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Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation

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Keywords

Alcohol, Social epidemiology, multilevel modelling, Public Health

ABSTRACT

Objectives

The influence of neighbourhood deprivation on the risk of harmful alcohol consumption, measured by the separate categories of excess consumption and binge drinking, has not been studied. The objectives of the study was to investigate the joint effects of neighbourhood deprivation with age, gender and socio-economic status (SES) on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a representative sample of the adult population of Wales, UK.

Design

Cross-sectional study: a multi-level analysis of a population-based dataset.

Setting

Wales, UK, adult population ~ 2.4 million.

Participants

58 282 respondents aged 18 years and over to four successive annual Welsh Health Surveys (2003/04-2007), nested within 32 692 households, 1839 census lower super output areas and the 22 unitary authority areas in Wales.

Primary outcome measure

Maximal daily alcohol consumption during the past week was categorised using the UK Department of Health definition of 'none/never drinks', 'within guidelines', 'excess

consumption but less than binge' and 'binge'. The data were analysed using continuation ratio ordinal multilevel models with multiple imputation for missing covariates.

Results

Respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference = 3.7%, 95% CI: 2.6 to 4.8). The effect of deprivation varied significantly with age and gender, but not with SES. Younger males in deprived neighbourhoods were most likely to binge drink but the largest interaction effect of deprivation on binge drinking was found for middle-aged males living in the most deprived areas.

Conclusion

Neighbourhood deprivation is an important factor in the understanding of socio-economic patterns of categories of harmful alcohol consumption and for public health policy development.

ARTICLE SUMMARY

Article Focus

- A recent systematic review found little evidence that living in neighbourhoods of high socio-economic deprivation is associated with a higher risk of harmful alcohol consumption

- The important distinction between excess alcohol consumption and binge drinking has not previously been investigated

Key Messages

- A higher risk of binge drinking was found in residents living in deprived neighbourhoods, particularly in young and middle-aged men

- A higher risk of excess consumption, but less than binge, was found in residents of less deprived neighbourhoods

- Neighbourhood socio-economic deprivation is an important factor to consider in public health alcohol policy development

Strengths and Limitations

- The main strength is the large representative dataset of over 58 000 respondents, or around one in fifty of the socially diverse Welsh adult population. The ordinal alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health

- The cross-sectional analysis used the administratively defined census LSOA as a proxy for 'neighbourhood' and cannot investigate the possibility of causal relationships. Social desirability bias may result in under-reported alcohol consumption, although it is not known whether this varies between neighbourhoods.

INTRODUCTION

Excess alcohol consumption causes a major global burden of disease, injury and social and economic cost.[1] Binge drinking, typically defined as consuming at least double the guideline limits in a single day during the previous week,[2] is an increasing problem which is rising particularly in young women.[3] It is associated with anti-social behaviour,[4] and around half of all violent crimes in the UK.[5] Binge drinking causes an extra burden on health services; between 20-40 % of people presenting to accident and emergency departments are intoxicated, increasing to 80% after midnight.[4] Recent data show that around 37% of men and 29% of women exceeded the current UK guidelines for safe levels of alcohol consumption of ≤ 3 units per day for women and ≤4 units per day for men in the past week; and 20% of men and 13% of women engaged in binge drinking, defined as > 6 units per day for women and > 8 units per day for men.[6] Given the wide range of harm resulting from this substantial level of consumption, the potential impact on health at the population level from a reduction in consumption is considerable.

Research investigating the socio-economic patterning of harmful alcohol consumption has generally found that lower socio-economic status (SES) groups drink more heavily and higher SES groups drink more frequently,[7] consistent with binge drinking being found to be more prevalent in the economically disadvantaged.[8] However, subtle variations in cut-points based on units have led to prevalence estimates for binge drinking in young men to differ by 22%,[2] and these summary SES relationships have been found to vary substantially with age, gender, educational level, employment status and the measure of consumption.[2,7-12]

In addition to socio-economic effects found at the individual level, it is theorised that small-area, or neighbourhood, socio-economic deprivation might exert an independent effect on

harmful alcohol consumption. However, a recent systematic review which included multilevel studies of neighbourhood deprivation and alcohol consumption found little evidence to support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in a quality assessment, one study set in the West of Scotland, UK, found no significant association between neighbourhood deprivation and drinking above guideline limits or the number of units consumed in the past week.[14] A second study set in California, USA, found that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males) was significantly higher for people living in the least deprived neighbourhoods with no significant variation with individual SES.[15]

The two other studies described an association between high neighbourhood deprivation and high consumption.[16,17] Data from the nationally representative Third National Health and Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood deprivation measure at the level of the census tract was associated with heavy alcohol use, defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01, 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A second US study found that higher mean income and income inequality at the larger community district level was significantly associated with a higher number of drinks per month among drinkers.[17] Four subsequent papers reporting small studies found no significant association between alcohol consumption and neighbourhood income,[18,19] neighbourhood unemployment,[20] or a composite measure of relative socio-economic disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada found a small effect of neighbourhood deprivation on the number of drinks consumed per week in men, but not in women.[22]

Possible explanations for these inconsistencies in neighbourhood associations found between studies may result from different methods of defining excess, or harmful, consumption, with some choosing definitions based on national guidelines for 'safe' consumption or units,[14] number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations for inconsistent neighbourhood associations may result from different measures of area deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors for excess alcohol consumption.[14-22]

Despite the substantial public health consequences of alcohol consumption and the possible importance of neighbourhood in explaining patterns of consumption, no previous study to our knowledge has investigated multilevel associations with neighbourhood deprivation which distinguish between excess consumption and binge drinking as distinct categories. Little is known on whether any associations vary within population groups. The aim of the present study was to investigate the joint effects of neighbourhood deprivation with age, gender and SES on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a representative sample of the adult population of Wales, UK.

METHODS

Participants

Data were drawn from four successive cross-sectional waves of the Welsh Health Survey 2003/04 to 2007, an interviewer-led household and individual survey of the adult population resident in Wales, UK.[23,24] The population of Wales is approximately 3 million (2001 Census) and the dataset available includes a total of 60 555 adults aged 18 years and over. The sampling methods and the survey process are described in detail elsewhere.[24]

Alcohol outcome measure

Participants were asked to state the highest number of units they had drunk on any one day in the previous seven days, using a standard prompt to convert different types and quantities of alcoholic drinks into units. The dataset provided the classification of units into ordinal categories of maximal daily consumption based on the UK Department of Health definitions (Table 1), with categories for 'none/never drinks', 'within guidelines', 'excess consumption but less than binge, and 'binge'.[25]

Table 1 Categorisation of the alcohol consumption outcome variable

Category	Maximum units drunk on any day in the last week
None/never drinks	Did not drink in the last seven days
Within guidelines	Men drinking no more than 4 units, women no more than 3 units
Excess consumption but less than binge	Men drinking more than 4 and up to and including 8 units, women more than 3 and up to and including 6 units
Binge	Men drinking more than 8 units, women more than 6 units

Source: reference 25

Neighbourhood deprivation measure

The Welsh Index of Multiple Deprivation 2005 (WIMD2005) was used as the measure of neighbourhood deprivation.[26] WIMD2005 scores are available for lower super output areas (LSOA), a unit of statistical geography defined by the 2001 UK Census. We used the LSOA as the closest available proxy for neighbourhood. There are 1896 LSOAs in Wales which have a mean population size of around 1500 and are constrained to a minimum of 1000. Respondents were linked to their LSOA of residence by the data owners and the dataset included 1839 LSOAs, nested within the 22 unitary authority (UA) local government areas in Wales. Each LSOA was assigned to one of five ordinal categories of WIMD2005 scores with equal counts of LSOAs in each quintile.

Measure of SES and potential confounding variables

The principal measure of SES defined for the analysis was the National Statistics Socio-economic Classification (NS-SEC3) variable for the head of household, defined as the person with the highest income. The categories were: professional/managerial, intermediate, routine and manual occupations, and never worked/long-term unemployed. Age was analysed in 10-year bands by gender. We considered other measures of SES as confounding variables: individual employment status (employed, seeking work, training/student, retired, permanently sick or disabled, at home), highest educational qualification (degree, intermediate, none), and ethnicity (White, Black and minority ethnic) and housing tenure (owner occupier, social and private renting) (table 1).

Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the questions on alcohol consumption, and 50 641 had complete covariate information recorded in the dataset.

Statistical Analysis

Since the outcome measure is an ordered categorical variable, the data were analysed using a continuation ratio model,[27] which allowed estimation of the association between neighbourhood deprivation and the likelihood of moving up one category of alcohol consumption, y, (e.g. from excess consumption but less than binge, to binge drinking). This continuation ratio approach used a linear predictor, $\eta_{k,}$ to explain the probability of continuing to a higher category, conditional on reaching a certain ordinal level. The linear predictor was modelled by covariates x_k and fixed effects β :

$$\text{logit } p(y > k \mid y \geq k) = \eta_{k} = x_k\beta$$

This extends naturally to the multilevel framework, where we adopted the random effects model:

$$\text{logit } p(y > k \mid y \geq k,b) = x_k\beta + z_kb$$

where the linear predictor now has two components: $x_k\beta$ are the fixed effects, and z_kb described the multilevel structure in the data. Again, in principle the influence of both fixed and random effects may vary according to the level k.

We estimated the regression coefficients beta and the covariance matrix Var (b) and we derived p(y=k | b=0), the predicted probabilities of membership of ordinal category k for the median geographical context b=0 for each quintile of deprivation and category of SES.

The sequential modelling strategy started with the "null" four-level variance components model, with category-specific intercepts and random effects for households, LSOAs and UAs. The WIMD2005 categorical variable was fitted to estimate the unadjusted neighbourhood deprivation fixed effects in model 1. NS-SEC3, age group, gender, the interaction between age group and gender, and the potential confounders were then added to form model 2. The final model 3 was fitted with cross-level interactions in separate models for WIMD2005 interacting with age group and gender, and WIMD2005 with NS-SEC3. Multiple imputation of five datasets using chained equations in R software was used to account for missing covariates.[28,29]

The magnitude of the variation between LSOAs and between UAs was estimated using the standard deviation (SD) of their random effects, since these are measured on the same scale as the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/- 0.67, and the differences between LSOA and between UA quartiles were computed by 1.34*SD to compare with the magnitude of the estimated fixed effects for SES.

RESULTS

Descriptive analysis

Overall, 22 218 (38.1%) of the total 58 282 respondents reported their levels of alcohol consumption as 'none or never drinks', 16 059 (27.6%) reported 'within guidelines', 9664 (16.6%) reported 'excess consumption but less than binge' and 10 341 (17.7%) reported 'binge' drinking. Both excess consumption and particularly binge drinking were higher in males than females. Excess consumption was highest in the 35-64 year age groups and binge drinking was highest in 18-34 year olds, declining with increasing age (table 2). The 'never worked and long-term unemployed' group and respondents with no educational qualifications showed substantially lower levels of both excess consumption and binge drinking than the three higher NS-SEC3 socio-economic groups and those with some educational achievement. For employment status, the economically active who were employed or seeking work had higher levels of excess and binge consumption than economically inactive respondents. The proportion of respondents drinking to excess decreased with increasing neighbourhood deprivation but binge drinking showed the opposite pattern of increasing with higher deprivation (table 2).

Table 2 Excess alcohol consumption and binge drinking by socio-economic status

		Excess consumption, less than binge	%	Binge	%	Total
Gender	Female	4702	15.0	3482	11.1	31261
	Male	4962	18.4	6859	25.4	27021
Age group	18-24	1001	14.5	2041	29.6	6888
	25-34	1286	17.5	2105	28.7	7329
	35-44	2007	19.6	2427	23.7	10225
	45-54	2110	21.5	1931	19.7	9815
	55-64	1961	19.2	1268	12.4	10216
	65-74	951	12.4	444	5.8	7697
	75-84	316	6.4	106	2.2	4923
	85+	32	2.7	19	1.6	1189
NS-SEC3: SES	Professional and managerial occupations	3850	19.5	3354	17.0	19699
	Intermediate occupations	1742	16.1	1873	17.3	10802
	Routine and manual occupations	3566	14.7	4397	18.2	24197
	Never worked and long-term unemployed	131	8.9	173	11.8	1465
Employment status	Employed	5766	20.9	6961	25.2	27571
	Seeking work	138	14.9	274	29.6	925
	Training/student	483	14.8	739	22.6	3273
	Permanently sick or disabled	599	13	547	11.8	4619
	Retired	1539	11.8	755	5.8	13091
	At home	696	13.2	507	9.6	5284
	Other	276	14.9	349	18.8	1856
Highest educational qualification	No qualifications	2140	12.6	2095	12.3	17026
	Intermediate qualifications	5405	18.3	6428	21.7	29601
	Degree/degree equivalent and above	1773	21.5	1445	17.5	8247
Tenure	Owner occupier	8010	17.5	7883	17.2	45725
	Social renting	956	11.8	1340	16.5	8123
	Private renting / Other	663	15.6	1085	25.5	4262
Ethnicity	White	9492	16.8	10165	18.0	56438
	Black and minority ethnic	108	8.8	100	8.2	1222
WIMD2005: Deprivation quintile	Least deprived	2304	19.5	1967	16.7	11786
	Less deprived	2111	17.2	1927	15.7	12267
	Mid deprived	2063	16.0	2219	17.2	12875
	More deprived	1726	15.0	2234	19.4	11544
	Most deprived	1460	14.9	1994	20.3	9810

Multilevel models

The unadjusted predicted probabilities for the five neighbourhood deprivation quintiles in model 1 are shown in table 3. As with the descriptive analysis, the probability of excess consumption was higher in less deprived neighbourhoods with decreasing probability across the quintiles of deprivation. Binge drinking showed the opposite pattern of increasing probability with higher deprivation. The differences in magnitude between the model predicted probabilities and the descriptive data shown in table 2 are explained by the addition of the random effects in model 1.

After including NS-SEC3, age group and gender, and the confounding variables in model 2, the adjusted difference between the deprivation quintiles for binge drinking increased, with less effect on the excess consumption category (table 3): respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference in proportions = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference in proportions = 3.7%, 95% CI: 2.6 to 4.8).

Table 3 shows the predicted probabilities of consumption for the NS-SEC3 categories in the fully adjusted model 2. There was little difference in excess consumption with SES. The descriptive analysis finding of a higher probability of binge drinking in the three higher SES groups compared to the never worked/long-term unemployed category remained after adjustment.

Table 3 Model parameter estimates and predicted probabilities (%) for excess alcohol consumption and binge drinking for neighbourhood deprivation and SES

	Parameter estimate (SE)	Excess consumption, less than binge %	Binge %
Model 1[a]			
WIMD2005:			
Neighbourhood deprivation quintiles			
Least deprived	Reference	22.2	9.7
Less deprived	-0.2042* (0.0372)	20.1	9.9
Mid deprived	-0.4105* (0.0370)	19.1	11.2
More deprived	-0.6544* (0.0375)	17.6	12.6
Most deprived	-0.8526* (0.0391)	17.2	12.6
Model 2[b]			
WIMD2005:			
Neighbourhood deprivation quintiles			
Least deprived	Reference	21.3	10.6
Less deprived	-0.1973* (0.0387)	19.5	11.1
Mid deprived	-0.3879* (0.0386)	18.8	13.0
More deprived	-0.6073* (0.0395)	17.5	15.3
Most deprived	-0.7142* (0.0421)	17.6	17.5
NS-SEC3: SES			
Professional/managerial	Reference	19.8	14.6
Intermediate	-0.0973* (0.0265)	19.0	13.0
Routine occupations	-0.1519* (0.0226)	18.6	12.2
Never worked/long-term unemployed	-0.3339* (0.0614)	17.1	9.7

a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and random effects terms for household, LSOA and unitary authority

b Model 2 included NS-SEC3, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

* $p<0.001$

The two-way cross-level interaction between WIMD2005, age group and gender showed the effect of neighbourhood deprivation on the probability of excess consumption and binge drinking varied significantly between age group and gender. The model outputs are shown on the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-level interaction in females or older age groups was found for either excess consumption or binge drinking. Males had a higher probability of excess consumption in low deprivation quintiles than females. Although the probability of binge drinking in females increased with increasing deprivation quintile, the gradients were significantly steeper in males. The probability of binge drinking was highest at all levels of neighbourhood deprivation in males aged 18 to 34, and the interaction effect was largest in the 35-64 year age groups. The cross-level interaction between WIMD2005 and NS-SEC3 was not significant suggesting that the association of excess consumption and binge drinking with neighbourhood deprivation did not vary with SES.

Random effects variance

The majority of the unexplained random variation occurred at the household level (table 4). For LSOAs, in model 2, the SD = 0.156 giving the inter-quartile range = 0.21. This compares to a parameter estimate of -0.33 for the 'never worked' category of NS-SEC3, of -0.15 for 'routine' occupations and -0.10 for the 'intermediate' category, compared to the professional/managerial category (table 3). The size of this variation suggests there is important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation, although smaller than LSOA, remains of importance in explaining the spatial pattern of alcohol consumption.

