

The short-term impact of the alcohol act on alcohol-related deaths and hospital admissions in Scotland: a natural experiment

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ABSTRACT

Background and aim The introduction of the Alcohol Act in Scotland on 1 October 2011, which included a ban on multi-buy promotions, was probably associated with a fall in off-trade alcohol sales in the year after its implementation. The aim of this study was to test if the same legislation was associated with reduced levels of alcohol-related deaths and hospital admissions in the 3-year period after its introduction. **Design** A natural experiment design using time-series data to assess the impact of the Alcohol Act legislation in Scotland. Comparisons were made with unexposed populations in the rest of Great Britain. **Setting** Scotland with comparable data obtained for geographical control groups in other parts of Great Britain. **Participants** For alcohol-related deaths, a total of 17 732 in Scotland and 88 001 in England and Wales throughout 169 4-week periods between January 2001 and December 2013 and for alcohol-related hospital admissions, a total of 121 314 in Scotland and 696 892 in England throughout 182 4-week periods between January 2001 and December 2014. **Measurements** Deaths and hospital admissions in Scotland and control groups that were wholly attributable to alcohol for consecutive 4-week periods between January 2001 and December 2014. Data were obtained by age, sex and area-based socio-economic position. **Findings** There was no evidence to suggest that the Alcohol Act was associated with changes in the overall rate of alcohol-related deaths [incidence rate ratio (IRR) = 0.99, 95% confidence interval (CI) = 0.91–1.07] or hospital admissions (IRR = 0.98, 95% CI = 0.95–1.02) in Scotland. In control group analyses, the pseudo intervention variable was not associated with a change in alcohol-related death rates in England/Wales (IRR = 0.99, 95% CI = 0.95–1.02), but was associated with an increase in alcohol-related hospital admission rates in England (IRR = 1.05, 95% CI = 1.03–1.07). In combined models, the interaction analysis did not provide support for a 'net effect' of the legislation on alcohol-related deaths in Scotland compared with England/Wales (IRR 0.99, 95% CI = 0.95–1.04), but suggested a net reduction in hospital admissions for Scotland compared with England (IRR = 0.93, 95% CI = 0.87–0.98). **Conclusion** The implementation of the Alcohol Act in Scotland has not been associated clearly with a reduction in alcohol-related deaths or hospital admissions in the 3-year period after it was implemented in October 2011.

Keywords Alcohol, multibuy promotion ban, natural experiment, policy evaluation, price legislation, Scotland, time-series analysis.

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INTRODUCTION

Deaths related to alcohol increased rapidly in Scotland during the 1990s and early 2000s, in contrast to declining trends in most other European countries [1,2]. In recognition of the scale of this public health problem, from 2008 to 2009 the Scottish Government introduced a comprehensive

alcohol strategy [3]. 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.

Legislation to introduce a minimum price per alcohol unit was included in Scotland's alcohol strategy and passed by the Scottish Parliament in 2012 [4], although its

implementation has been stalled due to a legal challenge. Conversely, the Alcohol (etc.) Scotland Act ('Alcohol Act') was implemented as intended on 1 October 2011 and introduced new regulations concerning the sale and promotion of alcohol by off-trade retailers (i.e. alcohol sold for off-premises consumption) [5]. These included (for more details see [6]): a ban on retailers selling multiple containers of alcohol for less than the total cost of buying each individually (e.g. promoting three bottles for £10 where an individual bottle might cost £4, or selling three bottles for the price of two); restricting the location of drinks promotions to within a single area of the store (extending prior legislation that restricted the sale of alcohol to a single area); the requirement of an age verification policy; powers to introduce a social responsibility levy on licence holders; and a requirement for Health Boards to be notified of premises' licence applications in their geographical area.

A number of systematic reviews and meta-analyses have confirmed that increasing alcohol prices is one of the most effective ways of reducing population alcohol consumption and related harms [7–10]. The evidence base for the impact of other changes to the regulatory environment, such as price-based promotions and restrictions to the locations of promotions, is more limited [10,11]. Using electronic alcohol sales data, Bray *et al.* [12] concluded that volume-based promotions encouraged people to buy larger-volume packages of beer. In a cross-sectional study in Australia, Jones *et al.* [13] showed that point-of-sale promotions were associated with an increase in the volume of alcohol purchased. End-of-aisle displays have also been shown to increase sales of alcohol products [14].

