Change in alcohol outlet density and alcohol-related harm to population health (CHALICE): a comprehensive record-linked database study in Wales

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Scientific summary

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Background

Excess alcohol consumption has many adverse effects on health, including an increased risk of liver cirrhosis, gastrointestinal tract and breast cancers, high blood pressure and stroke. There is also an increased risk of harm resulting from antisocial behaviour and violence. Binge drinking is a particular problem, with the highest prevalence in the 16- to 24-year age group for women and men. Up to 40% of attendances at accident and emergency (A&E) departments and around half of all violent crimes in the UK are alcohol related.

Around 37% of men and 25% of women exceeded UK guidelines for safe levels of alcohol consumption in 2014 (women more than three units per day; men more than four units per day) and 19% of men and 11% of women binge drink (women more than six units per day; men more than eight units per day). Given the wide range of harm resulting from this substantial level of excess consumption, the potential impact on health at the population level from a reduction in consumption is considerable.

One of the principal policies recommended by the British Medical Association to reduce alcohol consumption is to reduce easy access to alcohol through controls on hours of sale and outlet density. This uses the availability theory of alcohol-related harm, which states that harmful outcomes are linked directly or indirectly to a greater availability of alcohol, through a higher density of alcohol outlets, leading to higher consumption and hence alcohol-related harm.

However, the evidence relating outlet density to alcohol-related harm is not consistent. Many cross-sectional studies have suggested that high outlet densities are associated with a higher rate of a wide range of alcohol-related injuries. Fewer studies have investigated associations between outlet density and non-injury health outcomes, suggesting that high outlet densities are associated with high levels of consumption, sexually transmitted infections and alcohol-related hospital admissions. There have been few longitudinal studies but these have provided limited evidence that an increase in outlet density is associated with increased consumption and interpersonal violence and that a decrease in proximity to outlets is associated with a small decrease in consumption. No longitudinal studies of admissions to hospital have been published for non-violent outcomes. Many methodological questions remain over the best way to measure outlet density and how to model the relationship with alcohol-related harms. Little is known about the effects of a change in outlet density on inequalities in alcohol-related health and the role of population migration.

Objectives

We investigated associations between change in alcohol outlet density and important alcohol-related health outcomes in Wales.

The primary research question was:

- What is the impact of a change in the density of alcohol outlets on alcohol consumption and alcohol-related harms to health in the community?

Secondary research questions were:

- Does a health selection effect from population migration at small-area level explain any observed associations between outlet density and alcohol-related harm?
- What effect does change in outlet density have on population inequalities in alcohol-related health?

Methods

Design and setting

This study involved a natural experiment on the effect of change in alcohol outlet density between 2006 and 2011, measured at 2001 census Lower Layer Super Output Area (LSOA) level in Wales, UK. The population included 2.5 million people aged ≥ 16 years living in 1896 LSOAs. Data on outlets are held by the 22 local authorities in Wales under the Licensing Act 2003 [Great Britain. *Licensing Act 2003*. London: The Stationery Office; 2003. URL: www.legislation.gov.uk/ukpga/2003/17/contents (accessed 8 June 2015)].

Data sources

The five annual Welsh Health Survey (WHS) data sets from 2008 to 2012 were supplied by the Welsh Government Health Statistics and Analysis Unit under a data access agreement. Data on hospital admissions from 2006 to 2011 from the Patient Episode Database for Wales (PEDW) and attendances at A&E departments from 2009 to 2011 recorded in the Emergency Department Dataset (EDD) were anonymously record linked to the Welsh Demographic Service (WDS) population age–sex register within the Secure Anonymised Information Linkage (SAIL) Databank. Police-recorded crime data were supplied under a data access agreement by the four police forces in Wales.

Outcome measures

The primary outcome was self-reported units of alcohol consumed as defined in the WHS. Respondents were asked how often, on average, they drank alcohol and, if never, whether or not they had always been a non-drinker. Participants were asked to report the number and size of specified drinks consumed on their heaviest drinking day in the previous 7 days and these measures of consumption were coded into standard units, defined as 10 ml of pure ethanol or equivalent. The maximum number of units consumed on any day in the last week was classified into one of the ordinal categories of consumption based on the Department of Health definitions of never, none, sensible, excess but less than binge drinking and binge drinking.