Table 4 Random effects variance in sequential multilevel models

	Level	Variance	SD
Null model	HH	0.809	0.899
	LSOA	0.032	0.179
	UA	0.017	0.130
Model 1[a]	HH	0.824	0.908
	LSOA	0.028	0.167
	UA	0.019	0.139
Model 2[b]	HH	0.867	0.931
	LSOA	0.024	0.156
	UA	0.015	0.121
Model 3[c]	HH	0.866	0.931
	LSOA	0.023	0.153
	UA	0.014	0.120

a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and random effects terms for household, LSOA and unitary authority

b Model 2 included NS-SEC3, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

c Model 3 further included the two-way cross-level interaction between WIMD2005 deprivation quintile, age group and gender

DISCUSSION

Main results

The current study has investigated the difference in associations between neighbourhood deprivation and excess alcohol consumption and binge drinking as ordinal categories, based on the UK definition,[25] since it has been suggested that it is more appropriate to set benchmarks for daily than for weekly consumption of alcohol following greater concern about the health and social risks associated with single episodes of intoxication.[6] Excess consumption was more common in less deprived neighbourhoods. In contrast, binge drinking was more common in deprived neighbourhoods. These findings add to the previous US and Canadian studies which showed a significant neighbourhood effect,[16,17,22] by further assessing the complex interacting effects of neighbourhood deprivation with consumption category, age and gender, and SES. The joint effect of neighbourhood deprivation with age and gender was greatest for binge drinking in middle-aged males with no significant interaction with SES. We also found a substantial geographical effect of neighbourhood, since the magnitude of the unexplained variance in alcohol consumption was similar to the effect sizes of individual SES.

Possible mechanisms linking neighbourhood deprivation to harmful alcohol consumption

Three mechanisms have been proposed to explain how neighbourhood deprivation might exert an independent effect on the risk of harmful alcohol consumption, and a differential effect on middle-aged males.[16] First, the contagion hypothesis suggests that health behaviours are spread by social exchange and particularly social networks of personal friends. Thus, binge drinking may be more acceptable in middle-aged men resident in deprived neighbourhoods than in the non-deprived. Second, the stress of living in areas of high

neighbourhood disadvantage may make men more vulnerable to psychological distress. This then increases the risk that alcohol is used as a coping mechanism.

Third, the structural hypothesis argues that neighbourhood social norms and institutions define the pattern of health behaviours. Greater availability of cheap alcohol measured as higher alcohol outlet densities might influence harmful drinking rates, although the evidence summarised in systematic reviews of both cross-sectional and longitudinal studies is inconsistent.[30] There is some evidence that high deprivation neighbourhoods have a higher density of alcohol outlets,[15,31,32] and this might provide a mechanism to explain higher consumption in deprived neighbourhoods. However, two studies which found higher outlet densities in more deprived areas found that levels of consumption were highest in less deprived areas.[15,31] A third study found the spatial association between outlet density and deprivation did not vary systematically, suggesting the relationship between deprivation and outlet density may be different in different locations.[32] This deprivation-density hypothesis could not explain the findings of higher rates of excess consumption in the least deprived neighbourhoods in the current study. One possibility is the acceptance of social norms of regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to a different set of social normative binge drinking behaviour in the most deprived areas.

Strengths and limitations

Since 2003/04, the Welsh Health Survey has been an annual source of robust population survey data. It has the important strength of a large sampling fraction resulting in a representative response dataset that includes around one in fifty of the socially diverse Welsh adult population, with detailed exposure data linked to the small-area neighbourhood. The study findings from such a comprehensive dataset should be more widely generalisable.

Several limitations should be considered. The alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health.[25] However, the possibility of social desirability bias resulting in under-reported alcohol consumption should be considered,[33,34] although it is not known whether under-reporting varies between neighbourhoods. The questionnaire responses were consistent year-on-year from four different successive samples, suggesting that responses were reliable. Non-response bias was a possibility but the surveys had a consistently good overall response to the interviewer-led method, from 74% of sampled households and 85% of individuals within responding households in 2003/04,[24] to 74% and 82% respectively in 2010.[35]

The administratively defined census LSOA was used as a proxy for 'neighbourhood'. However, the direction of bias from using non-homogeneous administrative areas is towards conservative estimates.[36,37] Therefore it is unlikely that the current study over-estimated the associations between alcohol consumption and neighbourhood deprivation. Finally, no inferences about causal processes can be made. Reverse cause, for example, could suggest that binge drinking causes a decline in social position, but this explanation seems unlikely for excess alcohol consumption in which the associations were in the opposite direction to binge drinking.

In conclusion, the socio-economic patterning of excess alcohol consumption and binge drinking was complex. The study findings have implications for enhancing public health alcohol policy development, emphasising the importance of neighbourhood. Further longitudinal research on the spatial relationships between alcohol consumption, outlet density, and socio-economic deprivation at individual and neighbourhood levels is necessary to further

understand the underlying processes and provide further evidence for local and national policies to reduce alcohol-related harm.[38]

COMPETING INTERESTS

None

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Information Governance and data sharing

A formal data access agreement was signed with the Welsh Government in order to receive the dataset with the geographical variables for analysis. These data can only be accessed under such an agreement. There are no additional data available. Ethical approval was not required for this secondary analysis of an anonymised dataset.

Contributorship

All authors contributed to the design of the study. DLF is principal investigator and wrote the first draft of the paper with JW. DMF carried out the statistical modelling, supported by FD. JW carried out the literature reviews. All authors contributed to the critical revision of the manuscript and read and approved the final version.

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LIST OF TITLES FOR FIGURES

Figure 1 Estimated probabilities of excess alcohol consumption by age group and gender within deprivation quintiles

Figure 2 Estimated probabilities of binge drinking by age group and gender within deprivation quintiles

Figure 1: Estimated probabilities of excess alcohol consumption by age group and gender within deprivation quintiles

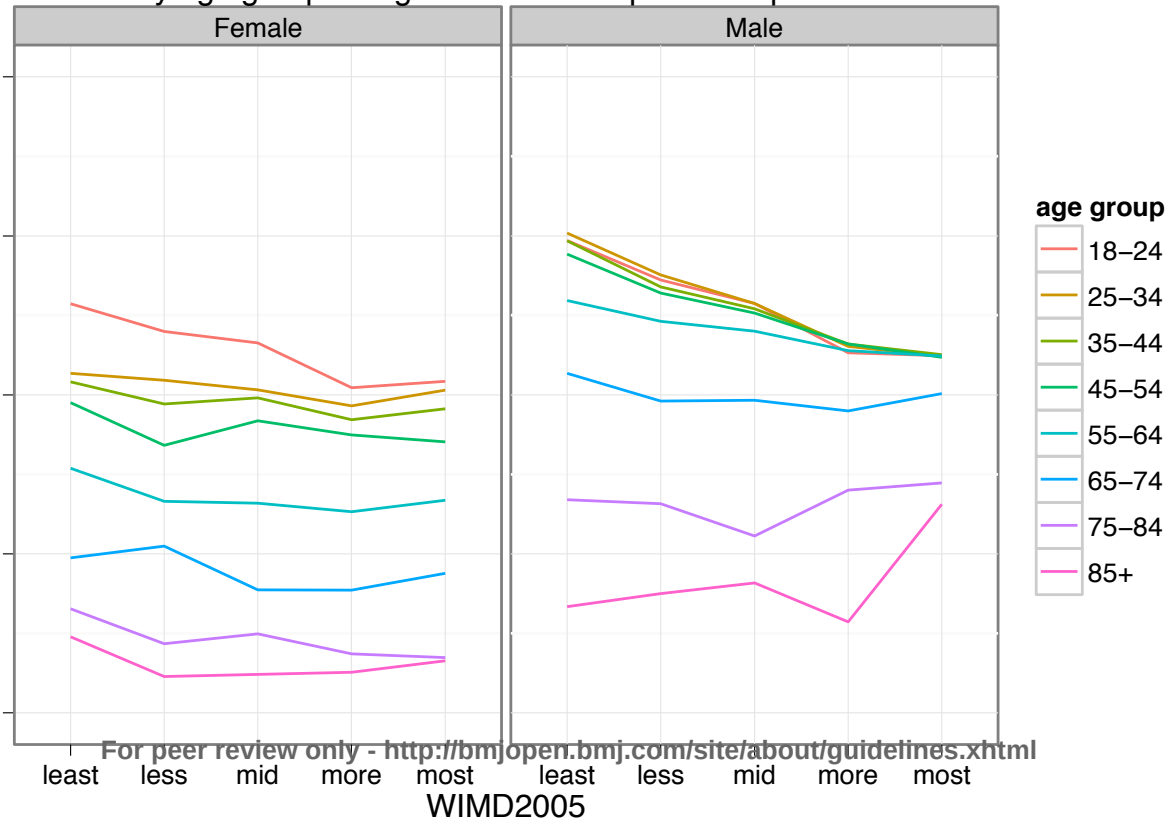
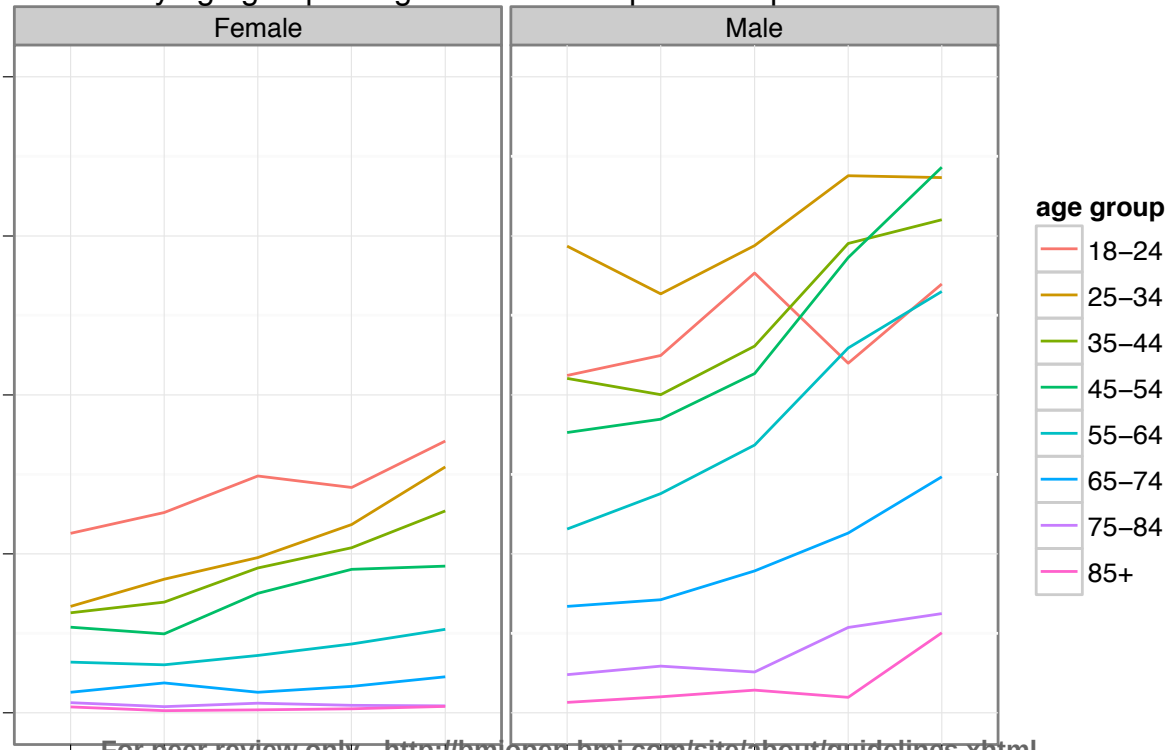


Figure 2: Estimated probabilities of binge drinking
by age group and gender within deprivation quintiles



STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	DONE?	Item No	Recommendation
Title and abstract	√	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
	√		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
	Introduction		
Background/rationale	√	2	Explain the scientific background and rationale for the investigation being reported
Objectives	√	3	State specific objectives, including any prespecified hypotheses
	Methods		
Study design	√	4	Present key elements of study design early in the paper
Setting	√	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	√	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	√	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	√	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	√	9	Describe any efforts to address potential sources of bias
Study size	√	10	Explain how the study size was arrived at
Quantitative variables	√	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	√	12	(*a*) Describe all statistical methods, including those used to control for confounding
	√		(*b*) Describe any methods used to examine subgroups and interactions
	√		(*c*) Explain how missing data were addressed
	√		(*d*) If applicable, describe analytical methods taking account of sampling strategy
	√		(*e*) Describe any sensitivity analyses
	Results		
Participants	√	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
	N/Known		(b) Give reasons for non-participation at each stage
	Would add little		(c) Consider use of a flow diagram
Descriptive data	√	14*	(a) Give characteristics of study participants (eg demographic,

			clinical, social) and information on exposures and potential confounders
	√		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	√	15*	Report numbers of outcome events or summary measures
Main results	√	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
	√ (equal count method for small-area boundaries)		(*b*) Report category boundaries when continuous variables were categorized
	N/A		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	√	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion			
Key results	√	18	Summarise key results with reference to study objectives
Limitations	√	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	√	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	√	21	Discuss the generalisability (external validity) of the study results
Other information			
Funding	√	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation

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Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation

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Keywords

Alcohol, Social epidemiology, multilevel modelling, Public Health

ABSTRACT

Objectives

The influence of neighbourhood deprivation on the risk of harmful alcohol consumption, measured by the separate categories of excess consumption and binge drinking, has not been studied. The objective of the study was to investigate the effect of neighbourhood deprivation with age, gender and socio-economic status (SES) on (1) excess alcohol consumption, and (2) binge drinking, in a representative population survey.

Design

Cross-sectional study: multi-level analysis.

Setting

Wales, UK, adult population ~ 2.2 million.

Participants

58 282 respondents aged 18 years and over to four successive annual Welsh Health Surveys (2003/04-2007), nested within 32 692 households, 1839 census lower super output areas and the 22 unitary authority areas in Wales.

Primary outcome measure

Maximal daily alcohol consumption during the past week was categorised using the UK Department of Health definition of 'none/never drinks', 'within guidelines', 'excess consumption but less than binge' and 'binge'. The data were analysed using continuation ratio ordinal multilevel models with multiple imputation for missing covariates.

Results

Respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference = 3.7%, 95% CI: 2.6 to 4.8). The effect of deprivation varied significantly with age and gender, but not with SES. Younger males in deprived neighbourhoods were most likely to binge drink but the largest interaction effect of deprivation on binge drinking was found for middle-aged males living in the most deprived areas.

Conclusion

This large-scale population study is the first to show that neighbourhood deprivation acts differentially on the risk of binge drinking between males and females at different age groups. Understanding the socio-economic patterns of harmful alcohol consumption is important for public health policy development.

ARTICLE SUMMARY

Article Focus

- A recent systematic review found little evidence that living in neighbourhoods of high socio-economic deprivation is associated with a higher risk of harmful alcohol consumption
- The important distinction between excess alcohol consumption and binge drinking has not previously been investigated

Key Messages

- A higher risk of binge drinking was found in residents living in deprived neighbourhoods, particularly in young and middle-aged men
- A higher risk of excess consumption, but less than binge, was found in residents of less deprived neighbourhoods
- Neighbourhood socio-economic deprivation is an important factor to consider in public health alcohol policy development

Strengths and Limitations

- The main strength is the large representative dataset of over 58 000 respondents, or around one in fifty of the socially diverse Welsh adult population. The ordinal alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health

- The cross-sectional analysis used the administratively defined census LSOA as a proxy for 'neighbourhood' and cannot investigate the possibility of causal relationships. Social desirability bias may result in under-reported alcohol consumption, although it is not known whether this varies between neighbourhoods.

INTRODUCTION

Excess alcohol consumption causes a major global burden of disease, injury and social and economic cost.[1] Binge drinking, typically defined as consuming at least double the guideline limits in a single day during the previous week,[2] is an increasing problem which is rising particularly in young women.[3] It is associated with anti-social behaviour,[4] and around half of all violent crimes in the UK.[5] Binge drinking causes an extra burden on health services; between 20-40 % of people presenting to accident and emergency departments are intoxicated, increasing to 80% after midnight.[4] Recent data show that around 37% of men and 29% of women exceeded the current UK guidelines for safe levels of alcohol consumption of ≤ 3 units per day for women and ≤4 units per day for men in the past week; and 20% of men and 13% of women engaged in binge drinking, defined as > 6 units per day for women and > 8 units per day for men.[6] Given the wide range of harm resulting from this substantial level of consumption, the potential impact on health at the population level from a reduction in consumption is considerable.

