BMJ Public Health

Alcohol consumption during pregnancy in Scotland following public health interventions: population-based study

Michael Kinsella [1], Martin Shaw,[2] Aizhan Kyzayeva [3,4], Alastair Leyland [3,4], Jill P Pell,[4] Deborah Lawlor,[5] Scott Nelson [1], Rachel Joyce Kearns [1,6]

To cite: Kinsella M, Shaw M, Kyzayeva A, *et al*. Alcohol consumption during pregnancy in Scotland following public health interventions: population-based study. *BMJ Public Health* 2025;**3**:e003264. doi:10.1136/bmjph-2025-003264

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjph-2025-003264).

Received 23 May 2025
Accepted 10 October 2025

Check for updates

© Author(s) (or their employer(s)) 2025. Re-use permitted under CC BY-NC. Published by BMJ Group.

[1]School of Medicine, University of Glasgow, Glasgow, UK
[2]Department of Medical Physics, NHS Greater Glasgow and Clyde, Glasgow, UK
[3]MRC/CSO Social and Public Health Sciences Unit, University of Glasgow, Glasgow, UK
[4]School of Health and Wellbeing, University of Glasgow, Glasgow, UK
[5]MRC Integrative Epidemiology Unit at The University of Bristol, University of Bristol, Bristol, UK
[6]Department of Anaesthesia, Glasgow Royal Infirmary, Glasgow, UK

Correspondence to
Dr Michael Kinsella; michael.kinsella@glasgow.ac.uk

ABSTRACT

Introduction Alcohol consumption during pregnancy is associated with adverse maternal and perinatal outcomes, with no safe lower limit established. We evaluated the individual and cumulative impact of three alcohol-related interventions on maternal alcohol use and perinatal outcomes in Scotland.

Methods Population-based study using Scottish National Health Service administrative linked data of all mothers giving birth in Scotland between 1 April 2013 and 31 December 2019. We investigated if alcohol consumption during pregnancy, as well as perinatal outcomes of small for gestational age (SGA), neonatal unit admission, and premature birth were affected by Public Health measures. The individual and cumulative effects of (1) Change in drink-driving legislation (5 December 2014), (2) UK Chief Medical Officers' (CMO) advice to abstain from alcohol during pregnancy (6 January 2016) and (3) Alcohol minimum unit pricing (MUP) (1 May 2018) were assessed using time series analysis.

Results Of 346 360 antenatal care initiates, 92.7% had alcohol consumption data. By 2019, 26.1% reported alcohol use during pregnancy, with 55.2% women consuming >4 units per week. In women reporting alcohol use, MUP introduction showed a significant reduction in consumption by 0.59 (95% CI −0.99 to −0.18) units/week, contributing to an overall 0.69 (95% CI −0.90 to −0.48) units/week decrease following all interventions. Additionally, we observed improvements in perinatal outcomes, including reduced SGA (adjusted relative risk (adjRR) 0.88, 95% CI 0.85 to 0.90), and neonatal unit admission (adjRR 0.94, 95% CI 0.91 to 0.96), but not stillbirth (adjRR 0.87, 95% CI 0.74 to 1.02) or preterm birth (adjRR 1.09, 95% CI 1.06 to 1.13) following the implementation of these collective public health interventions.

Conclusions One in four women self-reported alcohol consumption during early pregnancy. Only MUP was associated with lower consumption among pregnant women. The public health measures were collectively associated with improvement in select perinatal outcomes, highlighting the potential effectiveness of universal interventions.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The association between alcohol consumption during pregnancy and adverse outcomes is well-documented.

⇒ Despite global legislative efforts and public health initiatives aimed at reducing alcohol-related harm, the impact of these interventions on pregnant women and their offspring remains underexplored.

WHAT THIS STUDY ADDS

⇒ Cumulatively, the public health interventions led to a reduction in alcohol intake of almost 0.7 units per week in pregnant drinkers, and a decrease in small for gestational age births and neonatal unit admissions.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings advocate for sustained and integrated public health strategies to mitigate the risks associated with prenatal alcohol exposure.

INTRODUCTION

Alcohol consumption accounts for five per cent of worldwide morbidity and mortality, constituting a significant global public health challenge.[1] During pregnancy, 12%–41% of mothers report consuming alcohol, despite no safe lower limits being established and the potential detrimental impact on their offspring.[2–4] After reaching historically high levels of alcohol-related harm, the Scottish Government instituted a comprehensive strategy for Scotland incorporating a range of interventions, policies and legislation.[5] This included the introduction of a lower permissible drink-drive limit in 2014 and, more recently, minimum unit pricing (MUP) in 2018. In 2016 the UK Chief Medical Officers (CMO) also specifically advised pregnant women to completely abstain from alcohol for the first time. The effectiveness of these and similar public health interventions is increasingly being established,[6 7] with regulations related to drink driving reducing the number of road traffic injuries and deaths and the introduction of MUP associated with a decline in alcohol sales.[8 9]

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

While there is good evidence that heavy alcohol consumption in pregnancy can result in foetal alcohol spectrum disorders, the impact of low and modest consumption is unclear, and causal evidence of effects at these levels is challenging to ascertain.[10] Indeed, the UK CMOs' advice acknowledged the paucity of causal evidence in this area and invoked the 'precautionary principle' to recommend that women abstain from alcohol consumption during pregnancy.[11] The advice was based on being unable to rule out harmful effects. A systematic review of the effects of low alcohol consumption that informed the CMOs' advice found some evidence that low alcohol consumption might increase the risk of small for gestational age (SGA) and preterm birth.[12] A more recent update of that systematic review, which focused on evidence from randomised controlled trials (RCTs) and quasi-experimental studies, concluded that there was some evidence that prenatal alcohol consumption could lead to low birth weight and adverse cognitive outcomes, but the authors noted that none of the 23 included studies had a low risk of bias across all domains.[13] The availability of detailed linked data in Scotland, including on alcohol consumption in pregnancy, together with the implementation of general and pregnancy-specific alcohol reduction policies, provides a unique opportunity to add to the sparse evidence on the effects of alcohol in pregnancy on maternal and perinatal health.

The aim of this study was to evaluate alcohol consumption in pregnancy, measure the change in alcohol consumption following three distinct public health interventions, both as individual entities and cumulatively across all three interventions, and measure any associated changes in perinatal outcomes in Scotland.

METHODS

We linked four Scotland-wide administrative databases: Scottish Morbidity Record-2 (SMR02), Scottish Morbidity Record-1 (SMR01), Scottish Birth Record (SBR) and National Records of Scotland (NRS). The SMR02 records all maternity in-patient and day case admissions, including maternal and infant characteristics, maternal alcohol consumption and pregnancy outcomes. The SMR01 records all in-patient and day-case admissions. Both record diagnoses according to the International Classification of Diseases 9th or 10th revision.[14] SBR records all neonatal care, and the NRS registers all births, stillbirths and infant deaths in Scotland. Public Health Scotland reported 99% completeness for SMR02 in 2020/21. Data governance procedures and ethical approval to use the data were granted by the NHS Scotland Public Benefit and Privacy Panel for Health and Social Care (1920–0097). Local approval to use the data was granted by NHS Greater Glasgow and Clyde Research and Development (GN20PH059). Approval was obtained from all relevant local ethics committees. The NHS Scotland electronic data research and innovation service linked and de-identified data prior to analysis. This article is reported in accordance with the strengthening the reporting of observational studies in epidemiology guidelines.[15]

Inclusion criteria

We obtained data for all births in Scotland between 1 April 2013 and 31 December 2019 inclusive from SMR02. This 6 year period reflects a time with detailed recording of alcohol consumption at the initiation of antenatal care. All pregnant women in Scotland are routinely provided with antenatal care, which is free at the point of access, and for over 75% of patients, obstetric care is initiated in the first trimester.

