new model of connected health (CH) care. The advances in wearable technologies in the last decade are evidenced in a plethora of original articles, patent documentation, and focused systematic reviews. Although technological innovations continuously respond to emerging challenges and technology availability further supports the evolution of CH solutions, the widespread adoption of wearables remains hindered. Objective: This study aimed to scope the scientific literature in the field of pervasive wearable health monitoring in the time interval from January 2010 to February 2019 with respect to four important pillars: technology, safety and security, prescriptive insight, and user-related concerns. The purpose of this study was multifold: identification of 1. trends and milestones that have driven research in wearable technology in the last decade; 2. concerns and barriers from technology and user perspective; and 3. trends in the research literature addressing these issues. Methods: This study followed the scoping review methodology to identify and process the available literature. As the scope surpasses the possibilities of manual search, we relied on the natural language processing tool kit to ensure an efficient and exhaustive search of the literature corpus in three large digital libraries: Institute of Electrical and Electronics Engineers, PubMed, and Springer. The search was based on the keywords and properties to be found in articles using the search engines of the digital libraries. Results: The annual number of publications in all segments of research on wearable technology shows an increasing trend from 2010 to February 2019. The technology-related topics dominated in the number of contributions, followed by research on information delivery, safety, and security, whereas user-related concerns were the topic least addressed. The literature corpus evidences milestones in sensor technology (miniaturization and placement), communication architectures and fifth generation (5G) cellular network technology, data analytics, and evolution of

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[21] Loncar-Turukalo T, Zdravevski E, Machado da Silva J, Chouvarda I, Trajkovik V. Literature on Wearable Technology for Connected Health: Scoping Review of Research Trends, Advances, and Barriers. *J Med Internet Res*. 2019;21(9):e14017. Published 2019 Sep 5. doi:10.2196/14017

cloud and edge computing architectures. The research lag in battery technology makes energy efficiency a relevant consideration in the design of both sensors and network architectures with computational offloading. The most addressed user-related concerns were (technology) acceptance and privacy, whereas research gaps indicate that more efforts should be invested into formalizing clear use cases with timely and valuable feedback and prescriptive recommendations.

Conclusions: This study confirms that applications of wearable technology in the CH domain are becoming mature and established as a scientific domain. The current research should bring progress to sustainable delivery of valuable recommendations, enforcement of privacy by design, energy-efficient pervasive sensing, seamless monitoring, and low-latency 5G communications. To complement technology achievements, future work involving all stakeholders providing research evidence on improved care pathways and cost-effectiveness of the CH model is needed.

Majumder, Sumit et al (2019) [Review] Smartphone Sensors for Health Monitoring and Diagnosis[22]

Over the past few decades, we have witnessed a dramatic rise in life expectancy owing to significant advances in medical science and technology, medicine as well as increased awareness about nutrition, education, and environmental and personal hygiene. Consequently, the elderly population in many countries are expected to rise rapidly in the coming years. A rapidly rising elderly demographics is expected to adversely affect the socioeconomic systems of many nations in terms of costs associated with their healthcare and wellbeing. In addition, diseases related to the cardiovascular system, eye, respiratory system, skin and mental health are widespread globally. However, most of these diseases can be avoided and/or properly managed through continuous monitoring. In order to enable continuous health monitoring as well as to serve growing healthcare needs; affordable, non-invasive and easy-to-use healthcare solutions are critical. The ever-increasing penetration of smartphones, coupled with embedded sensors and modern communication technologies, make it an attractive technology for enabling continuous and remote monitoring of an individual's health and wellbeing with negligible additional costs. In this paper, we present a comprehensive review of the state-of-the-art research and developments in smartphone-sensor based healthcare technologies. A

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[22] Majumder S, Deen MJ. Smartphone Sensors for Health Monitoring and Diagnosis. *Sensors (Basel)*. 2019;19(9):2164. Published 2019 May 9. doi:10.3390/s19092164

discussion on regulatory policies for medical devices and their implications in smartphone-based healthcare systems is presented. Finally, some future research perspectives and concerns regarding smartphone-based healthcare systems are described.

Olatinwa, Damilola D. et al (2019) [Review] A Survey on LPWAN Technologies in WBAN for Remote Health-Care Monitoring[23]
In ubiquitous health-care monitoring (HCM), wireless body area networks (WBANs) are envisioned as appealing solutions that may offer reliable methods for real-time monitoring of patients' health conditions by employing the emerging communication technologies. This paper therefore focuses more on the state-of-the-art wireless communication systems that can be explored in the next-generation WBAN solutions for HCM. Also, this study addressed the critical issues confronted by the existing WBANs that are employed in HCM. Examples of such issues include wide-range health data communication constraint, health data delivery reliability concern, and energy efficiency, which are attributed to the limitations of the legacy short range, medium range, and the cellular technologies that are typically employed in WBAN systems. Since the WBAN sensor devices are usually configured with a finite battery power, they often get drained during prolonged operations. This phenomenon is technically exacerbated by the fact that the legacy communication systems, such as ZigBee, Bluetooth, 6LoWPAN, and so on, consume more energy during data communications. This unfortunate situation offers a scope for employing suitable communication systems identified in this study to improve the productivity of WBANs in HCM. For this to be achieved, the emerging communication systems such as the low-power wide-area networks (LPWANs) are investigated in this study based on their power transmission, data transmission rate, data reliability in the context of efficient data delivery, communication coverage, and latency, including their advantages, as well as disadvantages. As a consequence, the LPWAN solutions are presented for WBAN systems in remote HCM. Furthermore, this research work also points out future directions for the realization of the next-generation of WBANs, as well as how to improve the identified communication systems, to further enhance their productivity in WBAN solutions for HCM.

[23] Olatinwo DD, Abu-Mahfouz A, Hancke G. A Survey on LPWAN Technologies in WBAN for Remote Health-Care Monitoring. *Sensors (Basel).* 2019;19(23):5268. Published 2019 Nov 29. doi:10.3390/s19235268
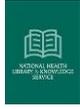
Ranjan, Yatharth et al (2019) RADAR-Base: Open Source Mobile Health Platform for Collecting, Monitoring, and Analyzing Data Using Sensors, Wearables, and Mobile Devices[24]

Background: With a wide range of use cases in both research and clinical domains, collecting continuous mobile health (mHealth) streaming data from multiple sources in a secure, highly scalable, and extensible platform is of high interest to the open source mHealth community. The European Union Innovative Medicines Initiative Remote Assessment of Disease and Relapse-Central Nervous System (RADAR-CNS) program is an exemplary project with the requirements to support the collection of high-resolution data at scale; as such, the Remote Assessment of Disease and Relapse (RADAR)-base platform is designed to meet these needs and additionally facilitate a new generation of mHealth projects in this nascent field.

Objective: Wide-bandwidth networks, smartphone penetrance, and wearable sensors offer new possibilities for collecting near-real-time high-resolution datasets from large numbers of participants. The aim of this study was to build a platform that would cater for large-scale data collection for remote monitoring initiatives. Key criteria are around scalability, extensibility, security, and privacy. Methods: RADAR-base is developed as a modular application; the backend is built on a backbone of the highly successful Confluent/Apache Kafka framework for streaming data. To facilitate scaling and ease of deployment, we use Docker containers to package the components of the platform. RADAR-base provides 2 main mobile apps for data collection, a Passive App and an Active App. Other third-Party Apps and sensors are easily integrated into the platform. Management user interfaces to support data collection and enrolment are also provided. Results: General principles of the platform components and design of RADAR-base are presented here, with examples of the types of data currently being collected from devices used in RADAR-CNS projects: Multiple Sclerosis, Epilepsy, and Depression cohorts. Conclusions: RADAR-base is a fully functional, remote data collection platform built around Confluent/Apache Kafka and provides off-the-shelf components for projects interested in collecting mHealth datasets at scale.

Yang, Jun Chang et al (2019) [Review] Electronic Skin: Recent Progress and Future Prospects for Skin-Attachable Devices for Health Monitoring, Robotics, and Prosthetics[25]

Recent progress in electronic skin or e-skin research is broadly reviewed, focusing on technologies needed in three main applications: skin-attachable electronics, robotics, and prosthetics. First, since e-skin will be exposed to prolonged stresses of various kinds and needs to be conformally adhered to irregularly shaped surfaces, materials with intrinsic stretchability and self-healing properties are of great importance. Second, tactile sensing capability such as the detection of pressure, strain, slip, force vector, and temperature are important for health monitoring in skin attachable devices, and to enable object manipulation and detection of surrounding environment for robotics and prosthetics. For skin attachable devices, chemical and electrophysiological sensing and wireless signal communication are of high significance to fully gauge the state of health of users and to ensure user comfort. For robotics and prosthetics, large-area integration on 3D surfaces in a facile and scalable manner is critical. Furthermore, new signal processing strategies using neuromorphic devices are needed to efficiently process tactile information in a parallel and low power manner. For prosthetics, neural interfacing electrodes are of high importance. These topics are discussed, focusing on progress, current challenges, and future prospects.

Bayo-Monton, Jose-Luis et al (2018) [Review] Wearable Sensors Integrated with Internet of Things for Advancing eHealth Care[26]

Health and sociological indicators alert that life expectancy is increasing, hence so are the years that patients have to live with chronic diseases and co-morbidities. With the advancement in ICT, new tools and paradigms are been explored to provide effective and efficient health care. Telemedicine and health sensors stand as indispensable tools for promoting patient engagement, self-management of diseases and assist doctors to remotely follow up patients. In this paper, we evaluate a rapid prototyping solution for information merging based on five health sensors and two low-cost ubiquitous computing components: Arduino and Raspberry Pi. Our study, which is entirely described with the purpose of reproducibility, aimed to evaluate the extent to which portable technologies are capable of

[25] Yang JC, Mun J, Kwon SY, Park S, Bao Z, Park S. Electronic Skin: Recent Progress and Future Prospects for Skin-Attachable Devices for Health Monitoring, Robotics, and Prosthetics. *Adv Mater.* 2019;31(48):e1904765. doi:10.1002/adma.201904765

[26] Bayo-Monton JL, Martinez-Millana A, Han W, Fernandez-Llatas C, Sun Y, Traver V. Wearable Sensors Integrated with Internet of Things for Advancing eHealth Care. *Sensors (Basel).* 2018;186.:1851. Published 2018 Jun 6. doi:10.3390/s18061851

integrating wearable sensors by comparing two deployment scenarios: Raspberry Pi 3 and Personal Computer. The integration is implemented using a choreography engine to transmit data from sensors to a display unit using web services and a simple communication protocol with two modes of data retrieval. Performance of the two set-ups is compared by means of the latency in the wearable data transmission and data loss. PC has a delay of $0.051 ± 0.0035$ s (max $= 0.2504$ s), whereas the Raspberry Pi yields a delay of $0.0175 ± 0.149$ s (max $= 0.294$ s) for $N = 300$. Our analysis confirms that portable devices ($p < < 0.01$) are suitable to support the transmission and analysis of biometric signals into scalable telemedicine systems.

Dunn, Jessilyn et al (2018) [Review] Wearables and the Medical Revolution[27]

Wearable sensors are already impacting healthcare and medicine by enabling health monitoring outside of the clinic and prediction of health events. This paper reviews current and prospective wearable technologies and their progress toward clinical application. We describe technologies underlying common, commercially available wearable sensors and early-stage devices and outline research, when available, to support the use of these devices in healthcare. We cover applications in the following health areas: metabolic, cardiovascular and gastrointestinal monitoring; sleep, neurology, movement disorders and mental health; maternal, pre- and neo-natal care; and pulmonary health and environmental exposures. Finally, we discuss challenges associated with the adoption of wearable sensors in the current healthcare ecosystem and discuss areas for future research and development.

Koydemir, Hatice Ceylan et al (2018) [Review] Wearable and Implantable Sensors for Biomedical Applications[28]

Mobile health technologies offer great promise for reducing healthcare costs and improving patient care. Wearable and implantable technologies are contributing to a transformation in the mobile health era in terms of improving healthcare and health outcomes and providing real-time guidance on improved health management and tracking. In this article, we review the biomedical applications of wearable and implantable medical devices and sensors, ranging from monitoring to prevention of diseases, as well as the

[27] Dunn J, Runge R, Snyder M. Wearables and the medical revolution. *Per Med.* 2018;155.:429- 448. doi:10.2217/pme-2018-0044

[28] Koydemir HC, Ozcan A. Wearable and Implantable Sensors for Biomedical Applications. *Annu Rev Anal Chem (Palo Alto Calif).* 2018;111.:127- 146. doi:10.1146/annurev-anchem-061417-125956

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materials used in the fabrication of these devices and the standards for wireless medical devices and mobile applications. We conclude by discussing some of the technical challenges in wearable and implantable technology and possible solutions for overcoming these difficulties.

Sonawane, Apurva et al (2017) [Review] Stability of Enzymatic Biosensors for Wearable Applications[29]

Technological evolution in wearable sensors accounts for major growth and transformation in a multitude of industries, ranging from healthcare to computing and informatics to communication and biomedical sciences. The major driver for this transformation is the new-found ability to continuously monitor and analyze the patients' physiology in patients' natural setting. Numerous wearable sensors are already on the market and are summarized. Most of the current technologies have focused on electrophysiological, electromechanical, or acoustic measurements. Wearable biochemical sensing devices are in their infancy. Traditional challenges in biochemical sensing such as reliability, repeatability, stability, and drift are amplified in wearable sensing systems due to variabilities in operating environment, sample/sensor handling, and motion artifacts. Enzymatic sensing technologies, due to reduced fluidic challenges, continue to be forerunners for converting into wearable sensors. This paper reviews the recent developments in wearable enzymatic sensors. The wearable sensors have been classified in three major groups based on sensor embodiment and placement relative to the human body: 1. on-body; 2. clothing/textile-based biosensors; and 3. biosensor accessories. The sensors, which come in the forms of stickers and tattoos, are categorized as on-body biosensors. The fabric-based biosensor comes in different models such as smart-shirts, socks, gloves, and smart undergarments with printed sensors for continuous monitoring.

Erdmier, Casey et al (2016) [Review] Wearable Device Implications in the Healthcare Industry[30]

This manuscript analyses the impact of wearable device technology in the healthcare industry. The authors provide an exploration of the different types of wearable technology that are becoming popular or are emerging

[29] Sonawane A, Manickam P, Bhansali S. Stability of Enzymatic Biosensors for Wearable Applications. *IEEE Rev Biomed Eng.* 2017;10:174–186. doi:10.1109/RBME.2017.2706661

[30] Erdmier C, Hatcher J, Lee M. Wearable device implications in the healthcare industry. *J Med Eng Technol.* 2016;404.:141-148. doi:10.3109/03091902.2016.1153738

into the consumer market and the personal health information and other user data these devices collect. The applications of wearable technology to healthcare and wellness are discussed, along with the impact of these devices on the industry. Finally, an analysis is provided, describing the current regulations in the US and UK that govern wearable devices and the impact of these device regulations on users and healthcare professionals.

Ghamari, Mohammad et al (2016) [Review] A Survey on Wireless Body Area Networks for eHealthcare Systems in Residential Environments[31]
Current progress in wearable and implanted health monitoring technologies has strong potential to alter the future of healthcare services by enabling ubiquitous monitoring of patients. A typical health monitoring system consists of a network of wearable or implanted sensors that constantly monitor physiological parameters. Collected data are relayed using existing wireless communication protocols to a base station for additional processing. This article provides researchers with information to compare the existing low-power communication technologies that can potentially support the rapid development and deployment of WBAN systems, and mainly focuses on remote monitoring of elderly or chronically ill patients in residential environments.

Khan, Yasser et al (2016) [Review] Monitoring of Vital Signs With Flexible and Wearable Medical Devices[32]
Advances in wireless technologies, low-power electronics, the Internet of things, and in the domain of connected health are driving innovations in wearable medical devices at a tremendous pace. Wearable sensor systems composed of flexible and stretchable materials have the potential to better interface to the human skin, whereas silicon-based electronics are extremely efficient in sensor data processing and transmission. Therefore, flexible and stretchable sensors combined with low-power silicon-based electronics are a viable and efficient approach for medical monitoring. Flexible medical devices designed for monitoring human vital signs, such as body temperature, heart rate, respiration rate, blood pressure, pulse oxygenation, and blood glucose have applications in both fitness monitoring and medical diagnostics. As a review of the latest development in flexible and wearable human vitals sensors, the essential components required for

[31] Ghamari M, Janko B, Sherratt RS, Harwin W, Piechockic R, Soltanpur C. A Survey on Wireless Body Area Networks for eHealthcare Systems in Residential Environments. *Sensors (Basel).* 2016;166.:831. Published 2016 Jun 7. doi:10.3390/s16060831
[32] Khan Y, Ostfeld AE, Lochner CM, Pierre A, Arias AC. Monitoring of Vital Signs with Flexible and Wearable Medical Devices. *Adv Mater.* 2016;28(22):4373-4395. doi:10.1002/adma.201504366

vitals sensors are outlined and discussed here, including the reported sensor systems, sensing mechanisms, sensor fabrication, power, and data processing requirements.

Trung, Tran Quang et al (2016) [Review] Flexible and Stretchable Physical Sensor Integrated Platforms for Wearable Human-Activity Monitoringand Personal Healthcare[33]

Flexible and stretchable physical sensors that can measure and quantify electrical signals generated by human activities are attracting a great deal of attention as they have unique characteristics, such as ultrathinness, low modulus, light weight, high flexibility, and stretchability. These flexible and stretchable physical sensors conformally attached on the surface of organs or skin can provide a new opportunity for human-activity monitoring and personal healthcare. Consequently, in recent years there has been considerable research effort devoted to the development of flexible and stretchable physical sensors to fulfill the requirements of future technology, and much progress has been achieved. Here, the most recent developments of flexible and stretchable physical sensors are described, including temperature, pressure, and strain sensors, and flexible and stretchable sensor-integrated platforms. The latest successful examples of flexible and stretchable physical sensors for the detection of temperature, pressure, and strain, as well as their novel structures, technological innovations, and challenges, are reviewed first. In the next section, recent progress regarding sensor-integrated wearable platforms is overviewed in detail. Some of the latest achievements regarding self-powered sensor-integrated wearable platform technologies are also reviewed. Further research direction and challenges are also proposed to develop a fully sensor-integrated wearable platform for monitoring human activity and personal healthcare in the near future.