Research investigating the socio-economic patterning of harmful alcohol consumption has generally found that lower socio-economic status (SES) groups drink more heavily and higher SES groups drink more frequently,[7] consistent with binge drinking being found to be more prevalent in the economically disadvantaged.[8] However, subtle variations in cut-points based on units have led to prevalence estimates for binge drinking in young men to differ by 22%,[2] and these summary SES relationships have been found to vary substantially with age, gender, educational level, employment status and the measure of consumption.[2,7-12]

In addition to socio-economic effects found at the individual level, it is theorised that small-area, or neighbourhood, socio-economic deprivation might exert an independent effect on

harmful alcohol consumption. However, a recent systematic review which included multilevel studies of neighbourhood deprivation and alcohol consumption found little evidence to support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in a quality assessment, one study set in the West of Scotland, UK, found no significant association between neighbourhood deprivation and drinking above guideline limits or the number of units consumed in the past week.[14] A second study set in California, USA, found that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males) was significantly higher for people living in the least deprived neighbourhoods with no significant variation with individual SES.[15]

The two other studies described an association between high neighbourhood deprivation and high consumption.[16,17] Data from the nationally representative Third National Health and Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood deprivation measure at the level of the census tract was associated with heavy alcohol use, defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01, 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A second US study found that higher mean income and income inequality at the larger community district level was significantly associated with a higher number of drinks per month among drinkers.[17] Four subsequent papers reporting small studies found no significant association between alcohol consumption and neighbourhood income,[18,19] neighbourhood unemployment,[20] or a composite measure of relative socio-economic disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada found a small effect of neighbourhood deprivation on the number of drinks consumed per week in men, but not in women.[22]

Possible explanations for these inconsistencies in neighbourhood associations found between studies may result from different methods of defining excess, or harmful, consumption, with some choosing definitions based on national guidelines for 'safe' consumption or units,[14] number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations for inconsistent neighbourhood associations may result from different measures of area deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors for excess alcohol consumption.[14-22]

Despite the substantial public health consequences of alcohol consumption and the possible importance of neighbourhood in explaining patterns of consumption, no previous study to our knowledge has investigated multilevel associations with neighbourhood deprivation which distinguish between excess consumption and binge drinking as distinct categories. Little is known on whether any associations vary within population groups. The aim of the present study was to investigate the effect of neighbourhood deprivation with age, gender and SES on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a representative sample of the adult population of Wales, UK.

METHODS

Participants

Data were drawn from four successive cross-sectional waves of the Welsh Health Survey 2003/04 to 2007, an interviewer-led household and individual survey of the adult population resident in Wales, UK.[23-25] The adult population of Wales is approximately 2.2 million (2001 Census) and the dataset available included a total of 60 555 adults aged 18 years and over. The sampling methods and the survey process are described in detail elsewhere.[24,25] Briefly, the sampling frame used was the Post Office's Postcode Address File. Private household addresses were randomly selected in a two stage design, sampling addresses within primary sampling units that were selected within the 22 unitary authority local government areas in Wales. Each adult member of the household was invited to complete a questionnaire. Response rates were high: in 2003/04 the adjusted household survey response was 74% with 85% of individuals responding within households,[24] with little change at 74% and 82% respectively in 2007.[25]

Alcohol outcome measure

Participants were asked to state the highest number of units they had drunk on any one day in the previous seven days, using a standard prompt to convert different types and quantities of alcoholic drinks into units. The dataset provided the classification of units into ordinal categories of maximal daily consumption based on the UK Department of Health definitions (Table 1), with categories for 'none/never drinks', 'within guidelines', 'excess consumption but less than binge, and 'binge'.[26]

Table 1 Categorisation of the alcohol consumption outcome variable

Category	Maximum units drunk on any one day in the last week
None/never drinks	Did not drink in the last seven days
Within guidelines	Men drinking no more than 4 units, women no more than 3 units
Excess consumption but less than binge	Men drinking more than 4 and up to and including 8 units, women more than 3 and up to and including 6 units
Binge	Men drinking more than 8 units, women more than 6 units

Source: reference 26

Neighbourhood deprivation measure

The Welsh Index of Multiple Deprivation 2005 (WIMD2005) was used as the measure of neighbourhood deprivation.[27] WIMD2005 includes seven weighted domains of deprivation: income (25%), employment (25%), education (15%), health (15%), geographical access to services (10%), housing (5%), and physical environment (5%). WIMD2005 scores are available for lower super output areas (LSOA), a unit of statistical geography defined by the 2001 UK Census.[28] There are 1896 LSOAs in Wales which have a mean population size of around 1500. Since the data included in each WIMD2005 domain are measured on different scales, each domain score is transformed to have a range of zero to 100 and the overall index is calculated using a weighted average, [27] taking a range of 1.4 to 78.9. WIMD2005 is highly correlated with the well-established Townsend index,[29] Spearman's $r = 0.86$, $n=1896$, $p<0.001$.

We used the LSOA as the closest available proxy for neighbourhood. Neighbourhood characteristics vary widely within Wales, from high to low levels of socioeconomic disadvantage, including deprived urban inner-city areas, less deprived city sub-urban

residential areas, post-industrial valley towns, market towns and rural, farming areas. Respondents were linked to their neighbourhood of residence by the data owners (the Welsh Government) and the dataset included individuals living in 1839 LSOAs, nested within the 22 unitary authorities (UA) in Wales. Each LSOA was assigned to one of five ordinal categories of WIMD2005 scores with equal counts of LSOAs in each quintile.

Measures of individual SES and potential confounding variables

The principal measure of SES defined for the analysis was the National Statistics Socio-economic Classification (NS-SEC3) variable for the head of household. This is a measure of occupational social class with the following categories: professional/managerial, intermediate, routine and manual occupations, and never worked/long-term unemployed. Age was analysed in 10-year bands by gender. We considered other available measures of SES that were associated with alcohol consumption in the dataset as confounding variables: individual employment status (employed, seeking work, training/student, retired, permanently sick or disabled, at home), highest educational qualification (degree, intermediate, none), ethnicity (White, Black and minority ethnic) and housing tenure (owner occupier, social and private renting) (table 2).

Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the questions on alcohol consumption, and 50 641 had complete covariate information recorded in the dataset.

Statistical Analysis

Since the outcome measure is an ordered categorical variable, the data were analysed using a continuation ratio model,[30] which allowed estimation of the association between neighbourhood deprivation and the likelihood of moving up one category of alcohol consumption, y, (e.g. from excess consumption but less than binge, to binge drinking). This continuation ratio approach used a linear predictor, $\eta_{k,}$ to explain the probability of continuing to a higher category, conditional on reaching a certain ordinal level. The linear predictor was modelled by covariates x_k and fixed effects β :

$$\text{logit } p(y > k \mid y \geq k) = \eta_{k} = x_k\beta$$

This extends naturally to the multilevel framework, where we adopted the random effects model:

$$\text{logit } p(y > k \mid y \geq k,b) = x_k\beta + z_kb$$

where the linear predictor now has two components: $x_k\beta$ are the fixed effects, and z_kb described the multilevel structure in the data. Again, in principle the influence of both fixed and random effects may vary according to the level k.

We estimated the regression coefficients beta and the covariance matrix Var (b) and we derived p(y=k | b=0), the predicted probabilities of membership of ordinal category k for the median geographical context b=0 for each quintile of deprivation and category of SES.

The sequential modelling strategy started with the “null” four-level variance components

model, with category-specific intercepts and random effects for households, LSOAs and UAs. The WIMD2005 categorical variable was fitted to estimate the unadjusted neighbourhood deprivation fixed effects in model 1. To allow increased flexibility in understanding the effects of deprivation on alcohol consumption, interactions between the change in alcohol consumption category and deprivation quintile were included in the continuation ratio models. The predicted probabilities of excess consumption and binge drinking are derived from the sum of the additive main effect and interaction coefficients.

Social class, age group, gender, the interaction between age group and gender, and the potential confounders were then added to form model 2. The final model 3 was fitted with cross-level interactions in separate models for WIMD2005 interacting with age group and gender, and WIMD2005 with social class. Multiple imputation of five datasets using chained equations in R software was used to account for missing covariates.[31,32]

The magnitude of the variation between LSOAs and between UAs was estimated using the standard deviation (SD) of their random effects, since these are measured on the same scale as the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/- 0.67, and the differences between LSOA and between UA quartiles were computed by 1.34*SD to compare with the magnitude of the estimated fixed effects for social class.

RESULTS

Descriptive analysis

Overall, 22 218 (38.1%) of the total 58 282 respondents reported their levels of alcohol consumption as 'none or never drinks', 16 059 (27.6%) reported 'within guidelines', 9664 (16.6%) reported 'excess consumption but less than binge' and 10 341 (17.7%) reported 'binge' drinking. Both excess consumption and particularly binge drinking were higher in males than females. Excess consumption was highest in the 35-64 year age groups and binge drinking was highest in 18-34 year olds, declining with increasing age (table 2). The 'never worked and long-term unemployed' group and respondents with no educational qualifications showed substantially lower levels of both excess consumption and binge drinking than the three higher social class groups and those with some educational achievement. For employment status, the economically active who were employed or seeking work had higher levels of excess and binge consumption than economically inactive respondents. The proportion of respondents drinking to excess decreased with increasing neighbourhood deprivation but binge drinking showed the opposite pattern of increasing with higher deprivation (table 2).

Table 2 Excess alcohol consumption and binge drinking by socio-economic status

		Excess consumption, less than binge	%	Binge	%	Total
Gender	Female	4702	15.0	3482	11.1	31261
	Male	4962	18.4	6859	25.4	27021
Age group	18-24	1001	14.5	2041	29.6	6888
	25-34	1286	17.5	2105	28.7	7329
	35-44	2007	19.6	2427	23.7	10225
	45-54	2110	21.5	1931	19.7	9815
	55-64	1961	19.2	1268	12.4	10216
	65-74	951	12.4	444	5.8	7697
	75-84	316	6.4	106	2.2	4923
	85+	32	2.7	19	1.6	1189
Social class:	Professional and managerial occupations	3850	19.5	3354	17.0	19699
	Intermediate occupations	1742	16.1	1873	17.3	10802
	Routine and manual occupations	3566	14.7	4397	18.2	24197
	Never worked and long-term unemployed	131	8.9	173	11.8	1465
Employment status	Employed	5766	20.9	6961	25.2	27571
	Seeking work	138	14.9	274	29.6	925
	Training/student	483	14.8	739	22.6	3273
	Permanently sick or disabled	599	13	547	11.8	4619
	Retired	1539	11.8	755	5.8	13091
	At home	696	13.2	507	9.6	5284
	Other	276	14.9	349	18.8	1856
Highest educational qualification	No qualifications	2140	12.6	2095	12.3	17026
	Intermediate qualifications	5405	18.3	6428	21.7	29601
	Degree/degree equivalent and above	1773	21.5	1445	17.5	8247
Tenure	Owner occupier	8010	17.5	7883	17.2	45725
	Social renting	956	11.8	1340	16.5	8123
	Private renting / Other	663	15.6	1085	25.5	4262
Ethnicity	White	9492	16.8	10165	18.0	56438
	Black and minority ethnic	108	8.8	100	8.2	1222
WIMD2005: Deprivation quintile	Least deprived	2304	19.5	1967	16.7	11786
	Less deprived	2111	17.2	1927	15.7	12267
	Mid deprived	2063	16.0	2219	17.2	12875
	More deprived	1726	15.0	2234	19.4	11544
	Most deprived	1460	14.9	1994	20.3	9810

Multilevel models

The unadjusted predicted probabilities for the five neighbourhood deprivation quintiles in model 1 are shown in table 3. As with the descriptive analysis, the probability of excess consumption was higher in less deprived neighbourhoods with decreasing probability across the quintiles of deprivation. Binge drinking showed the opposite pattern of increasing probability with higher deprivation. The differences in magnitude between the model predicted probabilities and the descriptive data shown in table 2 are explained by the addition of the random effects in model 1.

After including social class, age group and gender, and the confounding variables in model 2, the adjusted difference between the deprivation quintiles for binge drinking increased, with less effect on the excess consumption category (table 3): respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference in proportions = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference in proportions = 3.7%, 95% CI: 2.6 to 4.8).

Table 3 also shows the predicted probabilities of consumption for the social class categories in the fully adjusted model 2. There was little variation in excess consumption with social class. The descriptive analysis finding of a higher probability of binge drinking in the three higher social class groups compared to the never worked/long-term unemployed category remained after adjustment.

Table 3 Model parameter estimates and predicted probabilities (%) for excess alcohol consumption and binge drinking for neighbourhood deprivation and SES

	Parameter estimate (SE)	Excess consumption, less than binge %	Binge %
Model 1[a]			
WIMD2005:			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	22.2	9.7
Less deprived	-0.2042* (0.0372)	20.1	9.9
Mid deprived	-0.4105* (0.0370)	19.1	11.2
More deprived	-0.6544* (0.0375)	17.6	12.6
Most deprived	-0.8526* (0.0391)	17.2	12.6
Interaction: WIMD2005*change in alcohol consumption category:			
Within to excess: Less deprived	0.2033* (0.0446)		
Excess to binge: Less deprived	0.3254* (0.0565)		
Within to excess: Mid deprived	0.5656* (0.0443)		
Excess to binge: Mid deprived	0.7054* (0.0554)		
Within to excess: More deprived	0.9931* (0.0459)		
Excess to binge: More deprived	1.1510* (0.0563)		
Within to excess: Most deprived	1.3587* (0.0489)		
Excess to binge: Most deprived	1.3692* (0.0584)		
Model 2[b]			
WIMD2005:			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	21.3	10.6
Less deprived	-0.1973* (0.0387)	19.5	11.1
Mid deprived	-0.3879* (0.0386)	18.8	13.0
More deprived	-0.6073* (0.0395)	17.5	15.3
Most deprived	-0.7142* (0.0421)	17.6	17.5
Interaction: WIMD2005*change in alcohol consumption category:			
Within to excess: Less deprived	0.1954* (0.0470)		
Excess to binge: Less deprived	0.3282* (0.0588)		
Within to excess: Mid deprived	0.5720* (0.0467)		
Excess to binge: Mid deprived	0.7296* (0.0577)		
Within to excess: More deprived	1.0157* (0.0483)		
Excess to binge: More deprived	1.2033* (0.0586)		
Within to excess: Most deprived	1.3996* (0.0514)		
Excess to binge: Most deprived	1.4615* (0.0608)		
NS-SEC3: SES			
Professional/managerial	Reference	19.8	14.6
Intermediate	-0.0973* (0.0265)	19.0	13.0

Routine occupations	-0.1519* (0.0226)	18.6	12.2
Never worked/long-term unemployed	-0.3339* (0.0614)	17.1	9.7

a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and the interaction with change in category of consumption, and random effects terms for household, LSOA and unitary authority

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

* p<0.001

The two-way cross-level interaction between WIMD2005, age group and gender showed the effect of neighbourhood deprivation on the probability of excess consumption and binge drinking varied significantly between age group and gender. The model outputs are shown on the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-level interaction in females or older age groups was found for either excess consumption or binge drinking. Males had a higher probability of excess consumption in low deprivation quintiles than females. Although the probability of binge drinking in females increased with increasing deprivation quintile, the gradients were significantly steeper in males. The probability of binge drinking was highest at all levels of neighbourhood deprivation in males aged 18 to 34, and the interaction effect was largest in the 35-64 year age groups. The cross-level interaction between WIMD2005 and social class was not significant suggesting that the association of excess consumption and binge drinking with neighbourhood deprivation did not vary with SES.

Random effects variance

The majority of the unexplained random variation occurred at the household level (table 4). For LSOAs, in model 2, the SD = 0.156 giving the inter-quartile range of the distribution of the LSOA variance = 0.21. This compares to a parameter estimate of -0.33 for the 'never worked' category of social class, of -0.15 for 'routine' occupations and -0.10 for the 'intermediate' category, compared to the professional/managerial category (table 3). The size of this variation is of similar magnitude to the social class estimates, which suggests there is important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation, although smaller than LSOA, remains of importance in explaining the spatial pattern of alcohol consumption.

Table 4 Random effects variance in sequential multilevel models

	Level	Variance	SD	Intra-class correlation (%)
Null model	HH	0.809	0.899	74.4
	LSOA	0.032	0.179	14.8
	UA	0.017	0.130	10.8
Model 1[a]	HH	0.824	0.908	74.8
	LSOA	0.028	0.167	13.8
	UA	0.019	0.139	11.4
Model 2[b]	HH	0.867	0.931	77.1
	LSOA	0.024	0.156	12.9
	UA	0.015	0.121	10.0
Model 3[c]	HH	0.866	0.931	77.3
	LSOA	0.023	0.153	12.7
	UA	0.014	0.120	10.0

a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and the interaction with change in category of consumption, and random effects terms for household, LSOA and unitary authority

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

c Model 3 further included the two-way cross-level interaction between WIMD2005 deprivation quintile, age group and gender

DISCUSSION

Main results

The current study has investigated the difference in associations between neighbourhood deprivation and excess alcohol consumption and binge drinking as ordinal categories, based on the UK definition,[26] since it has been suggested that it is more appropriate to set benchmarks for daily than for weekly consumption of alcohol following greater concern about the health and social risks associated with single episodes of intoxication.[6] Excess consumption was more common in less deprived neighbourhoods. In contrast, binge drinking was more common in deprived neighbourhoods. These findings add to the previous US and Canadian studies which showed a significant neighbourhood effect,[16,17,22] by further assessing the complex interacting effects of neighbourhood deprivation with consumption category, age and gender, and social class. The interaction effect of neighbourhood deprivation with age and gender was greatest for binge drinking in middle-aged males with no significant interaction with social class. We also found a substantial variation between neighbourhoods, since the magnitude of the unexplained variance in alcohol consumption was similar to the effect sizes of individual SES.

