MESAS

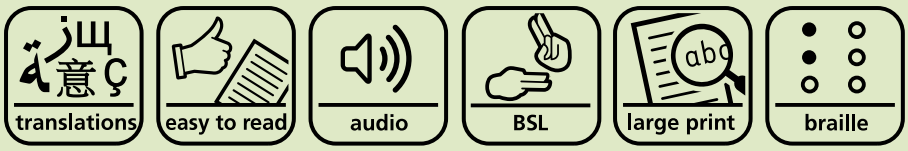
NHS Health Scotland

Evaluating the impact of Minimum Unit Pricing (MUP) on sales-based consumption in Scotland: an interrupted time series analysis

Analysis plan

October 2019

This resource may also be made available on request in the following formats:



0131 314 5300

nhs.healthscotland-alternativeformats@nhs.net

Published by NHS Health Scotland

1 South Gyle Crescent
Edinburgh EH12 9EB

NHS Health Scotland is a WHO Collaborating Centre for Health Promotion and Public Health Development.

Contents

Version table

Version	Date	Author/Editor	Comments
1.0	19/08/2019	Mark Robinson	Some information has been lifted directly from the accompanying Study Protocol available on the MUP Evaluation webpage (see healthscotland.scot/MUPEvaluation).
1.1	23/08/2019	Mark Robinson	Updated following review by Jim Lewsey and Danny Mackay. Main changes related to: wording around analytical method; description of sensitivity analyses.
1.2	07/10/2019	Mark Robinson	Updated following comments made by EAG members at meeting on 12/09/19.

Background

The scale of Scotland's damaging relationship with alcohol is well documented. The rate of deaths related to alcohol is among the highest in Western and Central Europe[1] and, despite falling from a peak in 2003, rates remain twice as high as those seen in England & Wales.[2] Recent estimates using Scotland-level data suggest that alcohol was a causal factor in over 3,700 deaths and 41,000 hospital admissions, and contributed to 8% of the overall disease burden.[3] This is driven by high levels of population consumption levels relative to neighbouring GB countries.[4] Alcohol-related heath harms are experienced most by those living in areas of high deprivation, with stark inequalities in both mortality and hospital admissions caused by alcohol.[2]

In recognition of the harm alcohol was causing to individuals, families, communities, and society at large, the Scottish Government introduced a comprehensive package of measures through its 2009 Framework for Action.[5] The strategy contained a range of policy and legislative actions which, collectively, aimed to reduce population levels of alcohol consumption and, in turn, associated levels of health and social harms. This included the Alcohol (Minimum Pricing) (Scotland) Act (hereafter 'MUP Act'), which was passed in June 2012.[6] Following a lengthy legal challenge, which ended after the judgement of the Supreme Court in December 2017[7], the Scottish Government implemented MUP on 1 May 2018 setting a minimum price of 50 pence per unit (ppu), below which alcohol cannot be sold in Scotland.

The MUP Act includes a sunset clause, which requires that the legislation will expire at the end of the sixth year of implementation unless the Scottish Parliament votes for it to continue. To inform this decision there is a review clause, requiring the Minister to put a review report before Parliament as soon as possible after the end of the fifth year of implementation. The review report is required to assess the impact of MUP on the five licensing objectives (concerned with crime, public safety, public nuisance, public health and protecting children from harm) and on alcohol producers and licence holders. Differential impact (by age, sex, deprivation and drinking status) should be assessed where possible. Representatives of alcohol producers and

licence holders and those with a function related to health, prevention of crime, education, social work, and children and young people must be consulted in the preparation of the report for Parliament.

NHS Health Scotland has been commissioned by the Scottish Government to lead this evaluation through its Monitoring and Evaluating Scotland's Alcohol Strategy (MESAS) work programme. We have therefore developed a portfolio of studies to evaluate MUP (see our website for more details).* The evaluation is to be completed by 1 November 2023 at the latest and will form the basis of the review report. Part of the evaluation is a package of studies concerned with the impact of MUP on population alcohol consumption.