▶ **Contents**

[33] Trung TQ, Lee NE. Flexible and Stretchable Physical Sensor Integrated Platforms for Wearable Human-Activity Monitoring and Personal Healthcare. *Adv Mater.* 2016;28(22):4338- 4372. doi:10.1002/adma.201504244

CHAPTER 21
Telemedicine and Chronic Conditions

Systematic Reviews

Lee, Jung-Ah et al (2019) [Systematic Review] Effective Behavioral Intervention Strategies Using Mobile Health Applications for Chronic Disease Management: A Systematic Review[34]

Background: Mobile health (mHealth) has continuously been used as a method in behavioral research to improve self-management in patients with chronic diseases. However, the evidence of its effectiveness in chronic disease management in the adult population is still lacking. We conducted a systematic review to examine the effectiveness of mHealth interventions on process measures as well as health outcomes in randomized controlled trials to improve chronic disease management. Methods: Relevant randomized controlled studies that were published between January 2005 and March 2016 were searched in six databases: PubMed, CINAHL, EMBASE, the Cochrane Library, PsycINFO, and Web of Science. The inclusion criteria were RCTs that conducted an intervention using mobile devices such as smartphones or tablets for adult patients with chronic diseases to examine disease management or health promotion. Results: Of the 12 RCTs reviewed, 10 of the mHealth interventions demonstrated statistically significant improvement in some health outcomes. The most common features of mHealth systems used in the reviewed RCTs were real-time or regular basis symptom assessments, pre-programed reminders, or feedbacks tailored specifically to the data provided by participants via mHealth devices. Most studies developed their own mHealth systems including mobile apps. Training of mHealth systems was provided to participants in person or through paper-based instructions. None of the studies reported the relationship between health outcomes and patient engagement levels on the mHealth system. Conclusions: Findings from mHealth intervention studies for chronic disease management have shown promising aspects, particularly in improving self-management and some health outcomes.

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[34] Lee JA, Choi M, Lee SA, Jiang N. Effective behavioral intervention strategies using mobile health applications for chronic disease management: a systematic review. *BMC Med Inform Decis Mak*. 2018;181.:12. Published 2018 Feb 20. doi:10.1186/s12911-018-0591-0

Sprogis, Stephanie K. et al (2019) [Systematic Review] Patient Acceptability of Wearable Vital Sign Monitoring Technologies in the Acute Care Setting: A Systematic Review[35]

Aims and objectives: To examine patient acceptability of wearable vital sign monitoring devices in the acute setting.

Background: Wearable vital sign monitoring devices may improve patient safety, yet hospital patients' acceptability of these devices is largely unreported. Design: A systematic review. Methods: Cumulative Index to Nursing and Allied Health Literature Complete, MEDLINE Complete and EMBASE were searched, supplemented by reference list hand searching. Studies were included if they involved adult hospital patients (≥18 years), a wearable monitoring device capable of assessing ≥1 vital sign, and measured patient acceptability, satisfaction or experience of wearing the device. No date restrictions were enforced. Quality assessments of quantitative and qualitative studies were undertaken using the Downs and Black Checklist for Measuring Study Quality and the Critical Appraisal Skills Programme Qualitative Research Checklist, respectively. Meta-analyses were not possible given data heterogeneity and low research quality. Reporting adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and a Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist was completed. Results: Of the 427 studies screened, seven observational studies met the inclusion criteria. Six studies were of low quality and one was of high quality. In two studies, patient satisfaction was investigated. In the remaining studies, patient experience, patient opinions and experience, patient perceptions and experience, device acceptability, and patient comfort and concerns were investigated. In four studies, patients were mostly accepting of the wearable devices, reporting positive experiences and satisfaction relating to their use. In three studies, findings were mixed.

Conclusion: There is limited high-quality research examining patient acceptability of wearable vital sign monitoring devices as an a priori focus in the acute setting. Further understanding of patient perspectives of these devices is required to inform their continued use and development.

Relevance to clinical practice: The provision of patient-centred nursing care is contingent on understanding patients' preferences, including their acceptability of technology use.

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[35] Sprogis SK, Currey J, Considine J. Patient acceptability of wearable vital sign monitoring technologies in the acute care setting: A systematic review. *J Clin Nurs*. 2019;28(15-16):2732-2744. doi:10.1111/jocn.14893

Adamse, Corine et al (2018) [Systematic Review] The Effectiveness of Exercise-Based Telemedicine on Pain, Physical Activity and Quality of Life in the Treatment of Chronic Pain: A Systematic Review[36]

Introduction: The aim of this study was to systematically review the evidence on the effectiveness of exercise-based telemedicine in chronic pain. Methods: We searched the Cochrane, PubMed, MEDLINE, EMBASE, CINAHL and PEDRO databases from 2000 to 2015 for randomised controlled trials, comparing exercise-based telemedicine intervention to no intervention or usual care in adults with chronic pain. Primary outcome data were pooled using random effect meta-analysis. Primary outcomes were pain, physical activity (PA), limitations in activities of daily living (ADL) and quality of life (QoL). Secondary outcomes were barriers, facilitators and usability of telemedicine. Results: Sixteen studies were included. Meta-analyses were performed in three subgroups of studies with comparable control conditions. Telemedicine versus no intervention showed significantly lower pain scores (MD -0.57, 95% CI -0.81; -0.34), but not for telemedicine versus usual care (MD -0.08, 95% CI -0.41; 0.26) or in addition to usual care (MD -0.25, 95% CI -1.50; 1.00). Telemedicine compared to no intervention showed non-significant effects for PA (MD 19.93 min/week, 95% CI -5.20; 45.06) and significantly diminished ADL limitations (SMD -0.20, 95% CI -0.29; -0.12). No differences were found for telemedicine in addition to usual care for PA or for ADL (SMD 0.16, 95% CI -0.66; 0.34). Telemedicine versus usual care showed no differences for ADL (SMD 0.08, 95% CI -0.37; 0.53). No differences were found for telemedicine compared to the three control groups for QoL. Limited information was found on the secondary outcomes. Conclusions: Exercise-based telemedicine interventions do not seem to have added value to usual care. As substitution of usual care, telemedicine might be applicable but due to limited quality of the evidence, further exploration is needed for the rapidly developing field of telemedicine.

[36] Adamse C, Dekker-Van Weering MG, van Etten-Jamaludin FS, Stuiver MM. The effectiveness of exercise-based telemedicine on pain, physical activity and quality of life in the treatment of chronic pain: A systematic review. *J Telemed Telecare*. 2018;248.:511- 526. doi:10.1177/1357633X17716576

Albahri, O.S. et al (2018) [Systematic Review] [Systematic Review of Real-time Remote Health Monitoring System in Triage and Priority-Based Sensor Technology: Taxonomy, Open Challenges, Motivation and Recommendations](37)

The new and ground-breaking real-time remote monitoring in triage and priority-based sensor technology used in telemedicine have significantly bounded and dispersed communication components. To examine these technologies and provide researchers with a clear vision of this area, we must first be aware of the utilised approaches and existing limitations in this line of research. To this end, the ScienceDirect, IEEE Xplore and Web of Science databases were checked for articles on triage and priority-based sensor technology in telemedicine. The retrieved articles were filtered according to the type of telemedicine technology explored. A total of 150 articles were selected and classified into two categories. The first category includes reviews and surveys of triage and priority-based sensor technology in telemedicine. The second category includes articles on the three-tiered architecture of telemedicine. Tier 1 represents the users. Sensors acquire the vital signs of the users and send them to Tier 2, which is the personal gateway that uses local area network protocols or wireless body area network. Medical data are sent from Tier 2 to Tier 3, which is the healthcare provider in medical institutes. Then, the motivation for using triage and priority-based sensor technology in telemedicine, the issues related to the obstruction of its application and the development and utilisation of telemedicine are examined on the basis of the findings presented in the literature.

Baig, Mirza Mansoor et al (2017) [Systematic Review] [A Systematic Review of Wearable Patient Monitoring Systems - Current Challenges and Opportunities for Clinical Adoption](38)

The aim of this review is to investigate barriers and challenges of wearable patient monitoring (WPM) solutions adopted by clinicians in acute, as well as in community, care settings. Currently, healthcare providers are coping with ever-growing healthcare challenges including an ageing population, chronic diseases, the cost of hospitalization, and the risk of medical errors. WPM systems are a potential solution for addressing some of these challenges by

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37 Albahri OS, Albahri AS, Mohammed KI et al Systematic Review of Real-time Remote Health Monitoring System in Triage and Priority-Based Sensor Technology: Taxonomy, Open Challenges, Motivation and Recommendations. *J Med Syst*. 2018;425.:80. Published 2018 Mar 22. doi:10.1007/s10916-018-0943-4

38 Baig MM, GholamHosseini H, Moqeem AA, Mirza F, Lindén M. A Systematic Review of Wearable Patient Monitoring Systems - Current Challenges and Opportunities for Clinical Adoption. *J Med Syst*. 2017;417.:115. doi:10.1007/s10916-017-0760-1

enabling advanced sensors, wearable technology, and secure and effective communication platforms between the clinicians and patients. A total of 791 articles were screened and 20 were selected for this review. The most common publication venue was conference proceedings (13, 54%). This review only considered recent studies published between 2015 and 2017. The identified studies involved chronic conditions (6, 30%), rehabilitation (7, 35%), cardiovascular diseases (4, 20%), falls (2, 10%) and mental health (1, 5%). Most studies focussed on the system aspects of WPM solutions including advanced sensors, wireless data collection, communication platform and clinical usability based on a specific area or disease. The current studies are progressing with localized sensor-software integration to solve a specific use-case/health area using non-scalable and 'silo' solutions. There is further work required regarding interoperability and clinical acceptance challenges. The advancement of wearable technology and possibilities of using machine learning and artificial intelligence in healthcare is a concept that has been investigated by many studies. We believe future patient monitoring and medical treatments will build upon efficient and affordable solutions of wearable technology.

Vegesna, Ashok et al (2017) [Systematic Review] Remote Patient Monitoring via Non-Invasive Digital Technologies: A Systematic Review[39]
Background: We conducted a systematic literature review to identify key trends associated with remote patient monitoring (RPM) via noninvasive digital technologies over the last decade. Materials and methods: A search was conducted in EMBASE and Ovid MEDLINE. Citations were screened for relevance against predefined selection criteria based on the PICOTS (Population, Intervention, Comparator, Outcomes, Timeframe, and Study Design) format. We included studies published between January 1, 2005 and September 15, 2015 that used RPM via noninvasive digital technology (smartphones/personal digital assistants [PDAs], wearables, biosensors, computerized systems, or multiple components of the formerly mentioned) in evaluating health outcomes compared to standard of care or another technology. Studies were quality appraised according to Critical Appraisal Skills Programme. Results: Of 347 articles identified, 62 met the selection criteria. Most studies were randomized control trials with older adult

[39] Vegesna A, Tran M, Angelaccio M, Arcona S. Remote Patient Monitoring via Non-Invasive Digital Technologies: A Systematic Review. *Telemed J E Health*. 2017;231.:3-17. doi:10.1089/tmj.2016.0051
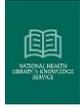
populations, small sample sizes, and limited follow-up. There was a trend toward multicomponent interventions (n = 26), followed by smartphones/PDAs (n = 12), wearables (n = 11), biosensor devices (n = 7), and computerized systems (n = 6). Another key trend was the monitoring of chronic conditions, including respiratory (23%), weight management (17%), metabolic (18%), and cardiovascular diseases (16%). Although substantial diversity in health-related outcomes was noted, studies predominantly reported positive findings. Conclusions: This review will help decision makers develop a better understanding of the current landscape of peer-reviewed literature, demonstrating the utility of noninvasive RPM in various patient populations. Future research is needed to determine the effectiveness of RPM via noninvasive digital technologies in delivering patient healthcare benefits and the feasibility of large-scale implementation.

Conflict of interest statement: Statement AV is a postdoctoral student from Jefferson College of Population Health and a US HEOR Fellow at Novartis Pharmaceuticals Corporation. MT is a postdoctoral student from Scott and White Health Plan, University of Texas at Austin and a US HEOR Fellow at Novartis Pharmaceuticals Corporation. SA and MA are employees of Novartis Pharmaceuticals Corporation. Novartis Pharmaceuticals Corporation provided funding for this work.

Stephani, Victor et al (2016) [Systematic Review] A Systematic Review of Randomized Controlled Trials of mHealth Interventions Against Non-Communicable Diseases in Developing Countries[40]

Background: The reasons of deaths in developing countries are shifting from communicable diseases towards non-communicable diseases (NCDs). At the same time the number of health care interventions using mobile phones is growing rapidly. We review studies assessing the health-related impacts of mHealth on NCDs in low- and middle-income countries. Methods: A systematic literature search of three major databases was performed in order to identify randomized controlled trials of mHealth interventions. Identified studies were reviewed concerning key characteristics of the trial and the intervention; and the relationship between intervention characteristics and outcomes was qualitatively assessed. Results: The search algorithms retrieved 994 titles. 8 RCTs were included in the review, including a total of 4375 participants. Trials took place mostly in urban areas,

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[40] Stephani V, Opoku D, Quentin W. A systematic review of randomized controlled trials of mHealth interventions against non-communicable diseases in developing countries. *BMC Public Health*. 2016;16:572. Published 2016 Jul 15. doi:10.1186/s12889-016-3226-3

tested different interventions ranging from health promotion over appointment reminders and medication adjustments to clinical decision support systems) and included patients with different diseases: diabetes, asthma, hypertension. Except for one study all showed rather positive effects of mHealth interventions on reported outcome measures. Furthermore, our results suggest that particular types of mHealth interventions that were found to have positive effects on patients with communicable diseases and for improving maternal care are likely to be effective also for NCDs. Conclusions: Despite rather positive results of included RCTs, a firm conclusion about the effectiveness of mHealth interventions against NCDs is not yet possible because of the limited number of studies, the heterogeneity of evaluated mHealth interventions and the wide variety of reported outcome measures. More research is needed to better understand the specific effects of different types of mHealth interventions on different types of patients with NCDs in low- and middle-income countries.

Miscellaneous

Bashi, Nazli et al (2020) [Scoping Review] Digital health interventions for chronic diseases: a scoping review of evaluation frameworks[41]
Background: Monitoring and evaluations of digital health (DH) solutions for the management of chronic diseases are quite heterogeneous and evidences around evaluating frameworks are inconsistent. An evidenced-based framework is needed to inform the evaluation process and rationale of such interventions. We aimed to explore the nature, extent and components of existing DH frameworks for chronic diseases. Methods: This review was conducted based on the five steps of Arksey and O'Malley's scoping review methodology. Out of 172 studies identified from, PubMed, Embase and Web of Science, 11 met our inclusion criteria. The reviewed studies developed DH frameworks for chronic diseases and published between 2010 and 2018. Results: According to WHO guidelines for monitoring and evaluation of DH interventions, we identified seven conceptual frameworks, two results frameworks, one logical framework and one theory of change. The

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[41] Bashi N, Fatehi F, Mosadeghi-Nik M, Askari MS, Karunanithi M. Digital health interventions for chronic diseases: a scoping review of evaluation frameworks. *BMJ Health Care Inform*. 2020;271.:e100066. doi:10.1136/bmjhci-2019-100066

frameworks developed for providing interventions such as self-management, achieving personal goals and reducing relapse for cardiovascular disease, diabetes, chronic obstructive pulmonary disease and severe mental health. A few studies reported evaluation of the frameworks using randomised clinical trials (n=3) and feasibility testing via Likert scale survey (n=2). A wide range of outcomes were reported including access to care, cost-effectiveness, behavioural outcomes, patient-provider communications, technology acceptance and user experience. Conclusion: There is a lack of evidence on the application of consistent DH frameworks. Future research should address the use of evidence-based frameworks into the research design, monitoring and evaluation process. This review explores the nature of DH frameworks for the management of chronic diseases and provides examples to guide monitoring and evaluation of interventions.

Bradway, Meghan et al (2020) [Scoping Review] Methods and Measures Used to Evaluate Patient-Operated Mobile Health Interventions: Scoping Literature Review[42]

Background: Despite the prevalence of mobile health (mHealth) technologies and observations of their impacts on patients' health, there is still no consensus on how best to evaluate these tools for patient self-management of chronic conditions. Researchers currently do not have guidelines on which qualitative or quantitative factors to measure or how to gather these reliable data. Objective: This study aimed to document the methods and both qualitative and quantitative measures used to assess mHealth apps and systems intended for use by patients for the self-management of chronic noncommunicable diseases. Methods: A scoping review was performed, and PubMed, MEDLINE, Google Scholar, and ProQuest Research Library were searched for literature published in English between January 1, 2015, and January 18, 2019. Search terms included combinations of the description of the intention of the intervention [eg self-efficacy and self-management] and description of the intervention platform [eg mobile app and sensor]. Article selection was based on whether the intervention described a patient with a chronic noncommunicable disease as the primary user of a tool or system that would always be available for self-management. The extracted data included study design, health conditions, participants, intervention type, methods used, and measured qualitative and quantitative data. Results: A

[42] Bradway M, Gabarron E, Johansen M et al Methods and Measures Used to Evaluate Patient-Operated Mobile Health Interventions: Scoping Literature Review. *JMIR Mhealth Uhealth*. 2020;84.:e16814. Published 2020 Apr 30. doi:10.2196/16814

total of 31 studies met the eligibility criteria. Studies were classified as either those that evaluated mHealth apps (ie single devices; n=15) or mHealth systems (ie more than one tool; n=17), and one study evaluated both apps and systems. App interventions mainly targeted mental health conditions including Post-Traumatic Stress Disorder, followed by diabetes and cardiovascular and heart diseases; among the 17 studies that described mHealth systems, most involved patients diagnosed with cardiovascular and heart disease, followed by diabetes, respiratory disease, mental health conditions, cancer, and multiple illnesses. The most common evaluation method was collection of usage logs (n=21), followed by standardized questionnaires (n=18) and ad-hoc questionnaires (n=13). The most common measure was app interaction (n=19), followed by usability/feasibility (n=17) and patient-reported health data via the app (n=15). Conclusions: This review demonstrates that health intervention studies are taking advantage of the additional resources that mHealth technologies provide. As mHealth technologies become more prevalent, the call for evidence includes the impacts on patients' self-efficacy and engagement, in addition to traditional measures. However, considering the unstructured data forms, diverse use, and various platforms of mHealth, it can be challenging to select the right methods and measures to evaluate mHealth technologies. The inclusion of app usage logs, patient-involved methods, and other approaches to determine the impact of mHealth is an important step forward in health intervention research. We hope that this overview will become a catalogue of the possible ways in which mHealth has been and can be integrated into research practice.