The secondary outcomes were emergency admissions to hospital with an alcohol-related cause, night-time attendance (from midnight to 06.00) at an A&E department as a proxy for an alcohol-related attendance, and violent crime against the person. We derived a set of *International Classification of Diseases*, Tenth Edition (ICD-10) codes to define an alcohol-related cause for hospital admission based primarily on the Office for National Statistics (ONS) definition of an alcohol-related death and the Centers for Disease Control and Prevention definition of alcohol-related cause. We defined an admission as an emergency admission with an alcohol code in the first three positions or in position four if the first three codes were non-diagnostic. A&E department data were not clinically coded and night-time attendance was the best available proxy for alcohol-related attendance. Police-recorded violence against the person was categorised according to the National Crime Recording Standards and we derived counts of such crimes per LSOA.

Measurement of alcohol availability

Lower Layer Super Output Area outlet density was estimated for each quarterly period between 2006 quarter 1 and 2011 quarter 4 (1) as the number of licensed outlets per capita aged ≥ 16 years using (i) the 2006 population for all quarterly estimates and (ii) quarterly population update estimates; and (2) using new methods of network analysis to estimate outlet density as alcohol availability by walking and driving. We computed the network distance from each of the 1,420,354 residences in Wales to each of the approximately 10,000 outlets in Wales that were located within two buffer zones of (1) a 10-minute walk and (2) a 10-minute drive, and used the mean weighted distance of all residences to all outlets in each LSOA as the measure of density.

We derived three measures of the alcohol availability process to model change in density preceding an outcome event: (1) the previous quarterly value; (2) the change in density (as the difference between quarterly values 1 year apart divided by the square root of the mean of the five quarterly values); and (3) volatility (as the sum of the absolute differences between five successive quarterly values divided by the square root of the mean of the five quarterly values).

Statistical analysis

For the primary outcome measure we fitted multilevel Poisson models of individuals nested within households, LSOAs and local authorities. We excluded 'never drinkers' and modelled counts of units of consumption as a function of the alcohol availability process measured by outlet density, adjusting for confounding using individual variables (age and sex), household socioeconomic position, LSOA Welsh Index of Multiple Deprivation quintile and rural–urban settlement type. We used space–time Geographically Weighted Regression (GWR) models to model the relationship between binge drinking and alcohol availability.

For the secondary outcomes of hospital admission and A&E attendance, we fitted Cox regression models of the time to admission or attendance as a function of baseline outlet density, adjusting for age, sex, deprivation quintile and settlement type. For hospital admissions we also fitted a multilevel Cox model with time-dependent covariates and Poisson longitudinal models. PEDW and A&E data were analysed through the remote access secure SAIL Databank Gateway.

For the secondary outcome of violence against the person, we used GWR models to model the relationship between LSOA counts of crime and outlet density.

We assessed the impact on health inequalities by stratifying each analysis to examine whether or not the modelled associations varied with deprivation quintile. We assessed the impact of population migration by re-estimating simple count per capita outlet densities using the baseline population, repeating the models above for the primary outcome and comparing them with the main models. All analyses were carried out using R (version 3.0.3, The R Foundation for Statistical Computing, Vienna, Austria), SPSS (version 20, IBM Corporation, Armonk, NY, USA) and MLwiN (version 2.29, Centre for Multilevel Modelling, Bristol, UK) software.

Results

The adjusted relative risk (RR) for the primary outcome of units of alcohol was 1.010 [95% confidence interval (CI) 1.006 to 1.014], implying a 1.0% increase in units consumed in the following year for a unit increase in previous quarter walking outlet density (equivalent to an absolute increase in outlets of 3–5 outlets). The RRs for positive and negative change and volatility were not statistically significant. We found no difference in the previous quarter walking outlet density risk between deprivation quintiles and no effect of population migration.

The risks of consumption were much less strongly associated with driving density (RR = 1.001, 95% CI 1.000 to 1.001) and all other driving availability measures were not significant. The GWR spatial model of binge drinking found a significant association with walking outlet density in the previous quarter, with an important degree of spatial variation in these associations.

In the baseline cohort analyses, the hazard ratio (HR) for emergency hospital admission ($n = 25{,}772$) was 1.21 (95% CI 1.15 to 1.26) for the highest quintile of previous quarter walking outlet density compared with the lowest, adjusting for confounders. The results were similar for driving outlet density (HR 1.20, 95% CI 1.14 to 1.26). The HR for walking density was slightly higher for emergency admissions coded F10 (mental and behavioural disorders, which include acute intoxication), at 1.27 (95% CI 1.19 to 1.35), and admissions with injury (HR 1.27, 95% CI 1.13 to 1.42). We found no difference in the risks between deprivation quintiles. The models for both consumption and hospital admissions suggested that change in outlet density had a greater effect on males than on females.