Maternal alcohol consumption

The primary outcome was self-reported units of alcohol consumption per week by pregnant women (defined as average units consumed per week in the preceding 3-month period), at the initiation of antenatal care obtained from the SMR02 dataset (see online supplemental figure 1 for alcohol questionnaire). In the UK, one unit of alcohol is defined as 10 millilitres (ml), or 8 grams of pure ethanol. Alcohol consumption of >0 and ≤1 unit per week was recorded as one unit, with all other values reported to the nearest whole unit up to 97 units per week. Women who drank alcohol were further subdivided into 'light drinkers' (>0 but ≤4 units per week) and 'women who consume >4 units per week'.

Maternal data and confounding variables

We obtained data on maternal characteristics and prior obstetric history. We considered confounding variables to be gestational age at booking, maternal age, body mass index (BMI) as calculated from booking weight and height measurements, and parity, coded as ordinal data. Self-reported drug misuse was coded as 'yes/no'. Socioeconomic status was measured using a person's Scottish Index of Multiple Deprivation (SIMD) derived from the area of residence at the time of delivery.[16] SIMD is a score calculated from 33 indicators covering seven domains (income, employment, health, education, access to services, crime and housing). SIMD was stratified into quintiles with one being the most deprived and five being the least deprived. Self-reported ethnicity was classified per the 2011 Scotland census. Smoking status was based on self-classification at the initiation of antenatal care and comprised current smokers or non-smokers (never/former smokers).

Perinatal outcomes

Linked offspring outcomes were obtained from SMR02, SBR and NRS and included preterm birth (<37 weeks of estimated gestation), SGA (birth weight below the 10th percentile), neonatal unit admission and stillbirth (intrauterine death after 24 weeks of estimated gestation).

Interventions

We evaluated three distinct alcohol-related interventions. Two represented universally applicable, enforceable statutory policies affecting the Scottish population, with the

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

second of the three interventions targeted directly at pregnant women. These interventions were:

1. A lower permissible drink-driving limit of 0.05 g/dL reduced from 0.08 g/dL: 5 December 2014.
2. UK CMO advice to all pregnant women to avoid alcohol consumption during pregnancy: 6 January 2016.
3. The introduction of minimum unit alcohol pricing (MUP): 1 May 2018.

We included a 3-month 'lag phase' to allow for an adoption and embedding phase for each intervention.

Statistical analyses

We performed interrupted time-series analysis to quantify changes in alcohol consumption reported at the initiation of antenatal care after implementing each of three government interventions, with a 3 month lag to all measures to take effect on reported alcohol intake. We divided the data into four periods for analysis: (1) Pre-existing trends (April 2013 to December 2014), (2) Post-drink-driving legislation (January 2015 to January 2016), (3) Post-UK CMOs' advice to abstain from alcohol during pregnancy (February 2016 to May 2018) and (4) Following MUP implementation (June 2018 to December 2019). Any woman for whom data on alcohol consumption were missing, or alcohol consumption greater than the upper limit of recording (98 units per week or greater), was excluded from the quantitative analysis of alcohol intake, though data were included in the analysis of offspring outcomes. Interventions were assessed for both step changes and trend changes. A step change was defined as the change in the mean units of alcohol consumed per week per woman from the month preceding the intervention to 3 months following the intervention. A trend change was defined as the monthly change in the mean reported units of alcohol consumed per week following the intervention. We performed analyses for each intervention individually, using a stacked additive approach (ie, the first and second interventions vs the preintervention period, and the second and third interventions vs all preceding periods); and cumulatively to include all interventions (online supplemental figure 2).

To model the time-series data and to account for autocorrelation, trends and seasonality, we used an autoregressive integrated moving average technique. The benefits of this approach include that it allows us to incorporate relations between observations while also exploring changes relative to the underlying background trends in the data and has been recommended for routine health data. To estimate the autoregressive, differencing and moving average components of the data, we used the Akaike Information criterion (AIC), with the lowest AIC statistic indicating the model with the best fit.[17]

Offspring outcomes were analysed using adjusted and non-adjusted models on imputed data. We imputed missing data for confounders using multiple imputations through chained equations to form 10 imputed datasets employing a predictive mean matching methodology. Ten iterations assured data output stability, and 10 imputations guaranteed the accuracy of pooled variable effect size estimates. Adjustments were made for maternal age, maternal BMI, ethnicity, parity, SIMD, smoking status, drug misuse and estimated gestation at booking. Risk ratios (RR) were calculated for outcomes using the immediate epoch before each intervention, using a stacked additive approach to include different combinations of interventions, and then for the cumulative effect of the three interventions on pregnancies after 1 May 2018 compared with those before December 2014. We used multivariable Poisson regression models with cluster robust sandwich estimators under the generalised estimation equation framework. These models were chosen in place of log-binomial models to avoid problems with convergence. The robust estimator was used to correct the inflated variance typically found in standard Poisson models and to account for the clustering effect of sequential births in the same women. This regression model produced adjusted relative risks (adjRR) and 95% CI. To understand the incidence of the adverse perinatal outcomes within the preintervention period, we calculated the incidence and the overall trend.

We performed the following additional sensitivity analyses to further evaluate the robustness of our findings. First, we measure the effect if no 3 month lag phase was included (immediate change), and then we extended our lag period from 3 months to 6 months to account for a potentially slower impact of policy changes. Second, we stratified the analysis of maternal alcohol consumption by smoking status. Third, we performed a sensitivity analysis removing the adjustment for gestational age at booking from the model. Fourth, we sought to address the observed variation in reported alcohol consumption during the final year of the 7 year study period. Although the wording of the alcohol consumption question remained consistent throughout the study, there was increased enforcement of data interpretation and recording policies in the latter period. We therefore considered the alcohol consumption data from the later period to be a more accurate reflection of true prevalence, whereas data from earlier years were likely subject to under-reporting due to inconsistencies in documentation and interpretation. To mitigate this discrepancy and adjust for probable under-reporting in the earlier years, we applied a retrospective normalisation process. This adjustment was conducted in three stages: (1) Initial adjustment (no normalisation): data from earlier years were adjusted based on observed reporting patterns, without applying any prevalence correction, (2) Partial normalisation (50% adjustment): a subset of women previously recorded as non-drinkers in the earlier period were randomly reclassified according to 50% of the alcohol consumption prevalence observed in the final year and (3) Full normalisation: the earlier data were fully aligned with the prevalence rates recorded during the final study year, with random reallocation of non-drinking women to reflect the distribution observed in the later period. This staged approach allowed us to explore the potential impact of under-reporting on

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

alcohol consumption trends and to generate sensitivity analyses based on varying degrees of data correction.

Analyses were conducted on the R software platform (V.4.0.5) and included modelling using the 'forecast' package (V.8.16).[18] Imputed data were used where any adjustment or stratification of analyses was required.

Role of the funding source

The funders had no role in the study design, data collection or analysis, interpretation of data, writing of the report or decision to submit.

Dissemination to participants and related patient and public communities

To maximise the impact of our findings, we will employ a multifaceted dissemination strategy, targeting both academic and public audiences. Our plan includes leveraging social media platforms such as X (previously known as Twitter) and Facebook to engage with the public, healthcare professionals and policymakers. We will collaborate with patient advocacy groups and professional societies such as the Royal College of Obstetricians and Gynaecologists and Royal Society for Public Health to ensure our research reaches a wide audience and is presented in an accessible format, including lay summaries and infographics. Press releases will be distributed to both national and international media outlets, and findings will be presented at national and international conferences to foster academic and clinical discussion. We aim to facilitate a feedback loop by encouraging commentary and discussion through our social media channels, allowing us to gauge public and professional response to our findings. This feedback will be invaluable for guiding future research directions and policy recommendations, ensuring our work remains aligned with patient needs and priorities.