O'Cathail, Micheal et al (2020) [Scoping Review]The Use of Patient-Facing Teleconsultations in the National Health Service: Scoping Review[43]
Background: The National Health Service (NHS) Long-Term Plan has set out a vision of enabling patients to access digital interactions with health care professionals within 5 years, including by video link. Objective: This review aimed to examine the extent and nature of the use of patient-facing teleconsultations within a health care setting in the UK and what outcome measures have been assessed. Methods: We conducted a systematic scoping review of teleconsultation studies following the Joanna Briggs Institute methodology. PubMed, Scopus, the Cochrane Library and the

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[43] O'Cathail M, Sivanandan MA, Diver C, Patel P, Christian J. The Use of Patient-Facing Teleconsultations in the National Health Service: Scoping Review. *JMIR Med Inform.* 2020;83.:e15380. Published 2020 Mar 16. doi:10.2196/15380
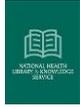
Cumulative Index to Nursing and Allied Health Literature were searched up to the end of December 2018 for publications that reported on the use of patient-facing teleconsultations in a UK health care setting. Results: The search retrieved 3132 publications, of which 101 were included for a full review. Overall, the studies were heterogeneous in design, in the specialty assessed, and reported outcome measures. The technology used for teleconsultations changed over time with earlier studies employing bespoke, often expensive, solutions. Two-thirds of the studies, conducted between 1995 and 2005, used this method. Later studies transitioned to web-based commercial solutions such as Skype. There were five outcome measures that were assessed: 1. technical feasibility; 2. user satisfaction; 3. clinical effectiveness; 4. cost; 5. logistical and operational considerations. Due to the changing nature of technology over time, there were differing technical issues across the studies. Generally, teleconsultations were acceptable to patients, but this was less consistent among health care professionals. However, among both groups, face-to-face consultations were still seen as the gold standard. A wide range of clinical scenarios found teleconsultations to be clinically useful but potentially limited to more straightforward clinical interactions. Due to the wide array of study types and changes in technology over time, it is difficult to draw definitive conclusions on the cost involved. However, cost savings for health care providers have been demonstrated by the goal-directed implementation of teleconsultations. The integration of technology into routine practice represents a complex problem with barriers identified in funding and hospital reimbursement, information technologies infrastructure, and integration into clinicians' workflow.

Conclusions: Teleconsultations appear to be safe and effective in the correct clinical situations. Where offered, it is likely that patients will be keen to engage, although teleconsultations should only be offered as an option to support traditional care models rather than replace them outright. Health care staff should be encouraged and supported in using teleconsultations to diversify their practice. Health care organizations need to consider developing a digital technology strategy and implementation groups to assist health care staff to integrate digitally enabled care into routine practice. The introduction of new technologies should be assessed after a set period with service evaluations, including feedback from key stakeholders.

Seljelid, Berit et al (2020) [Review] Content and system development of a digital patient-provider communication tool to support shared decision making in chronic health care: InvolveMe[44]

Background: Chronic conditions present major health problems, affecting an increasing number of individuals who experience a variety of symptoms that impact their health related quality of life. Digital tools can be of support in chronic conditions, potentially improving patient-provider communication, promoting shared decision making for treatment and care, and possibly even improving patient outcomes. This study aimed to develop a digital tool for patient-provider communication in chronic health care settings and describes the data collection and subsequent content and software development of the InvolveMe tool. InvolveMe will provide patients with the opportunity to report symptoms and preferences to their health care providers (HCP), and to use secure messaging to interact with the HCPs. Method: The study employed a combination of interviews with patients with chronic conditions and focus groups with HCPs, examining experiences with chronic conditions and the potential use of a digital tool for support. Participants were recruited from two outpatient clinics at a university hospital. Data collected from interviews and focus groups were analysed using thematic analysis. Content and software development was informed by the data collection and by tool development workshops. Results: Analyses from interviews with patients (n = 14) and focus groups with HCPs (n = 11) generated three main themes: 1. making symptoms and challenges visible; 2. mastering a new life; and 3. digital opportunities for follow-up. Each main theme generated separate subthemes. Theme 1 and 2 gave input for content development of the symptom and needs assessment part of the tool, while theme 3 provided ideas for the software development of the InvolveMe tool. Tool development workshops with patients (n = 6) and HCPs (n = 6) supplemented the development. Conclusions: A digital tool such as InvolveMe has the potential to support shared decision making for patients with chronic health conditions. Through integration with an existing patient portal such a tool can provide opportunities for meaningful interactions and communication between patients and HCP's, particularly with regards to symptoms, needs and preferences for care.

[44] Seljelid B, Varsi C, Solberg Nes L, Stenehjem AE, Bollerslev J, Børøsund E. Content and system development of a digital patient-provider communication tool to support shared decision making in chronic health care: InvolveMe. *BMC Med Inform Decis Mak*. 2020;201.:46. Published 2020 Mar 4. doi:10.1186/s12911-020-1065-8

Bonacaro, Antonio et al (2019) [Literature Review] The use of wearable devices in preventing hospital readmission and in improving the quality of life of chronic patients in the homecare Setting: A Narrative Literature Review[45]

Introduction: According to the World Health Organisation chronic diseases are the leading cause of mortality in the world, representing 60% of all deaths. Strategies employed to tackle chronic diseases aim to act on risk factors through adopting a healthy lifestyle. These strategies can be greatly implemented from the adoption of wearable devices, which allow a thorough and mini- mally invasive monitoring of patients' clinical data. This article aims to clarify whether wearable devices can help in preventing hospital readmission and improve quality of life in chronic patients. Method: A literature search of electronic databases was performed in January 2017. The following databases were searched: The Cochrane Database of Systematic Reviews, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Pub Med, EMBASE and MEDLINE.

Results: 33 articles met the inclusion criteria and were included in the literature review. Discussion: Various wearable devices are currently available to monitor and keep records of diffe- rent clinical information. Some of them are proved to prevent hospital re-admissions and to treat effectively life-threatening situations in certain categories of chronic patients. Higher level of acceptability and usability are achieved when users are involved in the testing stage prior to the release of the device and/or the features and terms of use are clearly described to patients and carers. Wearable devices are also proved to be more accurate than clinical assessment only in estimating the risk of falls in chronic patients, thus improving safety in the home care setting. Regardless of their features, wearable devices are yet to be used by both healthcare professionals and patients on a large scale.

[45] Bonacaro A, Rubbi I, Sookhoo D. The use of wearable devices in preventing hospital readmission and in improving the quality of life of chronic patients in the homecare Setting: A Narrative Literature Review. L'uso dei dispositivi indossabili nella prevenzione dei ripetuti ricoveri ospedalieri e nel miglioramento della qualità della vita dei pazienti cronici a domicilio. Una revisione narrativa della letteratura. *Prof Inferm.* 2019;722.:143- 151.

Madrigal, Lillian et al (2019) [Cross-Sectional Study] Electronic Health Behaviors Among US Adults With Chronic Disease: Cross-Sectional Survey[46]

Background: With increased access to technology and the Internet, there are many opportunities for utilizing electronic health, Internet, or technology-delivered health services and information for the prevention and management of chronic diseases. Objective: The aim of this paper was to explore 1. the differences in technology use; 2. web-based health information seeking and use behaviors; 3. attitudes toward seeking health information on the Web; and 4. the level of eHealth literacy between adults aged 18 and 64 years with and without chronic disease. Methods: A cross-sectional Internet survey was conducted in March 2017 with 401 US adults. Participant responses were examined to understand associations between chronic disease status and eHealth behaviors such as Internet health-seeking behaviors and web-based behaviors related to health, tracking health indicators with a mobile app, patient portal use, and preferences for health information.

Results: About 1 in 3 (252/401, 37.2%) participants reported at least 1 chronic disease diagnosis. Seventy-five percent (301/401) of all participants reported having ever searched for health information on the Web. Participants with a chronic disease reported significantly higher instances of visiting and talking to a health care provider based on health information found on the Web (40.0% [48/120] vs 25.8% [46/178], χ^2_2=6.7; P=.01; 43.3% [52/120] vs 27.9% [50/179]; χ^2_2=7.6; P=.006). The uses of health information found on the Web also significantly differed between participants with and without chronic diseases in affecting a decision about how to treat an illness or condition (49.2% [59/120] vs 35.0% [63/180], χ^2_3=6.7; P=.04), changing the way they cope with a chronic condition or manage pain (40.8% [49/120] vs 19.4% [35/180], χ^2_2=16.3; P<.001), and leading them to ask a doctor new questions or get a second opinion (37.5% [45/120] vs 19.6% [35/179], χ^2_2=11.8; P<.001). Chronic disease participants were significantly more likely to be tracking health indicators (43.9% [65/148] vs 28.3%, [71/251] χ^2_2=10.4; P=.006). In addition, participants with chronic disease diagnosis reported significantly higher rates of patient portal access (55.0% [82/149] vs 42.1% [106/252], χ^2_2=6.3; P=.01) and use (40.9% [61/149] vs 21.0% [53/252], χ^2_2=18.2; P<.001). Finally, both groups reported similar perceived skills in using the Internet for

[46] Madrigal L, Escoffery C. Electronic Health Behaviors Among US Adults With Chronic Disease: Cross-Sectional Survey. *J Med Internet Res.* 2019;213.:e11240. Published 2019 Mar 5. doi:10.2196/11240

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health information on the eHealth Literacy Scale (eHEALS). The majority of participants responded positively when asked about the usefulness of health information and importance of accessing health resources on the Web. Conclusions: The high rates of reported information seeking and use of Internet-based health technology among participants with chronic disease may reflect the uptake in eHealth to help manage chronic disease conditions. Health care providers and educators should continue to seek ways to interact and support patients in their management of chronic disease through eHealth platforms, including capitalizing on web-based resources, patient portals, and mobile phone apps for disease education and monitoring.

Maramba, Inocencio et al (2019) [Scoping Review] Methods of usability testing in the development of eHealth applications: A scoping review[47]
Background: The number of eHealth applications has exponentially increased in recent years, with over 325,000 health apps now available on all major app stores. This is in addition to other eHealth applications available on other platforms such as PC software, web sites and even gaming consoles. As with other digital applications, usability is one of the key factors in the successful implementation of eHealth apps. Reviews of the literature on empirical methods of usability testing in eHealth were last published in 2015. In the context of an exponentially increasing rate of App development year on year, an updated review is warranted. Objective: To identify, explore, and summarize the current methods used in the usability testing of eHealth applications. Methods: A scoping review was conducted on literature available from April 2014 up to October 2017. Four databases were searched. Literature was considered for inclusion if it was 1. focused on an eHealth application; 2. provided information about usability of the application; 3. provided empirical results of the usability testing; 4. a full or short paper published in English after March 2014. We then extracted data pertaining to the usability evaluation processes described in the selected studies. Results: 133 articles met the inclusion criteria. The methods used for usability testing, in decreasing order of frequency were: questionnaires (n = 105), task completion (n = 57), 'Think-Aloud' (n = 45), interviews (n = 37), heuristic testing (n = 18) and focus groups (n = 13). Majority of the studies used one (n = 45) or two (n = 46) methods of testing. The rest used a combination of three (n = 30) or four (n = 12) methods of testing usability. None of the

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[47] Maramba I, Chatterjee A, Newman C. Methods of usability testing in the development of eHealth applications: A scoping review. *Int J Med Inform*. 2019;126:95-104. doi:10.1016/j.ijmedinf.2019.03.018
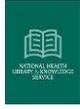
studies used automated mechanisms to test usability. The System Usability Scale (SUS) was the most frequently used questionnaire (n = 44). The ten most frequent health conditions or diseases where eHealth apps were being evaluated for usability were the following: mental health (n = 12), cancer (n = 10), nutrition (n = 10), child health (n = 9), diabetes (n = 9), telemedicine (n = 8), cardiovascular disease (n = 6), HIV (n = 4), health information systems (n = 4) and smoking (n = 4). Further iterations of the app were reported in a minority of the studies (n = 41). The use of the 'Think-Aloud' (Pearson Chi-squared test: $\chi2 = 11.15$, p < 0.05) and heuristic walkthrough (Pearson Chi-squared test: $\chi2 = 4.48$, p < 0.05) were significantly associated with at least one further iteration of the app being developed. Conclusion: Although there has been an exponential increase in the number of eHealth apps, the number of studies that have been published that report the results of usability testing on these apps has not increased at an equivalent rate. The number of digital health applications that publish their usability evaluation results remains only a small fraction. Questionnaires are the most prevalent method of evaluating usability in eHealth applications, which provide an overall measure of usability but do not pinpoint the problems that need to be addressed. Qualitative methods may be more useful in this regard. The use of multiple evaluation methods has increased. Automated methods such as eye tracking have not gained traction in evaluating health apps. Further research is needed into which methods are best suited for the different types of eHealth applications, according to their target users and the health conditions being addressed.

Triantafyllidis, Andreas et al (2019) [Review of Systematic Reviews]
Features, Outcomes, and Challenges in Mobile Health Interventions for Patients Living With Chronic Diseases: A Review of Systematic Reviews[48]
Background: Mobile health technology has the potential to play a key role in improving the health of patients with chronic non-communicable diseases. Objectives: We present a review of systematic reviews of mHealth in chronic disease management, by showing the features and outcomes of mHealth interventions, along with associated challenges in this rapidly growing field. Methods: We searched the bibliographic databases of PubMed, Scopus, and Cochrane to identify systematic reviews of mHealth interventions with advanced technical capabilities such as Internet-linked apps, interoperation

[48] Triantafyllidis A, Kondylakis H, Votis K, Tzovaras D, Maglaveras N, Rahimi K. Features, outcomes, and challenges in mobile health interventions for patients living with chronic diseases: A review of systematic reviews. *Int J Med Inform*. 2019;132:103984. doi:10.1016/j.ijmedinf.2019.103984

with sensors and communication with clinical platforms utilized in randomized clinical trials. The original studies included the reviews were synthesized according to their intervention features, the targeted diseases, the primary outcome, the number of participants and their average age, as well as the total follow-up duration. Results: We identified 5 reviews respecting our inclusion and exclusion criteria, which examined 30 mHealth interventions. The highest percentage of the interventions targeted patients with diabetes (n = 19, 63%), followed by patients with psychotic disorders (n = 7, 23%), lung diseases (n = 3, 10%), and cardiovascular disease (n = 1, 3%). 14 studies showed effective results: 9 in diabetes management, 2 in lung function, and 3 in mental health. Significantly positive outcomes were reported in 8 interventions (n = 8, 47%) from 17 studies assessing glucose concentration, one intervention assessing physical activity, 2 interventions (n = 2, 67%) from 3 studies assessing lung function parameters, and 3 mental health interventions assessing N-back performance, medication adherence, and number of hospitalizations. Divergent features were adopted in 14 interventions with significantly positive outcomes, such as personalized goal setting (n = 10, 71%), motivational feedback (n = 5, 36%), and alerts for health professionals (n = 3, 21%). The most significant found challenges in the development and evaluation of mHealth interventions include the design of studies with high quality, the construction of robust interventions in combination with health professional inputs, and the identification of tools and methods to improve patient adherence. Conclusions: This review found mixed evidence regarding the health benefits of mHealth interventions for patients living with chronic diseases. Further rigorous studies are needed to assess the outcomes of personalized mHealth interventions toward the optimal management of chronic diseases.

Volterrani, Maurizio et al (2019) [Review] Remote Monitoring and Telemedicine[49]

Telemedicine and remote monitoring represent more than the communication of health data via a 'remote connection'. Modern systems can be stand-alone and can be equipped with the ability to acquire and summarize data in order to inform the patient, carer or health care giver. The information can be held locally or be shared with a health care centre. Contemporary telemedicine and telemonitoring solutions have shifted their focus, trying to work on a system which is ubiquitous, efficient and

[49] Volterrani M, Sposato B. Remote monitoring and telemedicine. *Eur Heart J Suppl.* 2019;21(Suppl M):M54–M56. doi:10.1093/eurheartj/suz266

sustainable. Along with devices that collect and elaborate data, a new generation of plug and play sensors has also come to life, which with standardization can lower management costs and make introduction into practice more feasible. Multiple trials (TIM-HF, TEN-HMS and BEAT.HF) have reported varying outcomes, depending on the monitoring system and the background health care process. A special mention is necessary for home tele-rehabilitation programmes for patients with heart failure. Despite the progress obstacles remain, including adequate training, data ownership and handling and applicability to larger populations. This article will review contemporary advances in this area.