There is strong and consistent evidence to show that increasing the price of alcohol, thereby reducing its affordability, is an effective approach in reducing population levels of alcohol consumption and related harms.[8] Increasing the level of tax applied to alcohol is the most common approach to achieve such effects. However, other fiscal policies can be used. In Canada, for example, a form of minimum pricing applies across all ten provinces, though there is variation in the extent and frequency to which different drink types and outlets are affected.[9] Evaluation of the impact of minimum pricing in Canada has shown consistently that as alcohol prices increase, there is an associated decrease in population consumption, hospital admissions and deaths.[10, 11, 12]

The minimum pricing model in Canada, as well as those that exist in other countries, differ from the MUP legislation being implemented in Scotland, which will be the first country in the world to introduce such an approach. The Sheffield Alcohol Policy Model has estimated that a 50ppu will reduce alcohol consumption by 3% in Scotland when the policy reaches its full effect.[13] It is estimated that effects will be most pronounced among those drinking at harmful levels, particularly those on lower incomes. However, as Scotland is the first country to have introduced MUP, there have been no direct observations of its impact on population consumption.

* See www.healthscotland.scot/health-topics/alcohol/evaluation-of-minimum-unit-pricing

Aims and research questions

The aim of this study is to evaluate the impact of MUP on the volume of pure alcohol sold in Scotland using alcohol retail sales data.

The study will address the following research questions:

1. What is the impact of the introduction of MUP on the volume of pure alcohol sold in Scotland?
2. What is the impact of the introduction of MUP on the volume of pure alcohol sold by off-trade retailers in Scotland?
3. What is the impact of the introduction of MUP on the volume of pure alcohol sold by on-trade retailers in Scotland?
4. To what extent does any impact of the introduction of MUP on the volume of pure alcohol sold in Scotland vary by drink type?

Methods

Design

Using commercial data on alcohol retail sales, we will use a natural experimental design with interrupted time series analytical methods to assess whether the introduction of MUP is associated with changes in the level or trend of the volume of pure alcohol sold in Scotland. Data for England and Wales (combined) (hereafter England/Wales) will be used as the primary geographical control group; subnational English regions will be used in supplementary analyses. We will assess the impact of MUP on overall alcohol retail sales and for different trade sectors and drink types separately. We will adjust statistical models to account for seasonal and secular trends, as well as other important confounders (e.g. disposable income) and perform a number of sensitivity analyses to assess the robustness of our results.

Measures

The outcome measures for this study will be:

- Volume (Litres) of pure alcohol sold per adult in the off-trade (primary outcome measure)
- Volume (Litres) of pure alcohol sold per adult (primary outcome measure)
- Volume (Litres) of pure alcohol sold per adult in the on-trade (secondary outcome measure)

These will be considered overall and for individual drink categories (i.e. beer, spirits, wine, cider, perry, fortified wine, and RTDs).

Data

Off-trade alcohol sales data

We will use off-trade alcohol retail sales data obtained from market research company, Nielsen. Nielsen estimates retail sales in Great Britain using electronic

sales records from large retailers (retailers with ten or more retail shops operating under common ownership) and a weighted stratified random sample of smaller 'impulse' retailers (retailers in which the consumer mainly uses the store for impulse or top-up purchases i.e. not the main grocery shop). It is estimated that large, multiple retailers account for approximately 80% of total off-trade alcohol sales in Scotland.

As part of the MESAS work programme, Nielsen has provided NHS Health Scotland with off-trade alcohol sales data since 2010. Weekly data on the volume of alcohol sold (in litres of natural volume), by drink type, are available for Scotland and England/Wales from January 2009 and for North West (NW) and North East (NE) England from January 2012. Nielsen is currently contracted by NHS Health Scotland to continue to provide these data until 2021/22 meaning data will be available up until the end of calendar year 2021.

On-trade alcohol sales data

We will use on-trade alcohol retail sales data obtained from market research company, CGA Strategy. CGA is a market measurement, data and research consultancy company specialising in the out-of-home food and drink market. CGA estimate on-trade alcohol sales in Great Britain using a combination of delivery, sales, and survey data.

As part of the MESAS work programme, CGA has provided NHS Health Scotland with on-trade alcohol sales data since 2010. Data on the volume of alcohol sold (in litres of natural volume) for four-weekly periods, by drink type, are available for Scotland, England/Wales and English regions from January 2008. CGA is currently contracted by NHS Health Scotland to continue to provide these data until 2021/22 meaning data will be available up until the end of calendar year 2021.

