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## Review Paper

# Explaining trends in alcohol-related harms in Scotland, 1991–2011 (I): the role of incomes, effects of socio-economic and political adversity and demographic change



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## ABSTRACT

**Objective:** This paper tests the extent to which differing trends in income, demographic change and the consequences of an earlier period of social, economic and political change might explain differences in the magnitude and trends in alcohol-related mortality between 1991 and 2011 in Scotland compared to England & Wales (E&W).

**Study design:** Comparative time trend analyses and arithmetic modelling.

**Methods:** Three approaches were utilised to compare Scotland with E&W: 1. We modelled the impact of changes in income on alcohol-related deaths between 1991–2001 and 2001–2011 by applying plausible assumptions of the effect size through an arithmetic model. 2. We used contour plots, graphical exploration of age-period-cohort interactions and calculation of Intrinsic Estimator coefficients to investigate the effect of earlier exposure to social, economic and political adversity on alcohol-related mortality. 3. We recalculated the trends in alcohol-related deaths using the white population only to make a crude approximation of the maximal impact of changes in ethnic diversity.

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Excess mortality  
Scottish effect  
Age period cohort

Results: Real incomes increased during the 1990s but declined from around 2004 in the poorest 30% of the population of Great Britain. The decline in incomes for the poorest decile, the proportion of the population in the most deprived decile, and the inequality in alcohol-related deaths, were all greater in Scotland than in E&W. The model predicted less of the observed rise in Scotland (18% of the rise in men and 29% of the rise in women) than that in E&W (where 60% and 68% of the rise in men and women respectively was explained). One-third of the decline observed in alcohol-related mortality in Scottish men between 2001 and 2011 was predicted by the model, and the model was broadly consistent with the observed trends in E&W and amongst women in Scotland. An age-period interaction in alcohol-related mortality was evident for men and women during the 1990s and 2000s who were aged 40–70 years and who experienced rapidly increasing alcohol-related mortality rates. Ethnicity is unlikely to be important in explaining the trends or differences between Scotland and E&W.

Conclusions: The decline in alcohol-related mortality in Scotland since the early 2000s and the differing trend to E&W were partly described by a model predicting the impact of declining incomes. Lagged effects from historical social, economic and political change remain plausible from the available data.

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## Introduction

### Evaluating alcohol policy in Scotland

Alcohol has been suggested to be the most harmful substance misused in societies when the wider harms on health and social outcomes (e.g. violence and reduced economic output) are accounted for.<sup>1</sup> In Scotland, many alcohol-related harms rose rapidly from the mid-1990s before peaking in the mid-2000s and subsequently falling. Alcohol-related mortality in Scotland increased from being one of the lowest in Europe in 1980 to become the highest by the year 2000.<sup>2,3</sup> In response to these trends, the Scottish Government introduced a multi-faceted alcohol strategy (brought together in the 2009 Alcohol Framework but with some elements starting in 2007) which encompasses actions which aimed to improve alcohol services, reduce alcohol availability, restrict the marketing of alcohol, and increase the minimum price per unit of alcohol (the latter of which is currently subject of a legal challenge led by the Scotch Whisky Association).<sup>4,5</sup>

In order to be able to evaluate the impact of Scotland's alcohol strategy on alcohol-related outcomes, it is important to be able to disentangle the effects of the strategy from other external factors which may also influence those outcomes. The influence of external factors on alcohol-related outcomes forms a key part of the evaluation (Monitoring and Evaluating Scotland's Alcohol Strategy (MESAS)).<sup>6</sup> The evaluation approach includes the use of a concurrent comparison population (usually England & Wales (E&W)) on the basis that many external factors would have an impact on both the Scottish and comparison population such that the discrete impact of the alcohol strategy in Scotland could be determined.<sup>7</sup> This use of a comparison makes two implicit assumptions: that exposure to the external factors is the same across the populations; and that the same exposure has an equal magnitude of effect in both populations.

### Summary of the trends in alcohol-related outcomes

Table 1 below describes the key indicators of alcohol-related outcomes currently in use within MESAS and their trends in Scotland and E&W. Overall, the alcohol-related mortality (Fig. 1) and hospitalisation data for Scotland indicate a rise during the 1980s, and more quickly during the 1990s, until peaking around 2003–8 before subsequently falling. The trends in mortality in E&W are similar to those in Scotland, rising more modestly over the same time period and peaking around 2–3 years later, and then subsequently falling more slowly. It is also worth noting that several other health and social outcomes (largely affecting those aged <45 years) have shown similar trends to those of alcohol in recent years, including teenage pregnancy, crime (largely due to a reduction in youth crime), suicide and homicide.<sup>h</sup> Furthermore, there are marked increases in the proportion of young people who report that they do not drink alcohol over the last 10 years in Scotland and E&W, and an increase in the proportion of adults in Scotland reporting that they do not drink alcohol at all.<sup>8</sup>

### Explaining trends in alcohol-related harms

The theory of what determines overall population alcohol consumption,<sup>9</sup> and alcohol-related harms,<sup>10</sup> is well developed. Fig. 2 is an adaptation of the Room<sup>9</sup> and Holder<sup>10</sup> models which attempt to provide a simple depiction of the interaction of several complex systems which determine alcohol consumption and harm. Within the *alcohol harms and societal response subsystem*, both the level and distribution of health, economic and social harms are included (as is the design, provision and demand for services, and the design and implementation of policy aimed at addressing harms).

