Public Health Scotland

Scoping review: Age-restriction interventions for tobacco and nicotine vapour products in children and young people

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Contents

1. Key messages

We undertook a scoping review to identify evidence for two potential policies to restrict the sale and supply of tobacco to children and young people:

- Raising the legal smoking age each year to create a tobacco-free generation (TFG).
- Increasing the minimum legal age of sale (MLA) to 21 (MLA21) or 25 (MLA25).

To achieve the overall objective, we asked:

- What is the impact of increasing the age of sale for tobacco and nicotine vapour products (NVPs) on youth smoking/vaping rates, purchasing and health outcomes?
- Are there unintended consequences of implementation of these age-restriction measures?
- Is there evidence of health inequalities related to the introduction of these policy measures?

Evidence for introducing a tobacco-free generation (TFG)

Six studies were identified that looked at TFG as an endgame tobacco control measure. This policy has not been implemented nationally at large scale, so the evidence was limited to modelling studies. We found:

- A TFG policy could reduce smoking prevalence as well as potentially increase health-adjusted life years and offer cost savings. However, these benefits may take several decades to be realised. Combining TFG with other tobacco control strategies could be more effective at reducing smoking prevalence than TFG alone.

- There is no evidence of unintended consequences as there is no evaluation of real-world implementation.

- There is some evidence that TFG could reduce inequalities by sex and ethnicity.

Evidence for increasing the minimum legal age of sale

We identified one US modelling study that explored raising the MLA to 25, which forecast a reduction in smoking prevalence and initiation of tobacco use. Thirty-nine studies were identified that looked at increasing MLA to 21. Most relate to the United States (US) where Tobacco 21 legislation has been variably implemented. We found:

- Most studies found MLA21 reduced, or was projected to reduce, prevalence of smoking combustible cigarettes. However, the evidence was mixed for e-cigarette prevalence. There was inconsistent US evidence of the effect of MLA21 on youth initiation rates of smoking combustible and e-cigarettes. MLA21 also reduced smoking among pregnant young women and improved neonatal outcomes. There is limited evidence for the impact of MLA21 on long-term outcomes such as future cardiovascular events. For non-health outcomes, MLA21 reduced purchasing of tobacco products and e-cigarettes. There was some evidence that MLA21 increased perceived risk of combustible and e-cigarettes among young people. The policy was largely supported by young people and retailers.

- There was some evidence of retailer non-compliance, cross-border purchasing and accessing tobacco products from other sources, i.e. social networks, which could undermine the impact of the policy.

- There is some evidence of a differential impact of MLA21 on smoking prevalence rates by ethnicity, sex, rurality, socioeconomic status and sexual orientation.

Points for consideration

- This scoping review presents a summary of available evidence on TFG and MLA policies but does not provide an overall synthesis of effectiveness. This review should be used as a precursor to an evidence review or other evidence outputs.
- No quality appraisal of included studies was undertaken.
- Modelling studies are not a substitute for evaluation of policy implementation but provide useful evidence of the likely impact of a policy across a range of outcomes and different population subgroups.

2. Executive summary

2.1. What we did

Most smokers start in adolescence, so policies that restrict the sale of tobacco products by age have the potential to prevent smoking and related harm. We undertook a scoping review to identify evidence for two potential policies to restrict the sale and supply of tobacco to younger people:

- Raising the legal smoking age each year to create a tobacco-free generation (TFG).
- Increasing the minimum legal age of sale (MLA) to 21 (MLA21) or 25 (MLA25).

We undertook searches of eight bibliographic databases and an advanced Google search for peer-reviewed and grey literature from inception to July 2023. We included English-language studies that reported on the effect of age-restriction interventions for tobacco on any health and non-health outcomes among young people up to the age of 25. Eligible studies were undertaken in high-income countries for MLA21 and in any country for TFG policies. We only looked at evidence for combustible tobacco cigarettes and nicotine vapour products (NVPs) (an umbrella term that includes e-cigarettes and refill containers (e-liquids) intended for nicotine vaping).

We did not conduct critical appraisal of the evidence due to time constraints and the nature of the review but have summarised the types of evidence available and high-level findings. The scoping report should be used as a precursor to an evidence review or other evidence outputs.

In the results section, we use the terms the authors employed in the included studies for nicotine-containing product type (i.e. cigarettes, e-cigarettes or a combination of both), the health and non-health outcomes that were reported in the studies, regularity of exposure (i.e. past 30-day use, frequent use, current use) and categorisation of ethnicities.

2.2. What we found

2.2.1. Introducing a tobacco-free generation (TFG)

We identified six studies that looked at TFG as an endgame tobacco control measure either alone or in combination with other strategies. Two modelling studies and two evidence reviews were from New Zealand, one modelling study was from the Solomon Islands, and a further modelling study from Singapore. All four modelling studies looked at combustible cigarettes, and two of these also looked at e-cigarettes.

We found no primary studies that investigated the short-term effectiveness of TFG on health or non-health outcomes. Evidence from four modelling studies indicates that a TFG policy could reduce smoking prevalence, increase health-adjusted life years and offer cost savings. However, these benefits may take several decades to be realised. There is evidence from three studies that combined tobacco control strategies which include TFG could be more effective at reducing smoking prevalence than TFG alone. There is evidence from two modelling studies that TFG could reduce inequalities by sex and ethnicity.

2.2.2. Increasing the minimum legal age of sale

We identified only one study that explored the impact of increasing MLA to 25 (MLA25). A US modelling study forecast reductions in smoking prevalence over time compared with the status quo and MLA25 could delay or prevent initiation of tobacco use. No further studies evaluating MLA25 were identified.

We found 39 studies that looked at MLA21, of which 34 relate to the United States (US), where Tobacco 21 (T21) legislation was implemented variably over a long period of time. The staggered introduction of the legislation allowed the use of quasi-experimental research methods, in that states where T21 was enacted were the intervention groups and those where T21 laws were not enacted served as controls. Some of these controlled studies used difference-in-difference analysis, which is considered stronger evidence of effect compared to other included quasi-

experimental methods. In studies that did not have controls, such as cross-sectional and longitudinal studies, the effect of T21 cannot be interpreted.

Prevalence and initiation rates

Thirteen observational studies, of which 12 were controlled, showed that T21 was associated with a reduction in prevalence of combustible cigarette use in adolescents and young adults at national, state and local level, and all five modelling studies provided support for MLA21 as a potentially effective tobacco control option. However, not all reductions were statistically significant and there was some variation in the effect of T21 among age groups. Further, three uncontrolled studies found that T21 had no effect, and one uncontrolled study found that T21 appeared to increase combustible cigarette use. We identified some evidence to suggest variation in effect of T21 on smoking prevalence by ethnicity, sex, rurality, socioeconomic status and sexual orientation.

Observational evidence for the impact of MLA21 on NVP prevalence rates came exclusively from populations in the US and showed mixed effectiveness. T21 implementation was associated with reductions in e-cigarette use in eight studies (of which seven were controlled) and with increases in e-cigarette prevalence in five studies (of which two included controls). There was some inequalities evidence suggesting variability of effect of T21 on ethnicity and race. Protective effects of T21 policies were seen among certain populations.

Evidence from observational studies of the impact of MLA21 on combustible cigarette or NVP initiation among young people in the US is inconsistent: one non-controlled study found significant evidence that MLA21 reduced initiation, but two controlled studies found no significant change in initiation. Conversely, three modelling studies each suggested that MLA21 would lead to significant reductions in initiation in Australia and the US.

Prenatal and maternal health

There is evidence from three US studies, of which two were controlled, that T21 reduces smoking in pregnancy, increases gestational age, decreases the incidence of low birthweight and reduces the likelihood of sudden infant death syndrome.

Cardiovascular outcomes

There is evidence from a US modelling study that T21 could prevent future cardiovascular events (i.e. stroke and heart disease).

Healthcare costs

Evidence from two modelling studies predicted that MLA21 could reduce healthcare costs due to the lower smoking rate and reduced burden of cardiovascular diseases. T21 may affect healthcare costs by ethnicity and sex variably.

Purchasing behaviours

Most evidence for purchasing behaviours relates to the US. Thirteen observational studies found that raising the age of sale to 21 had successfully reduced purchasing of tobacco products and NVPs. However, there was some evidence of retailer non-compliance, cross-border purchasing and under-21s accessing products through older people in their social networks, and the size of the effect is likely to vary between different populations.

There was evidence from 10 studies that young people obtained combustible cigarettes and NVPs from sources other than directly from retailers, which could reduce the effectiveness of raising the minimum age of sale.

Perceptions

Evidence from three studies suggests that young people living in parts of the US with minimum sales age of 21 were likely to perceive cigarettes as more risky than young people in regions with a lower minimum sales age, and that this increased perception

of risk was greatest among those who already smoked. One study provides evidence that T21 in the US led to an increase in young people's perceptions of the risks associated with e-cigarettes, relative to their perceptions of the risks of combustible cigarettes.

Three studies analysing young people's awareness of, and attitudes towards, T21 policies in the US found that young people were largely aware of, and supportive of, T21, although with some doubts about its effect on consumption. Current smokers were less optimistic about the effectiveness than non-smokers. Retailers were highly aware of the intervention, predominantly supportive, and typically thought it was easy to comply with.

Knowledge and awareness

There was evidence from one observational study that knowledge of T21 was associated with reduced intention to use all tobacco products and was higher among states where it had not yet been implemented.