Two recent studies have evaluated specifically the impact of the Alcohol Act on population consumption levels in Scotland. Nakamura and colleagues analysed self-reported data from a household panel sample and concluded that the legislation had no overall effect on off-trade alcohol purchases in Scotland in the 9-month period after it was implemented [15]. Although the ban reduced the number of products purchased on each shopping trip, this was offset by an increase in the frequency of shopping trips in which alcohol was purchased. In another study, which analysed retail sales data—considered the most accurate data for estimating population consumption [16]—it was concluded that the legislation was associated with a 2.6% decrease in the total volume of alcohol sold in the off-trade per adult in Scotland [17]. This was driven mainly by a 4% fall in wine sales, but there was also an 8% fall in sales of pre-mixed drinks (e.g. vodka mixed with lemonade), although these account for a very small market share. While the studies arrived at different overall conclusions, it has been argued that there was some consistency in the results in terms of associations between the Alcohol Act and reductions in specific drink types [17].

A reduction in population alcohol consumption may be expected to translate into effects on alcohol-related health harms. Immediate impacts on acute alcohol-related hospital admissions, referring to conditions related generally to episodes of intoxication, have been observed in other countries following the introduction of alcohol policies [18,19]. Studies in Canada have also shown that increased minimum prices for alcohol are associated with immediate reductions in alcohol-related mortality [20] and reductions in chronic alcohol-related hospital admissions after 2 years [19]. These observations are supported by a systematic review that concluded that immediate effects following a change in population consumption would be expected on population rates of many chronic causes of alcohol-related health harm, including alcoholic liver disease, although the time lag for the full effect could be up to 20 years [21].

The aims of this study were to (1) investigate whether the Alcohol Act had any short-term impact on rates of alcohol-related deaths and hospital admissions in Scotland; and (2) to compare estimated effects in Scotland with appropriate control populations from the rest of Great Britain that were not exposed to the legislation.

METHODS

Design

Negative binomial regression was used to assess the impact of the Alcohol Act in Scotland on mortality and hospital admissions wholly attributable to alcohol. We used time-series data for Scotland grouped into consecutive 4-week periods (13 per year) throughout 13 years, including at least 2 years of series post-intervention for each outcome, with a concurrent control group of England/Wales (deaths) or England (hospital admissions). Models were adjusted for socio-demographic characteristics, seasonality and underlying trend.

The comparator groups for evaluating the impact of the Alcohol Act used data for England and England and Wales for deaths and admissions, respectively, because they were the comparator populations used as part of the wider evaluation of Scotland's alcohol strategy [3]. These were selected as being the most appropriate based on data availability and comparability, and the fact that many external factors would have an impact upon both the Scottish and comparison population such that the discrete impact of a particular alcohol policy or intervention in Scotland could be determined.

Data sources

National Records for Scotland (NRS) maintain a record of all deaths that occur in Scotland. We used a data set provided by NRS to determine the number of alcohol-related deaths occurring during 4-week periods in Scotland

between January 2001 and December 2013, by sex, age group (15–24; 25–34; 35–44; 45–54; 55–64; 65–74; 75+ years) and Carstairs deprivation decile (an area-based deprivation measure of socio-economic position: '1, most deprived' to '10, least deprived'). Alcohol-related deaths were defined as those coded with a condition that is wholly attributable to alcohol as the underlying cause, in accordance with the ICD-10 code list used in the United Kingdom [22] (Supporting information, Table S1.1). The 4-week periods were defined to coincide with the introduction of the Alcohol Act on 1 October 2011. Equivalent data for England/Wales (combined) were obtained by submitting a request to the Office for National Statistics. Carstairs deprivation deciles were calculated across the whole of Great Britain. In other words, the 10% of the Scottish population living in the most deprived decile in Scotland did not necessarily all live within the most deprived GB decile (see Supporting information, Section 2.1).

The Scottish Morbidity Record (SMR01) is a national data scheme that records comprehensive information relating to all in-patients and day cases admitted to acute National Health Service (NHS) hospitals in Scotland [23]. We obtained data on the number of patients admitted with an alcohol-related condition in 4-week periods between January 2001 and December 2014 from NHS National Services Scotland (NSS). SMR01 excludes psychiatric hospitals and attendances at Accident and Emergency that do not result in an admission. As with the data on deaths, hospital admission data were obtained by sex, age group and Carstairs deprivation decile. Alcohol-related hospital admissions were defined using the same International Classification of Diseases (ICD-10) code set used by NSS, who are responsible for publishing national statistics on alcohol-related hospital admissions in Scotland (Supporting information, Table S1.2). This includes only those conditions wholly attributable to alcohol. Data on patients with an alcohol-related condition coded only in the primary diagnostic position were included and patients were counted only once in each 4-week period, even if they had multiple admissions. Equivalent data for England were obtained by submitting a request to the NHS Health and Social Care Information Centre.