Robustness of alcohol retail sales data

We have previously performed detailed critiques of the validity and reliability of alcohol retail sales data for monitoring population levels of alcohol consumption in Scotland,[14, 15] including a comprehensive description of the sampling methods used by Nielsen/CGA to collect alcohol sales data.[14] From September 2011, Nielsen was no longer able to estimate off-trade sales by discount retailers, Aldi and Lidl. In order to continue trends in population alcohol consumption levels established prior to 2011, we have adjusted the data we receive using estimates of the alcohol market share of Aldi/Lidl obtained from consumer panel data.

Confounders

We intend to adjust our statistical models for the potentially confounding effects of income as this interacts with alcohol prices to determine alcohol affordability. Quarterly gross disposable household income data will be obtained for Scotland and England/Wales and expressed per adult. Other potential confounders, such as overall consumer spending, will also be considered.

Study time period

We will include data from January 2013 to April 2021. This provides us with data for over five full years before, and three full years after, the implementation of MUP. When using interrupted time series analysis to evaluate natural experimental designs, longer pre-intervention time periods can strengthen causal inferences by enabling better control of secular trends.[16] As noted above, we have access to weekly off-trade alcohol sales data from 2009 (for Scotland and England/Wales only) and four-weekly on-trade alcohol sales data from 2008. However, for the purposes of this study we will use data for both sectors from January 2013 only for three main reasons:

1 It enables consistency in the time periods used for each sector.

2. It provides us with the option of using data for subnational English regions if necessary (e.g. sensitivity/supplementary analysis).
3. The Alcohol Act in Scotland was introduced in October 2011 and we have previously demonstrated that it was associated with a reduction in the volume of pure alcohol sold off-trade in Scotland in the 12-month period after it was introduced, particularly off-trade wine.[17]

The study will report in two waves. The first wave will assess the impact of MUP on alcohol sales after one year of implementation (up to April 2019). The second wave will assess the impact of MUP on alcohol sales after three years of implementation (up to April 2021).

Analysis

The analytical approach described below is largely based on the approach we took when evaluating the impact of the Alcohol Act on off-trade alcohol sales.[17]

Conversion of natural volumes to pure alcohol volumes

Natural volume sales will be converted into pure alcohol volumes using alcohol-by-volume (ABV) percentages for each drink type. The ABV used will be based on the typical strength of drinks sold in that category as provided by the data suppliers. As part of the MESAS monitoring programme we have sourced more detailed ABV data at product level. We will explore whether these data can be used to refine our estimates of category-level ABV, though this will only be possible for more recent data (i.e. not as far back as 2013).

Expressing alcohol sales per adult

The volume of pure alcohol sold per adult (≥16 years) will be calculated using official mid-year population estimates available from National Records Scotland and the Office for National Statistics. Weekly and four-weekly population estimates (for off-trade sales and on-trade/total sales, respectively) will be interpolated.

We have previously been challenged on using 'alcohol sales per adult' as our key outcome measure, rather than 'alcohol sales per adult drinker'. The latter would take into account differences in the prevalence of non-drinkers between Scotland and England/Wales. While the MUP Act is a targeted measure aimed at reducing consumption among the heaviest drinkers, Scotland's overall alcohol strategy is aimed at reducing average population levels of consumption. For the purposes of this study, we will use the population that includes non-drinkers in the denominator. This is consistent with previous studies on the impacts of minimum pricing on population alcohol consumption in Canada.[10, 18] We will, however, express alcohol sales per adult drinker in sensitivity analysis.