2.3. Key points for consideration

Our scoping review has highlighted a number of key points for consideration as part of the development of TFG or MLA policies:

- While our scoping review identifies and summarises relevant research, it does not provide an evidence synthesis that would allow us to make overall conclusions about the effectiveness of these policies. It would therefore be useful to consider whether further, more robust and specific evidence synthesis would be required.

- The identified modelling studies, while not being a substitute for evaluation of policy implementation, provide useful evidence for policy ideas that have not yet been tried (such as TFG); the likely impact of a policy in isolation or in combination with other tobacco control policies; and for outcomes such as mortality and hospitalisation that typically occur over a longer period of time.

- We identified a number of health outcomes that were commonly investigated by the included studies. These included smoking prevalence and initiation as shorter-term outcomes, and hospitalisation and mortality as longer-term outcomes. Although we have not formally appraised the quality of the included studies, many of those included used study designs that are not well suited to policy evaluation. Consideration should be given to what quasi-experimental designs would be suitable and feasible to evaluate key health outcomes.

- Some studies also looked at important non-health outcomes (e.g. purchasing behaviour, knowledge and attitudes, compliance etc). Consideration should also be given to how evidence could be collected for these outcomes as part of a programme of policy evaluation.

3. Introduction

Smoking is still the leading cause of preventable illness and premature death in Scotland.[1] Regulation of tobacco is a potential means of improving health outcomes and reducing health inequalities.

Smoking prevalence among children and young people is declining. The percentage of 13- and 15-year-olds who were regular smokers of combustible cigarettes was 1.6% and 4.3% respectively, based on the 2021–2022 Scottish Health and Wellbeing Census.[2] Among 16–24-year-olds, Scottish Health Survey 2021 figures indicated 9% were regular smokers.[3] These compare with 2018 figures, which estimated 2% of 13-year-olds, 7% of 15-year-olds[4] and 19% of 16–24-year-olds were regular smokers.[5] By contrast, there has been a rise in daily vape use in recent years, particularly among children and young people.[6] The number of 13- and 15-year-olds who vape regularly (once a week or more) in Scotland between 2018 and 2021/22 has risen from 2% to 4.3% and 3% to 10.1% respectively.[2] This is in line with trends observed in other parts of the UK. Vaping is also prevalent among the 16–24 age cohort, with current use estimated at 16.8% of between November 2021 and November 2022.[7]

UK data indicate that there is a gradient in vape use by age, with ever use highest among 16- and 17-year-olds (29.1%) compared to 11- to 15-year-olds (10.4%).[7] To align with tobacco regulations, the impact of increasing the age of sale of nicotine vapour products (NVPs) is also important, and is a focus of the scoping review.

The Scottish Government is committed to achieving the 2034 smoke-free Scotland ambition of less than 5% smoking prevalence and investigating a package of measures to protect children and young people from becoming smokers and to help smokers quit.[8] In November 2023, the UK Government and devolved administrations announced a proposal for TFG legislation that would annually increase the legal smoking age to prohibit smoking for the next generation. A month-long public consultation on this age-restriction intervention, as well as on actions to reduce the appeal and availability of vapes to children and law enforcement, was conducted in November 2023.

There is an opportunity to learn from other countries' experiences of age-restriction measures, such as increasing the minimum age of sale legislation from 18 to 21 with the Tobacco 21 (T21) bill in the US.[9] New Zealand passed world-first national legislation on the TFG intervention in November 2022.[10] Implementation of TFG in New Zealand would likely have generated the first primary evaluation evidence of TFG. However, in November 2023 a new coalition government withdrew plans to implement the policy due to fiscal reasons.[11]

4. Objective

This scoping report outlines the available effectiveness evidence for two age-restriction interventions for tobacco or NVPs:

- Annually raising the legal smoking age to prohibit smoking for the next generation (i.e. the TFG intervention).
- Increasing the minimum legal age (MLA) of sale to 21 (or 25) to prevent young people from smoking.

4.1. Research questions

To achieve this objective, we identified three specific research questions that included studies should address:

- What is the impact of increasing the age of sale for tobacco and NVPs on youth smoking/vaping rates, purchasing and health outcomes?
- Are there unintended consequences of implementation of these age-restriction measures?
- Is there evidence of health inequalities related to the introduction of these policy measures?

5. Methodology

This scoping review identifies the types of available evidence on age-restriction interventions for tobacco and NVPs. We present a summary of available evidence, but not an overall synthesis of effectiveness. This review should be used as a precursor to an evidence review or other evidence outputs.

In this report, tobacco refers to combustible cigarettes and NVP is an umbrella term that includes e-cigarettes and refill containers (e-liquids) intended for nicotine vaping.[12] We have extracted and used the terms the authors employed in the included studies. Where the authors have not differentiated by nicotine-containing product type (i.e. combustible cigarette, e-cigarette), they have been reported under combustible cigarette use. Cigars, roll-your-own tobacco and smokeless tobacco products, cannabis vaping and the vaping of other legal or illegal substances are not subjects of this report.

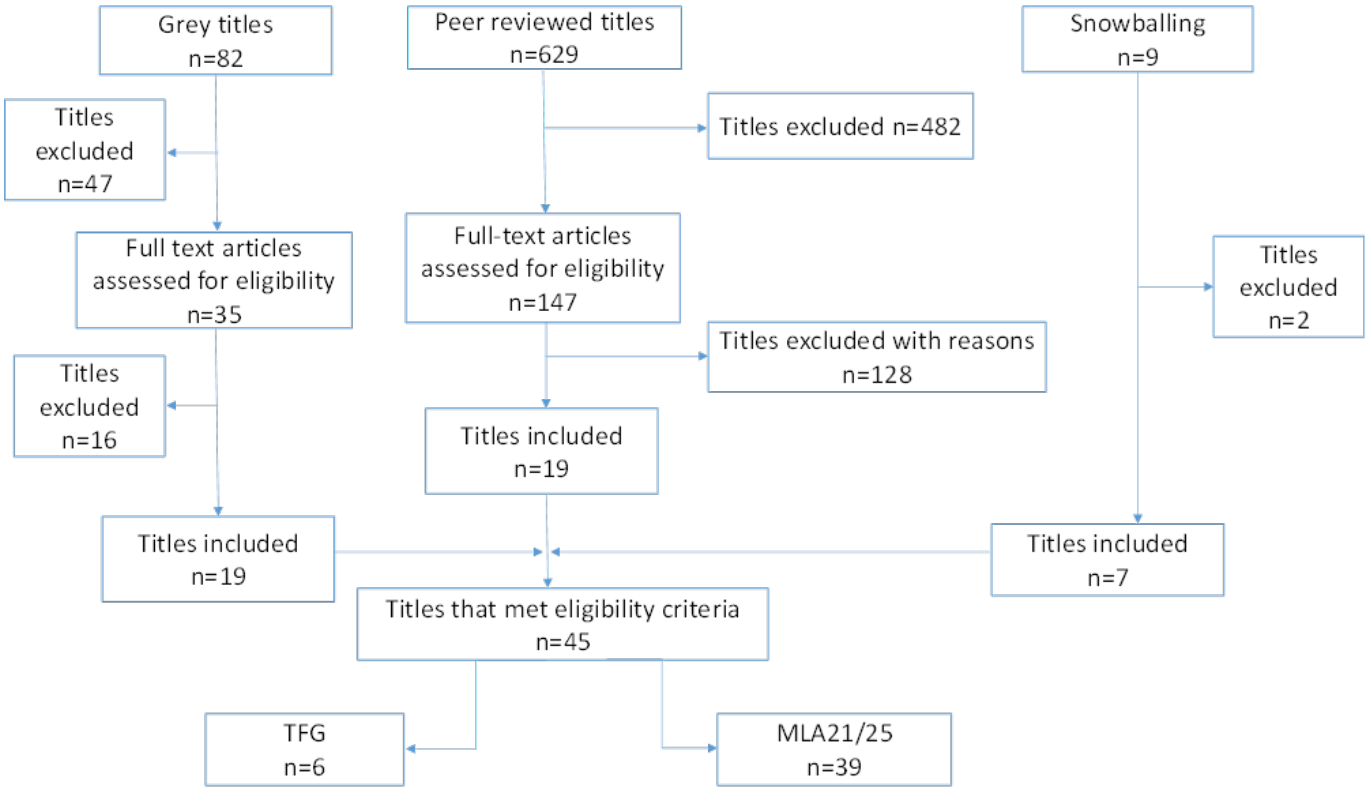
Critical appraisal of identified studies was not carried out due to the nature of the review and tight time constraints. Key characteristics of each study (study design, population (including subgroups), type of nicotine-containing product, intervention type, outcomes, results) were extracted into the software tool Covidence by one reviewer, and high-level findings are summarised by intervention and outcome.

In the results section, we use the terms the authors employed in the included studies for tobacco type, outcomes that aligned to regular use (i.e. past 30-day use, frequent use, current use) and categorisation of ethnicities. See the Technical Report for full methodology (Section 1), search strategy (Section 2) and data extraction tables (Section 3).

6. Overview of findings

After de-duplication, 629 published papers were screened based on their titles and abstracts. Of these, 147 full-text papers were assessed for eligibility. In addition, 82 grey literature papers were screened and nine studies were identified through a process of snowballing (i.e. searching reference lists of selected studies for additional citations). Our scoping review includes 45 studies. A PRISMA diagram outlines the selection process for this review (Figure 1).