For both outcomes, 4-week periods were used to increase the number of time-periods for analysis, while ensuring a sufficient number of events in each time-period. Data were not broken down by condition (or groups of conditions) for the main analysis, because the overarching aim of Scotland's alcohol strategy was to reduce overall alcohol-related deaths and hospital admissions [3].

Descriptive analysis

We determined the rate of alcohol-related deaths and hospital admissions during each 4-week period in each

population subgroup. Population counts for each subgroup were estimated for each 4-week period using population data from the 2001 and 2011 censuses, with linear interpolation between 2001 and 2011 and extrapolation beyond 2011. The overall crude rate in both of these outcomes during the study time-period was plotted in charts. In addition, to ease visual interpretation of trends, the time-series for each outcome was decomposed into trend and seasonal components using the *stl* command (seasonal decomposition by loess) in R Studio version 3.0.2 software (R Studio, Boston, MA, USA) [24]. This decomposition is not adjusted for sex, age or socio-demographic factors and uses a different approach to trends and seasonality than the regression approach described below and so is included for descriptive purposes only.

Statistical analysis

We used a two-stage multivariable regression approach to assess the impact of the Alcohol Act. First, we fitted separate models for deaths and admissions using data for each country. As the data were count data (i.e. a number of deaths or admissions) and the variance greater than the mean (over-dispersion), we used negative binomial regression models. Models were adjusted for sex, age group (15–34; 35–44; 45–54; 55–64; 65+ years) and Carstairs deprivation quintile ('1, most deprived' to '5, least deprived'). Population was accounted for as an offset variable and we adjusted our models for seasonality and the underlying trend in the data series (see Supporting information, Section 2.2). We selected a random-effects regression model, as this allowed the over-dispersion to vary by sex, age and socio-economic deprivation subcategory within each regression (note: the random-effects only refers to the distribution of the dispersion parameter; in the regression part of the model the sex, age and deprivation coefficients are fixed effects as with standard regression).

To analyse whether or not the introduction of the Alcohol Act was associated with a change in alcohol-related deaths or hospital admissions, we included a binary intervention variable in our models, with the value of 1 assigned to deaths or hospital admissions occurring after the legislation was introduced (1 October 2011 onwards) and the value of zero before. This variable was included as a pseudo intervention variable in the separate models for the comparator areas and modelled a different temporal trend in each intervention group.

We assessed goodness-of-fit of the selected model by comparing predicted values with observed values using the R^2 and root mean square error (RMSE) statistics. Plots of predicted versus observed values and the goodness-of-fit statistics for the main models are provided in the Supporting information, Figs S4.1–S4.4. The Bayes factor was calculated for the results of the main analysis [25].

Statistical analyses were undertaken using STATA/SE version 14 software (Stata Corp., College Station, TX, USA).

Sensitivity/supplementary analyses

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

- 1 We curtailed the pre-intervention period in the Scottish hospital admissions model to start at period 100 (the start of a downward trend in November 2008) to reduce the number of inflection points in the data series.
- 2 We re-fitted our final, best-fitting models using false legislation dates. In these models, the Alcohol Act variable was moved to coincide with the date 6 and 12 months before and after the actual implementation date. Such falsification tests are useful for assessing the plausibility of attribution of effects by checking effect specificity [26].
- 3 We repeated our analyses using North West and North East England (combined) [27] as the control. This was because it has been suggested that Northern England is a more appropriate control group for Scotland than England or England/Wales due to a more similar socio-demographic make-up and alcohol culture (perhaps reflecting a similar industrial history) [28].
- 4 We repeated our main analysis using admissions data for Scotland in which an alcohol-related condition had been coded in any diagnostic position (in Scotland there are six). This enabled us to examine the impact of restricting our analysis of hospital admissions data to those with an alcohol-related condition in the primary diagnostic position only.
- 5 We repeated our main analysis using admissions data for Scotland that were categorized as either acute or chronic (see Supporting information, Tables S1.2). Such an approach has been recommended when evaluating the impact of alcohol policies in population-level studies [18,19].

RESULTS

Descriptive analysis

There was a total of 17 732 alcohol-related deaths in Scotland and 88 001 in England/Wales throughout 169 4-week periods between January 2001 and December 2013. A total of 121 314 alcohol-related hospital admissions occurred in Scotland and 696 892 in England throughout 182 4-week periods between January 2001 and December 2014.