RESULTS

Between 1 April 2013 and 31 December 2019, 346 360 women initiated antenatal care, of whom 321 333 (92.8%) had data recorded for alcohol consumption (online supplemental tables 1 and 2, online supplemental figure 3). Initiation of antenatal care remained consistent at around ten weeks of gestation throughout the study period (online supplemental table 3). Of these, 36 208 (11.3%) women reported drinking alcohol (drinkers) and 281 125 (88.7%) women reported consuming no alcohol during pregnancy (non-drinkers) (table 1, online supplemental figure 3); 16 207 (44.8%) women were 'light drinkers' (>0 to ≤4 units per week), and 20 001 (55.2%) were 'women who drank >4 units per week' (table 1). Reporting of alcohol consumption varied throughout the study period from 2373 per year (5.8%) in 2013 to 12 225 women per year (26.1%) in 2019 (online supplemental table 2). Women who drank were more likely to be older, white, have lower BMI, misuse drugs and live in less socioeconomically deprived areas (table 1). Women from the most deprived areas were more likely to consume >4 units per week (table 1). Maternal characteristics were broadly similar during each of the intervention epochs (online supplemental table 4).

Maternal alcohol consumption

Over the study period, we found a small decrease in the mean alcohol consumption of women who reported drinking alcohol, from 7.09 (95% CI 6.71 to 7.47) units per week in 2013 to 6.70 (95% CI 6.55 to 6.84, p<0.001) units per week in 2019 (online supplemental table 5). In 'light drinkers' (>0 and ≤4 units per week), alcohol consumption increased from 2.38 (95% CI 2.31 to 2.45) in 2013 to 2.66 (95% CI 2.63 to 2.69, p<0.001) units per week in 2019. Contrastingly, alcohol consumption in 'women who drank >4 units' decreased from 10.87 (95% CI 10.46 to 11.27) units per week in 2013 to 10.18 (95% CI 10.01 to 10.35, p<0.001) units per week in 2019 (figure 1a, online supplemental table 5). Alcohol consumption was greatest in women who reported drinking from the most deprived residential areas (SIMD1 in 2019, 7.46 (95% CI 7.20 to 7.73) units per week versus the least deprived residential area (SIMD5 in 2019, 5.93 (95% CI 5.74 to 6.12) units per week, p<0.001) (figure 1b, online supplemental table 6). There was limited evidence of a reduction of this socioeconomic gradient in alcohol consumption over the study period (figure 1b). Women who smoked during pregnancy consistently consumed more alcohol across the study period (9.43 (95% CI 8.90 to 9.96) units per week in 2019 vs non-smokers (6.16 (95% CI 6.04 to 6.28), p<0.001)) (figure 1c, online supplemental table 7).

Impact of public health interventions on maternal alcohol consumption

Neither the introduction of the drink-driving legislation on the 5th of December 2014, nor the UK's CMO advice to all pregnant women to avoid alcohol consumption during pregnancy on the 6th of January 2016, had any discernible effect on self-reported alcohol consumption in pregnant women who drank, either when considered as individual interventions or cumulatively (table 2). In contrast, the introduction of the MUP in Scotland in 2018 led to a fall in alcohol consumption in pregnant drinkers by a mean of 0.59 (95% CI −0.99 to −0.18) units per week, when compared with the epoch before the intervention (ie, when both the drink-driving legislation and CMO advice were already in place) (table 2). By the end of the study period, following all three interventions, there was evidence of a step change in alcohol consumption, with a reduction of 0.69 (95% CI −0.90 to −0.48) units per week in pregnant drinkers, though there was no trend change (−0.01 (95% CI -0.15×10^{-2} to 0.04) units per week per month) (table 2). The results were similar after removing the 3-month lag period (online supplemental table 8) or extending to 6 months (online supplemental table 9) and in non-smokers (online supplemental table 10), though not in smokers (online supplemental table 11).

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 1 Maternal characteristics of women who booked pregnancies between April 2013 and December 2019, by reported alcohol intake

Characteristic	Non-drinker n=285 125*	Drinker n=36 208*	P value†	Alcohol 1–4 units, n=16 207*	Alcohol >4 units, n=20 001*	P value†
Maternal age, years (IQR)	30.00 (26.00, 34.00)	31.00 (27.00, 34.00)	<0.001	31.00 (27.00, 34.00)	31.00 (26.00, 34.00)	<0.001
SD (99 percentile)	*5.68 (18.00, 42.00)*	*5.53 (17.71, 43.91)*		*5.32 (20.00, 39.00)*	*5.68 (20.00, 39.00)*	
Maternal BMI, kg/m† (IQR)	25.16 (22.21, 29.62)	25.10 (22.27, 29.30)	0.029	24.91 (22.10, 29.04)	25.30 (22.41, 29.38)	0.15
SD (99 percentile)	*6.02 (17.43, 45.12)*	*5.69 (17.71, 43.94)*		*5.69 (19.27, 37.46)*	*5.69 (19.47, 37.37)*	
Missing	5905	442		95	347	
Maternal height, cm (IQR)	165.00 (160.00, 169.00)	165.00 (161.00, 169.00)	<0.001	165.00 (161.00, 169.00)	165.00 (161.00, 169.00)	<0.001
SD (99 percentile)	*6.49 (150.00, 180.00)*	*6.42 (150.35, 180.00)*		*6.43 (155.00, 175.00)*	*6.42 (155.00, 176.00)*	
Missing	5199	372		79	293	
Maternal weight, kg (IQR)	68.00 (60.00, 80.00)	69.00 (60.00, 80.00)	0.003	68.00 (60.00, 80.00)	69.00 (61.00, 80.00)	<0.001
SD (99 percentile)	*17.08 (45.00, 125.00)*	*16.30 (46.00, 122.00)*		*16.19 (51.00, 103.00)*	*16.38 (52.00, 103)*	
Missing	4537	315		68	247	
Ethnicity, n (%)			<0.001			<0.001
Black	3672 (1.6%)	144 (0.5%)		87 (0.7%)	57 (0.4%)	
Mixed	1431 (0.6%)	120 (0.4%)		66 (0.5%)	54 (0.3%)	
White	207 395 (92%)	28 351 (98%)		12 433 (97%)	15 918 (98%)	
Other	2828 (1.3%)	105 (0.4%)		60 (0.5%)	45 (0.3%)	
Asian	10 740 (4.8%)	328 (1.1%)		197 (1.5%)	131 (0.8%)	
Missing	59 059	7160		3364	3796	
SIMD quintile, n (%)			<0.001			<0.001
01	70 222 (25%)	8669 (24%)		3482 (22%)	5187 (26%)	
02	61 217 (22%)	7277 (20%)		3114 (19%)	4163 (21%)	
03	52 050 (18%)	6365 (18%)		2998 (19%)	3367 (17%)	
04	53 351 (19%)	6595 (18%)		3170 (20%)	3425 (17%)	
05	47 742 (17%)	7264 (20%)		3420 (21%)	3844 (19%)	
Missing	543	38		23	15	
Smoker during pregnancy, n (%)	46 265 (17%)	5875 (17%)	0.7	1925 (12%)	3950 (21%)	<0.001
Missing	6339	999		217	782	
Drug misuse, n (%)	4012 (1.6%)	673 (2.0%)	<0.001	202 (1.3%)	471 (2.6%)	<0.001
missing	40 517	2932		974	1958	
Parity, n (IQR)	1.00 (0.00, 1.00)	1.00 (0.00, 1.00)	<0.001	1.00 (0.00, 1.00)	1.00 (0.00, 1.00)	<0.001
SD (99 percentile)	*1.10 (0.00, 5.00)*	*1.02 (0.00, 4.00)*		*1.02 (0.00, 3.00)*	*1.02 (0.00, 3.00)*	