<sup>h</sup> These trends are summarised at [www.scotpho.org.uk](http://www.scotpho.org.uk).

**Table 1 – The key alcohol-related outcomes used in MESAS and their trends.**

Alcohol-related outcome	Description of trend in Scotland	Description of trend in England & Wales
Male age-standardised alcohol-related mortality	Rise in late 1980s and 1990s to peak in 2003, fall since	More gradual rise in late 1980s and 1990s to peak in 2008; more gradual fall since
Female age-standardised alcohol-related mortality	Rise in late 1980s and 1990s which slows from 2003; fall from 2006	More gradual rise in late 1980s and 1990s; little change since
Incident age-standardised alcohol-related hospitalisations (all people) <sup>a</sup>	Rise in 1990s to a plateau between 1998 and 2008, fall since	Rise in 1990s to a peak in 2008 with a smaller decline than Scotland since
Crime	Drink-driving offences have fallen since at least 2005; homicides have been falling since around 2005; and alcohol-related violence has declined since 2008/9	Homicides have been declining since around 2003/4 as has alcohol-related violence
Alcohol sales	Rise from the 1990s until a plateau in 2005–2009, then a steady decline until 2013, now flattening	Rise until a plateau 2003–2005, then fall to 2013, now flattening

<sup>a</sup> Incident alcohol-related hospitalisations are used in preference to other measures of service use (such as stays or patients) for the purpose of considering the influence of external factors because these are the most immediate measures of changes in the causes of alcohol-related harm. They relate to 'new patients' who have not had an alcohol-related admission in the 10 years previously.

The *consumption subsystem* covers the patterns and distribution of alcohol consumption within a population, and the *retail sales subsystem* relates to the activity of the alcohol industry (including the marketing, price and availability of alcohol and its affordability). The *formal regulation and control subsystem* relates to alcohol licensing policy and its implementation and enforcement. The *legal sanction subsystem* relates to the formal rules relating to alcohol consumption in specific circumstances, such as blood alcohol limits for driving and legal age of purchasing, and the enforcement of these rules. Finally, the *social norms subsystem* relates to the shared attitudinal and behavioural norms around alcohol consumption within a population.

One influence on alcohol social norms is the media discourse about alcohol. However, the evidence on the influence of the media discourse on alcohol consumption and harms is mixed and inconclusive (Fig. 2). It is unclear whether news coverage of alcohol influences alcohol social norms or influences alcohol policy directly or indirectly.<sup>11–15</sup> There is limited research on trends in news coverage of alcohol over the period of interest for Scotland and E&W, other than the increased news coverage of binge drinking amongst young people and alcohol-related crime and disorder during the mid-2000s across the UK.<sup>16</sup> It has been argued that this influenced public attitudes and influenced formal policy response across the UK; however, this media analysis did not look at differences across the nations and did not seek to measure changes in public attitudes or behaviour as a result.<sup>16,17</sup> More recent media analysis suggests that a changed framing of alcohol-related harms and policy interventions in the news may have both reflected shifting public attitudes to policy and alcohol harms in light of the political debates on the topic, and influenced policy by shifting the perceived acceptability of intervention.<sup>18,19</sup>

Using the existing literature and theory, we identified the most likely 'external factors' (i.e. those over and above the impact of Scotland's alcohol strategy) that could potentially explain the trends in Scotland, and differences with the comparison populations. The most plausible of these were:

1. Socio-economic and demographic changes
  - a. Changes in income
  - b. Lagged effects of earlier socio-economic and political changes
  - c. Demographic changes
2. Changes in alcohol policy
  - a. The 2002 Scottish Alcohol Action plan
  - b. The alcohol strategy/policy implemented in the comparison areas
3. Changes in culture
4. Changes in the alcohol market
  - a. Increased alcohol availability
  - b. Substitution effects between drugs and alcohol
5. Clinical changes
  - a. Changes in alcohol services
  - b. Artefactual changes in clinical coding