Figure 1. PRISMA diagram



Two age-of-sale restrictions were identified: introducing TFG (n=6) and MLA21 or 25 (n=39). Of the 45 studies, most were conducted in the US (n=33), but others were undertaken in New Zealand (n=4), UK (n=3), Canada (n=2), Singapore (n=1), Australia (n=1), and the Solomon Islands (n=1). The study designs were quasi-experimental (n=17), non-experimental (n=18; such as cross-sectional studies (n=6), longitudinal studies (n=3), before-and-after studies (n=5), a qualitative study

(n=1), literature review/briefing paper (n=3)) and modelling studies (n=10). A range of health outcomes were assessed within the included studies, including combustible cigarette and NVP prevalence rates (that aligned to regularity of use i.e. past 30-day use, frequent use, current use), adolescent initiation rates, health-adjusted life years, mortality, stroke/cardiovascular disease and prenatal health among young people. Non-health-related outcomes included purchasing behaviours, perceptions, knowledge and health economic outcomes.

7. Introducing a tobacco-free generation (TFG)

Summary

- We identified six studies that looked at the impact of TFG as an endgame tobacco control measure alone or in combination with other strategies.
- Although we found no primary studies that investigated the effectiveness of TFG on health or non-health outcomes, modelling studies indicate the TFG strategy could reduce combustible cigarette and e-cigarette prevalence, increase health gains and offer cost savings. However, these benefits may take several decades to be realised. There is some modelling evidence that combined strategies which include TFG could be more effective at reducing smoking prevalence than TFG alone.

  While there was some evidence from two modelling studies that predicted reduced inequalities for smoking prevalence by introducing TFG, some differences by sex and ethnicity were forecast for health gains.

TFG is one type of endgame policy, which is an initiative to permanently eliminate the use of tobacco and/or e-cigarettes when fully implemented.[13] When implementing TFG policies, the minimum age of sale increases every year, with the objective of a generation growing up never legally allowed to buy tobacco and therefore breaking the cycle of addiction. There are currently no countries where the TFG intervention is in place. Legislation was passed in New Zealand in 2022 and due to be implemented in 2024 affecting those born after 2009. However, it was recently revoked due a change in government and fiscal constraints.[14] A TFG policy is currently in place in Brookline, Massachusetts, and applies to those born after 2000. However, it is largely symbolic as it only applies to this small Boston suburb.[15] Legislation has been proposed in Malaysia[16] and is being considered in many countries including the Netherlands,[17] Scotland,[8] England,[18] Singapore, Russia and some Scandinavian countries.[19]

7.1. Effect on prevalence rates

We identified six studies that looked at TFG as an endgame tobacco control strategy to reduce prevalence among young people (Appendix 3.1). These assessed TFG either alone or in combination with other endgame strategies including retail outlet reduction, increasing licensing age of sale, taxes, denicotinisation (reducing the quantity of nicotine contained in smoked tobacco products) and sinking lid on the tobacco supply (which involves regular reductions in supply of tobacco products imported or for sale until they are no longer available).

All studies reported the impact of TFG on the prevalence of combustible cigarette smoking, and two also looked at prevalence of both combustible cigarettes and e-cigarette use.[20,21]

Two studies were high-level evidence summaries that related to New Zealand's Smokefree 2025 Aotearoa action plan.[19,22] The action plan considered a range of tobacco control interventions that have the potential to achieve the Smokefree 2025 Aotearoa goal of a prevalence of <5%, such as:

- reduced appeal and addictiveness of tobacco via reducing nicotine levels, removing filters or regulating product design
- reduced availability via increasing age limits for legal purchase or reducing retail outlets
- reduced affordability via setting a minimum price.[10]

The Aotearoa Ministry of Health (2021) briefing paper highlighted unpublished modelling data (Otago University) which indicated that increasing age limits for legal purchase until there is a smokefree generation could lead to 1.2% absolute lower prevalence for Māori and 0.4% for non-Māori by 2025 and halve smoking rates within 10–15 years of implementation. A combined approach of low-nicotine cigarettes, regulated product design, increasing purchase age (i.e. TFG) and a regulated market would meet the <5% prevalence goal in 2025 for Māori males and both non-Māori males and females. The evidence feasibility review which underpins the action plan also concurred that, while no direct evidence for TFG effectiveness is available, the

rationale for the policy is sound and modelling evidence supports potential for effectiveness and health system cost savings.[19]

We identified four published modelling studies. Two modelling studies provided data to support the Aotearoa New Zealand action plan[21,23] and each indicated that TFG alone would not meet the <5% smoking prevalence goal by 2025, but that it was associated with reductions in combustible cigarette prevalence. Modelling data from the Van der Deen study suggested that TFG strategy could halve combustible cigarette prevalence by 2025 for those aged <45 years for both Māori and non-Māori populations compared with a business-as-usual scenario.[23] Ouakrim et al modelled smoking and vaping behaviours, and predicted that a daily smoking (and vaping) prevalence (i.e. at least one cigarette/e-cigarette per day) of 6.9% (95% uncertainty interval (UI) 4.4 to 8.8%) could be achieved by 2040 with only a TFG strategy (compared with 15.4% in 2020). This compares with 7.9% prevalence (95% UI 5.1 to 9.8%) for the business-as-usual scenario.[*21]

The Solomon Islands have also embraced the <5% prevalence Tobacco-Free Pacific Goal by 2025. Singh and colleagues conducted a multistate life table simulation model using Global Burden of Disease data and estimated the effects of the following single policies on the 2016 population over the remainder of their lives: eliminating cigarette smoking, 25% per annum tax increases to 2025 and TFG.[24] They found that, compared with business-as-usual, TFG and tax strategies independently reduced projected smoking prevalence, but neither strategy met the Tobacco-Free Pacific Goal by 2025. Overall, tobacco tax increases were more effective at reducing smoking prevalence at younger ages than the TFG strategy due to greater price responsiveness. Males benefited more than females from both strategies due to higher baseline smoking rates.

[*] Baseline rates were not reported, but data from Ouakrim et al reported business-as-usual 2022 prevalence rates for Māori and non- Māori to be 31.8% (female 37.1%, male 30.6%) and 11.8% (female 11.8%, male 13.1%) respectively.

There is currently no direct evidence of short-term effectiveness for TFG available since this policy has not yet been implemented in any country. However, modelling data provide support for implementing this measure.[19] All studies indicated that the TFG strategy could reduce smoking prevalence rates, but its impact needed longer to take effect on reaching <5% prevalence target. Combined tobacco control strategies that include TFG could result in greater reductions in smoking prevalence compared with business-as-usual in three studies[20,21,23] and with TFG alone in two studies.[21,23]

Doan et al used data from Singapore* and countries such as USA, UK and Japan (where there is a large e-cigarette market share) to model the population's tobacco and e-cigarette use under status quo (i.e. tobacco control policies in 2017) and various policies including raising the minimum licensing age for combustible cigarettes to 21 (MLA21), introducing a TFG, raising tobacco taxes (every 2 or 5 years: TAX2 and TAX5 respectively) and legalising e-cigarettes (either on general sale to all people aged 18 and over, on prescription to smokers only from a doctor or restricting sale to adults aged 25 or over).[20] A combination of these policies was also modelled. Of the seven single policies considered, an aggressive tax regime (TAX2) and TFG independently might be the most effective at reducing cigarette use, followed by a combined approach of MLA21 and TAX5. Under the scenario where e-cigarettes are for general sale, there was an initial decrease in smoking prevalence as smokers of combustible cigarettes switched to e-cigarettes, but levels then stabilised. This suggests the policy where e-cigarettes are for general sale is effective in the short term but not as effective as other policies at reducing smoking prevalence in the long term. For e-cigarette use, the policies with the best modelled prevalence outcome (i.e. lowest prevalence) were MLA21 plus moderate tax rises and e-cigarettes on prescription. The authors note that their analyses supported MLA21 as a satisfactory measure, but that extending this to prohibit sales to birth

* Singapore has strict tobacco control policies including implementing a minimum legal age of 21 for combustible cigarettes, banning e-cigarettes and proposing a TFG beginning with a 2000 birth cohort.

cohorts from year 2000 would have a lasting effect, avoid difficulties in enforcing MLAs and minimise social supply.

Inequalities: The modelled inequalities evidence we identified compared Māori and non-Māori* populations in New Zealand. These studies predicted reduced inequalities in smoking prevalence.[23] There were also some differences in prevalence by sex in the Doan et al study.[20] However, any policy modelling or evaluation would need to consider inequalities in the Scottish context.

7.2. Effect on all-cause mortality

There is evidence from one New Zealand modelling study that TFG would contribute minimally to all-cause mortality reduction from 2020 to 2040 (31 deaths averted for TFG compared with 8,150 for the combined strategy) (Appendix 3.1).[21] Given the age profile of those affected by the TFG strategy and length of follow-up, the small number of deaths averted under TFG strategy is not unexpected.

7.3. Effect on future population health and healthcare costs

Three studies looked at the effect of TFG on health-adjusted life years (HALYs), which is a measurement of the health of a population typically used in estimates of the burden of disease (Appendix 3.1). Two studies modelled the potential impact of TFG in New Zealand[21] and one in the Solomon Islands.[24] Given the heterogeneity of the models and populations, HALY gains are not comparable. However, all studies reported that the TFG strategy increased HALYs, with two studies reporting the majority of health gains in the longer term.[21,24] Individual HALY results are reported below.