Possible mechanisms linking neighbourhood deprivation to harmful alcohol consumption

Three mechanisms have been proposed to explain how neighbourhood deprivation might exert an independent effect on the risk of harmful alcohol consumption, and a differential effect on middle-aged males.[16] First, the contagion hypothesis suggests that health behaviours are spread by social exchange and particularly social networks of personal friends. Thus, binge drinking may be more acceptable in middle-aged men resident in deprived neighbourhoods than in the non-deprived. Second, the stress of living in areas of high

neighbourhood disadvantage may make men more vulnerable to psychological distress. This then increases the risk that alcohol is used as a coping mechanism.

Third, the structural hypothesis argues that neighbourhood social norms and institutions define the pattern of health behaviours. Greater availability of cheap alcohol measured as higher alcohol outlet densities might influence harmful drinking rates, although the evidence summarised in systematic reviews of both cross-sectional and longitudinal studies is inconsistent.[33] There is some evidence that high deprivation neighbourhoods have a higher density of alcohol outlets,[15,34,35] and this might provide a mechanism to explain higher consumption in deprived neighbourhoods. However, two studies which found higher outlet densities in more deprived areas found that levels of consumption were highest in less deprived areas.[15,34] A third study found the spatial association between outlet density and deprivation did not vary systematically, suggesting the relationship between deprivation and outlet density may be different in different locations.[35] This deprivation-density hypothesis could not explain the findings of higher rates of excess consumption in the least deprived neighbourhoods in the current study. One possibility is the acceptance of social norms of regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to a different set of social normative binge drinking behaviour in the most deprived areas.

Strengths and limitations

Since 2003/04, the Welsh Health Survey has been an annual source of robust population survey data. It has the important strength of a large sampling fraction resulting in a representative response dataset that includes around one in fifty of the socially diverse Welsh adult population, with detailed exposure data linked to the small-area neighbourhood. The study findings from such a comprehensive dataset should be widely generalisable. Several

limitations should be considered. The alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health.[26] However, the possibility of social desirability bias resulting in under-reported alcohol consumption should be considered,[36,37] although it is not known whether under-reporting varies between neighbourhoods. The questionnaire responses were consistent year-on-year from four different successive samples, suggesting that responses were reliable. Non-response bias was a possibility but the surveys had a consistently good overall response to the interviewer-led method,[24,25]

The administratively defined census LSOA was used as a proxy for 'neighbourhood'. However, the direction of bias from using non-homogeneous administrative areas is towards conservative estimates.[38,39] Therefore it is unlikely that the current study over-estimated the associations between alcohol consumption and neighbourhood deprivation. Finally, no inferences about causal processes can be made. Reverse cause, for example, could suggest that binge drinking causes a decline in social position, but this explanation seems unlikely for excess alcohol consumption in which the associations were in the opposite direction to binge drinking. A further limitation was that the dataset did not permit investigation of the possible mechanisms for our study findings.

In conclusion, the socio-economic patterning of excess alcohol consumption and binge drinking was complex. The study findings have implications for enhancing public health alcohol policy development, emphasising the importance of neighbourhood. Further longitudinal research on the spatial relationships between alcohol consumption, outlet density, and socio-economic deprivation at individual and neighbourhood levels is necessary to further

understand the underlying processes and provide further evidence for local and national policies to reduce alcohol-related harm.[40]

COMPETING INTERESTS

None

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Information Governance and data sharing

A formal data access agreement was signed with the Welsh Government in order to receive the dataset with the geographical variables for analysis. These data can only be accessed under such an agreement. There are no additional data available. Ethical approval was not required for this secondary analysis of an anonymised dataset.

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LIST OF TITLES FOR FIGURES

Figure 1 Estimated probabilities of excess alcohol consumption by age group and gender within deprivation quintiles

Figure 2 Estimated probabilities of binge drinking by age group and gender within deprivation quintiles

Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation

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Keywords

Alcohol, Social epidemiology, multilevel modelling, Public Health

ABSTRACT

Objectives

The influence of neighbourhood deprivation on the risk of harmful alcohol consumption, measured by the separate categories of excess consumption and binge drinking, has not been studied. The objectives of the study was to investigate the joint effects of neighbourhood deprivation with age, gender and socio-economic status (SES) on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a representative sample of the adult population surveyof Wales, UK.

Design

Cross-sectional study: a multi-level analysis of a population based dataset.

Setting

Wales, UK, adult population ~ 2.24 million.

Participants

58 282 respondents aged 18 years and over to four successive annual Welsh Health Surveys (2003/04-2007), nested within 32 692 households, 1839 census lower super output areas and the 22 unitary authority areas in Wales.

Primary outcome measure

Maximal daily alcohol consumption during the past week was categorised using the UK Department of Health definition of 'none/never drinks', 'within guidelines', 'excess

consumption but less than binge' and 'binge'. The data were analysed using continuation ratio ordinal multilevel models with multiple imputation for missing covariates.

Results

Respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference = 3.7%, 95% CI: 2.6 to 4.8). The effect of deprivation varied significantly with age and gender, but not with SES. Younger males in deprived neighbourhoods were most likely to binge drink but the largest interaction effect of deprivation on binge drinking was found for middle-aged males living in the most deprived areas.

Conclusion

~~Neighbourhood deprivation is an important factor in the understanding of socio-economic patterns of categories of harmful alcohol consumption and for public health policy development.~~

This large-scale population study is the first to show that neighbourhood deprivation acts differentially on the risk of binge drinking between males and females at different age groups. Understanding the socio-economic patterns of harmful alcohol consumption ~~This~~ is ~~of~~ importan~~ce~~t for public health policy development.

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ARTICLE SUMMARY

Article Focus

- A recent systematic review found little evidence that living in neighbourhoods of high socio-economic deprivation is associated with a higher risk of harmful alcohol consumption
- The important distinction between excess alcohol consumption and binge drinking has not previously been investigated

Key Messages

- A higher risk of binge drinking was found in residents living in deprived neighbourhoods, particularly in young and middle-aged men
- A higher risk of excess consumption, but less than binge, was found in residents of less deprived neighbourhoods
- Neighbourhood socio-economic deprivation is an important factor to consider in public health alcohol policy development

Strengths and Limitations

- The main strength is the large representative dataset of over 58 000 respondents, or around one in fifty of the socially diverse Welsh adult population. The ordinal alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health

- The cross-sectional analysis used the administratively defined census LSOA as a proxy for 'neighbourhood' and cannot investigate the possibility of causal relationships. Social desirability bias may result in under-reported alcohol consumption, although it is not known whether this varies between neighbourhoods.

INTRODUCTION

Excess alcohol consumption causes a major global burden of disease, injury and social and economic cost.[1] Binge drinking, typically defined as consuming at least double the guideline limits in a single day during the previous week,[2] is an increasing problem which is rising particularly in young women.[3] It is associated with anti-social behaviour,[4] and around half of all violent crimes in the UK.[5] Binge drinking causes an extra burden on health services; between 20-40 % of people presenting to accident and emergency departments are intoxicated, increasing to 80% after midnight.[4] Recent data show that around 37% of men and 29% of women exceeded the current UK guidelines for safe levels of alcohol consumption of ≤ 3 units per day for women and ≤4 units per day for men in the past week; and 20% of men and 13% of women engaged in binge drinking, defined as > 6 units per day for women and > 8 units per day for men.[6] Given the wide range of harm resulting from this substantial level of consumption, the potential impact on health at the population level from a reduction in consumption is considerable.

Research investigating the socio-economic patterning of harmful alcohol consumption has generally found that lower socio-economic status (SES) groups drink more heavily and higher SES groups drink more frequently,[7] consistent with binge drinking being found to be more prevalent in the economically disadvantaged.[8] However, subtle variations in cut-points based on units have led to prevalence estimates for binge drinking in young men to differ by 22%,[2] and these summary SES relationships have been found to vary substantially with age, gender, educational level, employment status and the measure of consumption.[2,7-12]

In addition to socio-economic effects found at the individual level, it is theorised that small-area, or neighbourhood, socio-economic deprivation might exert an independent effect on

harmful alcohol consumption. However, a recent systematic review which included multilevel studies of neighbourhood deprivation and alcohol consumption found little evidence to support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in a quality assessment, one study set in the West of Scotland, UK, found no significant association between neighbourhood deprivation and drinking above guideline limits or the number of units consumed in the past week.[14] A second study set in California, USA, found that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males) was significantly higher for people living in the least deprived neighbourhoods with no significant variation with individual SES.[15]

The two other studies described an association between high neighbourhood deprivation and high consumption.[16,17] Data from the nationally representative Third National Health and Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood deprivation measure at the level of the census tract was associated with heavy alcohol use, defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01, 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A second US study found that higher mean income and income inequality at the larger community district level was significantly associated with a higher number of drinks per month among drinkers.[17] Four subsequent papers reporting small studies found no significant association between alcohol consumption and neighbourhood income,[18,19] neighbourhood unemployment,[20] or a composite measure of relative socio-economic disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada found a small effect of neighbourhood deprivation on the number of drinks consumed per week in men, but not in women.[22]

Possible explanations for these inconsistencies in neighbourhood associations found between studies may result from different methods of defining excess, or harmful, consumption, with some choosing definitions based on national guidelines for 'safe' consumption or units,[14] number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations for inconsistent neighbourhood associations may result from different measures of area deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors for excess alcohol consumption.[14-22]

Despite the substantial public health consequences of alcohol consumption and the possible importance of neighbourhood in explaining patterns of consumption, no previous study to our knowledge has investigated multilevel associations with neighbourhood deprivation which distinguish between excess consumption and binge drinking as distinct categories. Little is known on whether any associations vary within population groups. The aim of the present study was to investigate the ~~joint~~ effect~~s~~ of neighbourhood deprivation with age, gender and SES on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a representative sample of the adult population of Wales, UK.

METHODS

Participants

Data were drawn from four successive cross-sectional waves of the Welsh Health Survey 2003/04 to 2007, an interviewer-led household and individual survey of the adult population resident in Wales, UK.[23,24,25] The adult population of Wales is approximately 3 2.2 million (2001 Census) and the dataset available includeds a total of 60 555 adults aged 18 years and over. The sampling methods and the survey process are described in detail elsewhere.[24,25] Briefly, the sampling frame used was the Post Office's Postcode Address File. Private household addresses were randomly selected in a two stage design, sampling addresses within primary sampling units that were selected within the 22 unitary authority local government areas in Wales. Each adult member of the household was invited to complete a questionnaire. Response rates were high: in 2003/04 the adjusted household survey response was 74% with 85% of individuals responding within households.[24] with little change at 74% and 82% respectively in 2007.[25]

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Alcohol outcome measure

Participants were asked to state the highest number of units they had drunk on any one day in the previous seven days, using a standard prompt to convert different types and quantities of alcoholic drinks into units. The dataset provided the classification of units into ordinal categories of maximal daily consumption based on the UK Department of Health definitions (Table 1), with categories for 'none/never drinks', 'within guidelines', 'excess consumption but less than binge, and 'binge'.[256]

Table 1 Categorisation of the alcohol consumption outcome variable

Category	Maximum units drunk on any one day in the last week
None/never drinks	Did not drink in the last seven days
Within guidelines	Men drinking no more than 4 units, women no more than 3 units
Excess consumption but less than binge	Men drinking more than 4 and up to and including 8 units, women more than 3 and up to and including 6 units
Binge	Men drinking more than 8 units, women more than 6 units

Source: reference 2~~5~~6

Neighbourhood deprivation measure

The Welsh Index of Multiple Deprivation 2005 (WIMD2005) was used as the measure of neighbourhood deprivation.[2~~7~~6] WIMD2005 includes seven weighted domains of deprivation: income (25%), employment (25%), education (15%), health (15%), geographical access to services (10%), housing (5%), and physical environment (5%). WIMD2005 scores are available for lower super output areas (LSOA), a unit of statistical geography defined by the 2001 UK Census.[28] There are 1896 LSOAs in Wales which have a mean population size of around 1500. Since the data included in each WIMD2005 domain are measured on different scales, each domain score is transformed to have a range of zero to 100 and the overall index is calculated using a weighted average, [27] taking a range of 1.4 to 78.9. WIMD2005 is highly correlated with the well-established Townsend index,[29] Spearman's r = 0.86, n=1896, p<0.001.

We used the LSOA as the closest available proxy for neighbourhood. ~~There are 1896 LSOAs in Wales which have a mean population size of around 1500 and are constrained to a minimum of 1000.~~ Neighbourhood characteristics vary widely within Wales, from high to low

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levels of socioeconomic disadvantage, including deprived urban inner-city areas, less deprived city sub-urban residential areas, post-industrial valley towns, market towns and rural, farming areas. Respondents were linked to their ~~LSOA~~ neighbourhood of residence by the data owners (the Welsh Government) and the dataset included individuals living in 1839 LSOAs, nested within the 22 unitary authorities~~y (UA) local government areas~~ (UA) in Wales. Each LSOA was assigned to one of five ordinal categories of WIMD2005 scores with equal counts of LSOAs in each quintile.

Measures of individual SES and potential confounding variables

The principal measure of SES defined for the analysis was the National Statistics Socio-economic Classification (NS-SEC3) variable for the head of household. This is a measure of occupational social class with the following~~, defined as the person with the highest income. The~~ categories ~~were~~: professional/managerial, intermediate, routine and manual occupations, and never worked/long-term unemployed. Age was analysed in 10-year bands by gender. We considered other available measures of SES that were associated with alcohol consumption in the dataset as confounding variables: individual employment status (employed, seeking work, training/student, retired, permanently sick or disabled, at home), highest educational qualification (degree, intermediate, none), ~~and~~ ethnicity (White, Black and minority ethnic) and housing tenure (owner occupier, social and private renting) (table ~~1~~2).

Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the questions on alcohol consumption, and 50 641 had complete covariate information recorded in the dataset.

Statistical Analysis

Since the outcome measure is an ordered categorical variable, the data were analysed using a continuation ratio model,[~~27~~30] which allowed estimation of the association between neighbourhood deprivation and the likelihood of moving up one category of alcohol consumption, y, (e.g. from excess consumption but less than binge, to binge drinking). This continuation ratio approach used a linear predictor, $\eta_{k,}$ to explain the probability of continuing to a higher category, conditional on reaching a certain ordinal level. The linear predictor was modelled by covariates x_k and fixed effects β :

$$\text{logit } p(y > k \mid y \geq k) = \eta_{k} = x_k\beta$$

This extends naturally to the multilevel framework, where we adopted the random effects model:

$$\text{logit } p(y > k \mid y \geq k,b) = x_k\beta + z_kb$$

where the linear predictor now has two components: $x_k\beta$ are the fixed effects, and z_kb described the multilevel structure in the data. Again, in principle the influence of both fixed and random effects may vary according to the level k.

We estimated the regression coefficients beta and the covariance matrix Var (b) and we derived p(y=k | b=0), the predicted probabilities of membership of ordinal category k for the median geographical context b=0 for each quintile of deprivation and category of SES-.

The sequential modelling strategy started with the "null" four-level variance components

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model, with category-specific intercepts and random effects for households, LSOAs and UAs. The WIMD2005 categorical variable was fitted to estimate the unadjusted neighbourhood deprivation fixed effects in model 1. To allow increased flexibility in understanding the effects of deprivation on alcohol consumption, interactions between the change in alcohol consumption category and deprivation ~~fifth~~quintile were included in the continuation ratio models. The predicted probabilities of excess consumption and binge drinking are derived from the sum of the additive main effect and interaction coefficients.

Social class~~NS-SEC3~~, age group, gender, the interaction between age group and gender, and the potential confounders were then added to form model 2. The final model 3 was fitted with cross-level interactions in separate models for WIMD2005 interacting with age group and gender, and WIMD2005 with social class~~NS-SEC3~~. Multiple imputation of five datasets using chained equations in R software was used to account for missing covariates.[~~28~~31,32~~9~~]

The magnitude of the variation between LSOAs and between UAs was estimated using the standard deviation (SD) of their random effects, since these are measured on the same scale as the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/- 0.67, and the differences between LSOA and between UA quartiles were computed by 1.34*SD to compare with the magnitude of the estimated fixed effects for social class~~SES~~.

RESULTS

Descriptive analysis

Overall, 22 218 (38.1%) of the total 58 282 respondents reported their levels of alcohol consumption as 'none or never drinks', 16 059 (27.6%) reported 'within guidelines', 9664 (16.6%) reported 'excess consumption but less than binge' and 10 341 (17.7%) reported 'binge' drinking. Both excess consumption and particularly binge drinking were higher in males than females. Excess consumption was highest in the 35-64 year age groups and binge drinking was highest in 18-34 year olds, declining with increasing age (table 2). The 'never worked and long-term unemployed' group and respondents with no educational qualifications showed substantially lower levels of both excess consumption and binge drinking than the three higher social class ~~NS-SEC3 socio-economic~~ groups and those with some educational achievement. For employment status, the economically active who were employed or seeking work had higher levels of excess and binge consumption than economically inactive respondents. The proportion of respondents drinking to excess decreased with increasing neighbourhood deprivation but binge drinking showed the opposite pattern of increasing with higher deprivation (table 2).