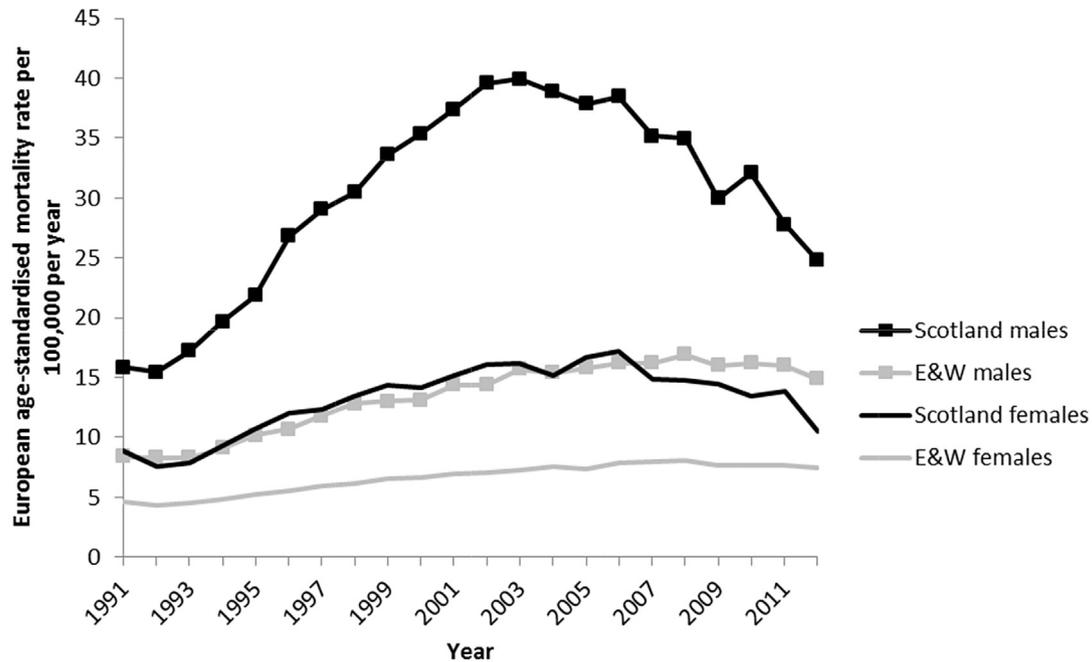


Fig. 1 – Alcohol-related deaths (underlying cause) in Scotland and England & Wales (E&W) by sex 1991–2012 (sources: National Records for Scotland and the Office for National Statistics).

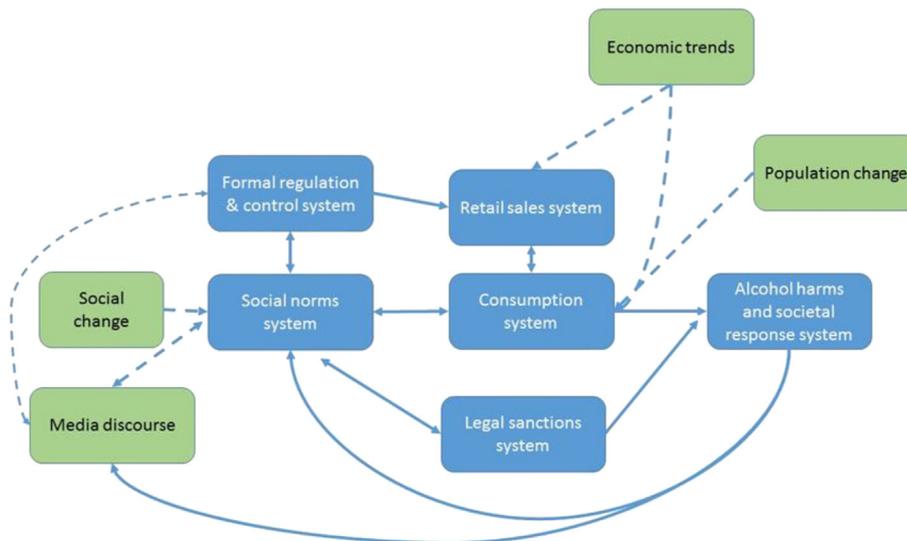


Fig. 2 – A theory for understanding population alcohol consumption (adapted From Holder 1998 and Room et al., 2009)\*. \*The blue boxes and solid lines are aspects theorised to operate within the community alcohol systems with the direction of influence shown by the arrows. The green boxes and dashed lines are aspects theorised as external to the community alcohol system but in the wider environment. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The large number of external factors has necessitated that the analysis be split into two linked papers. This paper seeks to examine the extent to which the three socio-economic and demographic exposures (income, lagged effects and demographic change) might explain the trends in alcohol-related mortality in Scotland,

and the difference in these trends to those in E&W. The accompanying paper in this issue<sup>20</sup> explores the role of the other exposures and provides a synthesis and conclusion of the extent to which the differing trends in alcohol-related mortality can be explained by these external factors.

## Methods

### Defining the hypotheses

#### *Income trends and the prevalence of deprivation*

Income increased during the 1990s before declining in real terms from around 2003 onwards in the poorest 30% of the population, and from around 2008 in the rest of the population.<sup>8</sup> This makes changing income, through its impact on alcohol affordability and consumption, a potential cause of the rise and fall in alcohol-related mortality in Scotland. However, alcohol-related mortality has not followed the same trend in E&W despite a similar income trend.<sup>8</sup> In this paper we test the hypothesis that the changes in income were greater in Scotland and that the impact was magnified because a higher proportion of the population lived in the most deprived circumstances, and a higher proportion of alcohol-related deaths were in the most deprived groups.