Solomon Islands data suggest that the TFG strategy could achieve a gain of 798 HALYs per 1,000 people (95% UI 403 to 1,321) over the lifetime of the 2016

* Throughout, the categorisation of ethnicities (i.e. Māori, Hispanic, Black, White, African American etc) was given by the authors of the study.

population. This compares with 1,510 HALYs per 1,000 for eradicating tobacco and 370 HALYs per 1,000 for the tax intervention. Data suggest that only 8% of HALYs accrued from TFG occur over the first 20 years (2016 to 2035). The majority are achieved over the rest of the lifespan.[24]

Two studies modelled the likely impacts of TFG on New Zealand's population. Preliminary modelling data suggest that 125,000 HALYs could be gained over the lifetime of the 2020 New Zealand population by introducing a TFG strategy, compared to business as usual (all ages, discounted at 3% per year[*]).[22] Published data by Ouakrim et al used a proportional multistate life table model to suggest that out of a combined package of policies, TFG alone contributes 13% of estimated HALYs gained (594,000 combined; 95% uncertainty interval (UI): 443,000 to 738,000; 3% discount rate) and 98% of HALYs gained over the lifespan of the population occurred after 2040.[21]

In a further New Zealand study, Van der Deen and colleagues also used a multistate life table model to estimate future population health and the timing of these gains, as well as forecasting healthcare costs associated with various endgame strategies (Appendix 3.2).[23] Health benefits were measured in terms of quantity and quality of life, and reported using quality-adjusted life year (QALY) as an outcome measure. Under TFG, QALYs accrued over 2011 population's lives were 83,200 (95% UI 55,400, 119,000). This compared with 28,900 (95% UI 16,500, 48,200) for retail outlet reduction and 282,000 (95% UI 189,000, 405,000) under sinking lid strategy. The timing of health gains and cost savings varied but those for TFG peaked in 2070, decades later in the 2011 New Zealand population's life than for other strategies.[23]

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[*] Discounting is a way of taking into account how the timing of future costs and benefits affects the value we place on them in the present. The 'discount rate' is the rate used to convert future cost and benefits into present values. For example, if we use an annual discount rate of 3%, then a cost of £1,000 10 years in the future would be worth £744 today (calculated as follows: £1,000/1.03^{10}).

In terms of healthcare costs, Van der Deen reported that TFG was a mid-range option, with cost savings estimated to be NZ$1.94 billion (95% UI NZ$1.3 to $2.18 billion). This equates to £1.54 billion, 95% UI £633 million to £1.74 billion based on currency conversion rates on 11 December 2023.

Inequalities: The Solomon Islands modelling study provided some insight into the differences in health gains by sex, with twice as many HALYs accrued over the lifetime under the TFG strategy among males compared with females (1,052 versus 535 HALYs respectively) due to males having higher baseline smoking rates.[24] One of the New Zealand modelling studies also reported differences in health gains by sex and ethnicity for the TFG strategy, with Māori females[i] projected to gain nine times as many HALYs per capita as non-Māori-females[i] and Māori males[i] gain to 3.6 times as many as non-Māori males[i]; all other interventions had similar Māori:non-Māori ratios of per capita HALY gains over the remainder of the 2020 Aotearoa/New Zealand population's lifespan.[21]

7.4. Effect on purchasing behaviour

We did not find any studies that reported on the effect of TFG on purchasing behaviours, but a literature review highlighted one New Zealand qualitative study in which tobacco control experts raised a concern that the tobacco control policy would increase ethnic and social disparities in smoking (Appendix 3.2).[22] This was anticipated to be influenced by retail non-compliance and social supply to minors (most likely via family rather than friends), which were considered more common in Māori and Pacific communities. However, Pacific tobacco control experts anticipated that this policy would receive community support.

8. Increasing the minimum legal age of sale

Summary

- We identified limited evidence for MLA25 with only one US modelling study that indicated MLA25 could reduce smoking prevalence and initiation of tobacco use.

- The evidence base for MLA21 was predominantly produced in the US. Most of the observational evidence and all modelling evidence found MLA21 reduced, or was projected to reduce, combustible tobacco cigarette prevalence. US observational evidence for the impact of MLA21 on NVP prevalence is mixed. There is some evidence to suggest variation in effect of MLA21 on smoking prevalence rates by ethnicity, sex, rurality, socioeconomic status and sexual orientation.

- US observational evidence is inconsistent, but modelling data from US and Australia suggest MLA21 reduces or could reduce initiation rates for combustible cigarettes and NVPs among adolescents and young people.

- There is some US evidence that MLA21 reduces smoking among pregnant young mothers and improves neonatal outcomes. There is limited evidence that MLA21 could prevent future cardiovascular events.

- Some modelling evidence forecast reductions in healthcare costs in the US due to the reduced smoking and reduced burden of cardiovascular diseases, with differential effects by ethnicity and sex.

- Most US evidence found that MLA21 successfully reduced purchasing of tobacco products and NVPs. However, there was some evidence of retailer non-compliance, cross-border purchasing and under 21s accessing products through older people in their social networks, and the size of the effect is likely to vary between different populations. Young people obtained tobacco

and NVPs from sources other than directly from retailers, which could reduce the effectiveness of MLA21.

- Evidence suggests that young people living in places with MLA21 may be more likely to perceive combustible cigarettes as more risky than young people in regions with a lower minimum sales age. There is evidence that inclusion of NVPs in MLA21 in some US states led to a greater increase in young people's perceptions of the risks associated with NVPs than with combustible tobacco cigarettes.

- US evidence suggests that young people were largely aware of, and supportive of, MLA21 policies, although with some doubts about its effect on consumption. Current smokers were less optimistic about effectiveness than were non-smokers. Retailers were highly aware of the intervention, predominantly supportive, and typically thought it was easy to comply with.

- There was limited evidence that knowledge of MLA21 was associated with reduced intention to use all tobacco products.

Although global prevalence of combustible tobacco cigarette smoking among 15–24-year-olds has been decreasing since 1990, it is still above 20% in many countries.[25] NVPs were developed in 2003 and their use has rapidly expanded among young people such that they are now a public health concern. Since 2014, NVPs have been the most commonly used tobacco product in the US, replacing conventional combustible cigarettes.[26]

Together with TFG, raising the MLA of sale of tobacco products to 21 or 25 is another policy measure to control the tobacco use among children and young people. Globally, 83% of smokers start smoking between the ages of 14 and 25 so this is a critical window of intervention.[25] In the UK, 66% of adults, who were current smokers or had been regular smokers, began smoking before the age of 18, and 40% reported smoking regularly before the age of 16.[27]

8.1. MLA25

We identified only one US modelling study that explored the impact of increasing the minimum legal age of sale of tobacco to 25 (MLA25). The 2015 Institute of Medicine's report suggested that modelling data forecast an estimated 16% reduction in smoking prevalence from 2014 to 2100 compared with the status quo (i.e. no change in the MLA). MLA25 could prevent or delay starting smoking, however the greatest impact is likely to be in 15–17-year-olds, with smaller reductions in initiation seen in older age groups.

No further studies evaluating MLA25 were identified.

8.2. MLA21

Legislation that prohibits retailers selling tobacco products rather than criminalising their purchase or possession by those under 21 is known as Tobacco 21 or T21. T21 applies to both tobacco and NVPs. T21 was implemented across the US on 20 December 2019. Although this is federal legislation and hence applies to all states, it is not yet enforceable at a national level and nine states do not yet have a state law for T21.[28] Prior to the federal legislation in 2019, T21 in the US started with the town of Needham, Massachusetts, which enacted the law in 2005. Hawaii also passed statewide T21 legislation in 2015, and many other towns and states followed. Outside the US, Ethiopia, Honduras, Kazakhstan, Mongolia, the Philippines, Singapore, Sri Lanka, Turkmenistan and Uganda are some of the countries that prohibit the sale of tobacco products to those under 21.[29] In addition, many cities or areas have T21 laws, for example Prince Edward Island in Canada.[30]

8.2.1. Effect on prevalence rates

We found 24 studies that looked at the effect of MLA21 on combustible tobacco cigarettes and NVP prevalence. Most of the evidence relates to the US, where T21 laws were implemented over a long period of time and the staggered introduction across different regions and states facilitated the use of quasi-experimental research methods. States where T21 was enacted became the intervention group

and those where T21 laws were not enacted served as controls. Some of these controlled studies used difference-in-difference analysis, which is considered stronger evidence of effect. In studies without controls, such as cross-sectional and longitudinal studies, the effect of T21 cannot be interpreted.

8.2.1.1. Combustible cigarette prevalence rates

We identified 22 studies that evaluated the effect of increasing the MLA to 21 on prevalence rates of combustible cigarettes (Appendix 3.3). Seventeen observational studies were conducted in the US and compared the impact of T21 before and after implementation using either prospective cohorts,[31,32,33] repeated cross-sections of data with controls[34,35,36,37,38,39,40,41,42,43,44,45] and without controls[46] or for different cohorts.[47] Five modelling studies were also identified: two were from the US and assessed T21[48,49] and three were from Australia,[50] Canada[51] and the UK[52] which evaluated the long-term effects of introducing an MLA21 policy.

Eight studies examined the effects of T21 policy by age.[32,34,35,36,37,38,40,42,43,44,46]

Eight studies assessed the effect of T21 at a national level.[33,34,35,36,38,39,40,44] Six studies looked at T21 policies enacted at state level such as Minnesota[37,42] and California[31,32,36,46] while others assessed local implementation in municipalities such as Needham, Massachusetts,[45] Cleveland, Ohio,[41] New York City (NYC), New York State[43] and Columbus, Ohio.[47]

The impact of MLA21 is summarised by effect and study design. National evaluations are described first, followed by state and regional ones.