Continued

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest.
Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 1 Continued

Characteristic	Non-drinker n=285 125*	Drinker n=36 208*	P value†	Alcohol 1–4 units, n=16 207*	Alcohol >4 units, n=20 001*	P value†
Missing	700	100		515	1125	
Year, n (%)			<0.001			<0.001
2013‡	35 275 (12%)	2373 (6.6%)		1051 (6.5%)	1322 (6.6%)	
2014	47 226 (17%)	3605 (10%)		1493 (9.2%)	2112 (11%)	
2015	46 689 (16%)	3435 (9.5%)		1.492 (9.2%)	1943 (9.7%)	
2016	45 568 (16%)	3508 (9.7%)		1554 (9.6%)	1953 (9.8%)	
2017	42 187 (15%)	3573 (9.9%)		1554 (9.6%)	2019 (10%)	
2018	37 914 (13%)	7459 (21%)		3385 (21%)	4074% (20%)	
2019	30 266 (11%)	12 255 (34%)		5678 (35%)	6577 (33%)	

*n (%).
†Wilcoxon rank sum test; Pearson's χ^2 test.
‡Start date 1 April 2013.
BMI, body mass index; SIMD, Scottish index of multiple deprivation.

Impact of alcohol-related public health interventions on perinatal outcomes

Over the period of the three public health interventions, the incidence of SGA decreased from 9.9% to 8.5%, and stillbirths from 4 per 1000 pregnancies to 3 per 1000 pregnancies, while the prevalence of preterm births increased from 7.0% to 7.7% (figure 2a,b, online supplemental table 12). This was not accompanied by a change in neonatal unit admissions, which were maintained at around 8.6% (figure 2c, online supplemental table 12). We used adjusted multivariable analyses to assess the effect of the individual alcohol-related interventions while accounting for the changes in the underlying maternal population. For SGA, the introduction of the drink-driving ban (adjRR 0.97 (95% CI 0.94 to 1.00)); CMO advice to abstain from alcohol (adjRR 0.95 (95% CI 0.92 to 0.98)); and MUP (adjRR 0.96 (95% CI 0.93 to 0.99)) were associated with a reduced risk of SGA when considered both individually and cumulatively across all three interventions (adjRR 0.88 (95% CI 0.85 to 0.90)) (table 3). The prevalence of preterm birth increased following all interventions (adjRR 1.09 (95% CI 1.06 to 1.13)). The public health interventions were associated with a reduction in the prevalence of neonatal unit admissions after CMO advice (adjRR 0.93 (95% CI 0.90 to 0.96)) and MUP (adjRR 0.96 (95% CI 0.93 to 0·99)), and cumulatively across all interventions (adjRR 0.94 (95% CI 0.91 to 0.96)). Rates of stillbirth were unaffected by the interventions both individually and cumulatively (adjRR 0.87 (95% CI 0.74 to 1.02)) (figure 2d, table 3). Results were similar when gestational age at booking was removed from the analysis (online supplemental table 13), and in unadjusted analyses (online supplemental table 14). To account for changes in reported alcohol consumption across the study period, alcohol intake was normalised to 0%, 50% and 100% of the reported prevalence in the final year of the study period in adjusted analyses (online supplemental tables 15–17). Results were consistent with the primary analysis.

DISCUSSION

We demonstrate that by 2019, up to 1 in 4 pregnant women in Scotland reported drinking on average 6–8 units of alcohol per week in early pregnancy, up from 7% in 2013. Although drink-driving legislation and specific guidance to pregnant women to abstain from alcohol were not individually or collectively associated with a sustained reduction in the amount of alcohol consumed by pregnant drinkers, the introduction of alcohol MUP was associated with a small reduction of approximately half a unit per week (4g ethanol) when compared with the preceding period. Cumulatively, the effect of all three interventions was a reduction of almost 0.7 units per week, with even greater effects of 1.2 units per week in women who were booked ≥9 weeks of gestation. There was some temporal evidence of a beneficial impact of the interventions on perinatal outcomes, with the prevalence of SGA

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

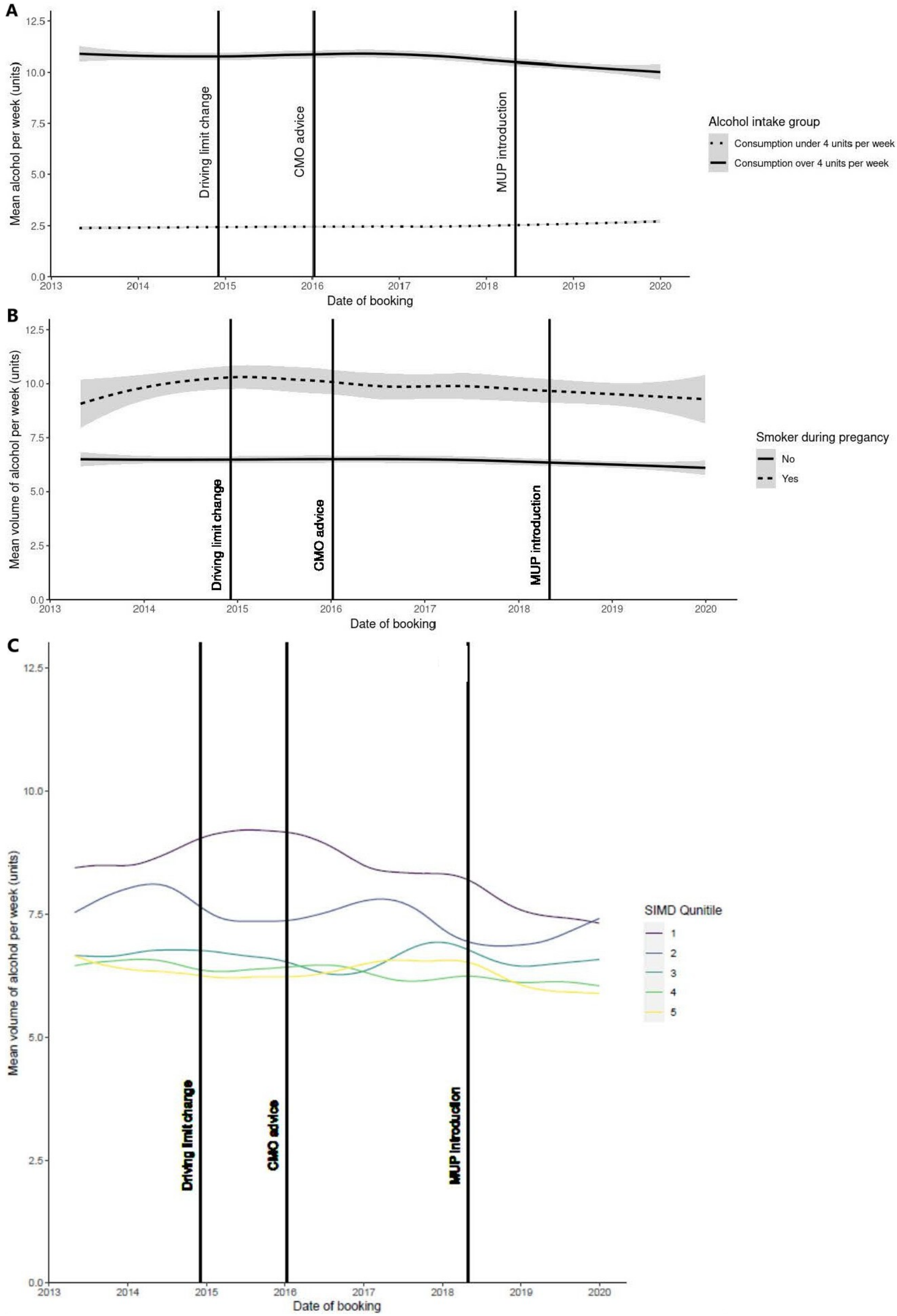

Figure 1 Temporal maternal alcohol consumption relative to baseline characteristics. (A) Mean alcohol consumption (units per week) in heavy and low drinkers following public health interventions in Scotland. (B) Mean alcohol consumption (units per week) by socioeconomic status in drinkers. (C) Mean alcohol consumption (units per week) by smoking status in drinkers.