#### *Effects of socio-economic and political changes in the 1980s*

A research programme concerning the causes of the higher mortality inequalities and lack of decline in mortality rates for young adults (compared to elsewhere in Europe), the excess mortality for Scotland compared to E&W even after adjusting for deprivation (the 'Scottish Effect') and the excess mortality for Glasgow even when compared to the equally deprived cities of Liverpool and Manchester (the 'Glasgow Effect'), has also sought to explain why alcohol-related mortality is higher despite very similar exposure to most of the determinants of health.<sup>21</sup> It has been proposed that the Scottish population may have been rendered vulnerable to the negative impacts of economic and social policies in the 1980s through overcrowding, selective depopulation and deindustrialisation, and disempowerment of the population.<sup>22</sup> As such, it may be that there is a group of people in Scotland, especially in the most deprived areas, who embodied these exposures<sup>23</sup> and who suffered from increased mortality from a range of causes (most particularly alcohol- and drug-related deaths, suicide and violence) lagged in time after the exposure.<sup>24–27</sup> This may have been due to increased consumption as a response to the changed context of their lives (e.g. a lack of job prospects), or greater vulnerability to the effects of alcohol (e.g. through lower social support or co-morbidity). If true, it is plausible that this age-period<sup>1</sup> interaction may have resulted in higher alcohol-related deaths in the period following the 1980s, and that the impact of these exposures may have declined with time as the cohort aged and as the most vulnerable individuals died.

#### *Demographic changes*

It has been proposed that the greater ethnic and religious diversity in E&W (in particular that there is a higher proportion of the population whose culture or religion discourages

alcohol consumption),<sup>28,29</sup> or changes in the extent of immigration from Eastern Europe (not tested here), may explain part of the alcohol-related trends in Scotland and the difference with E&W. Previous work using age-standardisation has shown that changes in the age-distribution cannot be responsible for the observed trends.<sup>8</sup>

### Income trends

#### *Data sources*

1. *Incomes* – To describe the trends in incomes in Scotland and E&W (for each ranked tenth of the population), we used the Households Below Average Income (HBAI) dataset. Data for 1994/5–2001/2 were used in the analysis of rising alcohol mortality and from the year in which incomes were the highest in each tenth to 2012/3 for the analysis of falling alcohol mortality. The data were adjusted for inflation and were calculated after housing costs (AHC).
2. *Deprivation* – The prevalence of Carstairs<sup>30</sup> deprivation in Scotland and E&W was calculated using 2001 Census data (using a GB-wide index for merged Scottish datazone areas and Lower Super Output Areas (LSOAs) to provide areas with similar population sizes), and the proportion of the Scottish and E&W populations in each GB-wide tenth were calculated.
3. *Alcohol-related mortality* – The European age-standardised alcohol-related mortality rates (using the 2013 European Standard Population) were obtained for each deprivation decile in 1991, 2001 and 2011 from NHS National Services Scotland (who used data supplied by National Records for Scotland).<sup>1</sup>

#### *Modelling the impact of changing incomes on alcohol-related mortality*

4. *Relationship between income and alcohol-related mortality* – we used existing estimates that a 10% rise in prices would lead to a reduction of 1781 (alcohol-attributable) deaths per annum in England after 10 years to estimate the relationship.<sup>31</sup> As the impact of a change in price accumulates linearly between zero and ten years, we estimated that after seven years (equivalent to the periods 1994–2001 and 2004–2011) 1247 ( $0.7 \times 1781$ ) deaths per annum would be averted. To convert this change from alcohol-attributable to the narrower measure of alcohol health harms used in MESAS (alcohol-related deaths), we multiplied 1247 by 0.37 (giving an estimated change of 461 deaths) as 37% of all alcohol-attributable deaths in 2010 were alcohol-related<sup>32</sup> (the base year for the estimates<sup>5</sup>). As there were 6669 alcohol-related deaths in England in 2010,<sup>33</sup> we estimated that the expected change resulting from a 10% decrease in income would be a 7% reduction in alcohol-related

<sup>1</sup> An age-period interaction is where a group of people across a discrete range of ages experience a collective exposure during a defined period of time. We define the cohort most vulnerable to this exposure as those born between 1955 and 1975 and living in the most deprived areas during the 1980s.

<sup>1</sup> The deprivation indices were only available for these years and the mortality data were obtained as three year rolling means. Alcohol-related mortality was defined using the definitions published by National Records for Scotland.

mortality rates (461/6669) after seven years. In the absence of better data, we assumed that this would apply equally across GB, for men and women and that the relationship between income and mortality was linear and the same as between prices and mortality. We varied this best estimate of a 7% change between 2% and 12% as sensitivity analyses.