Reductions in prevalence

The majority of the observational evidence (13 of 17 studies) showed that T21 was associated with a reduction in prevalence of combustible cigarette use in adolescents and young adults, and all five modelling studies provided support for MLA21 as a tobacco control policy. Although all studies showed reductions in cigarette use associated with T21, not all were significant and there was some

variation among age groups. Variation in population-level data and how it was analysed makes it difficult to draw comparisons between effect sizes of studies.

Controlled studies

Twelve controlled observational studies showed reductions in combustible cigarette prevalence. Four quasi-experimental studies and two controlled cross-sectional studies examined the impacts of statewide T21 laws on youth tobacco consumption predominantly using nationally representative datasets, and reported results by age, which show consistency in significant reductions across older age groups (16–17 years and 18–20 years). These studies are presented here.

The first of these is a study by Friedman et al in which difference-in-difference analyses indicated that local T21 policies were associated with a 3.1 percentage point reduction in the likelihood of being a current established smoker among 18-to-20-year-olds compared those without T21 policies ($p=0.012$). Partial implementation of T21 policies also significantly reduced the likelihood of smoking by a 1.2 percentage point decrease ($p<0.05$).[39]

Consistent with Friedman et al, Hansen et al reported that statewide T21 laws led to a significant decline in prior 30-day smoking participation among 18–20-year-olds by 2.5 to 3.9 percentage points compared to states without T21 (baseline rate 12.3%). When stratified by age, T21 reduced smoking by 3–7 percentage points among 18-year-old high school students and 2.8 percentage-points among 16–17-year-olds (baseline rates 18.3% and 12.5% respectively). They had no effect on smoking among 13–15-year-olds and 21–23-year-olds.[40]

In a one-year evaluation of state-wide T21 policies, Agaku et al reported that 16–17-year-olds and 18–20-year-olds living in states with T21 had a significantly lowered likelihood of being a current cigarette smoker compared with those living in states without T21 (adjusted prevalence ratios 0.7 and 0.58 respectively, $p<0.05$).[34]

Similarly, Abouk et al looked at cigarette use in middle- and high-school students and difference-in-difference analyses showed T21 significantly reduced 12th graders' cigarette use by 2.3 percentage points or 21.4% of the baseline smoking rate ($p<0.01$), but only modestly reduced cigarette use for 8th and 10th graders

(approximately 13–16 years old) by 1 percentage point and this was a non-significant reduction.[35]

Additionally at national level we identified two controlled cross-sectional studies from the US. The Friedman et al study did not separate by tobacco type and reported a combined prevalence for combustible and/or electronic cigarettes. The authors found that T21 laws were associated with a 39% reduction in the odds of both recent smoking (p=0.01) and current established smoking (p=0.04) among 18–20-year-olds who have ever tried a combustible or electronic cigarette, as compared to similar 21–22-year-olds.[38]

Colston et al reported combustible cigarette prevalence among senior high-school students, and found that 12th graders (aged 17–18) from T21 counties were 26% significantly less likely to report having smoked a cigarette in the past 30 days (adjusted risk ratio 0.74; 95% CI 0.60–0.91) than 12th graders from non-T21 counties, while 8th and 10th graders from T21 counties had similar or marginally lower likelihood of past 30-day smoking participation than 8th and 10th graders from non-T21 counties (adjusted risk ratio 0.91 and 0.96, respectively).[44]

Three quasi-experimental studies assessed the implementation of T21 in individual US states, such as California[36] and Minnesota.[37,42] Dove et al reported pre- and post-T21 decreases in daily smoking prevalence among 18–20-year-olds in California as 8% and 26% respectively. While the difference-in-difference estimate indicated a non-significant 20% decrease in daily smoking for 18–20-year-olds in California compared with the control states, there was a significant decrease of 38% in daily smoking after T21 in 18–20-year-olds compared with 21–23-year-olds in California ($p<0.05$).[36]

The effect of statewide implementation of T21 in Minnesota was assessed by age group in Wilhelm et al[42] and the Minnesota Department of Health.[37] Wilhelm et al reported that younger students (8th and 9th grade) from schools within jurisdictions with T21 policies demonstrated a 19% reduction in odds of cigarette use relative to students from schools without T21 ($p<0.05$); significant effects were not seen among older students (11th grade).[42] This trend was also demonstrated in the Minnesota Department of Health study.[37]

Three controlled studies assessed local implementation of T21 policies.[41,43,45] In a quasi-experimental study, Trapl et al reported that there was a decline in cigarette use among 9th to 12th grade students from 2013 to 2017 in Cleveland (which had enacted T21) (7.6% to 4.5%) and the inner suburbs that had not (10.6% to 5.8%). However, the difference-in-difference estimate was non-significant.[41]

Macinko et al reported that past 30-day cigarette use declined among 12–18-year-old adolescents between 2007 and 2016 in NYC but the rate of change was greater in the control locations (rest of New York State and four Florida counties). Difference-in-difference analysis suggested the effect of NYC's T21 policy on cigarette use was not significant compared with New York State, overall or for high- or middle-school students. However, for NYC compared to the Florida control, current cigarette use was statistically significant (overall and for under-18s, adjusted prevalence ratio 1.4 and 1.34; $p<0.05$). By 2015, the prevalence in NYC and four Florida counties was almost equivalent.[43]

In a controlled cross-sectional study, Schneider et al found T21 was associated with a significantly greater decrease in 30-day smoking in Needham, Massachusetts, relative to comparison communities ($p<.001$). This decline was consistent across high school grades 10–12.[45]

Uncontrolled studies

A small longitudinal study, in which Sax et al monitored combustible cigarette use in a cohort of 575 Californian youths during 2015–2019, found cigarette smoking prevalence significantly decreased after the implementation of T21 ($p<0.001$).[31] It is difficult to infer the meaning of this result in absence of controls.

Modelling studies

Five modelling studies predicted reduced combustible cigarette prevalence rates after implementing age restriction measures in the US,[48,49] UK,[52] Australia[50] and Canada.[51]

UK modelling data used a nationally representative sample from the Smoking Toolkit Study to estimate that increasing the MLA from 18 to 21 would lead to an immediate 30% reduction in the number of smokers in year one (2022) and further

reduce prevalence among 18–20-year-olds to 2% in 2030 (compared to 9.6% without this intervention).[52]

The first of the US modelling studies estimated that raising the MLA to 21 would likely lead to substantial reductions in smoking prevalence among 2015 teens by 2100, with decreases of approximately 12% compared with the status quo scenario.[48] One further US modelling study estimated the long-term regional effects of T21 in El Paso county (where the policy had been introduced in the state of Texas in 2019) and forecast a 2.7% decrease in smoking prevalence among adults aged 18–24 years by 2040 (from 9.5% in 2020).[49]

Both Skinner and Chaiton investigated the potential impacts of increasing MLA to legally purchase tobacco to 21 years among other tobacco control interventions in regional areas of Australia and Canada respectively.[50,51] Ontario modelling data indicated that increasing MLA to 21 would reduce smoking prevalence to 10.5% by the year 2035 compared with 13.2% under baseline status quo (8% among the 20–34-year-olds; 2.7 and 5.2 percentage point decrease, respectively), compared with a decrease of 2.8 percentage points for increasing tax on tobacco and 1.5 percentage points for tobacco outlet reduction.[51] However, Queensland state modelling data showed that while MLA21 could have minimal impact on smoking prevalence among 18–29-year-olds over the simulation period (1997–2037),[*] it could have an impact on adolescents.[50]

Increases in prevalence

Uncontrolled studies

We identified one uncontrolled study that reported T21 was associated with increases in combustible cigarette prevalence. In a before-and-after study that prospectively followed the same cohort of university students (first year in 2016,

[*] (0.08% reduction compared with business-as-usual scenario) relative to other scenarios (anti-smoking advertising 0.8% or licensing changes 1.46-2.4% reduction).

followed up as third year in 2018), T21 was associated with a significant increase in past-30-day e-cigarette use (from 6.6% to 8.2%, $p<0.05$) but with no significant difference between 2016 first-year students (6.6%) and 2018 first-year students (4.1%).[47]

Evidence of no effect on prevalence

Uncontrolled studies

Evidence for no effect of T21 came from three uncontrolled studies, in which two were longitudinal studies[32,33] and one was a cross-sectional study.[46]

Patel used a large nationally representative sample of 13,990 youths to measure the effects of local and statewide T21 implementation from 2014 to 2019[33] while Schiff et al followed a smaller cohort of 2,812 in southern California from 2015 to 2017.[32] Both reported that T21 had negligible or no effect on cigarette smoking among youth and young adults. In addition, no effect of T21 on past 30-day cigarette smoking was seen in one repeated cross-sectional study of high-school adolescents.[46]

Inequalities: Inequality evidence largely came from US observational studies evaluating the effects of T21 on combustible cigarette use. There is mixed evidence of effect of T21 by sex. Both Schneider et al and Trapl et al reported reduced disparities,[41,45] while Abouk et al found more pronounced effects among males than females (among older adolescents),[35] and Hansen suggested the reverse trend – but this was not statistically significant.[40]

Evidence of differential effects of T21 by ethnicity is reported in seven studies.[34,35,41,44,45,46,49] Schneider et al reported[45] and Garney et al predicted[49] no differences in combustible cigarette prevalence across different populations. However, Agaku et al noted the protective effect of T21 on White adolescents compared with other ethnic or racial groups[34] and Abouk, Colston, Grube and Trapl all reported greater reductions in disparities for people from ethnic minority backgrounds, in particular Hispanic populations.[35,41,44,46] Hansen et al reported that African Americans were more likely to be affected by T21 laws.[40]

Hansen et al also explored the differential effects of T21 laws in 18–20-year-olds by socioeconomic status, and found that T21 laws decreased smoking participation (defined as smoking every day or some days) relatively more in poor households than non-poor households; the opposite trend is observed for everyday smoking.[40] Colston also noted that parental education and further education modified the effects of T21.[44]

In a cross-sectional study assessing the sociodemographic profile of smokers targeted by an increased age restriction, Beard et al estimated that increasing the MLA to 21 years in England would currently target approximately 364,000 lower dependent smokers from more disadvantaged backgrounds aged 18–20 who have lower motivation to quit.[53]

Finally, Garcia-Ramirez et al reported that California's T21 was not significantly associated with changes in past-30 day cigarette use, although sexual minority students were more likely than non-sexual-minority students to report past-30 day use (odds ratio 2.47).[54]

8.2.1.2. NVP prevalence rates

We identified 13 observational studies evaluating the impact of increasing age restriction measures to 21 on the prevalence of e-cigarette use (Appendix 3.3). Nine were quasi-experimental studies,[34,35,37,40,41,42,43,55,56] two were longitudinal studies,[32,33] one was a repeated cross-sectional study[46] and one was a before-and-after study.[47] All studies were undertaken in the US and each one evaluated T21. The impact of T21 is summarised by effect on combustible cigarette prevalence and studies are separated by study design.