Bertoncello, Chiara et al (2018) [Review] How Does It Work? Factors Involved in Telemedicine Home-Interventions Effectiveness: A Review of Reviews[50]

Introduction: Definitive evidence of the effectiveness and cost-effectiveness of telemedicine home-interventions for the management of chronic diseases is still lacking. This study examines whether and how published reviews consider and discuss the influence on outcomes of different factors, including: setting, target, and intensity of intervention; patient engagement; the perspective of patients, caregivers and health professionals; the organizational model; patient education and support. Included reviews were also assessed in terms of economic and ethical issues. Methods: Two search algorithms were developed to scan PubMed for reviews published between 2000 and 2015, about ICT-based interventions for the management of hypertension, diabetes, heart failure, asthma, chronic obstructive pulmonary disease, or for the care of elderly patients. Based on our inclusion criteria, 25 reviews were selected for analysis. Results: None of the included reviews covered all the above-mentioned factors. They mostly considered target (44%) and intervention intensity (24%). Setting, ethical issues, patient engagement, and caregiver perspective were the most neglected factors. Only 4 reviews (16%) considered at least 4 of the 11 factors, the maximum number of factors considered in a review is 5. Conclusions: Factors that may be involved in ICT-based interventions, affecting their effectiveness or cost-effectiveness, are not enough studied in the literature. This research suggests to consider mostly the role of each one, comparing not only disease-related outcomes, but also patients and healthcare organizations

[50] Bertoncello C, Colucci M, Baldovin T, Buja A, Baldo V. How does it work? Factors involved in telemedicine home-interventions effectiveness: A review of reviews. *PLoS One*. 2018;13(11):e0207332. Published 2018 Nov 15. doi:10.1371/journal.pone.0207332

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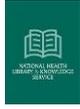
outcomes, and patient engagement, in order to understand how interventions work.

Greenhalgh, Trisha et al (2018) [Mixed-Methods Study] Real-World Implementation of Video Outpatient Consultations at Macro, Meso, and Micro Levels: Mixed-Method Study[51]

Background: There is much interest in virtual consultations using video technology. Randomized controlled trials have shown video consultations to be acceptable, safe, and effective in selected conditions and circumstances. However, this model has rarely been mainstreamed and sustained in real-world settings. Objective: The study sought to 1. define good practice and inform implementation of video outpatient consultations; and 2. generate transferable knowledge about challenges to scaling up and routinizing this service model. Methods: A multilevel, mixed-method study of Skype video consultations (micro level) was embedded in an organizational case study (meso level), taking account of national context and wider influences (macro level). The study followed the introduction of video outpatient consultations in three clinical services ⬚ diabetes, diabetes antenatal, and cancer surgery ⬚ in a National Health Service trust covering three hospitals in London. Data sources included 36 national-level stakeholders [exploratory and semistructured interviews], longitudinal organizational ethnography [300 hours of observations; 24 staff interviews], 30 videotaped remote consultations, 17 audiotaped face-to-face consultations, and national and local documents. Qualitative data, analyzed using sociotechnical change theories, addressed staff and patient experience and organizational and system drivers. Quantitative data, analyzed via descriptive statistics, included uptake of video consultations by staff and patients and microcategorization of different kinds of talk using the Roter interaction analysis system. Results: When clinical, technical, and practical preconditions were met, video consultations appeared safe and were popular with some patients and staff. Compared with face-to-face consultations for similar conditions, video consultations were very slightly shorter, patients did slightly more talking, and both parties sometimes needed to make explicit things that typically remained implicit in a traditional encounter. Video consultations appeared to work better when the clinician and patient already knew and trusted each other. Some clinicians used Skype adaptively to respond to patient requests for ad hoc encounters in a way

that appeared to strengthen supported self-management. The reality of establishing video outpatient services in a busy and financially stretched acute hospital setting proved more complex and time-consuming than originally anticipated. By the end of this study, between 2% and 22% of consultations were being undertaken remotely by participating clinicians. In the remainder, clinicians chose not to participate, or video consultations were considered impractical, technically unachievable, or clinically inadvisable. Technical challenges were typically minor but potentially prohibitive. Conclusions: Video outpatient consultations appear safe, effective, and convenient for patients in situations where participating clinicians judge them clinically appropriate, but such situations are a fraction of the overall clinic workload. As with other technological innovations, some clinicians will adopt readily, whereas others will need incentives and support. There are complex challenges to embedding video consultation services within routine practice in organizations that are hesitant to change, especially in times of austerity.

Orozco-Beltran, Domingo et al (2017) [Quasi-Experimental Study]
Telemedicine in Primary Care for Patients With Chronic Conditions: The ValCrònic Quasi-Experimental Study[52]

Background: The increase of chronic diseases prevalence has created the need to adapt care models and to provide greater home supervision. Objective: The objective of our study was to evaluate the impact of telemonitoring on patients with long-term conditions at high risk for rehospitalization or an emergency department visit, in terms of target disease control: diabetes, hypertension, heart failure, and chronic obstructive pulmonary disease. Methods: We conducted a quasi-experimental study with a before-and-after analysis to assess the effectiveness of the ValCrònic program after 1 year of primary care monitoring. The study included high-risk patients with 1 or more of the following conditions: diabetes, high blood pressure, heart failure, and chronic obstructive pulmonary disease. We assessed risk according to the Community Assessment Risk Screen. Participants used an electronic device to self-report relevant health information, which was then automatically entered into their eHealth record for consultation. Results: The total sample size was 521 patients. Compared with the preintervention year, there were

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significant reductions in weight (82.3 kg before vs 80.1 kg after; P=.001) and in the proportion of people with high systolic (≥140 mmHg; 190, 36.5% vs 170, 32.6%; P=.001) and diastolic (≥90 mmHg; 72, 13.8% vs 40, 7.7%; P=.01) blood pressures, and hemoglobin A1c ≥8% (186, 35.7% vs 104, 20.0%; P=.001). There was also a decrease in the proportion of participants who used emergency services in primary care (68, 13.1% vs 33, 6.3%; P<.001) and in hospital (98, 18.8% vs 67, 12.8%; P<.001). Similarly, fewer participants required hospital admission due to an emergency (105, 20.2% vs 71, 13.6%; P<.001) or disease exacerbation (55, 10.5% vs 42, 8.1%; P<.001). Conclusions: The ValCrònic telemonitoring program in patients at high risk for rehospitalization or an emergency department visit appears to be useful to improve target disease control and to reduce the use of resources.

Matthew-Maich, Nancy et al (2016) [Scoping Review] Designing, Implementing, and Evaluating Mobile Health Technologies for Managing Chronic Conditions in Older Adults: A Scoping Review[53]

Background: The current landscape of a rapidly aging population accompanied by multiple chronic conditions presents numerous challenges to optimally support the complex needs of this group. Mobile health technologies have shown promise in supporting older persons to manage chronic conditions; however, there remains a dearth of evidence-informed guidance to develop such innovations. Objectives: The purpose of this study was to conduct a scoping review of current practices and recommendations for designing, implementing, and evaluating mHealth technologies to support the management of chronic conditions in community-dwelling older adults. Methods: A scoping review methodology was used to map the relevant literature published between January 2005 and March 2015. In addition, hand searches of reference lists and a key journal were completed. Inclusion criteria were research and nonresearch papers focused on mHealth technologies designed for use by community-living older adults with at least one chronic condition, or health care providers or informal caregivers providing care in the home and community setting. Two reviewers independently identified articles for review and extracted data. Results: We identified 42 articles that met the inclusion criteria. Of these, described innovations focused on older adults with specific chronic conditions (n=17), chronic conditions in general (n=6), or older adults in

[53] Matthew-Maich N, Harris L, Ploeg J et al Designing, Implementing, and Evaluating Mobile Health Technologies for Managing Chronic Conditions in Older Adults: A Scoping Review. *JMIR Mhealth Uhealth*. 2016;42.:e29. Published 2016 Jun 9. doi:10.2196/mhealth.5127
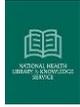
general or those receiving homecare services (n=18). Most of the mHealth solutions described were designed for use by both patients and health care providers or health care providers only. Thematic categories identified included the following: 1. practices and considerations when designing mHealth technologies; 2. factors that support/hinder feasibility, acceptability, and usability of mHealth technologies; and 3. approaches or methods for evaluating mHealth technologies.

Conclusions: There is limited yet increasing use of mHealth technologies in home health care for older adults. A user-centered, collaborative, interdisciplinary approach to enhance feasibility, acceptability, and usability of mHealth innovations is imperative. Creating teams with the required pools of expertise and insight regarding needs is critical. The cyclical, iterative process of developing mHealth innovations needs to be viewed as a whole with supportive theoretical frameworks. Many barriers to implementation and sustainability have limited the number of successful, evidence-based mHealth solutions beyond the pilot or feasibility stage. The science of implementation of mHealth technologies in home-based care for older adults and self-management of chronic conditions are important areas for further research. Additionally, changing needs as cohorts and technologies advance are important considerations. Lessons learned from the data and important implications for practice, policy, and research are discussed to inform the future development of innovations.

Rojahn, Katherine et al (2016) Remote Monitoring of Chronic Diseases: A Landscape Assessment of Policies in Four European Countries[54]
Background: Remote monitoring (RM) is defined as the surveillance of device-transmitted outpatient data. RM is expected to enable better management of chronic diseases. The objective of this research was to identify public policies concerning RM in four European countries. Methods: Searches of the medical literature, the Internet, and Ministry of Health websites for the UK, Germany, Italy, and Spain were performed in order to identify RM policies for chronic diseases, including end stage renal disease (ESRD), chronic pulmonary obstructive disease (COPD), diabetes, heart failure, and hypertension. Searches were first performed in Q1 2014 and updated in Q4 2015. In addition, in depth interviews were conducted with payers/policymakers in each country. Information was obtained on existing policies, disease areas and RM services covered and level of reimbursement,

[54] Rojahn K, Laplante S, Sloand J et al Remote Monitoring of Chronic Diseases: A Landscape Assessment of Policies in Four European Countries. *PLoS One*. 2016;115.:e0155738. Published 2016 May 19. doi:10.1371/journal.pone.0155738

other incentives such as quality indicators, past/current assessments of RM technologies, diseases perceived to benefit most from RM, and concerns about RM. Results: Policies on RM and/or telemedicine were identified in all four countries. Pilot projects (mostly in diabetes, COPD, and/or heart failure) existed or were planned in most countries. Perceived value of RM was moderate to high, with the highest rating given for heart failure. Interviewees expressed concerns about sharing of medical information, and the need for capital investment. Patients recently discharged from hospital, and patients living remotely, or with serious and/or complicated diseases, were believed to be the most likely to benefit from RM. Formal reimbursement is scarce, but more commonly available for patients with heart failure. Conclusions: In the four European countries surveyed, RM has attracted considerable interest for its potential to increase the efficiency of healthcare for chronic diseases. Although rare at this moment, incentives to use RM technology are likely to increase in the near future as the body of evidence of clinical and/or economic benefit grows. Conflict of interest statement: Competing Interests: The company selected by Baxter to conduct the study was Double Helix. Baxter Healthcare provided honoraria to TA and KIJ, as employees of Double Helix. TA and KIJ were involved in study conduct, data collection, analysis, and reporting as articulated in the 'author contributions' section. Baxter Healthcare has no ownership or legal relationship with Double Helix other than the contract for this study. The respective commercial affiliations of the authors does not alter the authors' adherence to PLOS ONE policies on sharing data and materials, with the exception of the primary research data as described in Data Availability section.
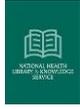
Wildevuur, Sabine E. et al (2015) [Scoping Review] Information and communication technology-enabled person-centered care for the "big five" chronic conditions: scoping review[55]

Background: Person-centered information and communication technology (ICT) could encourage patients to take an active part in their health care and decision-making process, and make it possible for patients to interact directly with health care providers and services about their personal health concerns. Yet, little is known about which ICT interventions dedicated to person-centered care (PCC) and connected-care interactions have been studied, especially for shared care management of chronic diseases. The aim of this research is to investigate the extent, range, and nature of these research activities and identify research gaps in the evidence base of health studies regarding the "big 5" chronic diseases: diabetes mellitus, cardiovascular disease, chronic respiratory disease, cancer, and stroke. Objective: The objective of this paper was to review the literature and to scope the field with respect to 2 questions: 1. which ICT interventions have been used to support patients and health care professionals in PCC management of the big 5 chronic diseases? ; and 2. what is the impact of these interventions, such as on health-related quality of life and cost efficiency? Methods: This research adopted a scoping review method. Three electronic medical databases were accessed: PubMed, EMBASE, and Cochrane Library. The research reviewed studies published between January 1989 and December 2013. In 5 stages of systematic scanning and reviewing, relevant studies were identified, selected, and charted. Then we collated, summarized, and reported the results. Results: From the initial 9380 search results, we identified 350 studies that qualified for inclusion: diabetes mellitus (n=103), cardiovascular disease (n=89), chronic respiratory disease (n=73), cancer (n=67), and stroke (n=18). Persons with one of these chronic conditions used ICT primarily for self-measurement of the body, when interacting with health care providers, with the highest rates of use seen in chronic respiratory (63%, 46/73) and cardiovascular (53%, 47/89) diseases. We found 60 relevant studies (17.1%, 60/350) on person-centered shared management ICT, primarily using telemedicine systems as personalized ICT. The highest impact measured related to the increase in empowerment (15.4%, 54/350). Health-related quality of life accounted for 8%. The highest impact connected to health professionals was an increase in clinical

[55] Wildevuur SE, Simonse LW. Information and communication technology-enabled person-centered care for the "big five" chronic conditions: scoping review. *J Med Internet Res*. 2015;173.:e77. Published 2015 Mar 27. doi:10.2196/jmir.3687

outcome (11.7%, 41/350). The impacts on organization outcomes were decrease in hospitalization (12.3%, 43/350) and increase of cost efficiency (10.9%, 38/350). Conclusions: This scoping review outlined ICT-enabled PCC in chronic disease management. Persons with a chronic disease could benefit from an ICT-enabled PCC approach, but ICT-PCC also yields organizational paybacks. It could lead to an increase in health care usage, as reported in some studies. Few interventions could be regarded as "fully" addressing PCC. This review will be especially helpful to those deciding on areas where further development of research or implementation of ICT-enabled PCC may be warranted.

CHAPTER 22
Videoconferencing and Video Consultations / COVID-19

Systematic Reviews

Christensen, LF et al (2019) [Systematic Review] [Patients' and Providers' Experiences With Video Consultations Used in the Treatment of Older Patients With Unipolar Depression: A Systematic Review](1)
This paper provides knowledge regarding the use of video consultations, especially for older people with depression. The results show that video consultations support mental health practice, especially as a useful alternative when face-to-face therapy is not possible. Any initial scepticism quickly disappeared when video consultations were experienced in action. The challenges seem to consist of technical problems and lack of support from staff. The experiences and satisfaction of older people with depression seem to be positive, although methodological limitations and deficiencies of the reviewed articles should be considered. More qualitative research is needed, and future studies should focus on specific diagnoses and providers' experiences.

Orlando, JF et al (2019) [Systematic Review] [Systematic review of patient and caregivers satisfaction with telehealth videoconferencing as a mode of service delivery in managing patients' health](2)
Telehealth is an alternative method of delivering health care to people required to travel long distances for routine health care. The aim of this systematic review was to examine whether patients and their caregivers living in rural and remote areas are satisfied with telehealth

1 Christensen LF, Moller AM, Hansen JP, Nielsen CT, Gildberg FA. Patients' and providers' experiences with video consultations used in the treatment of older patients with unipolar depression: A systematic review [published online ahead of print, 2019 Nov 2]. *J Psychiatr Ment Health Nurs*. 2019;10.1111/jpm.12574. doi:10.1111/jpm.12574 [Accessed 28 April 2020]
2 Orlando JF, Beard M, Kumar S. Systematic review of patient and caregivers' satisfaction with telehealth videoconferencing as a mode of service delivery in managing patients' health. *PLoS One*. 2019;14(8):e0221848. Published 2019 Aug 30. doi:10.1371/journal.pone.0221848 [Accessed 27 April 2020]

videoconferencing as a mode of service delivery in managing their health. The authors conclude that here were high levels of satisfaction across all these dimensions. Despite these positive findings, the current evidence base lacks clarity in terms of how satisfaction is defined and measured. People living in rural and remote areas are generally satisfied with telehealth as a mode of service delivery as it may improve access to health care and avoid the inconvenience of travel.

Rush, KL et al (2018) [Systematic Review] Videoconference Compared to Telephone in Healthcare Delivery: A Systematic Review[3]
Telehealth is an important tool for ensuring accessible healthcare access particularly over geographical distances. Videoconference and telephone are two common telehealth modalities, yet little is known as to the relative advantage of these modalities. This review compares the effectiveness of videoconference versus telephone in the delivery of healthcare. The authors conclude that videoconference appears to offer advantages over telephone particularly improved provider diagnostic accuracy and reduced readmission rates. Evidence showed little differences between the two modalities in terms of patient outcomes. However, the small heterogeneous sample prevents generalizability of the findings. More research is needed in this area to determine the circumstances under which videoconference is superior to telephone as a telehealth modality.

Miscellaneous

Chike-Harris, KE et al (2020) [Literature Review] Integration of Telehealth Education Into the Health Care Provider Curriculum: A Review[4]
A literature review of how telehealth care is integrated into various health care curricula. The authors conclude that a standardized telehealth curriculum needs to be developed, and national competencies need to be created, which will guide the development of standardized curriculum across health care training programs.