5. *Varying the relationship across deprivation groups* - We assumed that the impact of a change in income on mortality varied across the income distribution by a factor of 1.4. This was based on the previously modelled difference between a low and high income group of the impact of a change in alcohol prices,<sup>31</sup> which was adapted for our purpose by taking the modelled reduction in deaths in each group, weighting it by the proportion of the population in the low and high income groups and then calculating the slope across the population (and assuming the same differences for men and women and across ages). We then varied that factor between 1.0 and 1.8 as sensitivity analyses.
6. *Applying the impact of income change in each population tenths* - We assumed that the income tenths were the same as the (GB-wide) deprivation tenths of the population. We then calculated the change in alcohol-related mortality for 1991–2001 and 2001–2011 (separately for Scotland, E&W, men and women) as the mathematical product of:
  - a. the percentage change in income (step 1 above)
  - b. the alcohol-related mortality rates in each GB-wide decile (step 3 above)
  - c. the relationship between income and mortality (steps 4 & 5 above) - i.e. 0.7 (calculated as 10% change in income resulting in a 7% change in mortality (10%/7%))
7. *Estimating the total population impact* - We then estimated the impact of changing incomes on the whole population (but separately for Scotland, E&W, men and women) by taking the modelled change in mortality in each population tenth (step 6 above) and weighting these mortality rates for the proportion of each GB-wide deprivation tenth the Scottish and E&W populations comprised (steps 2 above). The estimated alcohol-related mortality rates in 2001 and 2011 were then compared with the real observed rates.

Given the limitations in income trends (only available from 1994) and alcohol-related mortality data by GB-wide Carstairs deprivation tenths, we could not incorporate lagged impacts of change in income nor examine exactly the same time period for changes in incomes and mortality.

### **Effects of social, economic and political changes in the 1980s**

In the absence of data to measure individual exposure to the effects of economic and social policy (e.g. unemployment, privatisation, relative poverty, etc.), an approximation was made by looking for cohort effects amongst those who were young adults in the 1980s and by focussing on those living in the most deprived areas (defined as those living in the most deprived fifth of Scottish postcode sectors (by Carstairs score)).<sup>i</sup> We plotted alcohol-related mortality rates using data from National Records for Scotland for 1974–2013 grouped by age at death, year of death and birth cohort (to examine age, period and cohort (APC) effects) and constructed contour (lines and colours showing population age groups at

particularly points in time with the same mortality rates) plots,<sup>34</sup> for the most deprived fifth and the least deprived four fifths of the population separately.

For age-period-cohort regression modelling, alcohol-related death and population data were grouped into five-year age groups (for ages 15–89 years for the overall population and 15–84 years for the deprivation analyses) and five year time periods (from 1976 to 2010) stratified by sex and Carstairs deprivation. We used generalised linear regression assuming a negative binomial distribution and the intrinsic estimator command (`apc_ie`) in Stata version 13<sup>35</sup> (a means of modelling the independent age-period-cohort effects).<sup>36</sup> Generalised linear regression assuming a negative binomial distribution was used. Best fit was obtained by selecting a dispersion factor which resulted in 1/degrees of freedom deviance close to one. Models were fitted separately for each sex and deprivation specific strata (grouped again as the most deprived fifth and least deprived four fifths). For the most deprived fifth of males, the 1991 cohort data were replaced by those of the 1986 cohort to allow the model to converge. This equated to replacing data for period 2006–2010 for age group 15–19 years with that of period 2001–2005 for age group 15–19 years. The replacement was made at sub-group level and is not felt to have significantly affected the trends reported. The year for the synthetic cohorts was calculated as a function of the five year age and period groups, as being equal to mean period minus mean age.

### **Ethnic diversity**

As a crude means of assessing whether greater ethnic diversity might contribute to the differing trends, a comparison was made of the alcohol-related mortality rates in Scotland and E&W using a denominator of the white-only populations according to the definitions for the data collected at the 1991, 2001 and 2011 censuses (i.e. excluding: other mixed, Indian, Pakistani, Bangladeshi, Chinese, other Asian, African, Caribbean, other Black, Arab, any other (non-white) ethnic group), whilst keeping the numerator of all alcohol-related deaths in the populations. Direct standardization was used to adjust for differences in age distribution between the populations of interest using the 2013 European standard population.

## **Results**

The trends in income distribution are similar in Scotland and E&W in that incomes increased for the seven highest income tenths of the population until around 2008 in both populations and then decreased, but there was an earlier and more substantial relative decline amongst the lowest income deciles from around 2004 (although the decline starts around 2001 in the lowest income decile in E&W) (see Appendix A, [Supplementary Figure 1](#)). The percentage decline in incomes was greater for the deciles 3–10 in E&W than in Scotland, but greater in the lowest two deciles in Scotland (with a 23% decline in the lowest tenth in Scotland compared to 17% for the equivalent in E&W) ([Supplementary Figure 2](#)). The percentage of the Scottish population in the most deprived GB-wide Carstairs deciles was substantially higher ([Supplementary Figure 3](#)), and

the inequalities gradient in alcohol-related mortality across deciles much steeper (Supplementary Figure 4), than in E&W.