Reductions in prevalence

T21 implementation was associated with reductions in e-cigarette use in eight studies, of which seven were controlled[34,35,37,40,41,42,55] and one was uncontrolled.[32]

Controlled studies

Seven quasi-experimental studies compared states with T21 policies with control states where T21 had not been enacted. Four quasi-experimental studies looked at T21 implementation nationally,[34,35,40,55] two at state level[37,42] and one locally.[41] All showed reductions in e-cigarette prevalence, with some variation across age groups and significance of effect.

The first national evaluation of T21 reported that this policy significantly reduced e-cigarette use across all high-school age groups (8th, 10th and 12th grade students), with difference-in-difference estimates indicating the effects are more notable among 12th graders compared with 8th/10th graders (6.8 vs 2.2 percentage points respectively, $p<0.01$).[35] Hansen et al also reported that T21 significantly reduced daily e-cigarette use among 18-year-old students by 5.2 percentage points ($p<0.05$), but was not effective at reducing use among those aged 16–17.[40] Another national study evaluated T21 policies after one year of implementation and found a non-significant reduction associated with e-cigarette use among high school students in T21 areas (adjusted prevalence ratio 0.91; 95%CI 0.79, 1.04).[34]

A large national analysis by Choi et al reported that T21 policy was associated with a relative reduction among grade 9 to 12 students. This quasi-experimental study analysed cross-sectional data from Youth Risk Behavior Survey state surveys in 2017 and 2019 in 34 US states and found that both states with and without the T21 policy enacted showed increased frequent e-cigarette use, although this increase was twice as large among states without T21 policies than those without (adjusted odds ratio 2.29 and 4.07 respectively, $p=0.02$).[55]

Two quasi-experimental studies examined T21 policies at state level using data from the Minnesota Student Survey, and both reported greater reductions among younger age groups. The first is a report by Minnesota Department of Health which found that T21 policies were associated with less use of e-cigarettes among 8th and 9th graders (15% for no T21 areas versus 11.8% for T21 areas, significance level not reported).[37] The second is an analysis of repeated cross-sectional data across a three-year period (2016–2019) which observed a 22% reduced likelihood of 13–15-year-olds using e-cigarettes in areas with T21 compared with those without T21 ($p<0.05$).[42]

The final controlled study examined local implementation of T21 in the city of Cleveland and found that although a decreasing trend in e-cigarette use among 9th–12th grade high-school students one year post legislation was seen in both Cleveland and its surrounding municipalities without age restriction policies, a significant reduction of 23% ($p<0.001$) was seen in Cleveland compared with local municipalities, which recorded percentages ranging from 20.1% (2015) to 12.4% (2017).[41]

Uncontrolled studies

Finally, we identified one uncontrolled study using prospective state-level data which reported reduced NVP prevalence after T21 among young people. In a longitudinal study of 19–20-year-olds from communities across southern California, Schiff and colleagues showed a small decrease in past 30-day e-cigarette use from 12.9% pre-T21 to 9.4% post-T21, but the significance of this change was not reported.[32]

Increases in prevalence

Five studies showed that the T21 policy was associated with increases in e-cigarette prevalence; two of these included controls[43,56] and three did not.[33,46,47]

Controlled studies

The first controlled study compared the impact of T21 in NYC among high-school students with two controls (New York state and four Florida cities). Increased prevalence was broadly similar for NYC (6.85% in 2014 to 14.9% in 2016) compared with New York state (8.1% in 2014 to 14.1% in 2016) suggesting there was minimal impact of T21 (NYC Youth Tobacco Survey). However, the 2015 prevalence of 15.9% in NYC was significantly different to that of four Florida cities (20.74%) ($p<0.001$) (Youth Risk Behaviour Surveillance). While T21 may have reduced e-cigarette use, without earlier data (questions on e-cigarette use were first included in Youth Risk Behaviour Surveillance in 2015) this result is difficult to interpret.[43]

Debchoudhury et al also reported increases in e-cigarette use among older high-school students in NYC. Current e-cigarette prevalence increased from 8.1% in

2014 to 23.5% in 2018 (p<0.001), which was similar to e-cigarette trends for pupils in the rest of the state where T21 had not been implemented (12.0% in 2014 to 29.3% in 2018, p<0.001). Among middle-school pupils, current e-cigarette use increased between 2014 (4.8%) and 2016 (9.0%) then fell by 2018 (5.7%) (2014 vs 2018, p=0.576). This compared with an increase for the rest of state data (2.2% versus 7.4%, p<0.001).[56]

Uncontrolled studies

In a longitudinal study using nationally representative data from a large prospective cohort of individuals aged 15–21, Patel et al reported that there was a significant positive association between T21 exposure and e-cigarette use (adjusted odds ratio 1.45, p<0.003).[33] At state level, a repeated cross-sectional study also provided some evidence of a positive association in past-month e-cigarette use (adjusted odds ratio 1.09, p<0.001).[46]

A before-and-after study showed T21 was associated with a four-fold increase in 30-day e-cigarette use in a prospective cohort of students (mean age 18.6 years followed from 2016 to 2018 (7.4% to 32.6%, p<0.05) and a significant difference in use between first-year students (mean age 18.6 years) in 2016 and 2018 (p<0.05).[47]

Inequalities: Inequality evidence for the effect of T21 on e-cigarette prevalence was inconsistent in terms of ethnicity,[41,56] with differential effects observed in three of out five studies.[34,35,46,56]

One quasi-experimental study assessed rural–urban differences in local T21 implementation in Kansas and noted that there were marked changes in e-cigarette prevalence between rural and urban areas in 2018 to 2019 (6.7 versus 2.1 percentage point change respectively), but when T21 areas were compared with non-T21 areas, benefits were seen for both rural and urban areas.[57]

A before-and-after study by Garcia-Ramirez et al found that California's T21 law did not lead to any significant changes in 30-day e-cigarette use among sexual-minority youth (odds ratio 1.02; 95% CI 0.98, 1.06), although it led to a significant increase among non-sexual-minority students (odds ratio 1.06; 95% CI 1.04, 1.09).[54]

8.2.2. Effect on adolescent initiation rates

We identified seven papers that presented evidence about whether T21 laws may reduce initiation of tobacco products or NVPs among young people (Appendix 3.3).[43,44,48,50,58,59,60]

Three papers presented observational studies which found evidence that T21 laws reduced the likelihood of young people initiating tobacco use.[43,44,58]

Uncontrolled studies

A non-controlled analysis of young people's tobacco-related behaviours before and after the introduction of T21 in Oregon found that, among people who were current tobacco users, the increase in minimum sales age was associated with statistically significant decreases in tobacco use having been initiated in the previous six months.[58] Among current smokers aged 13–17, this proportion decreased from 34% to 25%, while in those aged 18–20 the proportion decreased from 23% to 18%.

Controlled studies

A national, cross-sectional study comparing counties with comprehensive T21 coverage with counties without comprehensive T21 coverage found that the presence of T21 laws was associated with lower likelihood of initiation of first tobacco use among students in the 8th, 10th or 12th grade, as well initiation of daily smoking among 10th and 12th graders. However, none of these associations were statistically significant.[44] Similarly, a quasi-experimental study of the impacts of T21 in NYC, compared with the rest of New York state, found no significant association between the implementation of T21 and mean age of tobacco initiation.[43]

Modelling studies

While the observational studies provided uncertain evidence, studies modelling the effects of a minimum sales age of 21 in Queensland, Australia,[50] Minnesota[59] and the US as a whole[48] are uniformly positive. The Institute of Medicine's interpretation of their modelling suggested that T21 would likely prevent or delay initiation of

tobacco product use among under-21s in the US, particularly those aged 15–17, and that the strength of the effect would increase gradually over at least a 10-year period.[48] The conclusions of the Institute of Medicine's modelling study were reinforced by Boyle and colleagues' estimation that T21 in Minnesota would lead to 3,355 fewer under-21s initiating smoking while under 21, increasing the proportion of 15-year-olds who do not smoke from 76% to 80%.[59] In Australia, Skinner and colleagues' modelling study estimating the impact of various tobacco control interventions projected that if T21 were to have been implemented in 2018, it would have the long-term impact of reducing the adolescent initiation rate by nearly 30% by 2037, compared with a control scenario.[50]