Table 2 Excess alcohol consumption and binge drinking by socio-economic status

		Excess consumption, less than binge	%	Binge	%	Total
Gender	Female	4702	15.0	3482	11.1	31261
	Male	4962	18.4	6859	25.4	27021
Age group	18-24	1001	14.5	2041	29.6	6888
	25-34	1286	17.5	2105	28.7	7329
	35-44	2007	19.6	2427	23.7	10225
	45-54	2110	21.5	1931	19.7	9815
	55-64	1961	19.2	1268	12.4	10216
	65-74	951	12.4	444	5.8	7697
	75-84	316	6.4	106	2.2	4923
	85+	32	2.7	19	1.6	1189
Social class: ~~NS-SEC3: SES~~	Professional and managerial occupations	3850	19.5	3354	17.0	19699
	Intermediate occupations	1742	16.1	1873	17.3	10815
	Routine and manual occupations	3566	14.7	4397	18.2	24197
	Never worked and long-term unemployed	131	8.9	173	11.8	1465
Employment status	Employed	5766	20.9	6961	25.2	27571
	Seeking work	138	14.9	274	29.6	925
	Training/student	483	14.8	739	22.6	3273
	Permanently sick or disabled	599	13	547	11.8	4619
	Retired	1539	11.8	755	5.8	13091
	At home	696	13.2	507	9.6	5284
	Other	276	14.9	349	18.8	1856
Highest educational qualification	No qualifications	2140	12.6	2095	12.3	17026
	Intermediate qualifications	5405	18.3	6428	21.7	29601
	Degree/degree equivalent and above	1773	21.5	1445	17.5	8247
Tenure	Owner occupier	8010	17.5	7883	17.2	45725
	Social renting	956	11.8	1340	16.5	8123
	Private renting / Other	663	15.6	1085	25.5	4262
Ethnicity	White	9492	16.8	10165	18.0	56438
	Black and minority ethnic	108	8.8	100	8.2	1222
WIMD2005: Deprivation quintile	Least deprived	2304	19.5	1967	16.7	11786
	Less deprived	2111	17.2	1927	15.7	12267
	Mid deprived	2063	16.0	2219	17.2	12875
	More deprived	1726	15.0	2234	19.4	11544
	Most deprived	1460	14.9	1994	20.3	9810

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Multilevel models

The unadjusted predicted probabilities for the five neighbourhood deprivation quintiles in model 1 are shown in table 3. As with the descriptive analysis, the probability of excess consumption was higher in less deprived neighbourhoods with decreasing probability across the quintiles of deprivation. Binge drinking showed the opposite pattern of increasing probability with higher deprivation. The differences in magnitude between the model predicted probabilities and the descriptive data shown in table 2 are explained by the addition of the random effects in model 1.

After including social class~~NS-SEC3~~, age group and gender, and the confounding variables in model 2, the adjusted difference between the deprivation quintiles for binge drinking increased, with less effect on the excess consumption category (table 3): respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference in proportions = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference in proportions = 3.7%, 95% CI: 2.6 to 4.8).

~~In common with other ordinal models, coefficients of multilevel continuation ratio models can be challenging to interpret directly. When exponentiated, they represent conditional odds ratios for being in a higher level of alcohol consumption. The increasingly negative main effect deprivation coefficients lead to decreasing excess consumption probabilities but increasing binge drinking probabilities (table 3). This is because the coefficients of the main effects and the interaction terms are additive and so the predicted probabilities are derived from the sum of the main effect and interaction coefficients.~~ ~~directly. When exponentiated, they represent conditional odds ratios for being in a higher level of alcohol consumption. The~~

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~~apparent paradox of increasingly negative main effect deprivation coefficients leading to decreasing excess consumption probabilities but increasing binge probabilities (table 3) is explained by the inclusion of interaction terms between the change in alcohol consumption category and deprivation. The coefficients are additive and the predicted probabilities are derived from the sum of the main effect and interaction coefficients. Even without interactions, however, linear contrasts can result in non-linear (and non-monotonic) changes in the probabilities associated with different alcohol consumption categories. This underlines the importance of the estimated marginal probabilities in table 3 being more easily interpretable and more revealing of the complexities of the relationship between deprivation and alcohol consumption.~~

Table 3 also shows the predicted probabilities of consumption for the social class ~~NS-SEC3~~ categories in the fully adjusted model 2. There was little ~~difference~~ variation in excess consumption with social class~~SES~~. The descriptive analysis finding of a higher probability of binge drinking in the three higher social class ~~SES~~ groups compared to the never worked/long-term unemployed category remained after adjustment.

Table 3 Model parameter estimates and predicted probabilities (%) for excess alcohol consumption and binge drinking for neighbourhood deprivation and SES

	Parameter estimate (SE)	Excess consumption, less than binge %	Binge %
Model 1[a]			
WIMD2005:			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	22.2	9.7
Less deprived	-0.2042* (0.0372)	20.1	9.9
Mid deprived	-0.4105* (0.0370)	19.1	11.2
More deprived	-0.6544* (0.0375)	17.6	12.6
Most deprived	-0.8526* (0.0391)	17.2	12.6
Interaction: WIMD2005*change in alcohol consumption category:			
Within to excess: Less deprived	0.2033* (0.0446)		
Excess to binge: Less deprived	0.3254* (0.0565)		
Within to excess: Mid deprived	0.5656* (0.0443)		
Excess to binge: Mid deprived	0.7054* (0.0554)		
Within to excess: More deprived	0.9931* (0.0459)		
Excess to binge: More deprived	1.1510* (0.0563)		
Within to excess: Most deprived	1.3587* (0.0489)		
Excess to binge: Most deprived	1.3692* (0.0584)		
Model 2[b]			
WIMD2005:			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	21.3	10.6
Less deprived	-0.1973* (0.0387)	19.5	11.1
Mid deprived	-0.3879* (0.0386)	18.8	13.0
More deprived	-0.6073* (0.0395)	17.5	15.3
Most deprived	-0.7142* (0.0421)	17.6	17.5
Interaction: WIMD2005*change in alcohol consumption category:			
Within to excess: Less deprived	0.1954* (0.0470)		
Excess to binge: Less deprived	0.3282* (0.0588)		
Within to excess: Mid deprived	0.5720* (0.0467)		
Excess to binge: Mid deprived	0.7296* (0.0577)		
Within to excess: More deprived	1.0157* (0.0483)		
Excess to binge: More deprived	1.2033* (0.0586)		
Within to excess: Most deprived	1.3996* (0.0514)		
Excess to binge: Most deprived	1.4615* (0.0608)		
NS-SEC3: SES			
Professional/managerial	Reference	19.8	14.6
Intermediate	-0.0973* (0.0265)	19.0	13.0

Routine occupations	-0.1519* (0.0226)	18.6	12.2
Never worked/long-term unemployed	-0.3339* (0.0614)	17.1	9.7

a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and the interaction with change in category of consumption, and random effects terms for household, LSOA and unitary authority

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

* p<0.001

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Model 2[b]			
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Least deprived	Reference	21.3	10.6
Less deprived	0.1973* (0.0387)	19.5	11.1
Mid deprived	0.3879* (0.0386)	18.8	13.0
More deprived	0.6073* (0.0395)	17.5	15.3
Most deprived	0.7142* (0.0421)	17.6	17.5
NS-SEC3: SES			
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Routine occupations	0.1519* (0.0226)	18.6	12.2
Never worked/long-term unemployed	0.3339* (0.0614)	17.1	9.7

a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and random effects terms for household, LSOA and unitary authority

b Model 2 included NS-SEC3, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure
* p<0.001

The two-way cross-level interaction between WIMD2005, age group and gender showed the effect of neighbourhood deprivation on the probability of excess consumption and binge drinking varied significantly between age group and gender. The model outputs are shown on the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-level interaction in females or older age groups was found for either excess consumption or binge drinking. Males had a higher probability of excess consumption in low deprivation quintiles than females. Although the probability of binge drinking in females increased with increasing deprivation quintile, the gradients were significantly steeper in males. The probability of binge drinking was highest at all levels of neighbourhood deprivation in males aged 18 to 34, and the interaction effect was largest in the 35-64 year age groups. The cross-level interaction between WIMD2005 and social class ~~NS-SEC3~~ was not significant suggesting that the association of excess consumption and binge drinking with neighbourhood deprivation did not vary with SES.

Random effects variance

The majority of the unexplained random variation occurred at the household level (table 4). For LSOAs, in model 2, the SD = 0.156 giving the inter-quartile range of the distribution of the LSOA variance = 0.21. This compares to a parameter estimate of -0.33 for the 'never worked' category of social class~~NS-SEC3~~, of -0.15 for 'routine' occupations and -0.10 for the 'intermediate' category, compared to the professional/managerial category (table 3). The size of this variation is of similar magnitude to the social class estimates, which suggests there is important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation, although smaller than LSOA, remains of importance in explaining the spatial pattern of alcohol consumption.

Table 4 Random effects variance in sequential multilevel models

	Level	Variance	SD	Intra-class correlation (%)
Null model	HH	0.809	0.899	74.4
	LSOA	0.032	0.179	14.8
	UA	0.017	0.130	10.8
Model 1[a]	HH	0.824	0.908	74.8
	LSOA	0.028	0.167	13.8
	UA	0.019	0.139	11.4
Model 2[b]	HH	0.867	0.931	77.1
	LSOA	0.024	0.156	12.9
	UA	0.015	0.121	10.0
Model 3[c]	HH	0.866	0.931	77.3
	LSOA	0.023	0.153	12.7
	UA	0.014	0.120	10.0

a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and the interaction with change in category of consumption, and random effects terms for household, LSOA and unitary authority

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

~~a Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and random effects terms for household, LSOA and unitary authority~~

~~b Model 2 included NS-SEC3, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure~~

c Model 3 further included the two-way cross-level interaction between WIMD2005 deprivation quintile, age group and gender

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DISCUSSION

Main results

The current study has investigated the difference in associations between neighbourhood deprivation and excess alcohol consumption and binge drinking as ordinal categories, based on the UK definition,[~~25~~26] since it has been suggested that it is more appropriate to set benchmarks for daily than for weekly consumption of alcohol following greater concern about the health and social risks associated with single episodes of intoxication.[6] Excess consumption was more common in less deprived neighbourhoods. In contrast, binge drinking was more common in deprived neighbourhoods. These findings add to the previous US and Canadian studies which showed a significant neighbourhood effect,[16,17,22] by further assessing the complex interacting effects of neighbourhood deprivation with consumption category, age and gender, and social class~~SES~~. The ~~joint~~ interaction effect of neighbourhood deprivation with age and gender was greatest for binge drinking in middle-aged males with no significant interaction with social class~~SES~~. We also found a substantial ~~geographical effect of~~ variation between neighbourhoods, since the magnitude of the unexplained variance in alcohol consumption was similar to the effect sizes of individual SES.

Possible mechanisms linking neighbourhood deprivation to harmful alcohol consumption

Three mechanisms have been proposed to explain how neighbourhood deprivation might exert an independent effect on the risk of harmful alcohol consumption, and a differential effect on middle-aged males.[16] First, the contagion hypothesis suggests that health behaviours are spread by social exchange and particularly social networks of personal friends. Thus, binge drinking may be more acceptable in middle-aged men resident in deprived neighbourhoods than in the non-deprived. Second, the stress of living in areas of high

neighbourhood disadvantage may make men more vulnerable to psychological distress. This then increases the risk that alcohol is used as a coping mechanism.

Third, the structural hypothesis argues that neighbourhood social norms and institutions define the pattern of health behaviours. Greater availability of cheap alcohol measured as higher alcohol outlet densities might influence harmful drinking rates, although the evidence summarised in systematic reviews of both cross-sectional and longitudinal studies is inconsistent.[3~~0~~3] There is some evidence that high deprivation neighbourhoods have a higher density of alcohol outlets,[15,3~~1~~4,3~~2~~5] and this might provide a mechanism to explain higher consumption in deprived neighbourhoods. However, two studies which found higher outlet densities in more deprived areas found that levels of consumption were highest in less deprived areas.[15,3~~1~~4] A third study found the spatial association between outlet density and deprivation did not vary systematically, suggesting the relationship between deprivation and outlet density may be different in different locations.[3~~2~~5] This deprivation-density hypothesis could not explain the findings of higher rates of excess consumption in the least deprived neighbourhoods in the current study. One possibility is the acceptance of social norms of regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to a different set of social normative binge drinking behaviour in the most deprived areas.

Strengths and limitations

Since 2003/04, the Welsh Health Survey has been an annual source of robust population survey data. It has the important strength of a large sampling fraction resulting in a representative response dataset that includes around one in fifty of the socially diverse Welsh adult population, with detailed exposure data linked to the small-area neighbourhood. The

study findings from such a comprehensive dataset should be ~~more~~ widely generalisable. Several limitations should be considered. The alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health.[26~~5~~] However, the possibility of social desirability bias resulting in under-reported alcohol consumption should be considered,[33~~6~~,34~~7~~] although it is not known whether under-reporting varies between neighbourhoods. The questionnaire responses were consistent year-on-year from four different successive samples, suggesting that responses were reliable. Non-response bias was a possibility but the surveys had a consistently good overall response to the interviewer-led method,[24,25]~~Non-response bias was a possibility but the surveys had a consistently good overall response to the interviewer-led method, from 74% of sampled households and 85% of individuals within responding households in 2003/04,[24] to 74% and 82% respectively in 2010.[5~~35~~]~~

The administratively defined census LSOA was used as a proxy for 'neighbourhood'. However, the direction of bias from using non-homogeneous administrative areas is towards conservative estimates.[36~~8~~,37~~9~~] Therefore it is unlikely that the current study over-estimated the associations between alcohol consumption and neighbourhood deprivation. Finally, no inferences about causal processes can be made. Reverse cause, for example, could suggest that binge drinking causes a decline in social position, but this explanation seems unlikely for excess alcohol consumption in which the associations were in the opposite direction to binge drinking. A further limitation was that the dataset did not permit investigation of the possible mechanisms for our study findings.

In conclusion, the socio-economic patterning of excess alcohol consumption and binge drinking was complex. The study findings have implications for enhancing public health

alcohol policy development, emphasising the importance of neighbourhood. Further longitudinal research on the spatial relationships between alcohol consumption, outlet density, and socio-economic deprivation at individual and neighbourhood levels is necessary to further understand the underlying processes and provide further evidence for local and national policies to reduce alcohol-related harm.[40~~38~~]

COMPETING INTERESTS

None

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Information Governance and data sharing

A formal data access agreement was signed with the Welsh Government in order to receive the dataset with the geographical variables for analysis. These data can only be accessed under such an agreement. There are no additional data available. Ethical approval was not required for this secondary analysis of an anonymised dataset.