Supplementary Figure 5 and Figure 3 show the results of the modelled impact of changing incomes on alcohol-related mortality after accounting for: the differences in the prevalence of deprivation between Scotland and E&W; the differences between Scotland and E&W in the changes in income (in particular, the bigger fall in the lowest income tenth in Scotland) and the more extreme inequality in mortality across deciles in Scotland. The rise in alcohol-related mortality was partly predicted in the modelled impact of rising incomes with 29% and 77% of the increases in men, and 48% and 103% in women, in Scotland and E&W respectively, predicted by the model (Supplementary Figure 5). The model also predicted part of the 29% of the observed decline in alcohol-related mortality in Scottish men. The modelled estimates for women in Scotland and E&W were all within three standardised deaths per 100,000 per year (Fig. 3). The models of the rise and fall was sensitive to change in the relationship between income on mortality (had the model used a larger impact of changing incomes on mortality (e.g. a 13% change in mortality for a 10% change in income) the model would have had a much closer fit to the observed mortality rates). However, the model was relatively insensitive to variation in the extent to which this relationship differed across deprivation deciles (Supplementary Figures 6 & 7).

#### Effects of social, economic and political changes in the 1980s

Figure 4 shows the contour plot for alcohol-related mortality rates by age and year for men and women in Scotland over time. The peak age of alcohol mortality risk has been in persons in their late fifties to late sixties for both sexes (indicated by the red areas). This risk per year was around 0.00020 for women ( $10^{-3.7}$ ) and around 0.00040 for men ( $10^{-3.4}$ ) until the early 1990s, after which rates increased, peaking at around 0.00040 ( $10^{-3.4}$ , equivalent to the earlier period male mortality risk) for females in the early 2000s, and around 0.00100 ( $10^{-3.0}$ ) for males of the same age. The age specific mortality risks (ASMRs) rose

quickly at younger ages, from around 40–55 years, in the 1990s, with notable increases for both sexes. For example, female ASMRs at around age 48 rose from around 0.00010 ( $10^{-4.0}$ ) in the late 1980s to around 0.00040 ( $10^{-3.4}$ ) in the early 2000s. For males the equivalent changes were from around 0.00025 ( $10^{-3.6}$ ) to around 0.00063 ( $10^{-3.2}$ ). Alcohol mortality rates also increased similarly for adults above working age, with ASMRs for 70 year old females increasing from around 0.00013 ( $10^{-3.9}$ ) in the late 1980s to 0.00032 ( $10^{-3.5}$ ) in the early 2000s, and for 70 year old males increasing from around 0.00032 in the late 1980s to 0.00079 ( $10^{-3.1}$ ) in the early 2000s.

The 'hotspots' (red areas) of high alcohol-related mortality in the mid-2000s for those aged 40–70 years indicate that there is an age-period interaction whereby middle-aged adults may have experienced a negative period effect (indicated by the diffuse red area for this age group and time period) in contrast to the lack of change for younger and older groups at this time. The plot does not suggest a simple period effect (which would have been indicated by a vertical line), birth cohort effect (diagonal line from bottom left to top right) or age effect (horizontal banding), but instead increases for certain age groups during the 1990s.

Supplementary Figure 8 shows the mortality rates for Scotland for the most deprived fifth and least deprived four fifths of the population. Although there are fewer observations of individual ASMRs as a result of this disaggregation, and so more empty (white) cells, general trends and differences between deprivation groups are clear. The increase in ASMRs during the early 1990s occurred across all strata, and similarly the spreading out of increased ASMRs to a wider range of ages is also common to all four groups. However, differences in terms of the pre-1990s and early 2000s ASMRs between deprivation groups are also clear. For example, within the least deprived four fifths ASMRs for males around the age of 65 years were around 0.00040 ( $10^{-3.4}$ ) in the late 1980s, and by the early 2000s these had risen to around 0.00063 ( $10^{-3.2}$ ); the equivalent ASMR changes for males in the most deprived fifth changed from around 0.00063 ( $10^{-3.2}$ ) to 0.00200 ( $10^{-2.7}$ ). This corresponds to an increase in ASMRs of around 3.2 times in the bottom fifth, in comparison to around 1.6