Descriptive analysis

Data for our outcome measures will be initially analysed descriptively to enable trends and other key information to be presented in tables and figures. In addition, to ease visual interpretation of trends, the time series for each primary outcome will be decomposed into trend and seasonal components. We used this approach to present trends in alcohol-related mortality rates in an earlier paper.[19] This will also be important for ensuring that the pre-implementation trends in Scotland and control groups are similar, a pre-requisite when using interrupted time series analysis for evaluating natural experiments.[16]

Statistical analysis

We will use interrupted time-series methods to assess the impact of MUP on the volume of pure alcohol sold per adult in Scotland. Interrupted time series methods provide one of the most robust quasi-experimental study designs, enabling underlying temporal and seasonal trends to be accounted for.[20]

Based on our prior experience of analysing alcohol retail sales data using interrupted time series methods,[17] we will use time series regression with Seasonal Autoregressive Integrated Moving Average (SARIMA) errors as our main analytical approach. This approach is particularly good at addressing temporal and seasonal trends in the data series and so is useful for assessing the independent impact of policy interventions. Indeed, this approach provided an excellent fit to the off-trade sales data when we previously tested the impact of the introduction of another national policy.

In line with the guidance produced by Beard et al (2019)[21] and based on our previous approach,[17] our analytical strategy will consist of initially modelling the alcohol sales data time-series to obtain an adequate preliminary model and then modelling and testing the effect of the intervention.

1. Data preparation

We will assess whether the outcome measures have a normal distribution using Kernel Density plots. If the data are not normally distributed, they will be transformed using the natural logarithm.

2. Diagnosis of autocorrelation and non-stationarity

The presence of serial and seasonal autocorrelation and non-stationarity will be diagnosed using autocorrelation (AC) and partial autocorrelation functions (PC). These will enable the correlation between error terms at different lag periods and the number of autoregressive (AR) and moving average (MA) terms to be identified. The data series will undergo regular differencing if non-stationarity in the mean/variance of the series is identified and cannot be rectified by the inclusion of a deterministic term. Seasonal differencing will be applied if significant seasonal lags remain in the residuals after modelling with the best fit model, identified from the PAC and AC plots/functions.

3. Testing for structural breaks

Structural breaks in time series can bias coefficient and standard error estimates. Therefore, we intend to test for the presence of structural breaks using the Bai and Perron[22] methodology or indicator saturation methods.[23] These break points will then be incorporated into the final intervention model.

4. Select the baseline model

Based on steps 1–3, candidate models will be investigated using plots and autocorrelation plots of the stationary data series. The most appropriate and parsimonious model will be selected using the Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC) statistics.[24] Lagged effects of the intervention will not be explored in light of findings from other studies in the MUP Evaluation portfolio

which have shown that the legislation has been complied with and implemented effectively.

5. Testing the effect of the intervention

To estimate the magnitude and uncertainty of the intervention effect, we will include a binary explanatory variable, with the value of zero for the time before MUP is introduced (January 2013 to April 2018) and the value of one after the introduction of MUP (May 2018 to April 2021). We will assess the change in the level and the slope of alcohol sales after MUP was introduced.[25] We will also test for an intervention effect that reduces the variability in sales over time by squaring the residuals from the best fit model and applying a test for pre-post change in the magnitude of the residuals.

6. Adjusting the model for additional covariates

Analyses will be performed with and without adjustment for potential confounders. Covariates entered into adjusted models will include:

- Disposable income or a measure of consumer spending (in all models)
- On-trade sales (adjusted for in off-trade models to account for substitution)
- Sales of other alcoholic drink types (in models of specific drink types to account for substitution)

7. Comparison with the unexposed geographical control

To enable comparison with a control group, the same analytical technique described above will be performed using data for England/Wales, where the legislation does not apply. In addition, we will enter the time–series of corresponding alcohol sales in England/Wales as a covariate in the SARIMA models for Scotland.

8. Assessment of model fit

After the models are fitted, AIC and Bayesian Information Criteria (BIC) statistics will be obtained and compared. In addition, standard diagnostic tests will be performed to ensure that the residuals of the fitted models are not significantly different from those expected from white noise or a random series.