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 2 Step and trend changes in reported alcohol consumption in pregnancy following public health interventions

Drinking status	Step or trend change	Introduction of new drink driving limits in Scotland	Recommendation to abstain from alcohol in pregnancy from the Chief Medical Officers of the UK (CMO)[1]	Introduction of a £0.5 minimum sale price of 1 unit of alcohol in Scotland (MUP)	Effect of drink-driving limits and CMO	Effect of CMO and MUP	Collective impact of all three interventions
Analysis cohort (n=32 133)	Step change,* units of alcohol per week change (95% CI)	−0.13 (−0.25 to −0.01)	−0.02 (−0.15 to 0.12)	1.06 (0.88 to 1.25)	−0.02 (−0.14 to 0.11)	1.09 (0.97 to 1.21)	0.14 (−0.11 to 0.39)
	Trend change†, units per week per month (95% CI)	0.02 (−0.03 to 0.05)	-0.02×10^{-2} (−0.03 to 0.03)	−0.02 (−0.03 to 0.06)	-0.25×10^{-2} (−0.03 to 0.02)	0.02 (-0.36×10^{-2} to 0.04)	0.01 (−0.05 to 0.07)
Drinker cohort (n=36 208)	Step change*, units of alcohol per week change (95% CI)	−0.29 (−0.86 to 0.29)	0.08 (−0.37 to 0.53)	−0.59 (−0.99 to −0.18)	−0.07 (−0.02 to 0.01)	−0.33 (−0.53 to −0.13)	−0.69 (−0.90 to −0.48)
	Trend change†, units per week per month (95% CI)	0.04 (−0.04 to 0.13)	−0.01 (−0.03 to 0.02)	0.01 (−0.02 to 0.05)	0.01 (−0.15 to 0.29)	−0.01 (−0.03 to −0.01)	−0.01 (-0.15×10^{-2} to 0.04)
Heavy drinker cohort (n=20 001)	Step change* to units of alcohol per week change (95% CI)	−0.35 (−1.01 to 0.29)	0.11 (−0.38 to 0.60)	−0.83 (−1.27 to 0.37)	0.48 (0.10 to 0.86)	−0.46 (−0.70 to −0.22)	−0.23 (−0.61 to 0.14)
	Trend change†, units per week per month (95% CI)	0.06 (−0.04 to 0.16)	−0.02 (−0.05 to 0.15)	0.02 (−0.02 to 0.06)	−0.02 (−0.04 to 0.32×10^{-2})	−0.01 (−0.03 to 0.01)	0.01 (−0.03 to 0.05)
Light drinker cohort (n=16 207)	Step change*, units of alcohol per week change (95% CI)	−0.06 (−0.21 to 0.08)	−0.02 (−0.14 to 0.10)	0.18 (0.07 to 0.30)	−0.06 (−0.14 to 0.02)	0.18 (−0.07 to 0.18)	0.24 (0.17 to 0.32)
	Trend change†, units per week per month (95% CI)	0.01 (−0.01 to 0.03)	0.12×10^{-2} (−0.01 to 0.01)	0.00 (−0.01 to 0.01)	0.20×10^{-2} (−0.01 to 0.01)	0.01 (-0.01×10^{-2} to 0.02)	0.07×10^{-2} (-0.86×10^{-2} to 0.99×10^{-2})

*Step change—a change of mean alcohol units per week in the month before and compared with the 3 months after the intervention.
†Trend change—a change in the mean alcohol units per week per month after the intervention when compared with change in the mean alcohol units per week per month prior to the intervention to starting at 3 months postintervention.
MUP, Minimum Unit Pricing for Alcohol.

and neonatal admissions declining overall. In contrast, the prevalence of stillbirths did not change while preterm births increased throughout the study period.

MUP compared with the existing drink-driving legislation and CMO advice to abstain from alcohol in pregnancy was associated with a small decline in alcohol consumption in pregnant drinkers and in the risk of SGA in all pregnancies. The reduction in alcohol consumption is in accordance with the known reduction in alcohol-related sales in Scotland and other countries on the introduction of MUP.[19 20] The success of MUP, particularly in women who consume >4 units per week, is likely to relate to its mandatory and comprehensive implementation, and the clarity of the underlying message. The reduction in SGA with the introduction of MUP is consistent with two previous reviews of RCTs and quasi-experimental studies suggesting that greater alcohol consumption in pregnancy does cause an increase in SGA.[12 13] That a population-level intervention such as MUP contributed toward reducing maternal alcohol consumption in women who drink during pregnancy and improved key perinatal outcomes in the obstetric population is an important finding and supports the introduction of population-based measures. Drink-driving legislation was originally introduced in Scotland in 1967, and the legislation in 2014 further lowered the permissible drink-driving limit from 0.08 g/dL to the lowest detectable concentration 0.05 g/dL. Despite this 'zero tolerance' approach, we did not observe a change in mean maternal alcohol consumption in pregnant drinkers following this legislation, nor following the UK CMOs' advice to abstain completely from alcohol. This was despite broad awareness by midwives of these policies and wide adoption of alcohol product labels to discourage drinking or state 'it is safest not to drink alcohol when pregnant'.[21] Whether the failure of the CMO advice to impact alcohol consumption was due to the lack of targeted intervention programmes and/or the limited effectiveness of labelling in reducing alcohol consumption is unclear. The cumulative effects of the interventions over time led to a reduction in alcohol use across all socioeconomic strata, with a reduction in the difference between SIMD 1 and