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[3] Rush KL, Howlett L, Munro A, Burton L. Videoconference compared to telephone in healthcare delivery: A systematic review. *Int J Med Inform*. 2018;118:44–53. doi:10.1016/j.ijmedinf.2018.07.007 [Accessed 27 April 2020]
[4] Chike-Harris KE, Durham C, Logan A, Smith G, DuBose-Morris R. Integration of Telehealth Education into the Health Care Provider Curriculum: A Review [published online ahead of print, 2020 Apr 3]. *Telemed J E Health*. 2020;10.1089/tmj.2019.0261. doi:10.1089/tmj.2019.0261 [Accessed 27 April 2020]

Gordon, HS (2020) [Observational Study] "I'm Not Feeling I'm Part of the Conversation" Patients' Perspectives on Communicating in Clinical Video Telehealth Visits[5]

Clinical video telehealth (CVT) offers the opportunity to improve access to healthcare providers in medically underserved areas. However, because CVT encounters are mediated through technology, they may result in unintended consequences related to the patient-provider interaction. This study identified several themes related to patients' perspectives on CVT. In general, patients expressed satisfaction with CVT visits including better access to appointments, shorter travel time, and less time in the waiting room. Yet, patients also identified several challenges and concerns about CVT visits compared with in-person visits, including concerns about errors in their care because of perceived difficulty completing the physical exam, perceptions that providers paid less attention to them, barriers to speaking up and asking questions, and difficulty establishing a provider-patient relationship. Patients reported feeling less involved during the visit, difficulty finding opportunities to speak, and feeling rushed by the provider.

Greenhalgh, T et al (2020) COVID-19: A Remote Assessment in Primary Care[6]

Most patients with COVID-19 can be managed remotely with advice on symptomatic management and self-isolation. Although such consultations can be done by telephone in many cases, video provides additional visual cues and therapeutic presence. Breathlessness is a concerning symptom, though there is currently no validated tool for assessing it remotely. Safety-netting advice is crucial because some patients deteriorate in week 2, most commonly with pneumonia.

Greenhalgh, T et al (2020) [Editorial] Video Consultations for COVID-19[7]

The rapid spread of COVID-19, and the fact that healthcare facilities could be sources of contagion, has focused attention on new models of care that

[5] Gordon HS, Solanki P, Bokhour BG, Gopal RK. "I'm Not Feeling I'm Part of the Conversation" Patients' Perspectives on Communicating in Clinical Video Telehealth Visits [published online ahead of print, 2020 Feb 3]. *J Gen Intern Med*.

[6] Greenhalgh T, Koh GCH, Car J. Covid-19: a remote assessment in primary care. *BMJ*. 2020;368:m1182. Published 2020 Mar 25. doi:10.1136/bmj.m1182 [Accessed 28 April 2020]

[7] Greenhalgh T, Wherton J, Shaw S, Morrison C. Video consultations for covid-19. *BMJ*. 2020;368:m998. Published 2020 Mar 12. doi:10.1136/bmj.m998 [Accessed 28 April 2020]

avoid face-to-face contact between clinician and patient. There has been particular interest in video consultations, which are already being rolled out in many countries as part of national digital health strategies. This editorial discusses the appropriateness of video consultations for dealing with the coronavirus crisis, and the challenges involved in scaling up this model at speed.

Shaw et al (2020) [Ethnographic Study] [Video consultations between patients and clinicians in diabetes, cancer, and heart failure services: linguistic ethnographic study of video-mediated interaction](#)[8]
Using conversation analysis, this study aimed to identify and analyse the communication strategies through which video-mediated consultations are accomplished and to produce recommendations for patients and clinicians to improve the communicative quality of such consultations. We conducted an in-depth analysis of the clinician-patient interaction in a sample of video-mediated consultations and a comparison sample of face-to-face consultations drawn from 4 clinical settings across 2 trusts (1 community and 1 acute care) in the UK National Health Service. The video dataset consisted of 37 recordings of video-mediated consultations (with diabetes, antenatal diabetes, cancer, and heart failure patients), 28 matched audio recordings of face-to-face consultations, and field notes from before and after each consultation. We also conducted 37 interviews with staff and 26 interviews with patients. Using linguistic ethnography (combining analysis of communication with an appreciation of the context in which it takes place), we examined in detail how video interaction was mediated by 2 software platforms (Skype and FaceTime). Patients had been selected by their clinician as appropriate for video-mediated consultation. Most consultations in our sample were technically and clinically unproblematic. However, we identified 3 interactional challenges: (1) opening the video consultation, (2) dealing with disruption to conversational flow (e.g., technical issues with audio and/or video), and (3) conducting an examination. Operational and technological issues were the exception rather than the norm. In all but 1 case, both clinicians and patients (deliberately or intuitively) used established communication strategies to successfully negotiate these challenges. Remote physical examinations required the patient (and, in some

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8 Shaw SE, Seuren LM, Wherton J, et al. Video Consultations Between Patients and Clinicians in Diabetes, Cancer, and Heart Failure Services: Linguistic Ethnographic Study of Video-Mediated Interaction. *J Med Internet Res.* 2020;22(5):e18378. Published 2020 May 11. doi:10.2196/18378

cases, a relative) to simultaneously follow instructions and manipulate technology (e.g., camera) to make it possible for the clinician to see and hear adequately. A remote video link alters how patients and clinicians interact and may adversely affect the flow of conversation. However, our data suggest that when such problems occur, clinicians and patients can work collaboratively to find ways to overcome them. There is potential for a limited physical examination to be undertaken remotely with some patients and in some conditions, but this appears to need complex interactional work by the patient and/or their relatives. We offer preliminary guidance for patients and clinicians on what is and is not feasible when consulting via a video link.

Colucci, M (2019) A Matter of Communication: A New Classification to Compare and Evaluate Telehealth and Telemedicine Interventions and Understand Their Effectiveness as a Communication Process[9]
This article attempts to define functions and applications of telemedicine and telehealth in order to achieve a simplified and comprehensive taxonomy. This may be used as a tool to evaluate their efficacy and to address health policies from the perspective of the centrality of information in the healthcare. Starting from a lexical frame, telemedicine or telehealth is conceived as a communication means and their action as a communication process. As a performance, the communication is related to the health outcome. Three functions (telemetry, telephasis, and telepraxis) and nine applications are identified. Understanding the mechanisms of telemedicine and telehealth effectiveness is crucial for a value-driven healthcare system. This new classification-focusing on the end effect of telemedicine and telehealth and on the type of interactions between involved actors-moves toward a new and simplified methodology to compare different studies and practices, design future researches, classify new technologies and guide their development, and finally address health policies and the healthcare provision.

[9] Colucci M, Baldo V, Baldovin T, Bertoncello C. A "matter of communication": A new classification to compare and evaluate telehealth and telemedicine interventions and understand their effectiveness as a communication process. *Health Informatics J.* 2019;252.:446–460. doi:10.1177/1460458217747109 [Accessed 27 April 2020]

Donaghy, E et al (2019) [Qualitative Study] Acceptability, Benefits, and Challenges of Video Consulting: A Qualiative Study in Primary Care[10]

People increasingly communicate online, using visual communication mediums such as Skype and FaceTime. Growing demands on primary care services mean that new ways of providing patient care are being considered. Video consultation (VC) over the Internet is one such mode. The aim of this paper is to explore patients' and clinicians' experiences of VC. The findings were that the visual component of VCs offers distinct advantages over telephone consultations. When integrated with current systems VCs can provide a time-saving alternative to face-to-face consultations when formal physical examination is not required, especially for people who work. Demand for VC services in primary care is likely to rise, but improved technical infrastructure is required to allow VC to become routine. However, for complex or sensitive problems face-to-face consultations remain preferable.

Grondin, F et al (2019) [Conceptual Framework] Empathy in computer-mediated interactions: A conceptual framework for research and clinical practice[11]

Empathy plays a crucial role in fostering positive social interactions and is elicited through verbal and nonverbal socioemotional cues. Computer-mediated communication (CMC) rapidly connects individuals at a distance but can partly filter out nonverbal cues. We draw from available telehealth and emotion communication literature to elaborate a cohesive conceptual framework of online empathy, a tool the field is currently lacking. The distinctive features of online communication and their impacts on the empathic interaction are described. We also detail strategies that users can employ to facilitate feeling, conveying, and being perceived as empathic in CMC.

[10] Donaghy E, Atherton H, Hammersley V et al Acceptability, benefits, and challenges of video consulting: a qualitative study in primary care. *Br J Gen Pract.* 2019;69(686):e586–e594. Published 2019 Aug 29. doi:10.3399/bjgp19X704141 [Accessed 28 April 2020]

[11] Grondin, F., Lomanowska, A., Jackson, P. Empathy in computer-mediated interactions: a conceptual framework for research and clinical Practice. *Clin Psychol Sci Pract* 2019 264. e12298. Doi.org/10.1111/cpsp.1298

Hammersley, V et al (2019) [Quasi-Experimental Study] Comparing the Content and Quality of Video, Telephone, and Face-To-Face Consultations: A Non-Randomised, Quasi-Experimental, Exploratory Study in UK Primary Care[12]

Growing demands on primary care services have led to policymakers promoting video consultations (VCs) to replace routine face-to-face consultations (FTFCs) in general practice. This study concludes that VC may be suitable for simple problems not requiring physical examination. VC, in terms of consultation length, content, and quality, appeared similar to TC. Both approaches appeared less 'information rich' than FTFC. Technical problems were common and, though patients really appreciated VC, infrastructure issues would need to be addressed before the technology and approach can be mainstreamed in primary care.

Ignatowicz, A et al (2019) [Review] Internet Videoconferencing for Patient-Clinician Consultations in Long-Term Conditions: A Review of Reviews and Applications in Line With Guidelines and Recommendations[13]

The authors conducted a review of the existing reviews of literature relating to the use of Internet videoconferencing for consultations between healthcare professionals and patients with long-term conditions in their own home. The review was followed with an assessment of UK National Institute for Health and Clinical Excellence guidelines for patient care in the context of common long-term illnesses to examine where videoconferencing could be implemented in line with these recommendations.

The review of reviews found no formal evidence in favour of or against the use of Internet videoconferencing. Patients were satisfied with the use of videoconferencing but there was limited evidence that it led to a change in health outcomes. Evidence of healthcare professional satisfaction when using this mode of communication with patients was limited. The review of guidelines suggested a number of opportunities for adoption and expansion of Internet videoconferencing. Implementing videoconferencing in line with current evidence for patient care could offer support and provide

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[12] Hammersley V, Donaghy E, Parker R et al Comparing the content and quality of video, telephone, and face-to-face consultations: a non-randomised, quasi-experimental, exploratory study in UK primary care. *Br J Gen Pract*. 2019;69(686):e595–e604. Published 2019 Aug 29. doi:10.3399/bjgp19X704573 [Accessed 27 April 2020]

[13] Ignatowicz A, Atherton H, Bernstein CJ et al Internet videoconferencing for patient-clinician consultations in long-term conditions: A review of reviews and applications in line with guidelines and recommendations. *Digit Health*. 2019;5:2055207619845831. Published 2019 Apr 23. doi:10.1177/2055207619845831 [Accessed 28 April 2020]

information on using a communication channel that suits individual patient needs and circumstances. The evidence base for videoconferencing is growing, but there is still a lack of data relating to cost, ethics and safety. While the current evidence base for Internet videoconferencing is equivocal, it is likely to change as more research is undertaken and evidence published. With more videoconferencing services added in more contexts, research needs to explore how Internet videoconferencing can be implemented in ways that it is valued by patients and clinicians, and how it can fit within organisational and technical infrastructure of the healthcare services.

Pappas, Y et al (2019) Diagnosis and Decision-Making in Telemedicine[14]
This article provides an analysis of the skills that health professionals and patients employ in reaching diagnosis and decision-making in telemedicine consultations. The authors hope the findings of this study can be used to inform training programs in telemedicine that focus on the development of effective skills for professionals and the provision of information to patients.

Sartori, D. et al (2019) Preparing Trainees for Telemedicine: A Virtual OSCE Pilot[15]
Provision of health care remotely, has become an essential means of delivering timely, cost-effective and efficacious care. The virtues of telemedicine are many; these include enhancing patient-centred home visits, providing just-in-time consultation, coordinating multidisciplinary care, and more. There has been recent recognition that formal telemedicine curricula and competency assessment will be necessary components of graduate medical education in the near future. Despite this, there exists a significant unmet need to prepare the next generation of trainees to develop the unique skills necessary for the practice of telemedicine.

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[14] Pappas Y, Vseteckova J, Mastellos N, Greenfield G, Randhawa G. Diagnosis and Decision-Making in Telemedicine. *J Patient Exp.* 2019;64.:296–304. doi:10.1177/2374373518803617 [Accessed 27 April 2020]
[15] Sartori DJ, Olsen S, Weinshel E, Zabar SR. Preparing trainees for telemedicine: a virtual OSCE pilot. *Med Educ.* 2019;535.:517–518. doi:10.1111/medu.13851 [Accessed 27 April 2020]

Seuren, LM et al (2019) [Qualitative Study] Physical Examinations via Video for Patients With Heart Failure: Qualitative Study Using Conversation Analysis[16]

This study explores the opportunities and challenges of remote physical examination of patients with heart failure using video-mediated communication technology. It concludes that video examinations are possible in the context of heart failure services; however, they are limited, time consuming, and challenging for all involved; guidance and training are needed to support rollout of this new service model, along with research to understand if the challenges identified are relevant to different patients and conditions and how they can be successfully negotiated.

Stommel, W et al (2019) [Conversation Analysis] Other-attentiveness in video consultation openings: a conversation analysis of video-mediated versus faces-to-face consultations[17]

For patients recovering from surgery, a video consultation is a suitable alternative to conventional consultations. Video consultations have been found to be beneficial, but little is known about their organization, compared to face-to-face consultations. In this article, we explore potential extra interactional work conducted by participants in video-mediated consultations. We focus on the beginning of the consultation. Our data consist of 39 recorded, postoperative, oncological consultations, both face-to-face and through video-mediated communication (VMC), which we analyzed using conversation analysis. Although surgeons commonly launched the beginning with an announcement of the pathology report as the reason for the consultation, we found that in VMC, "how are you?" was regularly inserted after the testing of the technology. The question is a suitable strategy, as it displays overt other-attentivemess, while also being medically relevant. However, subsequently, surgeons may unilaterally close the elicited self-report to then address the pathology report. Thus, the extra interactional work of other-attentiveness is again attenuated.

[16] Seuren LM, Wherton J, Greenhalgh T, Cameron D, A'Court C, Shaw SE. Physical Examinations via Video for Patients With Heart Failure: Qualitative Study Using Conversation Analysis. *J Med Internet Res*. 2020;222.:e16694. Published 2020 Feb 20. doi:10.2196/16694 [Accessed 27 April 2020]

[17] Stommel, W., van Goor, H., Stommel, H. (2019) Other-attentiveness in video consultation openings: a conversation analysis of video-mediated versus face-to-face consultations. *J Comp Mediated Communication* 2019 246. 275-292.

Atherton, H et al (2018) [Case Study] The Potential of Alternatives to Face-To-Face Consultation in General Practice, and the Impact on Different Patient Groups: A Mixed-Methods Case Study[18]

There is international interest in the potential role of different forms of communication technology to provide an alternative to face-to-face consultations in health care. There has been considerable rhetoric about the need for general practices to offer consultations by telephone, e-mail or Internet video. However, little is understood about how, under what conditions, for which patients and in what ways these approaches may offer benefits to patients and practitioners in general practice.

The authors objectives in this mixed methods case study were to review existing evidence about alternatives to face-to-face consultation; conduct a scoping exercise to identify the ways in which general practices currently provide these alternatives; recruit eight general practices as case studies for focused ethnographic research, exploring how practice context, patient characteristics, type of technology and the purpose of the consultation interact to determine the impact of these alternatives; and synthesise the findings in order to develop a website resource about the implementation of alternatives to face-to-face consultations and a framework for subsequent evaluation.

The authors conclude that current low uptake of alternatives, lack of clarity about purpose and limited evidence of benefit may be at odds with current policy, which encourages the use of alternatives. We have highlighted key issues for practices and policy-makers to consider and have made recommendations about priorities for further research to be conducted, before or alongside the future roll-out of alternatives to the face-to-face consultation, such as telephone consulting, e-consultation, e-mail and video consulting.

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[18] Atherton H, Brant H, Ziebland S et al *The potential of alternatives to face-to-face consultation in general practice, and the impact on different patient groups: a mixed-methods case study.* Southampton (UK): NIHR Journals Library; 2018. [Accessed 28 April 2020]

Greenhalgh, T et al (2018) [Mixed-Methods Study] Real-World Implementation of Video Outpatient Consultations at Macro, Meso, and Micro Levels: Mixed-Method Study[19]

The study sought to 1. define good practice and inform implementation of video outpatient consultations; and 2. generate transferable knowledge about challenges to scaling up and routinizing this service model.

When clinical, technical, and practical preconditions were met, video consultations appeared safe and were popular with some patients and staff. Compared with face-to-face consultations for similar conditions, video consultations were very slightly shorter, patients did slightly more talking, and both parties sometimes needed to make explicit things that typically remained implicit in a traditional encounter. Video consultations appeared to work better when the clinician and patient already knew and trusted each other. Some clinicians used Skype adaptively to respond to patient requests for ad hoc encounters in a way that appeared to strengthen supported self-management. The reality of establishing video outpatient services in a busy and financially stretched acute hospital setting proved more complex and time-consuming than originally anticipated. By the end of this study, between 2% and 22% of consultations were being undertaken remotely by participating clinicians. In the remainder, clinicians chose not to participate, or video consultations were considered impractical, technically unachievable, or clinically inadvisable. Technical challenges were typically minor but potentially prohibitive.

Video outpatient consultations appear safe, effective, and convenient for patients in situations where participating clinicians judge them clinically appropriate, but such situations are a fraction of the overall clinic workload. As with other technological innovations, some clinicians will adopt readily, whereas others will need incentives and support. There are complex challenges to embedding video consultation services within routine practice in organizations that are hesitant to change, especially in times of austerity.