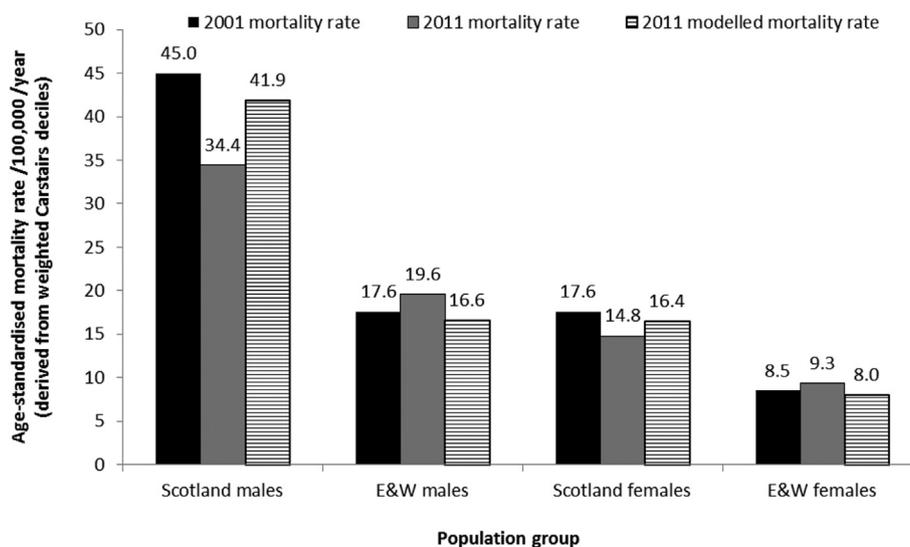
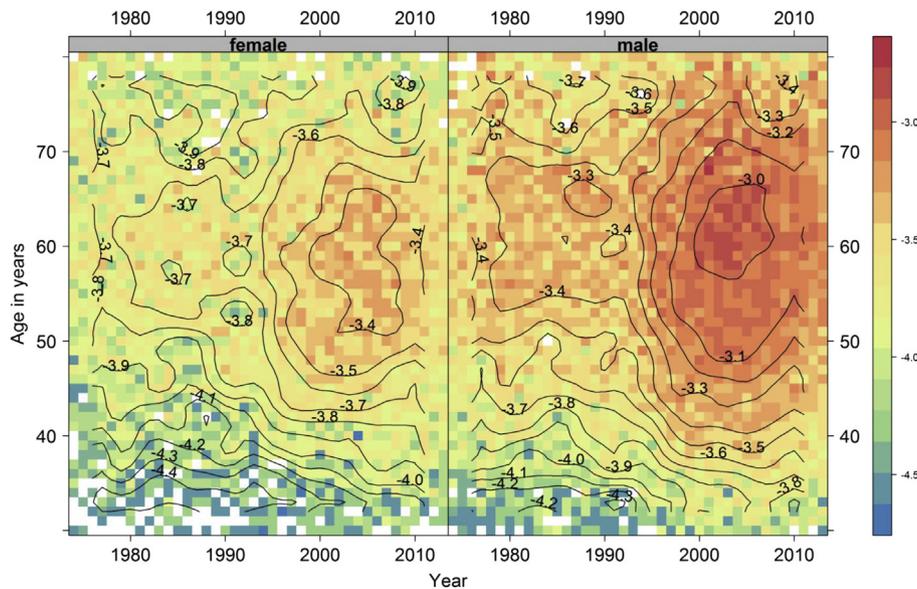


Fig. 3 – Changes in age-standardised mortality rates in Scotland and England & Wales (E&W) between 2001 and 2011 compared with a plausible impact of changes in incomes.



**Fig. 4 – Contour plot of log (base 10) age-specific crude alcohol-related mortality rates in Scotland for each single age from 30 to 80 years and each year from 1974 to 2013 stratified by sex.**

times in the four fifths. There is therefore a similar patterning by deprivation strata, but with much greater increases in mortality rates in the most deprived fifth.

Supplementary Figure 9 shows the alcohol-related mortality trajectories for birth cohorts as they age. It can be seen that there is a general peaking of rates around middle age for most groups but the peak ages decreased with subsequent cohorts. Most cohorts had a rise in rates from their historical trends during the 1990s and 2000s before returning to the former age patterning. However, the cohorts born between 1930 and 1960 and the most deprived quintiles had the most dramatic interaction with the period effects, suggesting that those of late working age in the most deprived areas during the 1990s and 2000s experienced the greatest increase in alcohol-related deaths. The IE coefficients suggest that there is a strong age effect for the population overall (with a peak in middle age indicated by the positive IE coefficients), an increasing period effect during the 1990s (indicated by the increasing IE coefficients at this time), and with lower rates amongst the most recent birth cohorts (indicated by the linear decline in coefficients across birth cohorts) (Supplementary Figures 10–12). Examining the IE coefficients by deprivation quintiles shows very little difference between the most deprived fifth and the rest of the population (Supplementary Figures 13–15).

#### Ethnic diversity

Supplementary Figure 16 shows the impact of using only the white population as the denominator for alcohol-related deaths in Scotland and E&W for men and women. It shows that the greater non-white population in E&W (approximately 20% in 2011) makes a greater difference to trends than in Scotland, and a very small proportion of the decline in Scotland (and of the flattening trend in E&W) could plausibly be explained by the change in ethnic diversity.

## Discussion

### Main results

Our modelling of the impact of changing incomes predicted part of the rise in alcohol-related mortality between 1991 and 2001 across GB, although less of the observed rise in Scotland (18% of the rise in men and 29% of the rise in women) than in E&W (where 60% and 68% of the rise in men and women respectively was explained) was predicted. The model predicted approximately one-third of the decline observed in alcohol-related mortality in Scottish men between 2001 and 2011 and was broadly consistent with the observed trends in E&W and amongst women in Scotland (which did not change as much over this time period). Lagged effects from historical exposures were not clearly identified for particular birth cohorts from the age-period-cohort analyses, but there was evidence of an age-period interaction for working-age adults in the 1990s and 2000s, particularly in the most deprived areas. If we accept crude assumptions about the difference in alcohol consumption between white and non-white populations, this could only explain a marginal proportion of the higher alcohol-related mortality in Scotland compared to E&W.