Sensitivity and supplementary analyses

We plan to perform a number of additional analysis to test the robustness of our results:

- We will assess the impact of applying adjustment factors to off-trade alcohol sales data to account for the exclusion of sales by Aldi and Lidl.
- We will repeat the analysis expressing alcohol sales per adult drinker instead of per drinker (i.e. excluding non-drinkers from the denominator).
- We will test the robustness of the timing of any effect (if an effect is detected) by varying the date of implementation (i.e. false legislation dates). Such falsification tests are useful for assessing the plausibility of attribution of effects by checking effect specificity).[16] The intervention dummy variable will be moved to coincide with the date three and six months before and after the actual implementation date.
- We will repeat our analyses using NW and NE England as geographical controls. This is because it has been suggested that Northern England is a more appropriate control group for Scotland than England/Wales due to a more similar socio-demographic make-up and alcohol culture (perhaps reflecting a similar industrial history).[26]
- We will repeat our analyses using only 12 months pre-implementation data. As noted above, longer pre-intervention time periods can be advantageous in interrupted time series analysis; however, it is also suggested that equal proportions of data before and after the event can be useful.[21]

- We will assess the impact of MUP using an alternative analytical approach. Specifically we use an Unobserved Components Model, a form of structural time series method, across the entire outcome series.
- We will repeat our analysis with the outcome series as the difference in sales between Scotland and England/Wales.[27]

Software

It is planned that analyses will be performed using the following statistical software:

- R for decomposition analysis (STL routine)
- Stata 16 for modelling (based on previous analysis our team has performed suggest Stata's ARIMA procedure calculates more accurate standard errors than R)
- SAS or Python 3.7 (statsmodels v10.0 package) for Unobserved Components Model.

Reporting

We will report our study in line with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidance[28] and the guidelines produced by Beard et al (2019).[21] Results for both unadjusted and adjusted models will be presented in tables and plot. Plots will present trends in the post-MUP alcohol sales estimated from models that include observed post-MUP data and those that are predicted based on pre-MUP data (for example, see Colchero et al (2016)[29] or Olivier et al (2019)[30]).

References

[1] Whyte B and Ajetunmobi T. Still 'The sick man of Europe'? Scottish mortality in a European context 1950–2010. An analysis of comparative mortality trends. Glasgow: Glasgow Centre for Population Health; 2012. Available from: www.gcph.co.uk/publications/391_still_the_sick_man_of_europe

[2] Giles L and Robinson M. Monitoring and Evaluating Scotland's Alcohol Strategy: Monitoring report 2018. Edinburgh: NHS Health Scotland; 2018. Available from: www.healthscotland.scot/publications/mesas-monitoring-report-2018

[3] Tod E, Grant I, Wyper G et al. Hospital admissions, deaths and overall burden of disease attributable to alcohol consumption in Scotland. Edinburgh: NHS Health Scotland; 2018. Available from: www.scotpho.org.uk/publications/reports-and-papers/hospital-admissions-deaths-and-overall-burden-of-disease-attributable-to-alcohol-consumption-in-scotland

[4] Robinson M, Shipton D, Walsh D et al. Regional alcohol consumption and alcohol-related mortality in Great Britain: novel insights using retail sales data. BMC Public Health 2015;15:12458-15-1.

[5] Scottish Government. Changing Scotland's relationship with alcohol: A framework for action. Edinburgh: Scottish Government; 2009. Available from: www.scotland.gov.uk/Resource/Doc/262905/0078610.pdf

[6] Scottish Parliament. Alcohol (Minimum Pricing) (Scotland) Act. Edinburgh: Scottish Parliament; 2012. Available from: www.legislation.gov.uk/asp/2012/4/contents

[7] UK Supreme Court. Scotch Whisky Association and others (Appellants) v The Lord Advocate and another (Respondents) (Scotland). London: UK Supreme Court; 2017. Available from: www.supremecourt.uk/cases/docs/uksc-2017-0025-judgment.pdf

[8] Burton R, Henn C, Lavoie D et al. The public health burden of alcohol and the effectiveness and cost-effectiveness of alcohol control policies: an evidence review.

London, UK: Public Health England; 2016. Available from: www.gov.uk/government/publications/the-public-health-burden-of-alcohol-evidence-review

[9] Stockwell T and Thomas G. Is alcohol too cheap in the UK? The case for setting a Minimum Unit Price for alcohol. Institute of Alcohol Studies; 2013. Available from: www.ias.org.uk/uploads/pdf/News%20stories/iasreport-thomas-stockwell-april2013.pdf

[10] Stockwell T, Zhao J, Giesbrecht N et al. The raising of minimum alcohol prices in Saskatchewan, Canada: impacts on consumption and implications for public health. Am J Public Health 2012;102:e103–10.