The Institute of Medicine report was cited by the charity Action on Smoking and Health in a briefing paper making the case for setting a minimum age of sale of 21 in England, in which they argue that T21 could lead to 18,000 fewer new smokers within the first year of implementation.[60]

8.2.3. Effect on prenatal and maternal health

Three studies were identified that looked at the effects of MLA21 in pregnant women and their babies.[48,61,62] (Appendix 3.4)

8.2.3.1. Smoking prevalence and cigarette consumption

A quasi-experimental study by Yan et al found an average reduction in prenatal smoking of 0.453 cigarettes per day among young mothers* after raising the minimum cigarette purchase age to 21 in Pennsylvania, US, compared to all mothers. This represents a 15% decrease in the daily cigarette consumption during pregnancy for mothers aged 21.[61]

Another quasi-experimental study from the US[62] estimated that 37.4% of potential smokers among pregnant young women aged 18–21 years would have been

* Women who conceived between the ages of 19 years 11 months and 21 years 7 months.

prevented from smoking before pregnancy thanks to the implementation of T21, compared to a similar population residing in non-T21 regions. The study found that the effect of the policy was more pronounced during the first and second trimesters with a decrease of 50.5% and 53.4% respectively. There was a smaller reduction in smoking (14.8%) in the third trimester. Additionally, smoking intensity (e.g. number of cigarettes) dropped by 5.4% before pregnancy, 10.4% during the first trimester, and 5.2% during the third trimester.[62]

Inequalities: One study found that T21 was most effective at reducing daily cigarette consumption during pregnancy for non-Hispanic White populations and for mothers with fewer than 12 years of education.[61]

8.2.3.2. Birth outcomes

Following implementation of T21 in Pennsylvania, the incidence of low birthweight decreased by 19% and gestational age increased by 0.22 weeks for all mothers. As with smoking prevalence, the policy had greater impact on birth outcomes of mothers of non-Hispanic White ethnicity and with lower levels of education.[61]

Based on a literature review and a modelling study, the Institute of Medicine stated that raising the legal age of tobacco product purchasing to 21 in the US 'will likely improve maternal, foetal and infant outcomes by reducing the likelihood of maternal and paternal smoking'.[48] Their modelling prediction found that by 2100 there would be an estimated 286,000 fewer preterm births, 438,000 fewer cases of low birthweight, and about 4,000 fewer sudden infant death syndrome cases among mothers aged 15–49.

8.2.4. Effect on cardiovascular outcomes

One study reported the effect of T21 on cardiovascular outcomes. Garney and colleagues[49] estimated the implementation of T21 would help avert 5.4 cases of cardiovascular heart disease and 6.1 cases of stroke per 1,000 people over the lifetime in the adult population of El Paso, Texas.

Inequalities: The authors reported that the effect of the policy would benefit more adult men than women, and there would not be major differences among ethnicities (Appendix 3.5).[49]

8.2.5. Effect on purchasing behaviour

8.2.5.1. National-level evaluations in the US

Because T21 laws have been introduced in different US states at different points, the evidence base includes some quasi-experimental studies that compare its impacts against control populations, typically using large, representative sets of either sales data or self-reported purchasing data. This literature uniformly finds that T21 led to decreases in purchasing among children and young adults (Appendix 3.6). These are exemplified by Abouk and colleagues'[35] use of a large set of longitudinal, nationally representative survey data to analyse changes in 8th–12th graders' (approximately 13–18 years) purchasing of tobacco products and NVPs, comparing regions with T21 laws against regions without them. The analysis found that T21 led to a significant 7.1% decrease in overall purchasing of cigarettes, relative to states without T21 laws, and a significant 69% decrease in purchasing of e-cigarettes within those regions with the largest proportions of inhabitants aged under 21.

Abouk and colleagues' findings complemented those of previous controlled, longitudinal analyses of national survey data.[35] Hansen et al[40] found that T21 laws were associated with a 2.5% reduction in purchasing e-cigarettes among 18-year-olds. Liber et al[63] found that the effect of T21 laws on reducing sales of cigarette brands favoured by younger people was two (unadjusted) to three (adjusted) times greater than the effect on sales of brands in other age categories ($p<0.001$). Agaku et al[34] found that the proportion of middle- and high-school students who reported trying to buy a cigarette in the past 30 days fell from 14.1% in to 10.1% ($p<0.001$) in one year of implementation. Agaku et al[34] also found that the proportion of students who reported having been refused purchase due to being under age increased from 14.2% to 17.0% (no p-value reported). The evidence that retailers complied with T21 was echoed in Zhang and colleagues'[64] analysis of data

from secret shoppers in California, which found that retailer violations of age of sales laws decreased from 10.3% to 5.7% following introduction of T21.

While most studies focused on both tobacco and e-cigarette purchasing, or only tobacco purchasing, Choi et al[55] specifically investigated the effects of different policies on e-cigarette use, using large-scale youth survey data from 34 states, each with different e-cigarette policies in place, to compare the effects of different policies. They found that, in states with T21 laws, young people (aged 12–18) were less likely to report having bought e-cigarettes in retail stores.

8.2.5.2. State and regional evaluations in the US

In addition to national-level evaluations, there is evidence focusing on the effectiveness of T21 laws in specific states, cities or counties, with findings that typically reinforce those of the national-level evaluations. T21 policies were first introduced in the US at local level In Needham, Massachusetts in 2005 and NYC in 2013. Controlled analyses of longitudinal survey data found that purchases of cigarettes among current smokers in Needham declined significantly more (18.4% to 11.6%) than in control communities (19.4% to 19.0%, $p<0.001$),[45] while NYC saw a non-significant 6.02% reduction in cigarette purchasing by high-school students compared to 5.28% in control regions.[43]

The first states to introduce statewide T21 laws were California and Hawaii, both in 2016. These states respectively exhibited significant absolute reductions in monthly cigarette sales of 11.7% ($p<0.01$) and 4.4% ($p<0.01$),[65] and significant relative reductions of 9.41% (95% CI -15.52 to -3.30) and 0.57% (95% CI -0.83 to -0.30), using the rest of the US as a control.[66] Ali and colleagues[66] note that the impact of T21 was relatively minor in Hawaii, but also that it had a disproportionately large impact on menthol cigarette sales in Hawaii, highlighting that the impacts of T21 laws will vary between different populations. T21 appeared to successfully reduce cigarette sales in California despite longitudinal survey evidence of some shortcomings in retailer compliance. Most past-30-day e-cigarette users below the minimum sales age had not been refused purchase of cigarettes (65.4%) or e-cigarettes (82.0%) in the past 30 days. Consistent with these studies, evidence from self-reported survey data in Oregon suggests that their statewide T21 law led

to fewer current tobacco users reporting buying tobacco products from convenience stores, grocery stores, tobacconists or vape shops.[58]

8.2.5.3. Access to tobacco and NVPs from alternative sources

We identified some literature that presented evidence of young people obtaining tobacco products and NVPs from sources other than directly from retailers, which could reduce the effectiveness of raising the minimum age of sale (Appendix 3.6). Choi and colleagues'[55] repeat cross-sectional analysis of youth survey data from 34 states with different e-cigarette restrictions in place found that the proportion of youth in states with T21 policies who had had someone else purchase e-cigarettes for them increased from 10.2% before T21 to 19.3% after T21. Hansen and colleagues'[40] quasi-experimental study of impacts of statewide T21 laws indicated that being in a state with T21 laws was associated with a 2.5% increase in the probability of borrowing e-cigarettes. The authors interpret this as evidence of the practice of borrowing e-cigarettes somewhat reducing the effectiveness of T21 policies among 18-year-olds, but conversely suggest that reducing 18-year-olds' overall access to nicotine products has a knock-on effect on younger groups who disproportionately rely on older peers to access products on their behalf.[40] Similarly, Roberts and colleagues'[47] evaluation of a local T21 law in Columbus, Ohio found that 61.8% of e-cigarette users among university undergraduates reported borrowing e-cigarettes, and that people would travel outside of Columbus to areas not covered by the T21 law to purchase tobacco products.

Zhang and colleagues'[64] survey of tobacco retailers found that 23.6% (95% CI 21.3–25.9) had noticed under-aged people asking adult strangers to purchase tobacco products for them. Researchers in New Zealand who reviewed evidence about different tobacco control policies identified that, for youth access to tobacco, social supply (through both family and friends) plays a greater role than commercial supply, and they identified New Zealand's Māori and Pacific communities to be particularly likely to access tobacco in this way.[19] Reid et al[67] conducted a comparative analysis of young people's (16–19 years) perceived access to tobacco and e-cigarettes in the US, Canada and the UK, and found that a higher minimum age of purchase was strongly and statistically significantly associated with

perception of lower access, both when comparing across countries with different minimum ages in place, and when comparing within countries before and after they raised the minimum age. Perceived ease of access declined in all three countries but did so faster in the US following nationwide implementation of T21 laws. In the US, following nationwide T21, perceived ease of access for both cigarettes (adjusted odds ratio 0.80; 95% CI 0.71–0.89) and e-cigarettes (adjusted odds ratio 0.87; 95% CI 0.77–0.98) declined sharply.[67]

The finding that T21 in the US led to perceptions of reduced accessibility was reinforced by four other quantitative studies. Agaku and colleagues'[34] comparison of states with and without T21 laws found that T21 was associated with a significant 8.3% decrease in the perception that it was easy to buy tobacco products from shops ($p<.001$). Similarly, Abouk et al[35] found that perceived ease of obtaining tobacco products from shops reduced among their nationally representative sample of children aged approximately 13–18, although identified variation by ethnicity, with Hispanic participants viewing access as disproportionately easy, compared to other ethnicities, and the perceptions of Black participants not exhibiting any significant change. The Oregon Health Authority[58] and Schiff and colleagues[32] studied perceptions in Oregon and California, respectively, and each identified decreases in young people's perceptions that it was easy to purchase tobacco products or NVPs.