The crude rate of 4-week alcohol-related deaths was consistently higher in Scotland than in England/Wales during the time-period analysed (Fig. 1). In Scotland,

there has been a notable downwards trend since early 2005. In England/Wales, alcohol-related death rates have been relatively stable during the time-period analysed. In both Scotland and England/Wales there was clear seasonality in alcohol-related deaths, with peaks during the Christmas and New Year period and the lowest rates during summer months. In addition, most deaths throughout the study time-period occurred among men, adults aged 55–64 years, and those living in the most deprived areas (Supporting information, Table S3.1).

In general, the trend in alcohol-related hospital admissions in Scotland can be described as broadly stable between 2001 and 2004, upwards between 2004 and 2008 and downwards to 2014 (Fig. 2). In England, rates of alcohol-related hospital admissions increased between 2002 and 2009, remaining stable thereafter. Although there have been consistently higher alcohol-related hospital admission rates in Scotland, the difference between countries has decreased over time. Seasonal hospital admission patterns are different to those for deaths with the peak rate occurring over the summer months. In both countries, alcohol-related hospital admission rates were highest throughout the period of analysis among men, adults aged 45–54 years, and those living in the most deprived areas (Supporting information, Table S3.2).

Intervention effect

Table 1 shows the estimated effect of the Alcohol Act on alcohol-related deaths and hospital admissions in Scotland and England/Wales based on an adjusted multivariable regression model (results from our unadjusted regression models were very similar and are presented in the Supporting information, Table S3.3). There was no evidence to suggest that the Alcohol Act was associated with changes in the overall rate of alcohol-related deaths in Scotland [incidence rate ratio (IRR) = 0.99, 95% confidence interval (CI) = 0.91–1.07]. In England/Wales, there was no overall change in alcohol-related death rates after the implementation of the legislation in Scotland (IRR = 0.99, 95% CI = 0.95–1.02). In the combined model, the interaction analysis did not provide support for a 'net effect' of the legislation on alcohol-related deaths in Scotland compared with England/Wales (IRR = 0.99, 95% CI = 0.95–1.04).

For alcohol-related hospital admissions, the implementation of the Alcohol Act was not associated with a change in the overall rate in Scotland (IRR = 0.98, 95% CI = 0.95–1.02). In England, the pseudo-intervention variable was associated with an increase in alcohol-related hospital admission rates (IRR = 1.05, 95% CI = 1.03–1.07). In the combined model, the interaction analysis showed that the