[19] Greenhalgh T, Shaw S, Wherton J et al Real-World Implementation of Video Outpatient Consultations at Macro, Meso, and Micro Levels: Mixed-Method Study. *J Med Internet Res*. 2018;204.:e150. Published 2018 Apr 17. doi:10.2196/jmir.9897 [Accessed 28 April 2020]

Morony, S et al (2018) [Enhancing Communication Skills for Telehealth: Development and Implementation of a Teach-Back Intervention for a National Maternal and Child Health Helpline in Australia](#)[20]
Telehealth professionals require advanced communication skills, in part to compensate for lack of visual cues. Teach-Back is a best practice communication technique that has been recommended but not previously evaluated for consumer telehealth. The authors implemented Teach-Back at a national maternal and child health telephone helpline. They describe the intervention and report telenurse experiences learning to use Teach-Back.

Shaw, S et al (2018) [Mixed-Methods Study] [Advantages and limitations of virtual online consultations in an NHS acute trust: the VOCAL mixed-methods study](#)[21]
The objectives of this study were to define good practice and inform digital technology implementation in relation to remote consultations. The Authors conclude that virtual consultations appear to be safe, effective and convenient for patients who are preselected by their clinicians as 'suitable', but such patients represent a small fraction of clinic workloads. There are complex challenges to embedding virtual consultation services within routine practice in the NHS. Roll-out across the organisation and scale-up to other organisations are likely to require considerable support.

Shaw, S et al (2018) [Qualitative Analysis] [Qualitative analysis of remote consultations (QuARC): a study of technology-enhanced consultations in diabetes, cancer and heart failure](#)[22]
This study identifies and analyses the communication strategies through which remote consultations are accomplished and produces guidance for patients and clinicians to improve the communicative quality of remote consultations. The authors hope the study findings will address the current gap in knowledge about how technology shapes the fine detail of communication in remote consultations. Alongside academic outputs,

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[20] Morony S, Weir K, Duncan G, Biggs J, Nutbeam D, Mccaffery KJ. Enhancing communication skills for telehealth: development and implementation of a Teach-Back intervention for a national maternal and child health helpline in Australia. *BMC Health Serv Res*. 2018;181.:162. Published 2018 Mar 7. doi:10.1186/s12913-018-2956-6 [Accessed 27 April 2020]

[21] Shaw S, Wherton J, Vijayaraghavan S, et al. *Advantages and limitations of virtual online consultations in a NHS acute trust: the VOCAL mixed-methods study*. Southampton (UK): NIHR Journals Library; 2018.

[22] Shaw S et al (2018) Qualitative analysis of remote consultations (QuARC): a study of technology-enhanced consultation in diabetes, cancer and heart failure.
https://www.researchgate.net/publication/324896133_Qualitative_Analysis_of_Remote_Consultations_QuARC_A_study_of_technology-enhanced_consultations_in_diabetes_cancer_and_heart_failure [Accessed 27 April 2020]

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findings will inform the coproduction of information and guidance about communication strategies to support successful remote consultations.

Edirippulige, S, Armfield, NR, (2017) [Literature Review] Education and Training to Support the Use of Clinical Telehealth: A Review of the Literature[23]

Despite a growing literature base, substantial investment, and policy changes within governments, the integration of telehealth into routine clinical care has been limited. The availability of appropriate systematic education and training for practitioners has been highlighted as necessary for strong adoption. However, the availability and nature of telehealth-related education and training for practitioners is not understood. The authors carried out a review of the literature and conclude that published evidence in peer-reviewed literature on telehealth education and training is limited.

Tates, K et al (2017) [Experimental Study] The Effect of Screen-to-Screen Versus Face-to-Face Consultation on Doctor-Patient Communication: An Experimental Study With Simulated Patients[24]

This study aimed to examine 1. the impact of a consultation medium on doctors' and patients' communicative behavior in terms of information exchange, interpersonal relationship building, and shared decision making; and 2. the mediating role of doctors' and patients' communicative behavior on satisfaction with both types of consultation medium. In this study, the quality of doctor-patient communication, as indicated by information exchange, interpersonal relationship building, and shared decision making, did not differ significantly between web-based and face-to-face consultations. Doctors and simulated patients were equally satisfied with both types of consultation medium, and no differences were found in the manner in which participants perceived communicative behavior during these consultations. The findings suggest that worries about a negative impact of web-based video consultation on the quality of patient-provider consultations seem unwarranted as they offer the same interaction quality and satisfaction level as regular face-to-face consultations.

[23] Edirippulige S, Armfield NR. Education and training to support the use of clinical telehealth: A review of the literature. *J Telemed Telecare*. 2017;232.:273–282. doi:10.1177/1357633X16632968 [Accessed 27 April 2020]

[24] Tates K, Antheunis ML, Kanters S, Nieboer TE, Gerritse MB. The Effect of Screen-to-Screen Versus Face-to-Face Consultation on Doctor-Patient Communication: An Experimental Study with Simulated Patients. *J Med Internet Res*. 2017;19(12):e421. Published 2017 Dec 20. doi:10.2196/jmir.8033 [Accessed 27 April 2020]

Armfield, N et al (2015) [Literature Review] The Clinical Use of Skype--For Which Patients, With Which Problems and in Which Settings? A Snapshot Review of the Literature[25]

Low-cost and no-cost software-based video tools may be a feasible and effective way to provide some telemedicine services, particularly in low-resource settings. One of the most popular tools is Skype; it is freely available, may be installed on many types of devices, and is easy to use by clinicians and patients. While a previous review found no evidence in favour of, or against the clinical use of Skype, anecdotally it is believed to be widely used in healthcare for providing clinical services. However, the range of clinical applications in which Skype has been used has not been described. The authors carried out a literature review in order to identify and summarize the clinical applications of Skype. They found 239 unique articles. Twenty seven of the articles met the criteria for further review. The use of Skype was most prevalent in the management of chronic diseases such as cardiovascular diseases and diabetes, followed by educational and speech and language pathology applications. Most reported uses were in developed countries. In all but one case, Skype was reported by the authors to be feasible and to have benefit. However, while Skype may be a pragmatic approach to providing telemedicine services, in the absence of formal studies, the clinical and economic benefits remain unclear.

Edison, K et al (2013) Content and Style Comparison of Physician Communication in Teledermatology and In-Person Visits[26]

The body of research is rapidly growing regarding the use of telemedicine in patient care, including cost-effectiveness, patient access, patient outcomes, etc. Less has been done describing physician communication during different aspects of the clinical visit during actual versus virtual patient visits. The purpose of this study was to evaluate dermatology healthcare providers' communication via both modalities with regard to content and style. This research indicates that physician providers communicate with similar style and content whether using teledermatology or in-person.

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[25] Armfield NR, Bradford M, Bradford NK. The clinical use of Skype--For which patients, with which problems and in which settings? A snapshot review of the literature. *Int J Med Inform*. 2015;84(10):737–742. doi:10.1016/j.ijmedinf.2015.06.006 [Accessed 28 April 2020]

[26] Edison KE, Fleming DA, Nieman EL, Stine K, Chance L, Demiris G. Content and style comparison of physician communication in teledermatology and in-person visits. *Telemed J E Health*. 2013;197.:509–514. doi:10.1089/tmj.2012.0227 [Accessed 27 April 2020]

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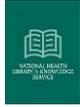
Miller, EA (2011) [The Continuing Need to Investigate the Nature and Content of Teleconsultation Communication Using Interaction Analysis Techniques](27)

The lack of systematically collected and analysed data about the effect of telemedicine on patient-provider communication is a frequently cited barrier for why video communication has yet to reach its full potential. Existing research provides little information about the subtle and detailed changes in communication that take place over video. Comprehensive investigations of actual medical encounter behaviour are therefore required, including verbal content analysis, which uses interaction analysis systems (IAS) to describe and categorize the communication that has taken place. Ten IAS studies were identified in the literature. Although it is difficult to generalize due to differences in methodology and context, some tentative conclusions can be drawn. First, on-site providers tend to be substantially less active than off-site providers, suggesting that the former typically serve as facilitators and observers, rather than active participants. Second, just as in the conventional face-to-face setting, providers' utterances tend to predominate in telemedicine. Third, conventional patterns of more task-focused than socio-emotional utterances tend to persist in telemedicine. However, some studies found telemedicine to be more patient-centred than conventional medicine, and others found it less so. The subtractive and enhancing effects of telemedicine on provider-patient relations and outcomes is not fully understood.

Agha, Z et al (2009) [Evaluation] [An Evaluation of Patient-Physician Communication Style During Telemedicine Consultations](28)

The objectives of this study were to measure and describe verbal and nonverbal communication during clinical TM consultations and to compare TM with in-person (IP) consultations in terms of the quality of physician-patient communication. The study findings indicate differences between TM and IP consultations in terms of physician-patient communication style. Results suggest that, when comparing TM and IP consultations in terms of physician-patient communication, TM visits are more physician centered, with the physician controlling the dialogue and the patient taking a relatively passive role. The authors note further research is needed.

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27 Miller EA. The continuing need to investigate the nature and content of teleconsultation communication using interaction analysis techniques. *J Telemed Telecare*. 2011;172.:55–64. doi:10.1258/jtt.2010.100203 [Accessed 27 April 2020]

28 Agha Z, Roter DL, Schapira RM. An evaluation of patient-physician communication style during telemedicine consultations. *J Med Internet Res*. 2009;113.:e36. Published 2009 Sep 30. doi:10.2196/jmir.1193 [Accessed 27 April 2020]

Liu, X et al (2007) [Doctor-patient Communication: A Comparison Between Telemedicine Consultation and Face-To-Face Consultation](#)[29]
The objective of this study was to compare doctor-patient communications in clinical consultations via telemedicine technology to doctor-patient communications in face-to-face clinical consultations. It found that the time spent on the telemedicine consultation was substantially longer than the time spent on the face-to-face consultation. No statistically significant differences were found in the number of either closed or open-ended questions asked by doctors between both types of consultation. Empathy-utterances, praise-utterances, and facilitation-utterances were, however, seen less in the telemedicine consultations than in the face-to-face consultations. The volume of the medical records was statistically smaller in the telemedicine consultations than in the face-to-face consultations. Patients were satisfied with the telemedicine consultation, but doctors were dissatisfied with it and felt hampered by the communication barriers. This study concludes that new training programs are needed for doctors to develop improved communication skills and the ability to express empathy in telemedicine consultations.

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[29] Liu X, Sawada Y, Takizawa T et al Doctor-patient communication: a comparison between telemedicine consultation and face-to-face consultation. *Intern Med.* 2007;465.:227–232. doi:10.2169/internalmedicine.46.1813 [Accessed 27 April 2020]

Appendix A
Subject Headings and Search Terms

CINAHL Subject Headings
The following CINAHL subject headings were used as part of the search strategies underlying these literature reviews:

assistive technology	[used for: Assistive Technologies; Technology, Assistive]
assistive technology devices	[used for: Adaptive Equipment; Assistive Devices; Assistive Technology Device; Self-Help Device; Self-Help Devices; Self-help Devices for People with Disabilities]
biomedical enhancement	[used for: Enhancement Technologies; Enhancement, Biomedical]
biosensing techniques	[used for: Biosensing Technique; Biosensing Technology]
biosensors	[used for: Bioprobe; Bioprobes; Biosensor; Electrode Enzyme; Electrodes, Enzyme; Immunosensor; Immunosensors]
cellular phone	[used for: Car Phone; Car Phones; Cell Phones; Cellular Phones; Cellular Telephone; Cellular Telephones; Mobile
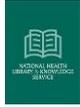
	Phone; Mobile Phones; Phone, Car; Phone, Cellular; Phone, Mobile; Phones, Car; Phones, Cellular; Phones, Mobile; Telephone, Cellular; Telephones, Cellular]
chronic disease	[used for: Chronic Diseases; Chronic Illness; Chronic Illnesses]
data analytics	[used for: Big Data]
health care delivery	[used for: Delivering of Health Care; Delivery of Health Care; Health Care Delivering; Healthcare Delivery]
information technology	[used for: Technology, Information]
Internet	[used as is]
mobile applications	[used for: App, Portable Electronic; App, Software; Apps, Portable Electronic; Apps, Software; Mobile App; Software App; Software Apps; Software Apps, Portable]
patient portals	[used as is]
printing, three-dimensional	[used for: 3-D Printers; 3-D Printing; 3D Printers; 3D Printing; Additive Manufacturing; Three-Dimensional Printers; Three-Dimensional Printing]

remote consultation	[used for: Consultation, Remote; Consultations Remote; Remote Consultations; Teleconsultation; Teleconsultations]
self-assessment	[used for: Self Appraisal; Self Appraisals; Self Assessments; Self Evaluation; Self Evaluations]
signal processing, computer-assisted	[used for: Computer Assisted Signal Processing; Digital Signal Processing; Signal Interpretation, Computer-Assisted; Signal Processing, Digital]
smartphone	[used for: Android; Smartphones; Windows Phone; iPhone]
social media	[used for: Social Medium; Web 2.0]
telecommunications	[used for: Broadband Communication Systems; Mobile Communication Systems; Telecommunication; Telecommunication Systems]
teleconferencing	[used for: Computer Conferencing; Teleconference; Teleconferences]
telehealth	[used for: Mobile Health; eHealth; mHealth]

telemedicine	[used as is]
telemetry	[used as is]
telephone	[used for: Phone; Phones; Telephone Use; Telephones]
telerehabilitation	[used as is]
textiles	[used for: Fabric; Fabrics; Textile]
virtual reality	[used for: Virtual Realities]
wearable sensors	[used for: Body Sensors; Sensor, Body; Sensor, Wearable; Sensors, Body; Sensors, Wearable; Vital Jacket; Wearable Sensor; Wearable Technologies; Wearable Technology]
wireless communications	[used for: Beeper; Beepers; Mobile Computing; Pager; Pagers; Wire Less Communication; Wire Less Communications; Wireless Communication; Wireless Communication Systems]

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EMTREE Subject Headings

The following EMBASE subject headings were used as part of the search strategies underlying these literature reviews:

assistive technology	[used as is]
big data	[used as is]
biosensor	[used for: biosensors; sensor, bio]
chronic disease	[used for: chronic illness]
feedback system	[used for: delayed feed back; delayed feedback; feed back control; feed back loop; feed back mechanism; feed back regulation; feed back system; feedback [MeSH Descriptor]; feedback control; feedback control system; feedback loop; feedback mechanism; feedback regulation; mechanism, feedback; regulation, feedback]
health care delivery	[used for: delivery of health care [MeSH Descriptor]; delivery of healthcare; health care supply; healthcare delivery; healthcare supply; provider-sponsored organisations; provider-sponsored organizations [MeSH Descriptor]; service delivery]

health care system	[used for: healthcare system]
information technology	[used as is]
internet	[used for: internet connection; world wide web]
medical technology	[used for: biomedical technology [MeSH Descriptor]; medical laboratory science [MeSH Descriptor]; stains and staining; technology, medical; technology, medical laboratory]
mobile application	[used for: mobile app; mobile applications [MeSH Descriptor]; mobile apps; portable software app; portable software application; portable software applications; portable software apps; tablet application]
mobile phone	[used for: cell phone [MeSH Descriptor]; cell phones; cellphone; cellphones; cellular phone; cellular telephone; mobile telephone]
nanotechnology	[used for: nanoscale technology; nanoscience]
remote sensing	

	[used for: monitoring, long distance; remote monitoring; remote sensing technology [MeSH Descriptor]; sensing, remote; telesensing]
self-evaluation	[used for: diagnostic self evaluation [MeSH Descriptor]; self appraisal; self assessment; self assessment (psychology); self deception; self diagnosis; self exploration; self objectivation; self observation; self testing; self-assessment [MeSH Descriptor]]
sensor	[used for: environmental sensor; sensor holder, reusable]
signal processing	[used for: digital signal processing; processing, signal; signal processing, computer-assisted [MeSH Descriptor]]
smartphone	[used for: smart phone; smartphones]
social media	[used for]
telecommunication	[used for: broadcasting; broadcasting industry; radar [MeSH Descriptor]; radar wave; satellite communications [MeSH Descriptor]; telecommunications [MeSH Descriptor]]
teleconference	[used for: teleconferencing]

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teleconsultation	[used for: remote consultation [MeSH Descriptor]; tele-consultation; telephone consultation]
telehealth	[used for: e-health; ehealth; tele-health]
telemedicine	[used for: tele medicine]
telemetry	[used for: biotelemetry; radio telemetry; radiotelemetry; teleradiometry]
telemonitoring	[used for: distant monitoring (patient); distant patient monitoring; remote monitoring (patient); remote patient monitoring; tele monitoring]
telephone	[used for: dataphone; telephone line]
telerehabilitation	[used for: e-rehabilitation; remote rehabilitation; tele-rehabilitation; virtual rehabilitation]
textile	[used for: textiles]
three dimensional printing	[used for: 3 dimensional printing; 3-D printing; 3D printing; 3DP additive manufacturing; additive layer manufacturing; additive manufacturing;

	printing, three-dimensional [MeSH Descriptor]; three-dimensional printing]
virtual reality	[used as is]
wearable computer	[used for: body-borne computer; wearable electronic device; wearable electronic devices [MeSH Descriptor]]
web-based intervention	[used for: internet-based intervention [MeSH Descriptor]; internet-intervention; online-based intervention; online-intervention; web intervention]
wireless communication	[used for: communication, wireless; wireless technology [MeSH Descriptor]]

MEDLINE Subject Headings (MeSH)