8.2.6. Perceptions and understanding of age of sale intervention

8.2.6.1. Relationships between experiences of increased age of sale and perceptions of risk

Three studies presented evidence about young people's perceptions of the risks associated with the use of tobacco products, NVPs or both (Appendix 3.7).[31,35,56] Abouk et al[35] conducted subgroup analysis on survey data from a nationally representative sample of school students and found that T21 appeared to increase perceived risk of e-cigarettes more than it increased perceived risk of cigarettes among participants in 8th and 10th grade (approximately 12–15 years).

Two studies presented evidence from specific states or regions in which T21 laws had been introduced. Sax and Doran[31] found that young people's perceptions of the riskiness of smoking increased following T21 in California among current smokers, but not those who did not currently smoke. Debchoudhury and colleagues[56] found that among New York City middle-school students (approximately 11–14 years), the belief that e-cigarettes are less harmful than regular cigarettes decreased from 31.9% to 20.2%, while the high-school students increasingly believed that e-cigarettes were either as harmful (from 16.9% to 22.5%) or more harmful (from 3.2% to 5.1%) than cigarettes. It is debatable whether an inaccurate public perception of risk is acceptable if it leads to desirable public health outcomes. It is also worth reflecting on whether viewing e-cigarettes being as risky as combustible cigarettes might increase tobacco use.

8.2.6.2. Perceptions of the appropriateness of specific implementations of increased age of sale

Three studies presented evidence about young people's perceptions of whether T21 had been, or is likely to be, successful, and the potential unintended consequences of the intervention (Appendix 3.7). Roberts et al[47] found that participants in Columbus, Ohio who were surveyed before and after the introduction of T21 typically supported the policy, but perceived that it had little effect on their peers' use of tobacco products. Zhang et al[64] conducted surveys in California and found that most people aged 18–24 were aware of the T21 law (63.6%; 95% CI 53.5–73.7) and that 61% (95% CI 51.8–71.6) of people aged 14–18 agreed that raising sales age reduces youth prevalence. Current smokers were less likely to agree that raising sales age reduces youth prevalence, albeit with very wide confidence intervals (adjusted odds ratio 0.08; 95% CI 0.01–0.54). They also surveyed tobacco retailers and found very high awareness (98%; 95% CI 98.0–99.2) and majority support (60.6%; 95% CI 58.1–63.2) for T21. Participants also typically agreed that it was easy to comply with (85.6%; 95% CI 83.8–87.5) and train staff for T21 (90.7%; 95% CI 89.0–92.5).[64] Finally, in Antin and colleagues'[68] qualitative exploration of perceptions of people aged 15–25 in California, one participant described sourcing homemade vaping liquid from a friend, which the authors highlight as a potentially risky way in which T21 may be circumvented, but more broadly the evidence

indicated that T21 could help some young people quit smoking completely instead of switching to other sources of nicotine. A quasi-experimental study by Dai et al[69] found that knowledge of T21 was associated with reduced intention to use all tobacco products among students aged 11–18 and living in Kansas, US.

8.2.7. Knowledge and awareness of age of sale policy

Dai and colleagues'[69] quasi-experimental study of knowledge and attitudes related to T21 and tobacco use found that awareness of the policy among youths was slightly higher in US regions where T21 had not been applied compared to those which had implemented the policy. Those students who had shown greater knowledge of the policy in T21 regions were more likely to be aged 15 or over, be Hispanic, be current tobacco users, support the policy and have peer influence of tobacco use. However, they were less likely to perceive difficulty in accessing tobacco (see Appendix 3.7).

8.2.8. Healthcare costs

We identified two modelling studies that assessed the costs and benefits of T21 (see Appendix 3.8). A study carried out in England[53] estimated that increasing the age of sale to 21 would target around 364,000 young people and incur direct NHS savings of £691 million a year if all affected young people were prevented from transitioning into long-term smokers by the policy (£1,900 per smoker) (healthcare costs at time of publication).

A study using agent-based modelling carried out in the US[49] estimated that increasing the age of sale to 21 would save an average of US$1,034 per adult (irrespective of sex) in healthcare costs due to the reduced smoking rate and reduced burden of cardiovascular diseases. All healthcare costs were discounted at 3% and converted to 2018 US dollars.

Inequalities: US modelling data suggested that males and African Americans appeared to have lower lifetime healthcare costs compared to women, Hispanic and White populations. This is mainly because they have a generally shorter life expectancy compared to other population groups.[49]

9. Discussion and conclusion

9.1. Limitations of our approach

Our approach has a number of limitations which should be considered when interpreting the findings of this report:

- While a scoping review is important in highlighting the number and types of evidence available as well as high-level author findings, it does not provide a synthesis of effectiveness and, as such, is a starting point for further evidence work.
- Scoping reviews also do not critically appraise included studies. Therefore, we were not able to comment on the quality of studies which needs to be taken into consideration in interpreting the results.
- We selected studies from OECD countries for the MLA21 intervention. In theory, the findings of these studies are generalisable to Scotland. However, in terms of the inequality data, there may be structural differences in the population (e.g. ethnicity, socioeconomic status, urban/rural profile) which mean the impacts are different in the Scottish context, and it may be important to validate these observations in Scotland. We anticipated that evidence for the TFG intervention would be limited and therefore we did not place any restrictions on countries for the inclusion criteria. Modelling studies from the Solomon Islands and Singapore were therefore considered in this review, and the transferability of the findings from these studies may require consideration in a Scottish context.

9.2. Introducing a tobacco-free generation (TFG)

The evidence base for TFG reflects its status as a policy idea that has not yet been implemented at a large scale. It therefore relies on a small number of modelling studies estimating short-term outcomes (e.g. smoking prevalence) and long-term outcomes (e.g. all-cause mortality and healthcare costs). Modelling studies are not a

substitute for evaluation of real-world implementation of policies as they can oversimplify complex situations and there may be uncertainty around inputs and assumptions. However, these studies allow us to predict the likely impact of TFG for a range of outcomes and across different population subgroups. Modelling studies also allow us to estimate the likely impact of outcomes, such as mortality, that are likely to accrue over several decades and would be difficult to assess in traditional evaluations. In addition, modelling studies allow us to estimate the likely impact of TFG on its own or in combination with other measures.

With the revocation of the TFG policy in New Zealand, there will be no evidence of short-term effectiveness of this intervention on heath and health economic outcomes, and no directly comparable evidence base for Scotland. If TFG is implemented in Scotland and its UK counterparts, it should be alongside a carefully planned programme of evaluation that includes assessing industry compliance. Scotland has set a precedent for such an approach with minimum unit pricing for alcohol.[70]

9.3. Raising the minimum legal age of sale

Effectiveness evidence is, however, available for other interventions that increase the MLA for purchasing tobacco. Given that these use the same mechanism as TFG, they are useful in their own right, and also for informing the potential development of TFG policies.

Evidence was very limited for the MLA25 intervention, with only one US modelling study identified. More evidence was identified for raising the MLA to 21, which largely comes from the US, where there has been widespread implementation of the T21 policy. This scoping review largely identified observational studies for the MLA21 intervention. Observational studies have several limitations including being prone to bias and confounding, therefore limiting the reliability of observational evidence. However, implementation of this policy in a staggered pattern across the US has yielded opportunities for quasi-experimental evaluation, with states/regions with T21 policies acting as an intervention arm and those without T21 policies serving as controls. Approximately 70% of the observational studies for both

combustible cigarettes and NVPs were controlled and are considered to offer more meaningful results. Further evidence synthesis could include conducting a rapid review to quality assess and synthesis findings from these studies or a systematic review with meta-analysis to establish a reliable estimate of the short-term effectiveness of MLA21 on smoking prevalence. More robust quasi-experimental methods, such as difference-in-difference analysis, should be considered.

We also identified MLA21 studies that reported non-health outcomes, such as purchasing of tobacco products and NVPs among children and young people, retailer compliance, cross-border purchasing and accessing of tobacco through social networks that could affect the effectiveness of MLA21. Consideration of these factors would be an important part of any monitoring and evaluation of TFG or MLA21 policies.

9.4. Key points for consideration

Our scoping review has highlighted a number of key points for consideration as part of the development of TFG or MLA policies:

- While our scoping review identifies and summarises relevant research, it does not provide an evidence synthesis that would allow us to make overall conclusions about the effectiveness of these policies. It would therefore be useful to consider whether further, more robust and specific, evidence synthesis would be required.

- The identified modelling studies, while not being a substitute for evaluation of policy implementation, provide useful evidence for policy ideas that have not yet been tried (such as TFG); the likely impact of a policy in isolation or in combination with other tobacco control policies; and for outcomes such as mortality and hospitalisation that typically occur over a longer period of time.

- We identified a number of health outcomes that were commonly investigated by the included studies. These included smoking prevalence and initiation as shorter-term outcomes, and hospitalisation and mortality as longer-term outcomes. Although we have not formally quality appraised the included

studies, many of those included used study designs that are not well suited to policy evaluation. Consideration should be given to what quasi-experimental designs would be suitable and feasible to evaluate key health outcomes.

- Some studies also looked at important non-health outcomes (e.g. purchasing behaviour, knowledge and attitudes, compliance etc). Consideration should also be given to how evidence could be collected for these outcomes as part of a programme of policy evaluation.

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