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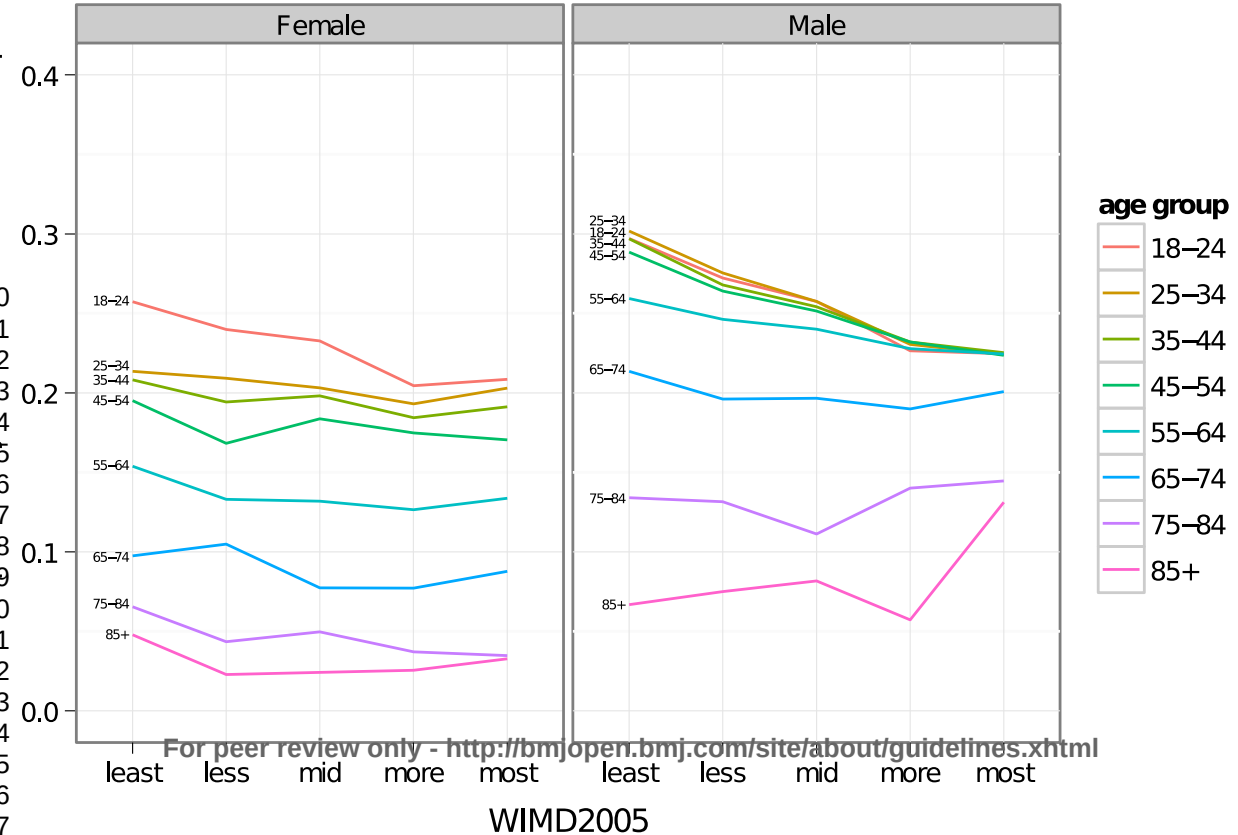
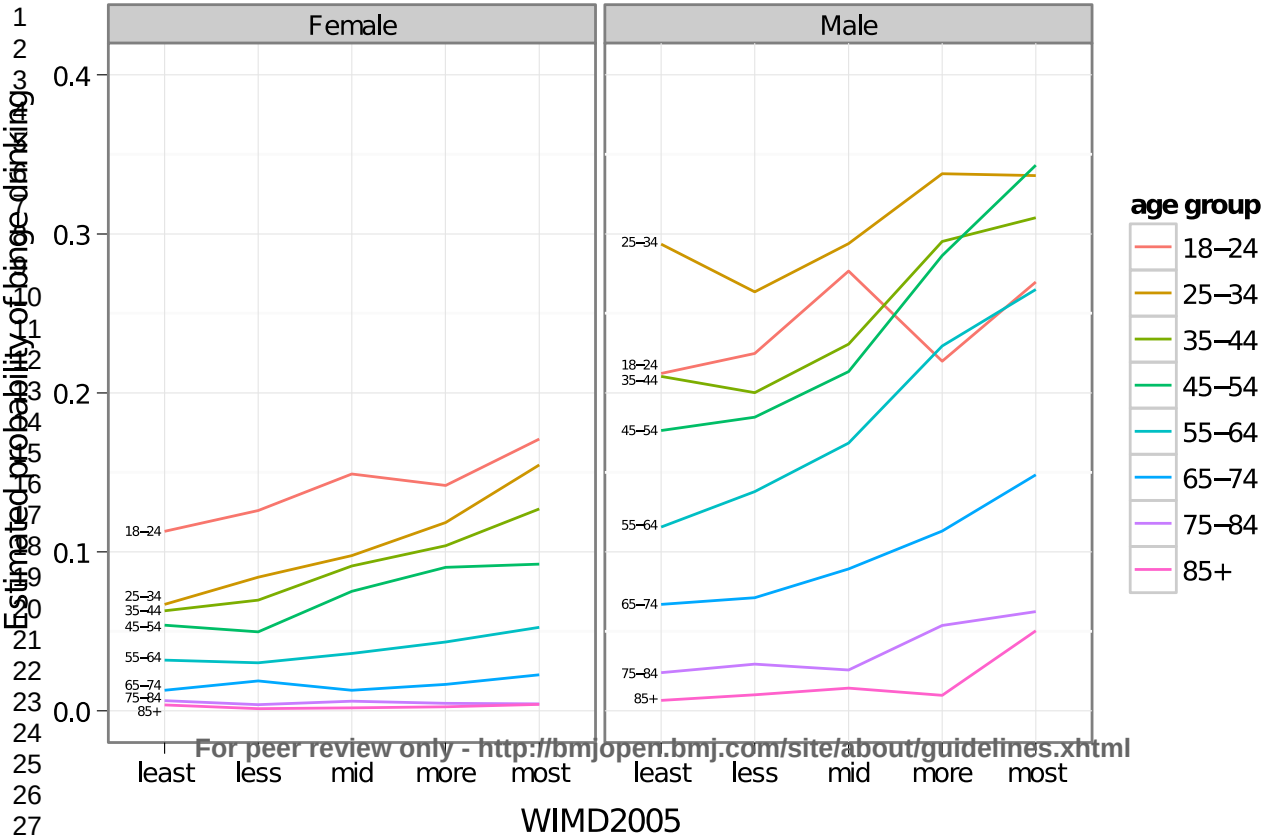
LIST OF TITLES FOR FIGURES

Figure 1 Estimated probabilities of excess alcohol consumption by age group and gender within deprivation quintiles

Figure 2 Estimated probabilities of binge drinking by age group and gender within deprivation quintiles





STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	DONE?	Item No	Recommendation
Title and abstract	√	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
	√		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
	Introduction		
Background/rationale	√	2	Explain the scientific background and rationale for the investigation being reported
Objectives	√	3	State specific objectives, including any prespecified hypotheses
	Methods		
Study design	√	4	Present key elements of study design early in the paper
Setting	√	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	√	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	√	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	√	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	√	9	Describe any efforts to address potential sources of bias
Study size	√	10	Explain how the study size was arrived at
Quantitative variables	√	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	√	12	(*a*) Describe all statistical methods, including those used to control for confounding
	√		(*b*) Describe any methods used to examine subgroups and interactions
	√		(*c*) Explain how missing data were addressed
	√		(*d*) If applicable, describe analytical methods taking account of sampling strategy
	√		(*e*) Describe any sensitivity analyses
	Results		
Participants	√	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
	N/Known		(b) Give reasons for non-participation at each stage
	Would add little		(c) Consider use of a flow diagram
Descriptive data	√	14*	(a) Give characteristics of study participants (eg demographic,

			clinical, social) and information on exposures and potential confounders
	√		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	√	15*	Report numbers of outcome events or summary measures
Main results	√	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
	√ (equal count method for small-area boundaries)		(*b*) Report category boundaries when continuous variables were categorized
	N/A		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	√	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
	Discussion		
Key results	√	18	Summarise key results with reference to study objectives
Limitations	√	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	√	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	√	21	Discuss the generalisability (external validity) of the study results
	Other information		
Funding	√	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation

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Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation

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Keywords

Alcohol, Social epidemiology, multilevel modelling, Public Health

ABSTRACT

Objectives

The influence of neighbourhood deprivation on the risk of harmful alcohol consumption, measured by the separate categories of excess consumption and binge drinking, has not been studied. The study objective was to investigate the effect of neighbourhood deprivation with age, gender and socio-economic status (SES) on (1) excess alcohol consumption, and (2) binge drinking, in a representative population survey.

Design

Cross-sectional study: multi-level analysis.

Setting

Wales, UK, adult population ~ 2.2 million.

Participants

58 282 respondents aged 18 years and over to four successive annual Welsh Health Surveys (2003/04-2007), nested within 32 692 households, 1839 census lower super output areas and the 22 unitary authority areas in Wales.

Primary outcome measure

Maximal daily alcohol consumption during the past week was categorised using the UK Department of Health definition of 'none/never drinks', 'within guidelines', 'excess consumption but less than binge' and 'binge'. The data were analysed using continuation ratio ordinal multilevel models with multiple imputation for missing covariates.

Results

Respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference = 3.7%, 95% CI: 2.6 to 4.8). The effect of deprivation varied significantly with age and gender, but not with SES. Younger males in deprived neighbourhoods were most likely to binge drink. Males aged 35-64 showed the steepest increase in binge drinking in deprived neighbourhoods but males aged 18-24 showed a smaller increase with deprivation.

Conclusion

This large-scale population study is the first to show that neighbourhood deprivation acts differentially on the risk of binge drinking between males and females at different age groups. Understanding the socio-economic patterns of harmful alcohol consumption is important for public health policy development.

ARTICLE SUMMARY

Article Focus

- A recent systematic review found little evidence that living in neighbourhoods of high socio-economic deprivation is associated with a higher risk of harmful alcohol consumption

- The important distinction between excess alcohol consumption and binge drinking has not previously been investigated

Key Messages

- A higher risk of binge drinking was found in residents living in deprived neighbourhoods, particularly in young and middle-aged men

- A higher risk of excess consumption, but less than binge, was found in residents of less deprived neighbourhoods

- Neighbourhood socio-economic deprivation is an important factor to consider in public health alcohol policy development

Strengths and Limitations

- The main strength is the large representative dataset of over 58 000 respondents, or around one in fifty of the socially diverse Welsh adult population. The ordinal alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health

- The cross-sectional analysis used the administratively defined census LSOA as a proxy for 'neighbourhood' and cannot investigate the possibility of causal relationships. Social desirability bias may result in under-reported alcohol consumption, although it is not known whether this varies between neighbourhoods.

INTRODUCTION

Excess alcohol consumption causes a major global burden of disease, injury and social and economic cost.[1] Binge drinking, typically defined as consuming at least double the guideline limits in a single day during the previous week,[2] is an increasing problem which is rising particularly in young women.[3] It is associated with anti-social behaviour,[4] and around half of all violent crimes in the UK.[5] Binge drinking causes an extra burden on health services; between 20-40 % of people presenting to accident and emergency departments are intoxicated, increasing to 80% after midnight.[4] Recent data show that around 37% of men and 29% of women exceeded the current UK guidelines for safe levels of alcohol consumption of ≤ 3 units per day for women and ≤4 units per day for men in the past week; and 20% of men and 13% of women engaged in binge drinking, defined as > 6 units per day for women and > 8 units per day for men.[6] Given the wide range of harm resulting from this substantial level of consumption, the potential impact on health at the population level from a reduction in consumption is considerable.

Research investigating the socio-economic patterning of harmful alcohol consumption has generally found that lower socio-economic status (SES) groups drink more heavily and higher SES groups drink more frequently,[7] consistent with binge drinking being found to be more prevalent in the economically disadvantaged.[8] However, subtle variations in cut-points based on units have led to prevalence estimates for binge drinking in young men to differ by 22%,[2] and these summary SES relationships have been found to vary substantially with age, gender, educational level, employment status and the measure of consumption.[2,7-12]

In addition to socio-economic effects found at the individual level, it is theorised that small-area, or neighbourhood, socio-economic deprivation might exert an independent effect on

harmful alcohol consumption. However, a recent systematic review which included multilevel studies of neighbourhood deprivation and alcohol consumption found little evidence to support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in a quality assessment, one study set in the West of Scotland, UK, found no significant association between neighbourhood deprivation and drinking above guideline limits or the number of units consumed in the past week.[14] A second study set in California, USA, found that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males) was significantly higher for people living in the least deprived neighbourhoods with no significant variation with individual SES.[15]

The two other studies described an association between high neighbourhood deprivation and high consumption.[16,17] Data from the nationally representative Third National Health and Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood deprivation measure at the level of the census tract was associated with heavy alcohol use, defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01, 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A second US study found that higher mean income and income inequality at the larger community district level was significantly associated with a higher number of drinks per month among drinkers.[17] Four subsequent papers reporting small studies found no significant association between alcohol consumption and neighbourhood income,[18,19] neighbourhood unemployment,[20] or a composite measure of relative socio-economic disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada found a small effect of neighbourhood deprivation on the number of drinks consumed per week in men, but not in women.[22]

Possible explanations for these inconsistencies in neighbourhood associations found between studies may result from different methods of defining excess, or harmful, consumption, with some choosing definitions based on national guidelines for 'safe' consumption or units,[14] number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations for inconsistent neighbourhood associations may result from different measures of area deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors for excess alcohol consumption.[14-22]

Despite the substantial public health consequences of alcohol consumption and the possible importance of neighbourhood in explaining patterns of consumption, no previous study to our knowledge has investigated multilevel associations with neighbourhood deprivation which distinguish between excess consumption and binge drinking as distinct categories. Little is known on whether any associations vary within population groups. The aim of the present study was to investigate the effect of neighbourhood deprivation with age, gender and SES on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a representative sample of the adult population of Wales, UK.

METHODS

Participants

Data were drawn from four successive cross-sectional waves of the Welsh Health Survey 2003/04 to 2007, an interviewer-led household and individual survey of the adult population resident in Wales, UK.[23-25] The adult population of Wales is approximately 2.2 million (2001 Census) and the dataset available included a total of 60 555 adults aged 18 years and over. The sampling methods and the survey process are described in detail elsewhere.[24,25] Briefly, the sampling frame used was the Post Office's Postcode Address File. Private household addresses were randomly selected in a two stage design, sampling addresses within primary sampling units that were selected within the 22 unitary authority local government areas in Wales. Each adult member of the household was invited to complete a questionnaire. Response rates were high: in 2003/04 the adjusted household survey response was 74% with 85% of individuals responding within households,[24] with little change at 74% and 82% respectively in 2007.[25]

Alcohol outcome measure

Participants were asked to state the highest number of units they had drunk on any one day in the previous seven days, using a standard prompt to convert different types and quantities of alcoholic drinks into units. The dataset provided the classification of units into ordinal categories of maximal daily consumption based on the UK Department of Health definitions (Table 1), with categories for 'none/never drinks', 'within guidelines', 'excess consumption but less than binge, and 'binge'.[26]

Table 1 Categorisation of the alcohol consumption outcome variable

Category	Maximum units drunk on any one day in the last week
None/never drinks	Did not drink in the last seven days
Within guidelines	Men drinking no more than 4 units, women no more than 3 units
Excess consumption but less than binge	Men drinking more than 4 and up to and including 8 units, women more than 3 and up to and including 6 units
Binge	Men drinking more than 8 units, women more than 6 units

Source: reference 26

Neighbourhood deprivation measure

The Welsh Index of Multiple Deprivation 2005 (WIMD2005) was used as the measure of neighbourhood deprivation.[27] The Index includes seven weighted domains of deprivation: income (25%), employment (25%), education (15%), health (15%), geographical access to services (10%), housing (5%), and physical environment (5%). These neighbourhood deprivation scores are available for lower super output areas (LSOA), a unit of statistical geography defined by the 2001 UK Census.[28] There are 1896 LSOAs in Wales which have a mean population size of around 1500. Since the data included in each neighbourhood deprivation domain are measured on different scales, each domain score is transformed to have a range of zero to 100 and the overall index is calculated using a weighted average, [27] taking a range of 1.4 to 78.9. This measure of neighbourhood deprivation is highly correlated with the well-established Townsend index,[29] Spearman's $r = 0.86$, $n=1896$, $p<0.001$.

We used the LSOA as the closest available proxy for neighbourhood. Neighbourhood characteristics vary widely within Wales, from high to low levels of socioeconomic disadvantage, including deprived urban inner-city areas, less deprived city sub-urban

residential areas, post-industrial valley towns, market towns and rural, farming areas. Respondents were linked to their neighbourhood of residence by the data owners (the Welsh Government) and the dataset included individuals living in 1839 LSOAs, nested within the 22 unitary authorities (UA) in Wales. Each LSOA was assigned to one of five ordinal categories of neighbourhood deprivation with equal counts of LSOAs in each quintile.

Measures of individual SES and potential confounding variables

The principal measure of SES defined for the analysis was the National Statistics Socio-economic Classification (NS-SEC3) variable for the head of household. This is a measure of occupational social class with the following categories: professional/managerial, intermediate, routine and manual occupations, and never worked/long-term unemployed. Age was analysed in 10-year bands by gender. We considered other available measures of SES that were associated with alcohol consumption in the dataset as confounding variables: individual employment status (employed, seeking work, training/student, retired, permanently sick or disabled, at home), highest educational qualification (degree, intermediate, none), ethnicity (White, Black and minority ethnic) and housing tenure (owner occupier, social and private renting) (table 2).

Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the questions on alcohol consumption, and 50 641 had complete covariate information recorded in the dataset.

Statistical Analysis

Since the outcome measure is an ordered categorical variable, the data were analysed using a continuation ratio model,[30] which allowed estimation of the association between neighbourhood deprivation and the likelihood of moving up one category of alcohol consumption, y, (e.g. from excess consumption but less than binge, to binge drinking). This continuation ratio approach used a linear predictor, $\eta_{k,}$ to explain the probability of continuing to a higher category, conditional on reaching a certain ordinal level. The linear predictor was modelled by covariates x_k and fixed effects β :

$$\text{logit } p(y > k \mid y \geq k) = \eta_{k} = x_k\beta$$

This extends naturally to the multilevel framework, where we adopted the random effects model:

$$\text{logit } p(y > k \mid y \geq k,b) = x_k\beta + z_kb$$

where the linear predictor now has two components: $x_k\beta$ are the fixed effects, and z_kb described the multilevel structure in the data. Again, in principle the influence of both fixed and random effects may vary according to the level k.

We estimated the regression coefficients beta and the covariance matrix Var (b) and we derived p(y=k | b=0), the predicted probabilities of membership of ordinal category k for the median geographical context b=0 for each quintile of deprivation and category of SES.

To model the variation in the four-category ordinal alcohol consumption outcome using a

continuation ratio model, we defined three additional binary explanatory variables, one for each transition between the alcohol outcome categories to indicate the level at which the transition was occurring. The sequential modelling strategy started with the "null" four-level variance components model, with category-specific intercepts and random effects for households, LSOAs and UAs. The neighbourhood deprivation categorical variable was fitted to estimate the unadjusted neighbourhood deprivation fixed effects in model 1. To allow a better understanding of the effects of deprivation on alcohol consumption, we fitted interactions between the neighbourhood deprivation quintiles and each additional explanatory variable indicating the relevant binary transition. The predicted probabilities of excess consumption and binge drinking were derived from the sum of these main effects and relevant interaction coefficients.