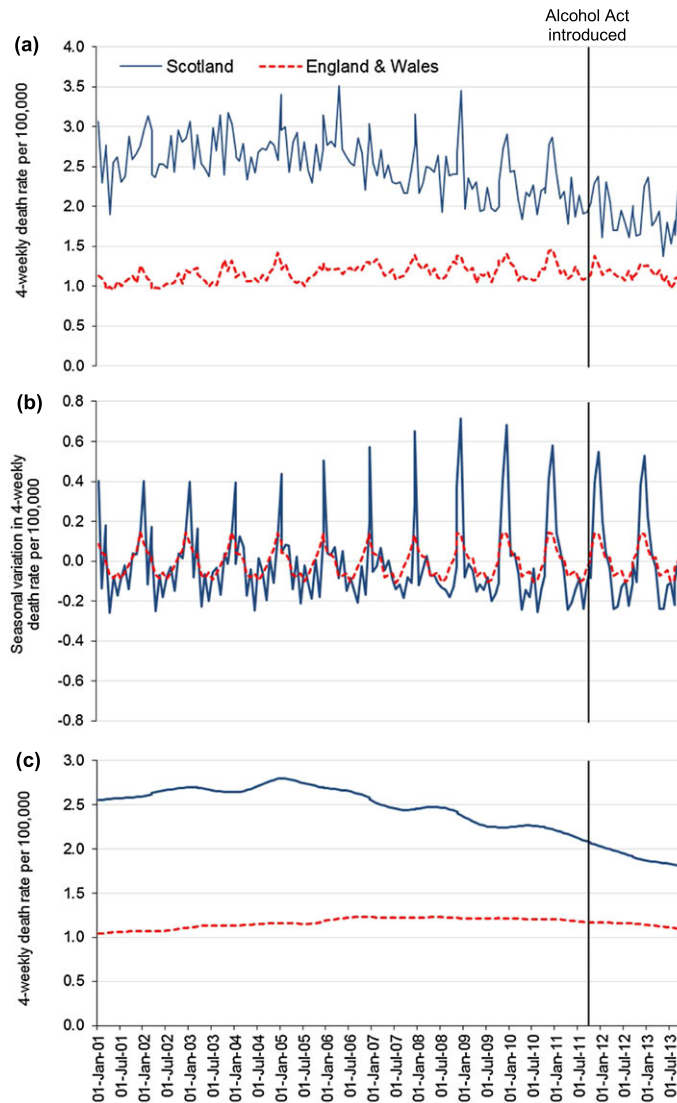


Figure 1 Trends in crude alcohol-related death rates in Scotland and England and Wales (a) and the decomposed seasonal (b) and trend (c) components, January 2001 and December 2013. The ICD-10 codes included in the definition of alcohol-related deaths are listed in the Supporting information, Table S1.

Alcohol Act was associated with a net reduction in alcohol-related hospital admissions in Scotland when compared with England (IRR = 0.93, 95% CI = 0.87–0.98).

Confidence in the results of all the main findings was augmented by the calculated Bayes factors (see Supporting information, Section 3.1).

Sensitivity/supplementary analysis

Restricting the time-period analysed for the hospital admissions data to November 2008 onwards did not have a notable impact on the estimated effect of the Alcohol Act on the overall rate of admissions in Scotland or England (Table 1). However, the estimated impact of the Alcohol Act variable was sensitive to the use of false

legislation dates, with both magnitude and direction of the best estimate changing depending on the date used (Table 1). This was particularly the case for the estimated effect of the pseudo Alcohol Act variable on hospital admissions in England; the IRR of 1.05 in the main analysis generally reduced in magnitude and moved closer to or below the null value of 1. When analyses were repeated using data for North West and North East England (combined), similar results were produced for alcohol-related deaths and hospital admissions as seen for England/Wales and England, respectively (Table 1). We were unable to model with sufficient robustness the impact of the legislation in hospital admissions data in Scotland when broken down by acute and chronic conditions; the effect estimate was particularly sensitive to the number of knots due to the