In the multilevel Cox model with time-dependent covariates, we found that the risk of emergency admission was significantly associated with the previous quarter walking outlet density. We modelled the non-linear dependence by splitting the previous quarter variable into two categories of lower (0 to 1 unit of outlet density) and upper (> 1 unit). The association was stronger at lower outlet density (HR 1.24, 95% CI 1.13 to 1.35) and persisted at higher levels (HR 1.01, 95% CI 1.01 to 1.02). Positive change in outlet density and volatility were not significant but a negative change was associated with a significantly slower decrease in risk in the quarter following the change.

For A&E attendances ($n = 87,704$), we found that the adjusted HR for walking outlet density was non-significant, with a stronger main effect for the highest quintile of driving outlet density (HR 1.28, 95% CI 1.24 to 1.31).

We found that the previous quarter walking outlet density and all the measures of change were associated with the risk of violent crime against the person in the following quarter. The RR of violent crime associated with a unit increase in walking outlet density was 1.066 (95% CI 1.065 to 1.066). This association varied little with deprivation quintile. Driving outlet density was also significantly associated with crime, but the effect was smaller than for walking outlet density.

Conclusions

This was a challenging project requiring substantial data processing and validation. Change in outlet density was associated with change in alcohol-related harms: consumption of alcohol, hospital admissions and violence against the person each tracked the changes in the previous quarter measure of outlet density. High baseline alcohol availability was significantly associated with a 20–25% increased risk of an emergency admission to hospital and less convincingly with an A&E attendance. Clearly, an increased burden to the NHS is associated with higher levels of outlet density. We found no evidence for an important effect of population migration. Social deprivation was, in general, strongly associated with our outcome measures, but did not substantially modify the associations between the outcomes and alcohol availability.

A strength of our findings is the consistency of these associations over a range of harmful outcomes explored using a range of statistical methods. A limitation of the research is the absence of any nationally standardised methods of alcohol outlet data collection, storage, collation, processing and validation. We were unable to use the incomplete data on on-sales and off-sales. The limitations of survey data are well known, whereas the hospital admission data set is not designed for detailed clinical interpretation. We were dependent on the quality of clinical coding and administrative records. The A&E data set did not contain any meaningful clinical coding and so alcohol attendances could not be identified other than by proxy. Police-recorded crime data were the best available and a valuable data source.

We took every possible step to explore and work with the strengths and limitations of these data sets and have drawn conservative conclusions from our findings. The method of estimating outlet density is generalisable to all geo-located data, including food and gambling outlets, and also to larger geographical areas such as green and natural recreational spaces. We make the following recommendations for work to underpin the operation and management of future projects:

1. A standard system of recording data on alcohol outlets is required for research purposes. A minimum data set should be defined and then used by each licensing authority that includes validated and reliable complete data on geographical location, opening and closing dates, type of outlet (e.g. on-sales and off-sales, pub, club, restaurant, shop, supermarket) and opening hours. Specifically, geographical location should include complete address data and the National Land and Property Gazetteer (NLPG) generated Unique Property Reference Number (UPRN) to facilitate data linkage.
2. A more precise agreed definition of an alcohol-related admission, to include, inter alia, ICD-10 codes, coding positions, episode numbers, super spells and transfers, would be of benefit.

We make the following recommendations for future research, subject to funding, based on our experience in this project:

1. A further analysis of our outlet data to classify data by type of outlet using existing geographical information system software. A second analysis of the outcome measures should then be carried out by outlet type. Further investigation of possible threshold effects by type would then be possible.
2. An analysis of hospital admissions and A&E attendances should be carried out for children and young people. We have collated these data and could process and analyse the data for this important population group.
3. Further methodological work on the estimation of network-based measures of outlet density, including further work on the impact of 'edge' effects, caused by national borders and islands.
4. We can compute a density value for each household residence, linked anonymously to individuals, rather than an arbitrary buffer zone or administrative boundary such as the LSOA. This finer-grained approach would remove the modifiable areal unit problem and associated bias and so it would be possible in further research to estimate a more accurate risk of hospital admission as a function of outlet density.
5. A formal health economic analysis is needed to estimate the population impact and economic cost of our model-predicted alcohol harms arising from outlet density.

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