Social class, age group, gender, the interaction between age group and gender, and the potential confounders were then added to form model 2. The final model 3 was fitted with cross-level interactions in separate models for neighbourhood deprivation interacting with age group and gender, and neighbourhood deprivation with social class. Multiple imputation of five datasets using chained equations in R software was used to account for missing covariates.[31,32]

The magnitude of the variation between LSOAs and between UAs was estimated using the standard deviation (SD) of their random effects, since these are measured on the same scale as the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/- 0.67, and the differences between LSOA and between UA quartiles were computed by 1.34*SD to compare with the magnitude of the estimated fixed effects for social class.

RESULTS

Descriptive analysis

Overall, 22 218 (38.1%) of the total 58 282 respondents reported their levels of alcohol consumption as 'none or never drinks', 16 059 (27.6%) reported 'within guidelines', 9664 (16.6%) reported 'excess consumption but less than binge' and 10 341 (17.7%) reported 'binge' drinking. Both excess consumption and particularly binge drinking were higher in males than females. Excess consumption was highest in the 35-64 year age groups and binge drinking was highest in 18-34 year olds, declining with increasing age (table 2). The 'never worked and long-term unemployed' group and respondents with no educational qualifications showed substantially lower levels of both excess consumption and binge drinking than the three higher social class groups and those with some educational achievement. For employment status, the economically active who were employed or seeking work had higher levels of excess and binge consumption than economically inactive respondents. The proportion of respondents drinking to excess decreased with increasing neighbourhood deprivation but binge drinking showed the opposite pattern of increasing with higher deprivation (table 2).

Table 2 Excess alcohol consumption and binge drinking by socio-economic status

		Excess consumption, less than binge	%	Binge	%	Total
Gender*	Female	4702	15.0	3482	11.1	31261
	Male	4962	18.4	6859	25.4	27021
Age group**	18-24	1001	14.5	2041	29.6	6888
	25-34	1286	17.5	2105	28.7	7329
	35-44	2007	19.6	2427	23.7	10225
	45-54	2110	21.5	1931	19.7	9815
	55-64	1961	19.2	1268	12.4	10216
	65-74	951	12.4	444	5.8	7697
	75-84	316	6.4	106	2.2	4923
	85+	32	2.7	19	1.6	1189
Social class **	Professional and managerial occupations	3850	19.5	3354	17.0	19699
	Intermediate occupations	1742	16.1	1873	17.3	10802
	Routine and manual occupations	3566	14.7	4397	18.2	24197
	Never worked and long-term unemployed	131	8.9	173	11.8	1465
Employment status**	Employed	5766	20.9	6961	25.2	27571
	Seeking work	138	14.9	274	29.6	925
	Training/student	483	14.8	739	22.6	3273
	Permanently sick or disabled	599	13.0	547	11.8	4619
	Retired	1539	11.8	755	5.8	13091
	At home	696	13.2	507	9.6	5284
	Other	276	14.9	349	18.8	1856
Highest educational qualification**	No qualifications	2140	12.6	2095	12.3	17026
	Intermediate qualifications	5405	18.3	6428	21.7	29601
	Degree/degree equivalent and above	1773	21.5	1445	17.5	8247
Tenure**	Owner occupier	8010	17.5	7883	17.2	45725
	Social renting	956	11.8	1340	16.5	8123
	Private renting / Other	663	15.6	1085	25.5	4262
Ethnicity*	White	9492	16.8	10165	18.0	56438
	Black and minority ethnic	108	8.8	100	8.2	1222
Neighbourhood deprivation quintile**	Least deprived	2304	19.5	1967	16.7	11786
	Less deprived	2111	17.2	1927	15.7	12267
	Mid deprived	2063	16.0	2219	17.2	12875
	More deprived	1726	15.0	2234	19.4	11544
	Most deprived	1460	14.9	1994	20.3	9810

* χ^2 test, $p<0.001$

** χ^2 test for trend, $p<0.001$

Multilevel models

The model 1 parameter estimates for the neighbourhood deprivation fixed effects and the interaction effects are shown in table 3, together with the unadjusted model predicted probabilities for the five neighbourhood deprivation quintiles. The probabilities of excess consumption and binge drinking were computed from the sum of the fixed and interaction estimates for each neighbourhood deprivation quintile. As we found in the descriptive analysis, the probability of excess consumption was higher in less deprived neighbourhoods with decreasing probability across the quintiles of deprivation. Binge drinking showed the opposite pattern of increasing probability with higher deprivation. The differences in magnitude between the model predicted probabilities and the descriptive data shown in table 2 are explained by the addition of the random effects in model 1.

Table 3 then shows the estimates for the neighbourhood deprivation fixed and interaction effects from model 2, which included social class, age group, gender, the interaction between age group and gender, and the other confounding variables. The sum of the estimates for the fixed and interaction effects for the neighbourhood deprivation quintiles were used as in model 1 to compute the probabilities of excess consumption and binge drinking. In this adjusted model, the difference between the deprivation quintiles for the probability of binge drinking increased, with less effect on the excess consumption category. Respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference in proportions = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference in proportions = 3.7%, 95% CI: 2.6 to 4.8).

Table 3 finally shows the predicted probabilities of consumption for the SES categories in the fully adjusted model 2. There was little variation in excess consumption with SES. The descriptive analysis finding of a higher probability of binge drinking in the three higher social class groups compared to the never worked/long-term unemployed category remained after adjustment.

Table 3 Model parameter estimates and predicted probabilities (%) for excess alcohol consumption and binge drinking for neighbourhood deprivation and SES

	Parameter estimate (SE)	Excess consumption, less than binge %	Binge %
Model 1[a]			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	22.2	9.7
Less deprived	-0.2042* (0.0372)	20.1	9.9
Mid deprived	-0.4105* (0.0370)	19.1	11.2
More deprived	-0.6544* (0.0375)	17.6	12.6
Most deprived	-0.8526* (0.0391)	17.2	12.6
Interaction:			
Within to excess: Less deprived	0.2033* (0.0446)		
Excess to binge: Less deprived	0.3254* (0.0565)		
Within to excess: Mid deprived	0.5656* (0.0443)		
Excess to binge: Mid deprived	0.7054* (0.0554)		
Within to excess: More deprived	0.9931* (0.0459)		
Excess to binge: More deprived	1.1510* (0.0563)		
Within to excess: Most deprived	1.3587* (0.0489)		
Excess to binge: Most deprived	1.3692* (0.0584)		
Model 2[b]			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	21.3	10.6
Less deprived	-0.1973* (0.0387)	19.5	11.1
Mid deprived	-0.3879* (0.0386)	18.8	13.0
More deprived	-0.6073* (0.0395)	17.5	15.3
Most deprived	-0.7142* (0.0421)	17.6	17.5
Interaction:			
Within to excess: Less deprived	0.1954* (0.0470)		
Excess to binge: Less deprived	0.3282* (0.0588)		
Within to excess: Mid deprived	0.5720* (0.0467)		
Excess to binge: Mid deprived	0.7296* (0.0577)		
Within to excess: More deprived	1.0157* (0.0483)		
Excess to binge: More deprived	1.2033* (0.0586)		
Within to excess: Most deprived	1.3996* (0.0514)		
Excess to binge: Most deprived	1.4615* (0.0608)		
SES			
Professional/managerial	Reference	19.8	14.6
Intermediate	-0.0973* (0.0265)	19.0	13.0
Routine occupations	-0.1519* (0.0226)	18.6	12.2
Never worked/long-term unemployed	-0.3339* (0.0614)	17.1	9.7

a Model 1 included fixed effects terms for neighbourhood deprivation quintiles and the interaction with the binary transition explanatory variable for change in category of consumption, and random effects terms for household, LSOA and unitary authority

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

* $p<0.001$

The two-way cross-level interaction between neighbourhood deprivation, age group and gender showed the effect of neighbourhood deprivation on the probability of excess consumption and binge drinking varied significantly between age group and gender. These model outputs are shown on the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-level interaction in females or older age groups was found for either excess consumption or binge drinking. Males had a higher probability of excess consumption in less deprived neighbourhoods than females. Although the probability of binge drinking in females increased with increasing deprivation quintile, the gradients were significantly steeper in males. The probability of binge drinking was highest at all levels of neighbourhood deprivation in males aged 25 to 34. The interaction effects suggested that males in the 35-64 year age groups showed the steepest increase in the probability of binge drinking associated with increasing neighbourhood deprivation, while the interaction effect in the 18-24 year age group suggested a weaker association of increasing binge drinking with increasing deprivation. The cross-level interaction between neighbourhood deprivation and social class was not significant suggesting that the association of excess consumption and binge drinking with neighbourhood deprivation did not vary with SES.

Random effects variance

The values for the intra-class correlation coefficients (%) given in table 4 show that the majority of the unexplained random variation occurred at the household level, suggesting that, as expected, drinking behaviour tends to cluster more within households than within neighbourhoods or within the larger-area UA. To examine the magnitude of the variation between neighbourhoods in comparison to the fixed-effect estimates for SES, the SD for LSOAs in model 2 = 0.156, giving the inter-quartile range of the distribution of the LSOA variance = 0.21. This compares to a parameter estimate of -0.33 for the 'never worked'

category of social class, of -0.15 for 'routine' occupations and -0.10 for the 'intermediate' category, compared to the professional/managerial category (table 3). The size of this variation is of similar magnitude to the social class estimates, which suggests there is important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation, although smaller than LSOA, remains of importance in explaining the spatial pattern of alcohol consumption.

Table 4 Random effects variance in sequential multilevel models

	Level	Variance	SD	Intra-class correlation (%)
Null model	HH	0.809	0.899	74.4
	LSOA	0.032	0.179	14.8
	UA	0.017	0.130	10.8
Model 1[a]	HH	0.824	0.908	74.8
	LSOA	0.028	0.167	13.8
	UA	0.019	0.139	11.4
Model 2[b]	HH	0.867	0.931	77.1
	LSOA	0.024	0.156	12.9
	UA	0.015	0.121	10.0
Model 3[c]	HH	0.866	0.931	77.3
	LSOA	0.023	0.153	12.7
	UA	0.014	0.120	10.0

a Model 1 included fixed effects terms for neighbourhood deprivation quintiles and the interaction with the binary transition explanatory variable for change in category of consumption, and random effects terms for household, LSOA and unitary authority

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

c Model 3 further included the two-way cross-level interaction between neighbourhood deprivation quintile, age group and gender

DISCUSSION

Main results

The current study has investigated the difference in associations between neighbourhood deprivation and excess alcohol consumption and binge drinking as ordinal categories, based on the UK definition.[26] This is because it has been suggested that it is more appropriate to set benchmarks for daily than for weekly consumption of alcohol following greater concern about the health and social risks associated with single episodes of intoxication.[6] Excess consumption was more common in less deprived neighbourhoods. In contrast, binge drinking was more common in deprived neighbourhoods. These findings add to the previous US and Canadian studies which showed a significant neighbourhood effect,[16,17,22] by further assessing the complex interacting effects of neighbourhood deprivation with consumption category, age and gender, and social class. The interaction effect of neighbourhood deprivation with age and gender showed the steepest increase in binge drinking with deprivation was in middle-aged males with no significant interaction with social class. We also found a substantial variation between neighbourhoods, since the magnitude of the unexplained variance in alcohol consumption was similar to the effect sizes of individual SES.

Possible mechanisms linking neighbourhood deprivation to harmful alcohol consumption

Three mechanisms have been proposed to explain how neighbourhood deprivation might exert an independent effect on the risk of harmful alcohol consumption, and a differential effect on middle-aged males.[16] First, the contagion hypothesis suggests that health behaviours are spread by social exchange and particularly social networks of personal friends.[33] Thus, binge drinking may be more acceptable in middle-aged men resident in deprived

neighbourhoods than in the non-deprived. Second, the stress of living in areas of high neighbourhood disadvantage may make men more vulnerable to psychological distress.[34,35] This then increases the risk that alcohol is used as a coping mechanism.

Third, the structural hypothesis argues that neighbourhood social norms and institutions define the pattern of health behaviours.[36] Greater availability of cheap alcohol measured as higher alcohol outlet densities might influence harmful drinking rates, although the evidence summarised in systematic reviews of both cross-sectional and longitudinal studies is inconsistent.[37] There is some evidence that high deprivation neighbourhoods have a higher density of alcohol outlets,[15,38,39] and this might provide a mechanism to explain higher consumption in deprived neighbourhoods. However, two studies which found higher outlet densities in more deprived areas found that levels of consumption were highest in less deprived areas.[15,38] A third study found the spatial association between outlet density and deprivation did not vary systematically, suggesting the relationship between deprivation and outlet density may be different in different locations.[39] This deprivation-density hypothesis could not explain the findings of higher rates of excess consumption in the least deprived neighbourhoods in the current study. One possibility is the acceptance of social norms of regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to a different set of social normative binge drinking behaviour in the most deprived areas.

Strengths and limitations

Since 2003/04, the Welsh Health Survey has been an annual source of robust population survey data. It has the important strength of a large sampling fraction resulting in a representative response dataset that includes around one in fifty of the socially diverse Welsh adult population, with detailed exposure data linked to the small-area neighbourhood. The

study findings from such a comprehensive dataset should be widely generalisable. Several limitations should be considered. The alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health.[26] However, the possibility of social desirability bias resulting in under-reported alcohol consumption should be considered,[40,41] although it is not known whether under-reporting varies between neighbourhoods. The questionnaire responses were consistent year-on-year from four different successive samples, suggesting that responses were reliable. Non-response bias was a possibility but the surveys had a consistently good overall response to the interviewer-led method,[24,25]

The administratively defined census LSOA was used as a proxy for 'neighbourhood'. However, the direction of bias from using non-homogeneous administrative areas is towards conservative estimates.[42,43] Therefore it is unlikely that the current study over-estimated the associations between alcohol consumption and neighbourhood deprivation. Finally, no inferences about causal processes can be made. Reverse cause, for example, could suggest that binge drinking causes a decline in social position, but this explanation seems unlikely for excess alcohol consumption in which the associations were in the opposite direction to binge drinking. A further limitation was that the dataset did not permit investigation of the possible mechanisms for our study findings.

In conclusion, the socio-economic patterning of excess alcohol consumption and binge drinking was complex. The study findings have implications for enhancing public health alcohol policy development, emphasising the importance of neighbourhood deprivation, as measured primarily by levels of low income and unemployment, as a determinant of harmful levels of consumption. Further longitudinal research on the spatial relationships between

alcohol consumption, outlet density, and socio-economic deprivation at individual and neighbourhood levels is necessary to further understand the underlying processes and provide further evidence for local and national policies to reduce alcohol-related harm.[44]

COMPETING INTERESTS

None

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Information Governance and data sharing

A formal data access agreement was signed with the Welsh Government in order to receive the dataset with the geographical variables for analysis. These data can only be accessed under such an agreement. There are no additional data available. Ethical approval was not required for this secondary analysis of an anonymised dataset.

Contributorship

All authors contributed to the design of the study. DLF is principal investigator and wrote the first draft of the paper with JW. DMF carried out the statistical modelling, supported by FD. JW carried out the literature reviews. All authors contributed to the critical revision of the manuscript and read and approved the final version.

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Figure 1 Estimated probabilities of excess alcohol consumption by age group and gender within neighbourhood deprivation quintiles

Figure 2 Estimated probabilities of binge drinking by age group and gender within neighbourhood deprivation quintiles

Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation

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Keywords

Alcohol, Social epidemiology, multilevel modelling, Public Health

ABSTRACT

Objectives

The influence of neighbourhood deprivation on the risk of harmful alcohol consumption, measured by the separate categories of excess consumption and binge drinking, has not been studied. The study objective ~~of the study~~ was to investigate the effect of neighbourhood deprivation with age, gender and socio-economic status (SES) on (1) excess alcohol consumption, and (2) binge drinking, in a representative population survey.

Design

Cross-sectional study: multi-level analysis.

Setting

Wales, UK, adult population ~ 2.2 million.

Participants

58 282 respondents aged 18 years and over to four successive annual Welsh Health Surveys (2003/04-2007), nested within 32 692 households, 1839 census lower super output areas and the 22 unitary authority areas in Wales.

Primary outcome measure

Maximal daily alcohol consumption during the past week was categorised using the UK Department of Health definition of 'none/never drinks', 'within guidelines', 'excess consumption but less than binge' and 'binge'. The data were analysed using continuation ratio ordinal multilevel models with multiple imputation for missing covariates.

Results

Respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference = 3.7%, 95% CI: 2.6 to 4.8). ~~T~~The effect of deprivation varied significantly with age and gender, but not with SES. Younger males in deprived neighbourhoods were most likely to binge drink. Males aged 35-64 showed the steepest increase in binge drinking in deprived neighbourhoods but males aged 18-24 showed a smaller increase with deprivation.

~~Younger males in deprived neighbourhoods were most likely to binge drink but the largest interaction effect of deprivation on binge drinking was found for middle-aged males living in the most deprived areas.~~

Conclusion

This large-scale population study is the first to show that neighbourhood deprivation acts differentially on the risk of binge drinking between males and females at different age groups. Understanding the socio-economic patterns of harmful alcohol consumption is important for public health policy development.