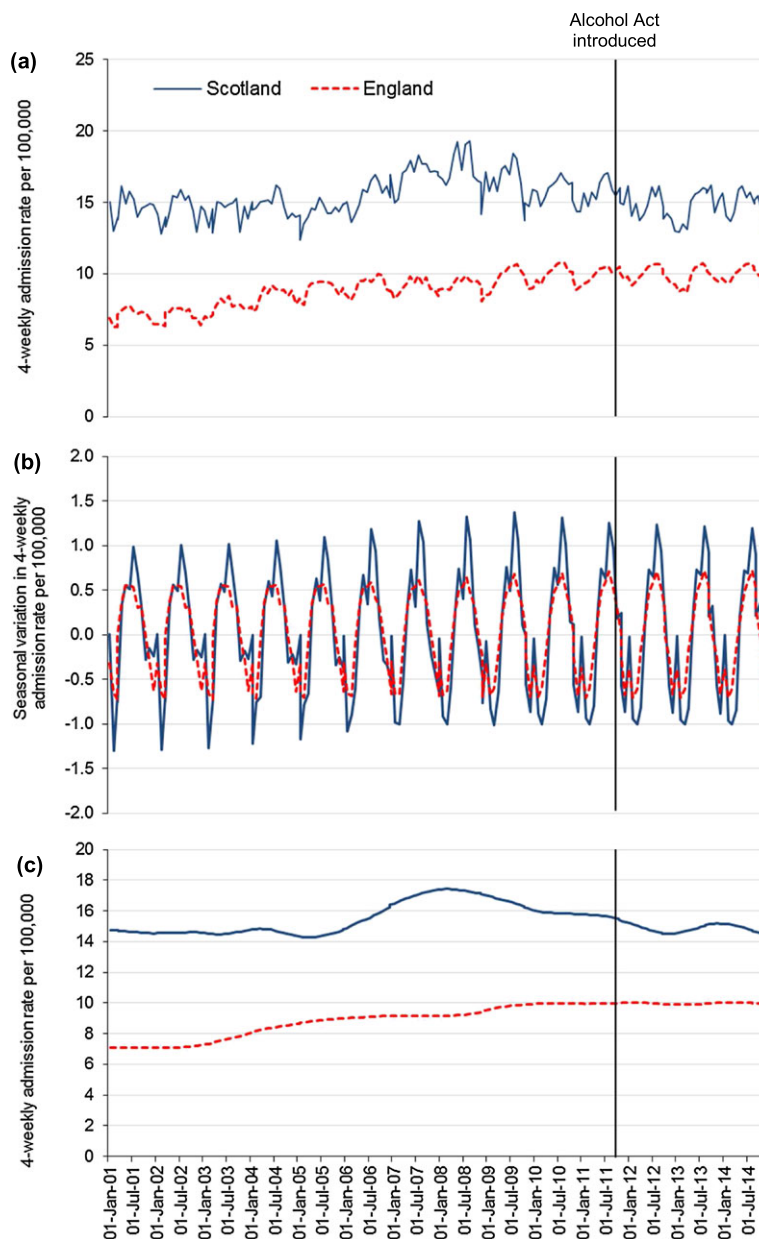


Figure 2 Trends in crude alcohol-related hospital admission rates in Scotland and England (a) and the decomposed seasonal (b) and trend (c) components, January 2001 and December 2014. The ICD-10 codes included in the definition of alcohol-related hospital admissions are listed in the Supporting information, Table S2.

reduced number of events within each 4-week period. Finally, broadening the definition of an alcohol-related hospital admission by including patients with an alcohol-related condition in any diagnostic position did not have a meaningful impact on the estimated effect of the Alcohol Act in Scotland (Supporting information, Table S3.4).

DISCUSSION

To our knowledge, this is the first study to investigate the impact of a ban on multi-buy promotions on alcohol-

related deaths and hospital admissions. Our main finding from the study is that the implementation of the Alcohol Act was not associated with any measurable short-term changes in overall rates of alcohol-related deaths or hospital admissions in Scotland.

Strengths and limitations

The data used in our analyses have complete national coverage and are likely to estimate accurately the true number of alcohol-related deaths and hospital admissions in

Table 1 Adjusted incidence rate ratios (IRRs) for the association between alcohol-related death and hospital admission rates in Scotland and comparator areas in the study time-periods before and after the Alcohol Act was introduced in Scotland.

	Scotland			England/Wales ^a			NE/NW England ^b		
	IRR	95% CI	P	IRR	95% CI	P	IRR	95% CI	P
Main analysis									
Deaths	0.99	0.91–1.07	0.73	0.99	0.95–1.02	0.42	1.00	0.92–1.10	0.94
Admissions	0.98	0.95–1.02	0.34	1.05	1.03–1.07	< 0.001	1.03	0.99–1.07	0.08
Sensitivity analysis: shorter pre-intervention trend									
Admissions	0.99	0.94–1.04	0.70	1.08	1.05–1.11	< 0.001	1.07	1.03–1.11	0.001
Sensitivity analysis: false legislation dates									
Deaths									
12 m pre	1.08	1.00–1.18	0.06	1.03	1.00–1.07	0.07	1.07	0.99–1.15	0.08
6 m pre	1.00	0.92–1.08	0.99	1.00	0.97–1.04	0.92	1.06	0.98–1.15	0.16
6 m post	0.99	0.92–1.07	0.79	0.99	0.96–1.02	0.65	1.07	0.97–1.18	0.19
12 m post	1.00	0.93–1.08	0.96	0.98	0.95–1.01	0.18	0.96	0.87–1.05	0.38
Admissions									
12 m pre	1.02	0.99–1.06	0.23	0.98	0.96–1.00	0.12	0.97	0.94–1.01	0.18
6 m pre	1.01	0.98–1.05	0.46	1.03	1.00–1.05	0.03	1.03	0.99–1.07	0.12
6 m post	0.95	0.92–0.99	0.01	0.99	0.97–1.00	0.13	0.99	0.96–1.02	0.41
12 m post	0.97	0.93–1.01	0.13	0.97	0.95–0.99	0.003	0.96	0.93–0.99	0.01

An IRR below 1 indicates a reduction in rates associated with the Alcohol Act. CI = confidence interval. ^aModels with hospital admissions as the outcome included data for England only. ^bSupplementary analysis. All models were adjusted for seasonality, underlying trends, sex, age group and area deprivation quintile.

Scotland and comparator areas. The use of data at individual patient-level and the inclusion of only alcohol-related ICD-10 codes that were wholly attributable to alcohol in the primary diagnostic position also enabled us to ensure that data were as comparable as possible and less likely to be affected by differences and/or changes in coding practices, a particular issue in terms of partially attributable conditions [29]. As we had data broken down by age group, sex and area-based deprivation, we were able to make adjustments for these socio-demographic characteristics in our statistical models. We were also able to account for seasonality and temporal trends. Most of our models had a good model fit.