The following MEDLINE subject headings were used as part of the search strategies underlying these literature reviews:

big data	[used as is]
biomedical technology	[used for: Health Care Technology; Health Technology; Biomedical Technologies; Technology, Biomedical; Technology, Health; Technology, Health Care Related Cross References:]

biosensing techniques	[used for: Bioprobes; Biosensors; Electrodes, Enzyme; Biosensing Technics; Bioprobe; Biosensing Technic; Biosensing Technique; Biosensor; Electrode, Enzyme; Enzyme Electrode; Enzyme Electrodes; Technic, Biosensing; Technics, Biosensing; Technique, Biosensing; Techniques, Biosensing Related Cross References:]
cell phone	[used for: Car Phone; Cell Phones; Cellular Phone; Mobile Phone; Telephone, Cellular; Mobile Telephone; Portable Cellular Phone; Transportable Cellular Phone; Car Phones; Cellular Phone, Portable; Cellular Phone, Transportable; Cellular Phones; Cellular Phones, Portable; Cellular Phones, Transportable; Cellular Telephone; Cellular Telephones; Mobile Phones; Mobile Telephones; Phone, Car; Phone, Cell; Phone, Cellular; Phone, Mobile; Phones, Car; Phones, Cell; Phones, Cellular; Phones, Mobile; Portable Cellular Phones; Telephone, Mobile; Telephones, Cellular; Telephones, Mobile; Transportable Cellular Phones Related Cross Reference:]
chronic disease	[used for: Chronic Illness; Chronically Ill; Chronic Diseases; Chronic Illnesses; Disease, Chronic; Diseases, Chronic; Illness, Chronic; Illnesses, Chronic Related Cross Reference:]
data science	[used for: Data Analytics; Data-Driven Science; Analytic, Data; Analytics, Data;

Data Analytic; Data Driven Science; Data Sciences; Data-Driven Sciences; Science, Data; Science, Data-Driven; Sciences, Data; Sciences, Data-Driven Related Cross Reference:]

delivery of health care

[used for: Delivery of Dental Care; Health Care; Health Care Delivery; Health Care Systems; Community-Based Distribution; Contraceptive Distribution; Delivery of Healthcare; Dental Care Delivery; Distribution, Non-Clinical; Distribution, Nonclinical; Distributional Activities; Healthcare; Healthcare Delivery; Healthcare Systems; Non-Clinical Distribution; Nonclinical Distribution; Activities, Distributional; Activity, Distributional; Care, Health; Community Based Distribution; Community-Based Distributions; Contraceptive Distributions; Deliveries, Healthcare; Delivery, Dental Care; Delivery, Health Care; Delivery, Healthcare; Distribution, Community-Based; Distribution, Contraceptive; Distribution, Non Clinical; Distributional Activity; Distributions, Community-Based; Distributions, Contraceptive; Distributions, Non-Clinical; Distributions, Nonclinical; Health Care System; Healthcare Deliveries; Healthcare System; Non Clinical Distribution; Non-Clinical Distributions; Nonclinical Distributions; System, Health Care; System, Healthcare; Systems, Health Care; Systems, Healthcare]

diagnostic self evaluation	[used for: Self-Evaluation; Self-Appraisal; Subjective Health; Subjective Health Complaint; Complaint, Subjective Health; Complaints, Subjective Health; Diagnostic Self Evaluations; Evaluations, Diagnostic Self; Health Complaint, Subjective; Health Complaints, Subjective; Health, Subjective; Self Appraisal; Self Evaluation; Self Evaluation, Diagnostic; Self Evaluations, Diagnostic; Self-Appraisals; Self-Evaluations; Subjective Health Complaints; Subjective Healths Related Cross Reference:]
distance counseling	[used for: E-Counseling; E-Therapy; Counseling, Distance; E Counseling; E Therapy; E-Therapies]
health technology	[used for: Health Care Technology; Health Technology; Biomedical Technologies; Technology, Biomedical; Technology, Health; Technology, Health Care Related Cross References:]
information technology	[used for: Information Technologies; Technology, Information]
internet	[used for: World Wide Web; Cyber Space; Cyberspace; Web, World Wide; Wide Web, World]

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internet-based intervention

[used for: Internet Intervention; Online Intervention; Web-based Intervention; Internet Based Intervention; Internet Interventions; Internet-Based Interventions; Intervention, Internet; Intervention, Internet-Based; Intervention, Online; Intervention, Web-based; Interventions, Internet; Interventions, Internet-Based; Interventions, Online; Interventions, Web-based; Online Interventions; Web based Intervention; Web-based Interventions]

mobile applications

[used for: Mobile Apps; Portable Electronic Applications; Portable Electronic Apps; Portable Software Applications; Portable Software Apps; App, Mobile; App, Portable Electronic; App, Portable Software; Application, Mobile; Application, Portable Electronic; Application, Portable Software; Applications, Mobile; Applications, Portable Electronic; Applications, Portable Software; Apps, Mobile; Apps, Portable Electronic; Apps, Portable Software; Electronic App, Portable; Electronic Application, Portable; Electronic Applications, Portable; Electronic Apps, Portable; Mobile App; Mobile Application; Portable Electronic App; Portable Electronic Application; Portable Software App; Portable Software Application; Software App, Portable; Software Application, Portable; Software Applications, Portable; Software Apps, Portable]

patient portals

[used for: Patient Internet Portals; Patient Portal; Patient Web Portal; Patient Web Portals; Internet Portal, Patient; Internet Portals, Patient; Patient Internet Portal; Portal, Patient; Portal, Patient Internet; Portal, Patient Web; Portals, Patient Internet; Portals, Patient Web; Web Portal, Patient; Web Portals, Patient]

printing, three-dimensional

[used for: Printing, Three Dimensional; Printings, Three-Dimensional; Three-Dimensional Printings; 3-Dimensional Printing; 3 Dimensional Printing; 3-Dimensional Printings; Printing, 3-Dimensional; Printings, 3-Dimensional; 3-D Printing; 3 D Printing; 3-D Printings; Printing, 3-D; Printings, 3-D; Three-Dimensional Printing; Three Dimensional Printing; 3D Printing; 3D Printings; Printing, 3D; Printings, 3D]

remote consultation

[used for: Consultation, Remote; Teleconsultation; Teleconsultations]

remote sensing technology

[used for: Remote Sensing Technologies; Technologies, Remote Sensing; Technology, Remote Sensing Related Cross References:]

self-assessment

[used for: Self Assessment; Self Assessment (Psychology); Assessment, Self; Self-Criticism; Assessment, Self (Psychology); Assessments, Self;

	Assessments, Self (Psychology); Self Assessments; Self Assessments (Psychology); Self Criticism; Self-Assessments; Self-Criticisms Related Cross Reference:]
self-help devices	[used for: Assistive Devices; Assistive Technology; Assistive Device; Assistive Technologies; Device, Assistive; Device, Self-Help; Devices, Assistive; Devices, Self-Help; Self Help Devices; Self-Help Device; Technologies, Assistive; Technology, Assistive Related Cross Reference:]
signal processing, computer-assisted	[used for: Digital Signal Processing; Signal Interpretation, Computer-Assisted; Signal Processing, Digital; Computer-Assisted Signal Interpretation; Computer-Assisted Signal Interpretations; Computer-Assisted Signal Processing; Interpretation, Computer-Assisted Signal; Interpretations, Computer-Assisted Signal; Signal Interpretation, Computer Assisted; Signal Interpretations, Computer-Assisted; Signal Processing, Computer Assisted Related Cross References:]
smartphone	[used for: Smart Phone; Smart Phones; Phone, Smart; Phones, Smart; Smartphones]
social media	[used for: Social Medium; Twitter Messaging; Web 2.0; 2.0s, Web; Media, Social; Messaging, Twitter; Web 2.0s]

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telecommunications	[used for: Teleconference; Telegraphy; Telecommunication; Teleconferences; Telegraphies]
telemedicine	[used for: Mobile Health; Telehealth; eHealth; mHealth; Health, Mobile Related Cross Reference:]
telemetry	[used for: Telemetries Related Cross Reference:]
telephone	[used for: Switchboard Service; Service, Switchboard; Services, Switchboard; Switchboard Services; Telephones]
telerehabilitation	[used for: Remote Rehabilitation; Tele-rehabilitation; Virtual Rehabilitation; Rehabilitation, Remote; Rehabilitation, Virtual; Rehabilitations, Remote; Rehabilitations, Virtual; Remote Rehabilitations; Tele rehabilitation; Tele-rehabilitations; Telerehabilitations; Virtual Rehabilitations]
textiles	[used for: Textile Related Cross Reference:]
virtual reality	[used for: Virtual Reality, Educational; Virtual Reality, Instructional; Educational Virtual Realities; Educational Virtual Reality; Instructional Virtual Realities;

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	Instructional Virtual Reality; Realities, Instructional Virtual; Reality, Educational Virtual; Reality, Instructional Virtual; Reality, Virtual; Virtual Realities, Educational; Virtual Realities, Instructional]
wearable electronic devices	[used for: Electronic Skin; Wearable Devices; Wearable Technology; Device, Wearable; Device, Wearable Electronic; Devices, Wearable; Devices, Wearable Electronic; Electronic Device, Wearable; Electronic Devices, Wearable; Skin, Electronic; Technologies, Wearable; Technology, Wearable; Wearable Device; Wearable Electronic Device; Wearable Technologies]
wireless technology	[used for: Technologies, Wireless; Technology, Wireless; Wireless Technologies]

Search Term Combinations

The following search term combinations were used as part of the search strategies underlying these literature reviews:

digital	[+ one or more of …]	**action plan; communication; health; health platform; health technology; patient monitoring; solutions; therapeutics; therapy**
electronic	[+ one or more of …]	**health; monitoring devices**
feedback	[+ one or more of …]	**real-time; remote**

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flexible	[+ one or more of …]	electronics; tactile sensors
health care	[+ one or more of …]	delivery; delivery methods; systems
mobile	[+ one or more of …]	based interventions; applications; health; health program; electronic adherence sensors
remote	[+ one or more of …]	device; feedback; monitoring; sensing; sensory technology
sensor-enabled	[+ one or more of …]	data collection
virtual	[+ one or more of …]	health; technology
wearable	[+ one or more of …]	devices; sensing electronics
wireless	[+ one or more of …]	communication; device; device

Additional Keywords

The following additional keywords were used as part of the search strategies underlying these literature reviews:

biosensing techniques
data analytics
distance counselling
ehealth or e-health
hand-held device
mhealth or m-health
microcontact
multifunctioning sensing
nanoenergy nano-system
physiological sensors
real-time feedback
self-sustainable
skin-mountable biomedical devices

smart technology
sweat sensing
tablet-based applications
telecare
telemanagement
telemonitor
triboelectric
web-based interventions
wi-fi
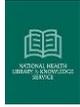
▶ **Contents**

Appendix B
Citation Sources by Chapter

ASTHMA

American Journal of Respiratory and Critical Care Medicine Conference
Annals of Allergy, Asthma and Immunology
Chronic Respiratory Disease
Clinics in Chest Medicine
Cochrane Clinical Answers
European Respiratory Journal
JMIR mHealth and uHealth
Journal of Allergy and Clinical Immunology: In Practice
Journal of Asthma
Journal of Medical Internet Research
Journal of the American Medical Informatics Association (JAMIA)
Medical Care
Medical Science Monitor
PLoS ONE
Respirology
Revue des Maladies Respiratoires
Telemedicine journal and e-health : the official journal of the American Telemedicine Association

AUDIOLOGY

Cochlear Implants International
Disability and Rehabilitation: Assistive Technology
Ear and Hearing
European Archives of Oto-Rhino-Laryngology
IEEE Transactions on Biomedical Circuits and Systems
IEEE Transactions on Visualization and Computer Graphics

International Journal of Audiology
Journal of Headache and Pain
Journal of International Advanced Otology
Journal of Medical Internet Research
Journal of Speech, Language and Hearing Research
Journal of the American Academy of Audiology
Laryngoscope Investigative Otolaryngology
Otology and Neurotology
Scientific Reports
Systematic Reviews

CANCER CARE

BMC Cancer
BMJ Open
Breast
Canadian Journal of Respiratory, Critical Care, and Sleep Medicine
Cancer Medicine
Cancer Nursing
Clinical Breast Cancer
Clinical Colorectal Cancer
Clinical Journal of Oncology Nursing
Disability and Rehabilitation
Dysphagia
Gerontology
Gynecologic Oncology
Integrative Cancer Therapies
International Journal of Nursing Studies
International Journal of Radiation Oncology, Biology and Physics
JCO Clinical Cancer Informatics
JMIR mHealth and uHealth
Journal of Advanced Nursing
Journal of Cancer Survivorship
Journal of Clinical Oncology
Journal of Geriatric Oncology
Journal of Medical Internet Research
Journal of Psychosocial Oncology
Journal of Telemedicine and Telecare

Journal of the National Comprehensive Cancer Network
Oncologist
Pain Practice
PLoS One
Psycho-oncology
Research in Sports Medicine
Seminars in Oncology Nursing
Studies in Health Technology and Informatics
Supportive Care in Cancer
Telemedicine Journal and E-Health

CHRONIC KIDNEY DISEASE

Advances in Chronic Kidney Disease
American Journal of Kidney Diseases
BMC Nephrology
British Journal of General Practice
Clinical Journal of the American Society of Nephrology
Cochrane Database of Systematic Reviews
Current Opinion in Critical Care
Current Opinion in Nephrology and Hypertension
JMIR mHealth uHealth
Journal of Comorbidity
Journal of Medical Internet Research
Journal of Medical Systems
Journal of Telemedicine and Telecare
Telemedicine Journal and E-Health

COPD

American Journal of Respiratory and Critical Care Medicine
Archivos Bronconeumologia
Artificial Intelligence in Medicine
BMC Health Services Research
BMC Medical Informatics and Decision Making
BMC Pulmonary Medicine
BMJ Open
BMJ Open Respiratory Research

Canadian Journal of Respiratory, Critical Care, and Sleep Medicine
Chronic Respiratory Disease
Clinical Respiratory Journal
Conference Proceedings: Annual international conference of the IEEE Engineering Medicine and Biology Society
Diagnostics (Basel)
European Respiratory Journal
Expert Review of Respiratory Medicine
Health Informatics Journal
IEEE Journal of Biomedical and Health Informatics
International Journal of Chronic Obstructive Pulmonary Disease
International Journal of Medical Informatics
International Journal of Nursing Studies
Irish Journal of Medical Science
JMIR Formative Research
JMIR Medical Informatics
JMIR Mhealth and Uhealth
Journal of Aerosol Medicine and Pulmonary Drug Delivery
Journal of Human Kinetics
Journal of Medical Internet Research
Journal of Medical Systems
Journal of Telemedicine and Telecare
Journal of Thoracic Disease
Lung
Medical and Biological Engineering and Computing
Physiotherapy
PLoS One
Pneumonologia i Alergologia Polska
Respiratory Care
Respiratory Medicine
Respiratory Medicine and Research
Respirology
Scientific Reports
Sensors (Basel)
Telemedicine Journal and E-Health
Thorax
Translational Behavorial Medicine

CYSTIC FIBROSIS

Accounts of Chemical Research
American Journal of Respiratory and
Critical Care Medicine
Annual Review of Biomedical Engineering
BMJ Open
JMIR mHealth and uHealth
Journal of Telemedicine and Telecare
La Clinica Terapeutica
Respiratory Care
Sensors
Telemedicine Journal and E-Health
Thorax

DERMATOLOGY

Acta Clinica Belgica
Acta Dermato-Venereologica
American Journal of Clinical Dermatology
Annals of Plastic Surgery
Archives of Dermatological Research
Australasian Journal of Dermatology
BMJ
British Journal of Dermatology
Clinical and Experimental Dermatology
Clinics in Dermatology
Cochrane Database of Systematic
Reviews
Current Dermatology Reports
Dermatitis
Dermatologic Clinics
Dermatologic Therapy
Dermatology
Dermatology Online Journal
Emergency Medicine Journal
Experimental Dermatology
Indian Dermatology Online Journal
International Journal of Dermatology
International Journal of Telemedicine and
Applications
JAMA Dermatology
JAMA Network Open
JMIR Mhealth and Uhealth
Journal for Healthcare Quality

Journal of Dermatological treatment
Journal of Evaluation in Clinical Practice
Journal of Investigative Dermatology
Journal of Medical Internet Research
Journal of Medical Systems
Journal of Telemedicine and Telecare
Journal of the American Academy of
Dermatology
Journal of the European Academy of
Dermatology and Venereology
Lancet Digital Health
Medicine (Baltimore)
Nature Medicine
Pediatric Dermatology
PLoS One
Postepy Dermatologii i Alergologii
Skin Research and Technology
Telemedicine Journal and E-Health

DIABETES

Acta Diabetologica
Annals of Saudi Medicine
BMC Health Services Research
BMC Nursing
BMJ Open
CMAJ: Canadian Medical Association
Journal
Cost Effectiveness and Resource
Allocation
Current Diabetes Reports
Diabetes and Metabolic Syndrome
Diabetes Care
Diabetes, Metabolic Syndrome and
Obesity: Targets and Therapy
Diabetes Metabolism Research and
Reviews
Diabetes, Obesity and Metabolism
Diabetes Research and Clinical Practice
Diabetes Technology and Therapeutics
European Journal of Endocrinology
European Journal of Ophthalmology
International Journal of Lower Extremity
Wounds
JMIR mHealth and uHealth
Journal of Clinical Nursing

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Journal of Diabetes and its Complications
Journal of Diabetes Research
Journal of General Internal Medicine
Journal of Medical Internet Research
Journal of Medical Systems
Journal of Telemedicine and Telecare
Journal of the Academy of Nutrition and Dietetics
Médecine des Maladies Métaboliques
Medical and Biological Engineering and Computing
Ophthalmic Epidemiology
Scientific Reports
Talanta
Wounds