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

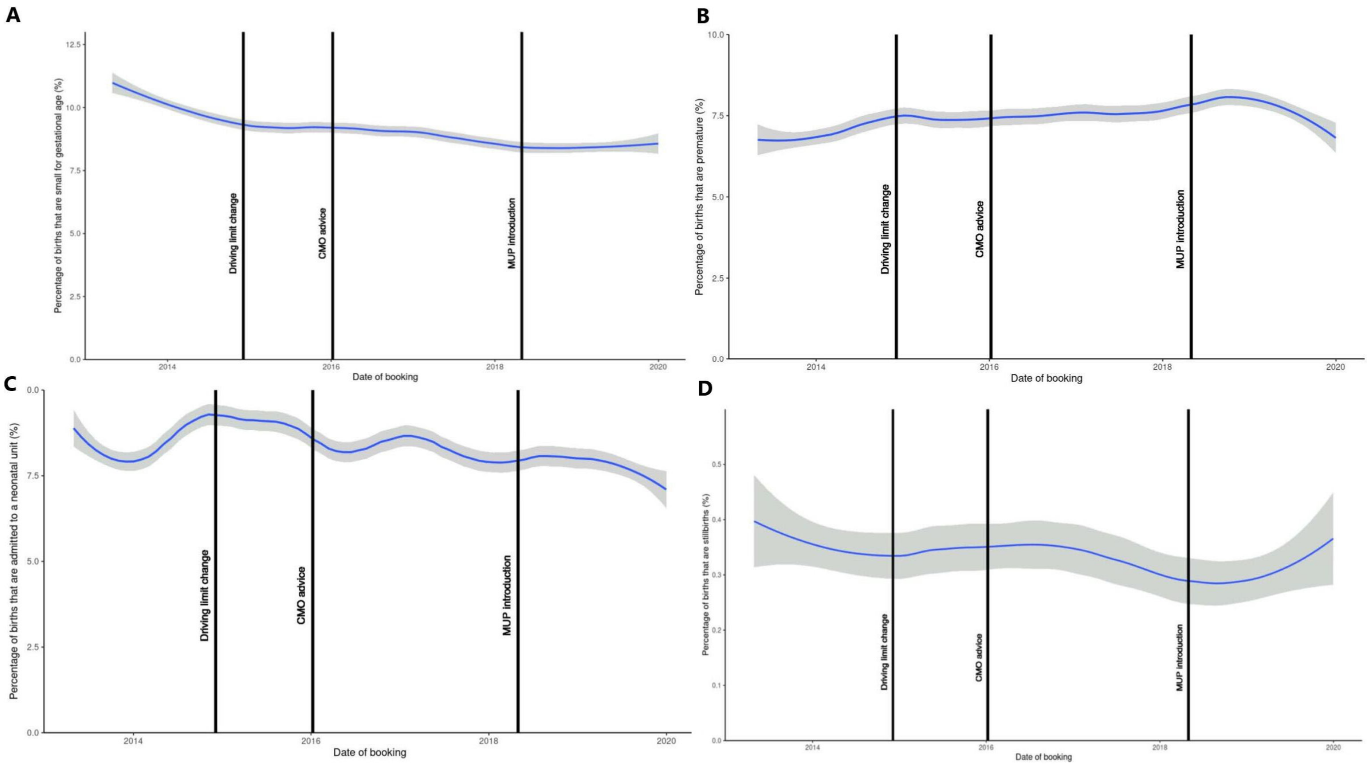

Figure 2 Prevalence of perinatal complications relative to alcohol-related public health interventions. (A) Small for gestational age births (%) following public health interventions in Scotland, unadjusted. (B) Premature births (%) following public health interventions in Scotland, unadjusted. (C) Neonatal unit admission (%) following public health interventions in Scotland, unadjusted. (D) Stillbirths (%) following public health interventions in Scotland, unadjusted. Gray shaded area represents 95% CI.

5 between 2013 and 2019. The persistence of the socioeconomic gradient, where drinkers in more deprived areas consume more heavily, is likely due to complex underlying determinants that a pricing intervention alone cannot resolve. These may include higher levels of chronic stress, differing social norms and alcohol and drugs being used as a coping mechanism, reinforcing the need for integrated strategies that combine universal policies with targeted support.

It has been recognised for many decades that low birth weight and being born SGA pose a risk factor for immediate perinatal and long-term adverse health outcomes.[22] We identified a reduction in SGA following MUP and a trend to reduce throughout the study period. Heavy alcohol consumption has previously been associated with an increased risk of SGA.[23] Although the prevalence of consumption of >4 units per week reduced over the studied period, we cannot exclude the possibility that other contemporary improvements in maternal health may have contributed. For example, wider use of low-dose aspirin, which is protective against SGA, with the effect estimates from RCTs similar to those reported here.[24] The increasing prevalence of preterm birth is likely to reflect altered obstetric care pathways rather than a biological effect, particularly given the known tocolytic mechanisms related to alcohol.[25] Many risk factors for preterm birth, including the proportion of mothers aged 40 years or over at delivery, obesity and socioeconomic deprivation, are common in Scotland and continue to increase, with obstetric interventions also increasing the risk of iatrogenic preterm birth.[26]

We acknowledge several limitations, including the short time period of 1 year after MUP introduction. However, extending the study period was not feasible as the COVID-19 pandemic would have introduced a major, unmeasurable confounding effect on both population behaviour and healthcare delivery. Additionally, the reliance on self-reported alcohol consumption is generally underestimated in women who drink more heavily and may bias our results, particularly for the 'light drinker' cohort.[27] However, our effect estimates for MUP are similar to those reported for alcohol sales which are regulated and reported in accordance with statutory legislation. The disparity between the background drinking prevalence among women in the general population (~80%) and the 26% prevalence observed in our pregnant cohort in 2019 likely reflects the success of public health messaging, with many women ceasing alcohol use either in anticipation of pregnancy or on conception. Furthermore, unlike dedicated population surveys, such as the Scottish Health Survey, alcohol use in pregnancy is recorded in a clinical context where social stigmas may influence accurate disclosure.[28] However, the persistence of alcohol consumption in a minority remains a key public health challenge. Factors such as unplanned pregnancy, socioeconomic stress, addiction and levels

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 3 Adjusted perinatal outcomes following public health interventions

	Preintervention. starting incidence, end incidence (trend)*	Introduction of new drink driving limits in Scotland†, adj‡ risk ratio (95% CI), P value	Recommendation to abstain from alcohol in pregnancy from the Chief Medical Officers of the UK (CMO)†, adj‡ risk ratio (95% CI), P value	Introduction of a £0.5 minimum sale price of 1 unit of alcohol in Scotland (MUP)†, adj‡ risk ratio (95% CI), P value	Effect of drink-driving limits and CMO§, adj‡ risk ratio (95% CI), P value	Effect of CMO and MUP¶, adj‡ risk ratio (95% CI), P value	Collective impact of all three intervention§, adj‡ risk ratio (95% CI), P value
Small for gestational age	6.5% to 5.6% (–2.65^{-4}%/day)	0.97 (0.94 to 1.00); 0.033	0.95 (0.92 to 0.98); <0.001	0.96 (0.93 to 0.99); 0.007	0.92 (0.89 to 0.94); <0.001	0.91 (0.88 to 0.94); <0.001	0.88 (0.85 to 0.90); <0.001
Prematurity	5.0% to 5.8% (2.28^{-4}%/day)	1.07 (1.03 to 1.11); <0.001	1.01 (0.98 to 1.05); 0.4	1.01 (0.98 to 1.04); 0.5	1.08 (1.05 to 1.12); <0.001	1.03 (0.99 to 1.06); 0.2	1.09 (1.06 to 1.13); <0.001
Neonatal unit admission	6.1% to 7.2% (2.60^{-4}%/day)	1.04 (1.01 to 1.08); 0.009	0.93 (0.90 to 0.96); <0.001	0.96 (0.93 to 0.99); 0.011	0.97 (0.95 to 1.00); 0.049	0.90 (0.87, 0.93); <0.001	0.94 (0.91, 0.96); <0.001
Stillbirth	–0.24% to 0.21% (–2.13^{-4}%/day)	1.03 (0.87 to 1.22); 0.7	0.90 (0.76 to 1.07); 0.2	0.93 (0.79 to 1.10); 0.4	0.93 (0.80 to 1.08); 0.3	0.84 (0.70, 1.01); 0.070	0.87 (0.74, 1.02); 0.10

*Estimated incidence of outcome at start and end of preintervention period and estimated change in incidence per day of study, over preintervention period. % (%/day).
†Relative to the epoch prior.
‡Adjusted for: estimated gestation at booking, smoking, drug use, age of mother, maternal body mass index, ethnicity, parity and Scottish index of multiple deprivation.
§Relative to pregnancies after 1 May 2018 relative to April 2013–December 2014.
¶Relative to the epoch prior to CMO advice.

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

of health literacy may contribute to continued drinking. Our findings highlight that while drinkers were more often from less deprived backgrounds, women from the most deprived areas who did consume alcohol reported significantly higher intake, suggesting the need for targeted interventions in this population.