### Strengths and weaknesses

The analysis of income trends uses the best available data for examining changes in income distribution over time. However, we had to assume that those living in the most deprived areas are also those with the lowest incomes although it is known that a substantial proportion of those who are most income deprived do not live in the most deprived areas.<sup>37</sup> The income data are drawn from the Family Resources Survey rather than routine tax or welfare administrative data and are therefore likely to under-represent the extremes of the

income distribution due to response and reporting biases. The incomes data and mortality data were not available for all the years we required and so there was some mismatch between the exposure and outcomes data which could have affected the results. The inflation rates applied to the incomes data are the same across all deciles, yet it is known that inflation and the costs of living are greater for the lowest income groups,<sup>38,39</sup> and so the income trends for that group may underestimate the real-terms decline they have experienced (even when using income After Housing Costs as we did here). The modelling also relied upon assumptions relating to the relationship between alcohol affordability and mortality, which although the best estimates available, are likely to be context-specific. The sensitivity analyses suggest that if the impact of changing income on mortality was greater than our best estimate then the difference between Scotland and E&W, and the trends, would have been better explained.

The analyses of age, period and cohort effects were constrained by the difficulties in accurately defining a negatively exposed population to track through time. This was limited both by a lack of data to measure exposure (e.g. identifying those who lost their jobs or suffered from deteriorating housing) and uncertainty in defining both the age groups affected (it was not a birth cohort effect but an impact that would have been expected to affect whole communities, but particularly those of working age) and the time period of exposure (starting in the early 1980s and then continuing in different forms in different places). The IE analyses confirmed the well-recognised age effects, but also identified birth cohort effects (which diminished with more recent cohorts) that were larger than the period effects during the 1990s and 2000s (and which were very similar in the most and least deprived groups). The higher mortality across adults from the late 1980s to the late 2000s, particularly in the most deprived groups, is consistent with the lagged effects theory,<sup>22</sup> but the analyses reported here are not able to test this fully.

The ethnicity analysis used the best available data from the Census which utilises a list of categories which encompasses multiple dimensions rather than being ascribed an ethnicity according to a single facet such as country of birth. The main limitation of this analysis is the assumption that all alcohol-related mortality is attributable to the white ethnic population alone which we recognize is not the case.<sup>29</sup> However, we argue that making this extreme assumption is helpful to provide an upper bound to the impact that changes in ethnicity might have had on the population mortality rates. This analysis does not consider the changes in the white population in the UK in recent years, particularly migration from Eastern Europe (the impact of which is uncertain).

The analyses in this paper have focused on alcohol-related mortality rather than the broader range of alcohol-related harms. Further consideration of the impact of these external factors on other outcomes would be a useful extension to this work.

### **How this fits with existing literature**

The affordability of alcohol is known to be an important determinant of alcohol consumption and harm,<sup>40</sup> as is the

general economic context.<sup>41</sup> Within the UK, previous economic downturns have been associated with declines in alcohol sales.<sup>8</sup> There is also evidence, both qualitative and quantitative, that deindustrialisation and associated socio-economic change, especially when introduced into a context that does not provide sufficient social protection and alternative employment (and one with few effective alcohol control measures), is associated with increased alcohol-related harms (most profoundly witnessed in Eastern Europe).<sup>21,22,25,42–45</sup> It therefore seems consistent with other evidence that changing affordability and lagged impacts of deindustrialisation and socio-economic change, may be part of the explanation for the trends in alcohol-related harms in Scotland.

### **Implications**

Given the likely importance of alcohol affordability in driving the downward trend in alcohol-related mortality, any future increase in incomes or decline in prices (as might result from economic growth or reduced alcohol taxes) might reasonably be expected to increase alcohol-related harms in Scotland once again. Indeed, the most recent trends in consumption, harms and alcohol affordability provide an early indication of this.<sup>8</sup> It is therefore important that a comprehensive range of alcohol control policies is in place to prevent this.<sup>39</sup> If lagged impacts are partly responsible for the rise and fall in alcohol-related harms, it might be expected that these will continue to exert downward pressure on the trends as the population of those exposed to negative socio-economic changes in the 1980s reaches an age of lower risk. However, the most recent economic downturn and changes to the social security system might be creating a further cohort of more vulnerable individuals who may experience future harms if an adequate alcohol control policy context is not in place.<sup>46</sup>

### **Conclusion**

Part of the increase and decline in alcohol-related mortality in Scotland since the early 2000s and the differing trend to England & Wales was predicted by modelling the impact of changing incomes over time. Lagged effects from historical deindustrialisation and socio-economic changes exposures remain plausible from the available data.

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#### **Ethical approval**

No ethical approval was required or sought for the analyses in this paper.

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## Competing interests

The authors declare they have no conflicts of interest.

## Contributions

CB, NC, LG, DS and GM generated the initial idea for the study. Analyses of data or literature for particular hypotheses were led by NC, LG, FL, RM, MM, JM, JP, DS and MT. GM drafted the manuscript. All authors provided critical input into the redrafting of the manuscript and approved the final draft.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.puhe.2015.12.013>.