In principle, other key strengths of this study were the long pre-intervention time-period and the inclusion of concurrent geographic control groups, both of which typically strengthen the evaluation of geographically bound natural experiments [30–32]. In practice, these features of the study design presented challenges to both our analytical methods and the interpretation of our results, particularly for models with alcohol-related hospital admissions as the outcome variable. It is recommended in natural experimental designs that exposed and unexposed groups have similar pre-intervention trends and that the outcomes would respond in a similar manner in the absence of the intervention [30]. However, for both outcomes in this study—alcohol-related deaths and hospital admissions—trends between

Scotland and comparator populations were distinctly different. The long time-series also included multiple inflection points, which made fitting models challenging. Furthermore, results from both our main and sensitivity/supplementary analyses support the finding that the dummy Alcohol Act variable entered into models for our control groups was associated with increased rates of alcohol-related hospital admissions. The net effect of the legislation could therefore be interpreted as being associated with reduced alcohol-related hospital admissions in Scotland. However, we feel that such an interpretation would be misplaced. As the control groups were not exposed to the legislation, and given that our sensitivity analyses showed that the use of false legislation dates moved the effect estimate closer to the null, unmeasured factors offer the best explanation for this seemingly spurious effect. The validity of results from the evaluation of non-randomized interventions can be undermined by the presence of residual confounding [30]. Other factors, such as changes in alcohol policies and the wider socio-economic context, can influence alcohol-related harms. However, such confounding would be likely only if the factor had a different effect over time in the intervention and control groups.

Other limitations include the relatively short post-intervention time-period for both health outcomes, enabling only the short-term impact of the legislation to be assessed. Nonetheless, assessing longer-term impacts

is also challenging, because of the increased likelihood of confounding. The use of wholly attributable alcohol conditions meant that it was not possible to assess the impact of the Alcohol Act on the wider range of deaths and hospital admissions that are partially attributable to alcohol. In addition, including only those admissions with an alcohol-related condition coded as the primary diagnosis, while enhancing comparability between intervention and control groups (which was priority at the outset of the study) meant that admissions where an alcohol-related condition was coded as a secondary diagnosis in a patient's admission were excluded. Additional analysis on admissions that included all diagnostic positions in Scotland did not, however, alter our findings substantively. Ideally, we would have stratified our analysis by acute and chronic conditions, as these may react differently to policy changes [18,19]. Due to a reduced number of events, particularly for acute conditions, the regression models were not sufficiently robust to allow this within our analytical approach. Our data also excluded alcohol-related emergency attendances that did not result in a hospital admission, mainly because of concerns over reliability, completeness and comparability with other countries. Finally, the small number of deaths and, to a lesser extent, hospital admissions in Scotland in each 4-week period, meant that there was large uncertainty around the best estimates of the intervention effect.

Interpretation

With the above caveats in mind, we focus our interpretations on the results observed in Scotland for rates of admissions and deaths overall. As we have demonstrated previously that the Alcohol Act was associated with a 2.6% decline in population consumption levels in Scotland [17], it was hypothesized that overall rates of alcohol-related deaths and admissions in Scotland would also decline. Our results do not support this hypothesis, which might be explained in several ways.

First, our study may not have been able to detect the intervention effect. Only small reductions in alcohol-related health harms would be expected, particularly in the short term, from a 2.6% reduction in off-trade consumption levels [33]. The study found that a best estimate of the effect of the Alcohol Act was for a 1–2% reduction in alcohol-related deaths and hospital admissions. However, the 95% confidence intervals were wide and are consistent with a 9% (5%) reduction or a 7% (2%) increase in alcohol-related death (hospital admission) rates. This problem is not unique to this study; population health evaluations are most definitive when the intervention effects are expected to be large [30].

Secondly, our study examined only the impact of the Alcohol Act on those conditions wholly attributable to alcohol. It is possible that the reduced population consumption levels translated into reductions in the wider range of alcohol-attributable causes (i.e. including those for which alcohol is only a partially attributable cause, such as ischaemic heart disease).

Thirdly, our study was concerned with the short-term effect on alcohol-related harms. Although immediate effects are expected for a number of alcohol-related conditions, the full effect of changes in population consumption on changes in alcohol-related harms (both wholly and partially alcohol-attributable) would not be expected within the study time-period [21]. It remains plausible that the reduced population consumption associated with the Alcohol Act in Scotland, if sustained, may translate into reduced levels of alcohol-related harm in Scotland during a longer time-period. Importantly, an assessment of the impact of policies after relatively short periods post-implementation is often expected by policymakers and politicians. Indeed, legislation to introduce minimum unit pricing in Scotland, which was passed in June 2012 but has not yet been implemented, includes a requirement to evaluate its impact on a number of outcomes, including health harms, after 5 years of implementation.