We recognise the temporal differences in data collection (5.8% vs 26.2% women reporting alcohol consumption in 2013 and 2019, respectively) and the potential under-reporting of drinking in the early epochs of the data. This variation is specifically why we did not include non-drinkers in our analyses of mean alcohol consumption and acknowledge that this may have underestimated mean alcohol consumption. However, we compared units of alcohol consumed per week over time and found that this did not differ between time periods, with period observed rates and estimates of units of consumption consistent with recent studies. As this study involved retrospective analysis of routinely collected administrative health data, we could not influence data quality at the point of collection. In particular, alcohol consumption data may have been subject to under-reporting in earlier years due to inconsistent recording practices, social desirability bias and variation in data entry methods (eg, paper vs electronic records). The observed increase in reported alcohol consumption over time likely reflects improved data completeness rather than a true rise in prevalence. We addressed this by undertaking our primary analysis on reported consumption among drinkers rather than on population-wide prevalence and performed sensitivity analyses using staged normalisation (0%, 50% and 100%) to adjust for probable under-reporting. These analyses demonstrated minimal impact on our perinatal outcomes, reinforcing the robustness of our findings despite potential misclassification in earlier data. We acknowledge missing data for alcohol consumption, though this remained relatively constant throughout the study period. Women with missing data were more likely to have adverse characteristics (smoking, socioeconomic deprivation, drug use), which will contribute to the uncertainty of the outcome estimates. However, the rate of missing data was similar between drinkers and non-drinkers. Analyses for neonatal outcomes were imputed to account for this. Self-reported alcohol consumption was solely recorded at the initiation of antenatal care, which was predominantly in the first trimester. To adjust for the minor variations in gestational age at booking throughout the cohort's time period, gestational age at booking was included in the models, with results similar to those where it was not included. Subsequent changes in alcohol consumption, as well as other confounding factors, across gestation or time period may have occurred, but alcohol consumption is likely to reduce across gestation due to societal pressure and therefore is only likely to have attenuated our results, and we adjusted our results across the study period. We acknowledge that SMR02 data captures average alcohol consumption in the 3 months prior to the first antenatal booking appointment (~10 weeks gestation), which incorporates a period before the woman is aware she is pregnant. We could not disaggregate the reported consumption into pre-conception and post-conception periods, though both are considered important in early organogenesis, a point highlighted in national guidelines advising women who are trying to conceive to abstain.[29] We were unable to perform adjustments for pregnancy-related complications (eg, pre-eclampsia, eclampsia, placenta previa), or chronic diseases due to inconsistencies in data collection and recording. We therefore focused on the robustly and consistently recorded variables, including maternal age, BMI, ethnicity, parity, socioeconomic status (SIMD), smoking and drug misuse. These factors, particularly SIMD and BMI, serve as strong proxies for the overall burden of chronic disease.

Smoking and alcohol consumption are frequently linked behaviours; however, our results were similar in non-smokers. Given the established adverse effect of smoking on pregnancy, future strategies may target reducing the combination of smoking and alcohol consumption in pregnancy. While the National Institute for Clinical Excellence guidance for antenatal care did not change during the study period, we recognise that concomitant public health interventions and local changes in obstetric care practices may have contributed to our findings. We appreciate that we were unable to determine individual effects of all of the interventions; however, the observed cumulative effect may suggest that small individual shifts in behaviour accumulated and that the three interventions were eventually synergistic. Similarly, we were unable to assess alternative outcomes, like miscarriage or fetal alcohol spectrum, which have been associated with alcohol consumption in some studies.[30] Lastly, our findings are restricted to the pregnant population, and as such, cannot be generalised to the wider Scottish population or to other countries with different legislative and public health alcohol-related interventions.

CONCLUSION

This study finds that maternal alcohol consumption in pregnancy is common, with around 1 in 4 women self-reporting alcohol consumption in early pregnancy. The amount of alcohol consumed by pregnant drinkers has decreased by around 0.7 units per week over the past 6 years in Scotland and is associated with the introduction of MUP, though not drinking-driving legislation nor CMO advice. We observed an overall reduction in the key perinatal outcomes of SGA and neonatal unit admission, despite an underlying increase in preterm births. This study supports the need for further broad-based policies, such as embedding routine brief interventions and motivational interviewing into antenatal care, developing targeted support for high-risk groups that address underlying social determinants, and enhancing pre-conception education about the risks of alcohol. Given the lack of evidence of safety even at lower levels of alcohol consumption, comprehensive education and continued public

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

policy efforts reinforcing low alcohol consumption for people embarking on pregnancy is warranted.

Acknowledgements We would like to acknowledge the support of the eDRIS team (Public Health Scotland) for their involvement in obtaining approvals, providing and linking data, and the use of the secure analytical platform within the National Safe Haven. The views expressed in this publication are those of the author(s) and not necessarily those of the UK National Health Service, or any funders or institutions acknowledged here.

Contributors MK, RJK, MS and SN had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: All authors. Acquisition, analysis or interpretation of data: All authors. Initial drafting of the manuscript: MK, RJK, MS and SN. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: MK, MS and AK. Obtained funding: RJK, MS, JPP, AL, DL and SN. Administrative, technical or material support: MS, AK, RJK and SN. Supervision: RJK, MS, AL, JPP, DL and SN. Other—obtaining regulatory approval and providing analysis advice: RJK, MS, AL, DL and SN. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. SN and RJK are the joint last authors.

Funding This work was supported by an NHS Research Scotland Senior Researcher Fellowship (RK) and by a grant from Wellbeing of Women (RGS2301). DAL's contribution is supported by the UK Medical Research Council (MC_UU_00032/05) and the British Heart Foundation (CH/F/20/90003 and AA/18/1/34219). AL's contribution is supported by the Medical Research Council (MC_UU_00022/2) and Chief Scientist Office, Scotland (SPHSU17). None of the funders had any role in the design, data analyses or interpretation of results. Views expressed in this paper are those of the authors and not necessarily of any funders.

Competing interests All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work. Outside of the submitted work, RJK is a board member and research lead for the Obstetric Anaesthetists' Association, and declares funding from the Chief Scientist's Office (Scotland) for research unrelated to this paper in the last 36 months. SMN has participated in Advisory Boards and received speakers' or consultancy fees from Access Fertility, Beckman Coulter, Ferring, Finox, Merck, MSD, Roche Diagnostics and The Fertility Partnership. SMN has declared funding from the Chief Scientist's Office and the National Institute of Health Research, for research unrelated to this paper in the last 36 months. All funds for these grants go to and are managed and audited by the University of Glasgow. DAL has declared funding from the National Institute of Health Research, Diabetes UK and the US National Institute of Health Research, for research unrelated to this paper in the last 36 months. All funds for these grants go to and are managed and audited by the University of Bristol. DL is a member of the UK Biobank strategic oversight committee, Chair of the scientific advisory board for the Bradford Health Research Institute public health 'ActEarly' Programme and Chair of the NIHR-BHF partnership working group on maternal cardiovascular health. She does not receive any payment for these activities. The authors whose names are listed immediately below certify that they have no affiliations with or involvement in any organisation or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript: MK, MS, AK, JPP and AL.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval Data governance procedures and ethical approval to use the data were granted by the NHS Scotland Public Benefit and Privacy Panel for Health and Social Care (1920-0097). Local approval to use the data was granted by NHS Greater Glasgow and Clyde Research and Development (GN20PH059). Approval was obtained from all relevant local ethics committees.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. All health care data used in this research is held by Public Health Scotland and is outlined in the Methods section of the main text.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: https://creativecommons.org/licenses/by-nc/4.0/.