DIALYSIS

Analyst
Blood Purification
Cardiorenal Medicine
Clinical Journal of the American Society of Nephrology
Clinical Kidney Journal
Clinical Nephrology
Computational and Mathematical Methods in Medicine
Computers in Biology and Medicine
Health Technology Assessment
Hemodialysis International
IEEE Engineering in Medicine and Biology Society (Conference Proceedings)
IEEE Reviews in Biomedical Engineering
IEEE Signal Processing in Medicine and Biology Symposium (SPMB)
IEEE Transactions on Biomedical Circuits and Systems
JMIR Human Factors
JMIR mHealth uHealth
Journal of Clinical Nursing
Journal of Electrocardiology
Journal of Mechanics in Medicine and Biology
Journal of Nephrology
Journal of Renal Care
Journal of Telemedicine and Telecare

Journal of the American Heart Association
Kidney Diseases (Basel)
Kidney International Reports
Nefrologia
Nephrology Dialysis Transplantation
Nephron
Peritoneal Dialysis International
PloS One
Renal Society of Australasia Journal
Seminars in Dialysis
Studies in Health Technology and Informatics
Telemedicine Journal and E-Health

HIGH-RISK FALLS

Archives of Gerontology and Geriatrics
Biomedical Engineering Online
BMC Geriatrics
Disability and Rehabilitation
Gerontologist
IEEE Engineering in Medicine and Biology Society (Conference Proceedings)
IEEE Journal of Biomedical and Health Informatics
Innovation in Aging
International Journal of Medical Informatics
JMIR mHealth and uHealth
Journal of Aging and Physical Activity
Journal of Biomedical Informatics
Journal of Geriatric Physical Therapy
Journal of Medical Internet Research
Journal of Medical Systems
Medical and Biological Engineering and Computing
Physiological Measurement
PLoS Medicine
PLoS One
Sensors
Telemedicine Journal and E-Health

ISCHEMIC HEART DISEASE

American Journal of Respiratory and Critical Care Medicine

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Archives of Cardiovascular Disease Supplements
BioMedical Engineering OnLine
BMC Cardiovascular Disorders
Clinical Interventions in Aging
Europace
Expert Review of Cardiovascular Therapy
Heart
JMIR Formative Research
Journal of Medical Internet Research
Journal of the American Medical Informatics Association: JAMIA
NPJ Digital Medicine
Ontario Health Technology Assessment Series
Preventive Medicine
Telemedicine Journal and E-Health

MOTOR NEURONE DISEASE

Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration
BMJ Open
Disability and Rehabilitation: Assistive Technology
European Respiratory Journal
Muscle and Nerve
NeuroRehabilitation
Thorax

MULTIPLE SCLEROSIS

Behavioural Neurology
Cochrane Database of Systematic Reviews
Current Opinion in Neurology
European Journal of Physical and Rehabilitation Medicine
JAMA Network Open
Journal of Telemedicine and Telecare
Multiple Sclerosis
Multiple Sclerosis Journal - Experimental, Translational and Clinical Vols.
Muscle and Nerve
Physiological Measurement
PLoS One

Revue Neurologique (Paris)
TELEM. E-poster presented at the 34th Congress of the European Committee for Treatment and Research in Multiple Sclerosis (ECTRIMS) (2018)

OLDER PERSONS' CARE

Aging Clinical and Experimental Research
Assistive Technology
Biosensors and Bioelectronics
Biosensors (Basel)
BMC Geriatrics
Disability and Rehabilitation: Assistive Technology
Geriatrics and Gerontology International
Gerontology
Health Information Science and Systems
Healthcare Informatics Research
IEEE Journal of Biomedical and Health Informatics
Journal of Medical Systems
Journal of Telemedicine and Telecare
JBI Database of Systematic Reviews and Implementation Reports
JMIR Aging
Sensors
Studies in Health Technology and Informatics
Technology and Health Care
Telemedicine Journal and E-Health : the official journal of the American Telemedicine Association

OPHTHALMOLOGY

Acta Diabetologica
American Journal of Ophthalmology
BMJ Open
British Journal of Ophthalmology
Clinical and Experimental Ophthalmology
Computer Methods and Programs in Biomedicine
Computers in Biology and Medicine
Current Opinion in Ophthalmology
Eye (London, England)

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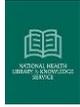
Graefe's Archive for Clinical and
Experimental Ophthalmology
International Journal of Medical
Informatics
JAMA Ophthalmology
JMIR Medical Informatics
Journal of AAPOS: The Official Publication
of the American Association for Pediatric
Ophthalmology and Strabismus
Journal of Medical Internet Research
Journal of Neuro-Ophthalmology
Journal of Telemedicine and Telecare
Medicine (Baltimore)
Ophthalmology
Survey of Ophthalmology
Telemedicine Journal and E-Health
Turkish Journal of Ophthalmology

PALLIATIVE CARE

American Journal of Hospice and
Palliative Care
Annali dell'Istituto Superiore di Sanita
BMC Medicine
BMC Palliative Care
BMJ Open
BMJ Supportive and Palliative Care
Cancer Nursing
Current Oncology Reports
International Journal of Palliative Nursing
JAMA Network Open
Journal of Clinical Nursing
Journal of Hospice and Palliative Nursing
Journal of Medical Internet Research
Journal of Pain and Symptom
Management
Journal of Palliative Medicine
Palliative and Supportive Care
Palliative Medicine
Psycho-oncology
Supportive Care in Cancer
Telemedicine Journal and E-Health

PROGRESSIVE SUPRANUCLEAR PALSY

Acta Otorhinolaryngologica Italica
Gait and Posture
International Journal of Language and
Communication Disorders
Journal of Neuroscience Nursing
Movement Disorders
PLoS One

STROKE REHABILITATION

Acta of Bioengineering and Biomechanics
American Journal of Occupational
Therapy
Annals of Neurosciences
Archives of Physical Medicine and
Rehabilitation
Assistive Technology
BioMed Research International
Disability and Rehabilitation
Disability and Rehabilitation: Assistive
Technology
European Journal of Physical and
Rehabilitation Medicine
International Journal of Environmental
Research and Public Health
International Journal of Medical
Informatics
International Journal of Rehabilitation
Research
Journal of Back and Musculoskeletal
Rehabilitation
Journal of Neuroengineering and
Rehabilitation
Journal of Stroke and Cerebrovascular
Diseases
Medicine (Baltimore)
Neurorehabilitation and Neural Repair
PLoS One
Sensors
Studies in Health Technology and
Informatics
Topics in Stroke Rehabilitation

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SUICIDE PREVENTION

Archives of Psychiatric Nursing
Archives of Suicide Research
Behavior Therapy
BMC Medicine
BMC Psychiatry
BMJ Open
Cognitive Behaviour Therapy
Crisis
Current Psychiatry Reports
General Hospital Psychiatry
Innovations in Clinical Neuroscience
JAMA Network Open
JMIR Mental Health
JMIR mHealth and uHealth
Journal of Affective Disorders
Journal of Consulting and Clinical
Psychology
Journal of Medical Internet Research
Journal of Medical Systems
Journal of Telemedicine and Telecare
PLoS One
Psychiatry Research
Psychological Services
Suicide and Life-Threatening Behavior

TELEHEALTH and BIOTECHNOLOGY

Accounts of Chemical Research
Artificial Intelligence in Medicine
Biosensors (Basel)
Digital Biomarkers
Frontiers in Chemistry
Health Informatics Journal
IEEE Transactions in Biomedical
Engineering
International Journal of Environmental
Research and Public Health
International Journal of Medical
Informatics
Journal of Medical Internet Research
Journal of Medical Systems
JMIR mHealth uHealth
JMIR Public Health and Surveillance
PLoS One

Sensors (Basel)

TELEHEALTH and CHRONIC CONDITIONS

BMC Medical Informatics and Decision
Making
BMC Public Health
BMJ Health and Care Informatics
European Heart Journal Supplements
International Journal of Medical
Informatics
JMIR Medical Informatics
JMIR mHealth and uHealth
Journal of Clinical Nursing
Journal of Medical Internet Research
Journal of Medical Systems
Journal of Telemedicine and Telecare
PLoS One
Professioni Infermieristiche
Telemedicine Journal and E-Health

VIDEO-CONFERENCING and VIDEO-CONSULTATIONS / COVID-19

BMC Health Services Research
BMJ
British Journal of General Practice
Clinical Psychology: Science and Practice
Digital Health
Health Informatics Journal
Health Services and Delivery Research
Internal Medicine
International Journal of Medical
Informatics

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▶ **Contents**

Appendix C
Citation Sources
(Complete)

Accounts of Chemical Research
Acta Clinica Belgica
Acta Dermato-Venereologica
Acta Diabetologica
Acta of Bioengineering and Biomechanics
Acta Otorhinolaryngologica Italica
Advances in Chronic Kidney Disease
Aging Clinical and Experimental Research
American Journal of Clinical Dermatology
American Journal of Hospice and Palliative Care
American Journal of Kidney Diseases
American Journal of Occupational Therapy
American Journal of Ophthalmology
American Journal of Respiratory and Critical Care Medicine
Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration
Analyst
Annali dell'Istituto Superiore di Sanita
Annals of Allergy, Asthma and Immunology
Annals of Neurosciences
Annals of Plastic Surgery
Annals of Saudi Medicine
Annual Review of Biomedical Engineering
Archives of Cardiovascular Disease Supplements
Archives of Dermatological Research
Archives of Gerontology and Geriatrics

Archives of Physical Medicine and Rehabilitation
Archives of Psychiatric Nursing
Archives of Suicide Research
Archivos Bronconeumologia
Artificial Intelligence in Medicine
Assistive Technology
Australasian Journal of Dermatology
Behavior Therapy
Behavioural Neurology
BioMed Research International
Biomedical Engineering Online
Biosensors and Bioelectronics
Biosensors (Basel)
Blood Purification
BMC Cancer
BMC Cardiovascular Disorders
BMC Geriatrics
BMC Health Services Research
BMC Medical Informatics and Decision Making
BMC Medicine
BMC Nephrology
BMC Nursing
BMC Palliative Care
BMC Psychiatry
BMC Public Health
BMC Pulmonary Medicine
BMJ
BMJ Health and Care Informatics
BMJ Open
BMJ Open Respiratory Research
BMJ Supportive and Palliative Care
Breast
British Journal of Dermatology
British Journal of General Practice
British Journal of Ophthalmology
Canadian Journal of Respiratory, Critical Care, and Sleep Medicine
Cancer Medicine
Cancer Nursing
Cardiorenal Medicine
Chronic Respiratory Disease
Clinical and Experimental Dermatology
Clinical and Experimental Ophthalmology
Clinical Breast Cancer

623

Clinical Colorectal Cancer
Clinical Interventions in Aging
Clinical Journal of Oncology Nursing
Clinical Journal of the American Society of Nephrology
Clinical Kidney Journal
Clinical Nephrology
Clinical Psychology: Science and Practice
Clinical Respiratory Journal
Clinics in Chest Medicine
Clinics in Dermatology
CMAJ: Canadian Medical Association Journal
Cochlear Implants International
Cochrane Clinical Answers
Cochrane Database of Systematic Reviews
Cognitive Behaviour Therapy
Computational and Mathematical Methods in Medicine
Computer Methods and Programs in Biomedicine
Computers in Biology and Medicine
Cost Effectiveness and Resource Allocation
Crisis
Current Dermatology Reports
Current Diabetes Reports
Current Oncology Reports
Current Opinion in Critical Care
Current Opinion in Nephrology and Hypertension
Current Opinion in Neurology
Current Opinion in Ophthalmology
Current Psychiatry Reports
Dermatitis
Dermatologic Clinics
Dermatologic Therapy
Dermatology
Dermatology Online Journal
Diabetes and Metabolic Syndrome
Diabetes Care
Diabetes Metabolism Research and Reviews
Diabetes Research and Clinical Practice
Diabetes Technology and Therapeutics

Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy
Diabetes, Obesity and Metabolism
Diagnostics (Basel)
Digital Biomarkers
Digital Health
Disability and Rehabilitation
Disability and Rehabilitation: Assistive Technology
Dysphagia
Ear and Hearing
Emergency Medicine Journal
Europace
European Archives of Oto-Rhino-Laryngology
European Heart Journal Supplements
European Journal of Endocrinology
European Journal of Ophthalmology
European Journal of Physical and Rehabilitation Medicine
European Respiratory Journal
Experimental Dermatology
Expert Review of Cardiovascular Therapy
Expert Review of Respiratory Medicine
Eye (London)
Frontiers in Chemistry
Gait and Posture
General Hospital Psychiatry
Geriatrics and Gerontology International
Gerontologist
Gerontology
Graefe's Archive for Clinical and Experimental Ophthalmology
Gynecologic Oncology
Health Informatics Journal
Health Information Science and Systems
Health Services and Delivery Research
Health Technology Assessment
Healthcare Informatics Research
Heart
Hemodialysis International
IEEE Engineering in Medicine and Biology Society (Conference Proceedings)
IEEE Journal of Biomedical and Health Informatics
IEEE Reviews in Biomedical Engineering

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IEEE Signal Processing in Medicine and Biology Symposium (SPMB)
IEEE Transactions on Biomedical Circuits and Systems
IEEE Transactions on Biomedical Engineering
IEEE Transactions on Visualization and Computer Graphics
Indian Dermatology Online Journal
Innovation in Aging
Innovations in Clinical Neuroscience
Integrative Cancer Therapies
Internal Medicine
International Journal of Audiology
International Journal of Chronic Obstructive Pulmonary Disease
International Journal of Dermatology
International Journal of Environmental Research and Public Health
International Journal of Language and Communication Disorders
International Journal of Lower Extremity Wounds
International Journal of Medical Informatics
International Journal of Nursing Studies
International Journal of Palliative Nursing
International Journal of Radiation Oncology, Biology and Physics
International Journal of Rehabilitation Research
International Journal of Telemedicine and Applications
Irish Journal of Medical Science
JAMA Dermatology
JAMA Network Open
JAMA Ophthalmology
JBI Database of Systematic Reviews and Implementation Reports
JCO Clinical Cancer Informatics
JMIR Aging
JMIR Formative Research
JMIR Human Factors
JMIR Medical Informatics
JMIR Mental Health
JMIR mHealth and uHealth

JMIR Public Health and Surveillance
Journal for Healthcare Quality
Journal of the American Association for Pediatric Ophthalmology and Strabismus
Journal of Advanced Nursing
Journal of Aerosol Medicine and Pulmonary Drug Delivery
Journal of Affective Disorders
Journal of Aging and Physical Activity
Journal of Allergy and Clinical Immunology: In Practice
Journal of Asthma
Journal of Back and Musculoskeletal Rehabilitation
Journal of Biomedical Informatics
Journal of Cancer Survivorship
Journal of Clinical Nursing
Journal of Clinical Oncology
Journal of Comorbidity
Journal of Computer-Mediated Communication
Journal of Consulting and Clinical Psychology
Journal of Dermatological treatment
Journal of Diabetes and its Complications
Journal of Diabetes Research
Journal of Electrocardiology
Journal of Evaluation in Clinical Practice
Journal of General Internal Medicine
Journal of Geriatric Oncology
Journal of Geriatric Physical Therapy
Journal of Headache and Pain
Journal of Hospice and Palliative Nursing
Journal of Human Kinetics
Journal of International Advanced Otology
Journal of Investigative Dermatology
Journal of Mechanics in Medicine and Biology
Journal of Medical Internet Research
Journal of Medical Systems
Journal of Nephrology
Journal of Neuroengineering and Rehabilitation
Journal of Neuro-Ophthalmology
Journal of Neuroscience Nursing

Journal of Pain and Symptom Management
Journal of Palliative Medicine
Journal of Patient Experience
Journal of Psychiatric and Mental Health Nursing
Journal of Psychosocial Oncology
Journal of Renal Care
Journal of Speech, Language and Hearing Research
Journal of Stroke and Cerebrovascular Diseases
Journal of Telemedicine and Telecare
Journal of the Academy of Nutrition and Dietetics
Journal of the American Academy of Audiology
Journal of the American Academy of Dermatology
Journal of the American Heart Association
Journal of the American Medical Informatics Association (JAMIA)
Journal of the European Academy of Dermatology and Venereology
Journal of the National Comprehensive Cancer Network
Journal of Thoracic Disease
Kidney Diseases (Basel)
Kidney International Reports
La Clinica Terapeutica
Lancet Digital Health
Laryngoscope Investigative Otolaryngology
Lung
Médecine des Maladies Métaboliques
Medical and Biological Engineering and Computing
Medical Care
Medical Education
Medical Science Monitor
Medicine (Baltimore)
Movement Disorders
Multiple Sclerosis
Multiple Sclerosis Journal
Muscle and Nerve
Nature Medicine

Nefrologia
Nephrology Dialysis Transplantation
Nephron
NeuroRehabilitation
Neurorehabilitation and Neural Repair
NPJ Digital Medicine
Oncologist
Ontario Health Technology Assessment Series
Ophthalmic Epidemiology
Ophthalmology
Otology and Neurotology
Pain Practice
Palliative and Supportive Care
Palliative Medicine
Pediatric Dermatology
Peritoneal Dialysis International
Physiological Measurement
Physiotherapy
PLoS Medicine
PLoS One
Pneumonologia i Alergologia Polska
Postepy Dermatologii i Alergologii
Preventive Medicine
Professioni Infermieristiche
Psychiatry Research
Psychological Services
Psycho-oncology
Renal Society of Australasia Journal
Research in Sports Medicine
ResearchGate
Respiratory Care
Respiratory Medicine
Respiratory Medicine and Research
Respirology
Revue des Maladies Respiratoires
Revue Neurologique (Paris)
Scientific Reports
Seminars in Dialysis
Seminars in Oncology Nursing
Sensors
Skin Research and Technology
Studies in Health Technology and Informatics
Suicide and Life-Threatening Behavior
Supportive Care in Cancer

Survey of Ophthalmology
Systematic Reviews
Talanta
Technology and Health Care
TELEM. e-poster presented at the 34th
Congress of the ECTRMS
Telemedicine Journal and eHealth
Thorax
Topics in Stroke Rehabilitation
Translational Behavorial Medicine
Turkish Journal of Ophthalmology
Wounds