Fourthly, the fact that wine was the drink type most affected by the Alcohol Act may have had implications for impacts on health harms [17]. Those at highest risk of an alcohol-related hospital admission or death—men, those living in more deprived areas and very heavy drinkers—are least likely to consume wine [34–36]. Wine is most likely to be consumed by population subgroups that have a relatively low rate of alcohol-related harms: women and those living in less deprived areas [34,35,37]. Thus, reduced consumption among these subgroups is unlikely to have had a measurable impact on alcohol-related harms.

Finally, rates of alcohol-related harm depend not only on average consumption levels, but on a range of other factors including patterns of consumption, drinking location and, as alluded to earlier, the socio-demographic characteristics of drinkers. Thus, despite a substantial evidence base supporting an association between aggregate measures of alcohol consumption and alcohol-related harms [7,21], it is plausible that changes in this intervention alone was not sufficient to reduce the risk of alcohol-related mortality for those at highest risk.

Implications

The results of this study do not suggest that implementation of the Alcohol Act has had a substantial impact on short-term alcohol-related deaths or hospital admissions in Scotland. Even though a restriction on promotions is an important aspect of creating an environment in which

alcohol is sold responsibly [7], policies that raise the price of alcohol, particularly the types of alcohol consumed by the heaviest drinkers, are likely to offer a more substantive immediate impact on alcohol-related harms [38].

The analytical challenges that emerged during the course of this study have implications for future evaluations of alcohol policy in Scotland and elsewhere. Fluctuating pre-intervention trends are problematic if attempting to maximize the use of time-series data by accounting for underlying secular and seasonal trends. However, such approaches are more powerful than simple pre-post study designs [31]. Inadequate control groups may serve to hinder rather than help interpretation and preliminary analysis should be set out a priori with criteria for deciding whether or not a control group is appropriate. Future evaluation studies should explore methods such as synthetic control and propensity score-based weighting, which may offer the potential to strengthen causal inference by enabling better control for unexposed geographical comparators [39,40].

CONCLUSION

In conclusion, this study suggests that the introduction of the Alcohol Act legislation in Scotland in October 2011, which was associated with reduced population consumption levels in the year after its implementation, has not had a measurable short-term effect on alcohol-related deaths or hospital admissions (those wholly attributable to alcohol). The longer-term impact of the Alcohol Act, and its impact on deaths and hospital admissions partially attributable to alcohol, remains unknown.

Declaration of interests

Purchase of the alcohol-related death and hospital admission data was funded by the Scottish Government. Consistent with the conditions set out in the Memorandum of Agreement between NHS Health Scotland and the Scottish Government as part of the Monitoring and Evaluating Scotland's Alcohol Strategy work programme, the Scottish Government was provided with the opportunity to review and comment on a draft version of the paper. However, the study authors were responsible for the final study design; collection, analysis, and interpretation of data; writing of the article; and the decision to submit the article for publication. We declare no other interests.

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article.

Table S1.1 ICD-10 codes included in the definition of alcohol-related deaths.

Table S1.2 ICD-10 codes included in the definition of alcohol-related hospital admissions.

Table S3.1 Socio-demographic patterning of alcohol-related death rates in Scotland and England and Wales in the study time-periods before and after the Alcohol Act was introduced in Scotland.

Table S3.2 Socio-demographic patterning of alcohol-related hospital admission rates in Scotland and England in the study time-periods before and after the Alcohol Act was introduced in Scotland.

Table S3.3 Unadjusted incidence rate ratios (IRRs) for the

association between alcohol-related death and hospital admission rates and the implementation of the Alcohol Act legislation in Scotland and comparator areas.

Table S3.4 Adjusted incidence rate ratios (IRRs) for the association between alcohol-related hospital admission rates and the implementation of the Alcohol Act legislation in Scotland using all six diagnostic positions.

Table S3.5 Calculated Bayes factors with interpretation for all of the main statistical models.

Figure S4.1 Plot of observed versus predicted rates of alcohol-related deaths in Scotland.

Figure S4.2 Plot of observed versus predicted rates of alcohol-related deaths in England/Wales.

Figure S4.3 Plot of observed versus predicted rates of alcohol-related hospital admissions in Scotland.

Figure S4.4 Plot of observed versus predicted rates of alcohol-related hospital admissions in England.