[11] Stockwell T, Zhao J, Martin G et al. Minimum alcohol prices and outlet densities in British Columbia, Canada: estimated impacts on alcohol-attributable hospital admissions. Am J Public Health 2013;103:2014–2020.

[12] Zhao J, Stockwell T, Martin G et al. The relationship between minimum alcohol prices, outlet densities and alcohol-attributable deaths in British Columbia, 2002–09. Addiction 2013;108:1059–1069.

[13] Angus C, Holmes J, Pryce R et al. Model-based appraisal of the comparative impact of Minimum Unit Pricing and taxation policies in Scotland: An adaptation of the Sheffield Alcohol Policy Model version 3. Sheffield: ScHARR: University of Sheffield; 2016. Available from: www.sheffield.ac.uk/scharr/sections/ph/research/alpol/publications#scottish

[14] Thorpe R, Robinson M, McCartney G and Beeston C. Monitoring and Evaluating Scotland's Alcohol Strategy: A review of the validity and reliability of alcohol retail sales data for the purpose of monitoring and evaluating Scotland's alcohol strategy. Edinburgh: NHS Health Scotland; 2012. Available from: www.healthscotland.com/documents/5761.aspx

[15] Henderson A, Robinson M, McAdams R et al. Tracking biases: An update to the validity and reliability of alcohol retail sales data for estimating population consumption in Scotland. Alcohol 2016;51:363–366.

[16] Craig P, Katikireddi SV, Leyland A et al. Natural experiments: An overview of methods, approaches, and contributions to public health intervention research. Annu Rev Public Health 2017;38:39–56.

[17] Robinson M, Geue C, Lewsey J et al. Evaluating the impact of the alcohol act on off-trade alcohol sales: a natural experiment in Scotland. Addiction 2014;109:2035–2043.

[18] Stockwell T, Auld MC, Zhao J et al. Does minimum pricing reduce alcohol consumption? The experience of a Canadian province. Addiction 2012;107:912–920.

[19] Robinson M, Bouttell J, Lewsey J et al. The short-term impact of the alcohol act on alcohol-related deaths and hospital admissions in Scotland: a natural experiment. Addiction 2018;113:429–439.

[20] Penfold RB and Zhang F. Use of interrupted time series analysis in evaluating health care quality improvements. Academic Pediatrics 2013;13:S38–S44.

[21] Beard E, Marsden J, Brown J et al. Understanding and using time series analyses in addiction research. Addiction 2019;114:1866–1884.

[22] Bai J and Perron P. Computation and analysis of multiple structural change models. Journal of Applied Econometrics 2003;18:1–22.

[23] Hendry DF, Johansen S and Santos C. Automatic selection of indicators in a fully saturated regression. Computational Statistics 2007;20:3–33.

[24] Akaike H. A new look at the statistical model identification. Automatic Control, IEEE Transactions on 1974;19:716–723.

[25] Bernal JL, Cummins S and Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. Int J Epidemiol 2017;46:348–355.

[26] Robinson M, Shipton D, Walsh D and McCartney G. Monitoring and Evaluating Scotland's Alcohol Strategy: a comparison of alcohol sales and alcohol-related mortality in Scotland and northern England. Edinburgh: NHS Health Scotland; 2013. Available from: www.healthscotland.com/documents/22520.aspx

[27] Jackson S, Beard E, Brown J and West R. What is the impact of the London Smoking Cessation Transformation Programme on regional quit attempts and quit success? A time series analysis of population-level data in England. Retrieved from osf.io/drcv9:2018.

[28] Vandenbroucke JP, von Elm E, Altman DG et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. PLoS Med 2007;4:e297.

[29] Colchero MA, Popkin BM, Rivera JA et al. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. BMJ 2016;352:h6704.

[30] Olivier J, Boufous S and Grzebieta R. The impact of bicycle helmet legislation on cycling fatalities in Australia. Int J Epidemiol 2019;48:1197–1203.

www.healthscotland.scot

@MESAS_NHS

6792 1/2020