Author note I, MK, the lead author (the manuscript's guarantor), affirm that the manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ORCID iDs
Michael Kinsella https://orcid.org/0000-0001-8172-4032
Aizhan Kyzayeva https://orcid.org/0000-0002-2981-8688
Alastair Leyland https://orcid.org/0000-0003-3741-7099
Scott Nelson https://orcid.org/0000-0002-9099-3047
Rachel Joyce Kearns https://orcid.org/0000-0001-6156-6858

REFERENCES

1 Global status report on alcohol and health 2018. World Health Organization; 2018. Available: https://apps.who.int/iris/handle/10665/274603 [Accessed 10 Jun 2023].
2 Popova S, Lange S, Probst C, *et al*. Estimation of national, regional, and global prevalence of alcohol use during pregnancy and fetal alcohol syndrome: a systematic review and meta-analysis. *Lancet Glob Health* 2017;5:e290–9.
3 Broccia M, Munch A, Hansen BM, *et al*. Heavy prenatal alcohol exposure and overall morbidities: a Danish nationwide cohort study from 1996 to 2018. *Lancet Public Health* 2023;8:e36–46.
4 Steane SE, Young SL, Clifton VL, *et al*. Prenatal alcohol consumption and placental outcomes: a systematic review and meta-analysis of clinical studies. *Am J Obstet Gynecol* 2021;225:607.
5 Scottish Government. Changing Scotland's relationship with alcohol: a framework for action. Edinburgh, UK Scottish Government; 2009. Available: https://www.ias.org.uk/uploads/pdf/News%20stories/scotland-alcohol-report0209.pdf [accessed 11 Jun 2023]
6 Kilian C, Lemp JM, Llamosas-Falcón L, *et al*. Reducing alcohol use through alcohol control policies in the general population and population subgroups: a systematic review and meta-analysis. *eClinicalMedicine* 2023;59:101996.
7 Siegfried N, Parry C. Do alcohol control policies work? An umbrella review and quality assessment of systematic reviews of alcohol control interventions (2006 - 2017). *PLoS One* 2019;14:e0214865.
8 Fell JC, Scherer M. Estimation of the Potential Effectiveness of Lowering the Blood Alcohol Concentration (BAC) Limit for Driving from 0.08 to 0.05 Grams per Deciliter in the United States. *Alcohol Clin Exp Res* 2017;41:2128–39.
9 Giles L, Mackay D, Richardson E, *et al*. Evaluating the impact of minimum unit pricing (MUP) on alcohol sales after 3 years of implementation in Scotland: A controlled interrupted time-series study. *Addiction* 2024;119:1378–86.
10 Jacobsen B, Lindemann C, Petzina R, *et al*. The Universal and Primary Prevention of Foetal Alcohol Spectrum Disorders (FASD): A Systematic Review. *J Primary Prevent* 2022;43:297–316.
11 Department of Health. UK Chief Medical Officers' low risk drinking guidelines. 2016. Available: https://assets.publishing.service.gov.uk/media/5a7f51b4e5274a2e87db5206/summary.pdf [Accessed 11 Jun 2023].
12 Mamluk L, Edwards HB, Savović J, *et al*. Low alcohol consumption and pregnancy and childhood outcomes: time to change guidelines indicating apparently "safe" levels of alcohol during pregnancy? A systematic review and meta-analyses. *BMJ Open* 2017;7:e015410.
13 Mamluk L, Jones T, Ijaz S, *et al*. Evidence of detrimental effects of prenatal alcohol exposure on offspring birthweight and neurodevelopment from a systematic review of quasi-experimental studies. *Int J Epidemiol* 2021;49:1972–95.

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

14 World Health Organization. The ICD-10 classification of mental and behavioural disorders: clinical descriptions and diagnostic guidelines. Geneva WHO; 1992. Available: https://apps.who.int/iris/handle/10665/37958 [accessed 20 Jul 2023]
15 Elm E von, Altman DG, Egger M, *et al*. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 2007;335:806–8.
16 Scottish Government. The Scottish index of multiple deprivation (SIMD). 2020. Available: https://www.gov.scot/collections/scottish-index-of-multiple-deprivation-2020 [Accessed 23 Jun 2023].
17 Akaike H. Information theory and an extension of the maximum likelihood principle. Selected papers of hirotugu akaike. Springer; 1998.199–213.
18 Hyndman RJ, Athanasopoulos G, Bergmeir C, *et al*. Package ‘forecast,’ 2020. Available: https://cran.r-project org/web/packages/forecast/forecast pdf [Accessed 15 Jul 2023].
19 O’Donnell A, Anderson P, Jané-Llopis E, *et al*. Immediate impact of minimum unit pricing on alcohol purchases in Scotland: controlled interrupted time series analysis for 2015-18. *BMJ* 2019;366:l5274.
20 Anderson P, O’Donnell A, Kaner E, *et al*. Impact of minimum unit pricing on alcohol purchases in Scotland and Wales: controlled interrupted time series analyses. *Lancet Public Health* 2021;6:e557–65.
21 Zuckermann AME, Morissette K, Boland L, *et al*. The effects of alcohol container labels on consumption behaviour, knowledge, and support for labelling: a systematic review. *Lancet Public Health* 2024;9:e481–94.
22 Finken MJJ, van der Steen M, Smeets CCJ, *et al*. Children Born Small for Gestational Age: Differential Diagnosis, Molecular Genetic Evaluation, and Implications. *Endocr Rev* 2018;39:851–94.
23 Patra J, Bakker R, Irving H, *et al*. Dose–response relationship between alcohol consumption before and during pregnancy and the risks of low birthweight, preterm birth and small for gestational age (SGA)—a systematic review and meta-analyses. *BJOG* 2011;118:1411–21.
24 Duley L, Meher S, Hunter KE, *et al*. Antiplatelet agents for preventing pre-eclampsia and its complications. *Cochrane Database Syst Rev* 2019;2019:CD004659.
25 Haas DM, Morgan AM, Deans SJ, *et al*. Ethanol for preventing preterm birth in threatened preterm labor. *Cochrane Database Syst Rev* 2015;2015:CD011445.
26 Goldenberg RL, Culhane JF, Iams JD, *et al*. Epidemiology and causes of preterm birth. *Lancet* 2008;371:75–84.
27 Stockwell T, Donath S, Cooper-Stanbury M, *et al*. Under-reporting of alcohol consumption in household surveys: a comparison of quantity-frequency, graduated-frequency and recent recall. *Addiction* 2004;99:1024–33.
28 Scottish Government. The Scottish health survey. 2023. Available: https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2024/11/scottish-health-survey-2023-volume-1-main-report/documents/scottish-health-survey-2023-main-report-volume-1/scottish-health-survey-2023-main-report-volume-1/govscot%3Adocument/scottish-health-survey-2023-main-report-volume-1.pdf [Accessed 20 Aug 2025].
29 Public Health England. Maternity high impact area: reducing the incidence of harms caused bu alcohol in pregnancy. Available: https://assets.publishing.service.gov.uk/media/67efd0e7d065389a655cef9c/Maternity_high_impact_area_4_Reducing_the_incidence_of_harms_caused_by_alcohol_in_pregnancy.pdf [Accessed 20 Aug 2025].
30 Saxov KR, Strandberg-Larsen K, Pristed SG, *et al*. Maternal alcohol consumption and the risk of miscarriage in the first and second trimesters: A systematic review and dose-response meta-analysis. *Acta Obstet Gynecol Scand* 2023;102:821–32.

BMJ Public Health: first published as 10.1136/bmjph-2025-003264 on 7 November 2025. Downloaded from https://bmjpublichealth.bmj.com on 10 November 2025 by guest. Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.