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ARTICLE SUMMARY

Article Focus

- A recent systematic review found little evidence that living in neighbourhoods of high socio-economic deprivation is associated with a higher risk of harmful alcohol consumption
- The important distinction between excess alcohol consumption and binge drinking has not previously been investigated

Key Messages

- A higher risk of binge drinking was found in residents living in deprived neighbourhoods, particularly in young and middle-aged men
- A higher risk of excess consumption, but less than binge, was found in residents of less deprived neighbourhoods
- Neighbourhood socio-economic deprivation is an important factor to consider in public health alcohol policy development

Strengths and Limitations

- The main strength is the large representative dataset of over 58 000 respondents, or around one in fifty of the socially diverse Welsh adult population. The ordinal alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health

- The cross-sectional analysis used the administratively defined census LSOA as a proxy for 'neighbourhood' and cannot investigate the possibility of causal relationships. Social desirability bias may result in under-reported alcohol consumption, although it is not known whether this varies between neighbourhoods.

INTRODUCTION

Excess alcohol consumption causes a major global burden of disease, injury and social and economic cost.[1] Binge drinking, typically defined as consuming at least double the guideline limits in a single day during the previous week,[2] is an increasing problem which is rising particularly in young women.[3] It is associated with anti-social behaviour,[4] and around half of all violent crimes in the UK.[5] Binge drinking causes an extra burden on health services; between 20-40 % of people presenting to accident and emergency departments are intoxicated, increasing to 80% after midnight.[4] Recent data show that around 37% of men and 29% of women exceeded the current UK guidelines for safe levels of alcohol consumption of ≤ 3 units per day for women and ≤4 units per day for men in the past week; and 20% of men and 13% of women engaged in binge drinking, defined as > 6 units per day for women and > 8 units per day for men.[6] Given the wide range of harm resulting from this substantial level of consumption, the potential impact on health at the population level from a reduction in consumption is considerable.

Research investigating the socio-economic patterning of harmful alcohol consumption has generally found that lower socio-economic status (SES) groups drink more heavily and higher SES groups drink more frequently,[7] consistent with binge drinking being found to be more prevalent in the economically disadvantaged.[8] However, subtle variations in cut-points based on units have led to prevalence estimates for binge drinking in young men to differ by 22%,[2] and these summary SES relationships have been found to vary substantially with age, gender, educational level, employment status and the measure of consumption.[2,7-12]

In addition to socio-economic effects found at the individual level, it is theorised that small-area, or neighbourhood, socio-economic deprivation might exert an independent effect on

harmful alcohol consumption. However, a recent systematic review which included multilevel studies of neighbourhood deprivation and alcohol consumption found little evidence to support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in a quality assessment, one study set in the West of Scotland, UK, found no significant association between neighbourhood deprivation and drinking above guideline limits or the number of units consumed in the past week.[14] A second study set in California, USA, found that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males) was significantly higher for people living in the least deprived neighbourhoods with no significant variation with individual SES.[15]

The two other studies described an association between high neighbourhood deprivation and high consumption.[16,17] Data from the nationally representative Third National Health and Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood deprivation measure at the level of the census tract was associated with heavy alcohol use, defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01, 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A second US study found that higher mean income and income inequality at the larger community district level was significantly associated with a higher number of drinks per month among drinkers.[17] Four subsequent papers reporting small studies found no significant association between alcohol consumption and neighbourhood income,[18,19] neighbourhood unemployment,[20] or a composite measure of relative socio-economic disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada found a small effect of neighbourhood deprivation on the number of drinks consumed per week in men, but not in women.[22]

Possible explanations for these inconsistencies in neighbourhood associations found between studies may result from different methods of defining excess, or harmful, consumption, with some choosing definitions based on national guidelines for 'safe' consumption or units,[14] number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations for inconsistent neighbourhood associations may result from different measures of area deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors for excess alcohol consumption.[14-22]

Despite the substantial public health consequences of alcohol consumption and the possible importance of neighbourhood in explaining patterns of consumption, no previous study to our knowledge has investigated multilevel associations with neighbourhood deprivation which distinguish between excess consumption and binge drinking as distinct categories. Little is known on whether any associations vary within population groups. The aim of the present study was to investigate the effect of neighbourhood deprivation with age, gender and SES on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a representative sample of the adult population of Wales, UK.

METHODS

Participants

Data were drawn from four successive cross-sectional waves of the Welsh Health Survey 2003/04 to 2007, an interviewer-led household and individual survey of the adult population resident in Wales, UK.[23-25] The adult population of Wales is approximately 2.2 million (2001 Census) and the dataset available included a total of 60 555 adults aged 18 years and over. The sampling methods and the survey process are described in detail elsewhere.[24,25] Briefly, the sampling frame used was the Post Office's Postcode Address File. Private household addresses were randomly selected in a two stage design, sampling addresses within primary sampling units that were selected within the 22 unitary authority local government areas in Wales. Each adult member of the household was invited to complete a questionnaire. Response rates were high: in 2003/04 the adjusted household survey response was 74% with 85% of individuals responding within households,[24] with little change at 74% and 82% respectively in 2007.[25]

Alcohol outcome measure

Participants were asked to state the highest number of units they had drunk on any one day in the previous seven days, using a standard prompt to convert different types and quantities of alcoholic drinks into units. The dataset provided the classification of units into ordinal categories of maximal daily consumption based on the UK Department of Health definitions (Table 1), with categories for 'none/never drinks', 'within guidelines', 'excess consumption but less than binge, and 'binge'.[26]

Table 1 Categorisation of the alcohol consumption outcome variable

Category	Maximum units drunk on any one day in the last week
None/never drinks	Did not drink in the last seven days
Within guidelines	Men drinking no more than 4 units, women no more than 3 units
Excess consumption but less than binge	Men drinking more than 4 and up to and including 8 units, women more than 3 and up to and including 6 units
Binge	Men drinking more than 8 units, women more than 6 units

Source: reference 26

Neighbourhood deprivation measure

The Welsh Index of Multiple Deprivation 2005 (WIMD2005) was used as the measure of neighbourhood deprivation.[27] ~~WIMD2005~~ The Index includes seven weighted domains of deprivation: income (25%), employment (25%), education (15%), health (15%), geographical access to services (10%), housing (5%), and physical environment (5%). ~~WIMD2005~~ These neighbourhood deprivation scores are available for lower super output areas (LSOA), a unit of statistical geography defined by the 2001 UK Census.[28] There are 1896 LSOAs in Wales which have a mean population size of around 1500. Since the data included in each neighbourhood deprivation~~WIMD2005~~ domain are measured on different scales, each domain score is transformed to have a range of zero to 100 and the overall index is calculated using a weighted average, [27] taking a range of 1.4 to 78.9. ~~WIMD2005~~ This measure of neighbourhood deprivation is highly correlated with the well-established Townsend index,[29] Spearman's $r = 0.86$, $n=1896$, $p<0.001$.

We used the LSOA as the closest available proxy for neighbourhood. Neighbourhood characteristics vary widely within Wales, from high to low levels of socioeconomic

disadvantage, including deprived urban inner-city areas, less deprived city sub-urban residential areas, post-industrial valley towns, market towns and rural, farming areas. Respondents were linked to their neighbourhood of residence by the data owners (the Welsh Government) and the dataset included individuals living in 1839 LSOAs, nested within the 22 unitary authorities (UA) in Wales. Each LSOA was assigned to one of five ordinal categories of neighbourhood deprivation ~~WIMD2005 scores~~ with equal counts of LSOAs in each quintile.

Measures of individual SES and potential confounding variables

The principal measure of SES defined for the analysis was the National Statistics Socio-economic Classification (NS-SEC3) variable for the head of household. This is a measure of occupational social class with the following categories: professional/managerial, intermediate, routine and manual occupations, and never worked/long-term unemployed. Age was analysed in 10-year bands by gender. We considered other available measures of SES that were associated with alcohol consumption in the dataset as confounding variables: individual employment status (employed, seeking work, training/student, retired, permanently sick or disabled, at home), highest educational qualification (degree, intermediate, none), ethnicity (White, Black and minority ethnic) and housing tenure (owner occupier, social and private renting) (table 2).

Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the questions on alcohol consumption, and 50 641 had complete covariate information recorded in the dataset.

Statistical Analysis

Since the outcome measure is an ordered categorical variable, the data were analysed using a continuation ratio model,[30] which allowed estimation of the association between neighbourhood deprivation and the likelihood of moving up one category of alcohol consumption, y, (e.g. from excess consumption but less than binge, to binge drinking). This continuation ratio approach used a linear predictor, $\eta_{k,}$ to explain the probability of continuing to a higher category, conditional on reaching a certain ordinal level. The linear predictor was modelled by covariates x_k and fixed effects β :

$$\text{logit } p(y > k \mid y \geq k) = \eta_{k} = x_k\beta$$

This extends naturally to the multilevel framework, where we adopted the random effects model:

$$\text{logit } p(y > k \mid y \geq k,b) = x_k\beta + z_kb$$

where the linear predictor now has two components: $x_k\beta$ are the fixed effects, and z_kb described the multilevel structure in the data. Again, in principle the influence of both fixed and random effects may vary according to the level k.

We estimated the regression coefficients beta and the covariance matrix Var (b) and we derived p(y=k | b=0), the predicted probabilities of membership of ordinal category k for the median geographical context b=0 for each quintile of deprivation and category of SES.

To model the variation in the four-category ordinal alcohol consumption outcome using a

continuation ratio model, we ~~first re-express this ordinal outcome in terms of~~defined three additional ~~-~~binary explanatory variables~~:~~, one for each ~~-yes/no-~~ transition~~s~~ between the alcohol outcome categories to indicate the level at which the transition was occurring~~non-drinking and drinking within guidelines.~~

~~between drinking within guidelines and exceeding guidelines, and between exceeding guidelines and binge drinking. This necessitates the inclusion of an additional explanatory variable indicating which transition is being referred to. The advantage of this transformation is that standard software for logistic regression and its extensions to random effects models can be used to analyse the ordinal data.~~

The sequential modelling strategy started with the "null" four-level variance components model, with category-specific intercepts and random effects for households, LSOAs and UAs. The neighbourhood deprivation~~WIMD2005~~ categorical variable was fitted to estimate the unadjusted neighbourhood deprivation fixed effects in model 1. To allow ~~increased flexibility in~~ a better understanding of the effects of deprivation on alcohol consumption, we fitted interactions between the neighbourhood deprivation quintiles and ~~the~~each additional explanatory variable indicating the relevant binary transition. ~~in question were included in the continuation ratio models to allow the use of completely flexible models for our ordinal data~~~~To allow increased flexibility in understanding the effects of deprivation on alcohol consumption, interactions between the change in alcohol consumption category and deprivation quintile were included in the continuation ratio models.~~ The predicted probabilities of excess consumption and binge drinking we~~a~~re derived from the sum of these ~~additive~~ main effects and relevant interaction coefficients.

Social class, age group, gender, the interaction between age group and gender, and the potential confounders were then added to form model 2. The final model 3 was fitted with cross-level interactions in separate models for neighbourhood deprivation~~WIMD2005~~ interacting with age group and gender, and neighbourhood deprivation~~WIMD2005~~ with social class. Multiple imputation of five datasets using chained equations in R software was used to account for missing covariates.[31,32]

The magnitude of the variation between LSOAs and between UAs was estimated using the standard deviation (SD) of their random effects, since these are measured on the same scale as the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/- 0.67, and the differences between LSOA and between UA quartiles were computed by 1.34*SD to compare with the magnitude of the estimated fixed effects for social class.

RESULTS

Descriptive analysis

Overall, 22 218 (38.1%) of the total 58 282 respondents reported their levels of alcohol consumption as 'none or never drinks', 16 059 (27.6%) reported 'within guidelines', 9664 (16.6%) reported 'excess consumption but less than binge' and 10 341 (17.7%) reported 'binge' drinking. Both excess consumption and particularly binge drinking were higher in

males than females. Excess consumption was highest in the 35-64 year age groups and binge drinking was highest in 18-34 year olds, declining with increasing age (table 2). The 'never worked and long-term unemployed' group and respondents with no educational qualifications showed substantially lower levels of both excess consumption and binge drinking than the three higher social class groups and those with some educational achievement. For employment status, the economically active who were employed or seeking work had higher levels of excess and binge consumption than economically inactive respondents. The proportion of respondents drinking to excess decreased with increasing neighbourhood deprivation but binge drinking showed the opposite pattern of increasing with higher deprivation (table 2).

Table 2 Excess alcohol consumption and binge drinking by socio-economic status

		Excess consumption,	%	Binge	%	
Gender*	Female	4702	15.0	3482	11.1	31261
	Male	4962	18.4	6859	25	
Age group**	18-24	1001	14.5	2041	29	
	25-34	1286	17.5	2105	28.7	7329
	35-44	2007	19.6	2427	23.7	10225
	45-54	2110	21.5	1931	19.7	9815
	55-64	1961	19.2	1268	12.4	10216
	65-74	951	12.4	444	5.8	7697
	75-84	316	6.4	106	2.2	4923
	85+	32	2.7	19	1.6	1189
Social class**	Professional and managerial occupations	3850	19.5	3354	17.0	19699
	Intermediate occupations	1742	16.1	1873	17.3	10802
	Routine and manual occupations	3566	14.7	4397	18.2	24197
	Never worked and long-term unemployed	131	8.9	173	11.8	1465
Employment status**	Employed	5766	20.9	6961	25.2	27571
	Seeking work	138	14.9	274	29.6	925
	Training/student	483	14.8	739	22.6	3273
	Permanently sick or disabled	599	13.0	547	11.8	4619
	Retired	1539	11.8	755	5.8	13091
	At home	696	13.2	507	9.6	5284
	Other	276	14.9	349	18.8	1856
Highest educational qualification**	No qualifications	2140	12.6	2095	12.3	17026
	Intermediate qualifications	5405	18.3	6428	21.7	29601
	Degree/degree equivalent and above	1773	21.5	1445	17.5	8247
Tenure**	Owner occupier	8010	17.5	7883	17.2	45725
	Social renting	956	11.8	1340	16.5	8123
	Private renting / Other	663	15.6	1085	25.5	4262
Ethnicity*	White	9492	16.8	10165	18	
	Black and minority ethnic	108	8.8	100	8.2	1222
Neighbourhood deprivation~~WIMD2005: quintile~~** ~~Deprivation quintile~~	Least deprived	2304	19.5	1967	16.7	11786
	Less deprived	2111	17.2	1927	15.7	12267
	Mid deprived	2063	16.0	2219	17.2	12875
	More deprived	1726	15.0	2234	19.4	11544
	Most deprived	1460	14.9	1994	20.3	9810

* χ^2 test, p<0.001

** χ^2 test for trend, p<0.001

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Multilevel models

The model 1 parameter estimates for the neighbourhood deprivation fixed effects and the interaction effects are shown in table 3, together with the unadjusted model predicted probabilities for the five neighbourhood deprivation quintiles. ~~in model 1 are shown in table 3.~~ The probabilities of excess consumption and binge drinking were computed from the sum of the fixed and interaction estimates for each neighbourhood deprivation quintile. As ~~with~~ we found in the descriptive analysis, the probability of excess consumption was higher in less deprived neighbourhoods with decreasing probability across the quintiles of deprivation. Binge drinking showed the opposite pattern of increasing probability with higher deprivation. The differences in magnitude between the model predicted probabilities and the descriptive data shown in table 2 are explained by the addition of the random effects in model 1.

Table 3 then shows the estimates for the neighbourhood deprivation fixed and interaction effects from model 2, which~~After~~ includ~~inged~~ social class, age group, ~~and~~ gender, the interaction between age group and gender, and the other confounding variables ~~in model 2,~~ The sum of the estimates for the fixed and interaction effects for the neighbourhood deprivation quintiles were used as in model 1 to compute the probabilities of excess consumption and binge drinking. In this ~~the~~ adjusted model, the difference between the deprivation quintiles for the probability of binge drinking increased, with less effect on the excess consumption category ~~(table 3).~~ ~~:~~ ~~r~~Respondents in the most deprived neighbourhoods were more likely to binge drink than in the least deprived (adjusted estimates: 17.5% vs. 10.6%; difference in proportions = 6.9%, 95% CI: 6.0 to 7.8), but were less likely to report excess consumption (17.6% vs. 21.3%; difference in proportions = 3.7%, 95% CI: 2.6 to 4.8).

Table 3 ~~also~~ finally shows the predicted probabilities of consumption for the ~~social class~~SES categories in the fully adjusted model 2. There was little variation in excess consumption with ~~social class~~SES. The descriptive analysis finding of a higher probability of binge drinking in the three higher social class groups compared to the never worked/long-term unemployed category remained after adjustment.

Table 3 Model parameter estimates and predicted probabilities (%) for excess alcohol consumption and binge drinking for neighbourhood deprivation and SES

	Parameter estimate (SE)	Excess consumption, less than binge %	Binge %
Model 1[a]			
~~**WIMD2005:**~~			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	22.2	9.7
Less deprived	-0.2042* (0.0372)	20.1	9.9
Mid deprived	-0.4105* (0.0370)	19.1	11.2
More deprived	-0.6544* (0.0375)	17.6	12.6
Most deprived	-0.8526* (0.0391)	17.2	12.6
Interaction: ~~WIMD2005*change in alcohol consumption category:~~			
Within to excess: Less deprived	0.2033* (0.0446)		
Excess to binge: Less deprived	0.3254* (0.0565)		
Within to excess: Mid deprived	0.5656* (0.0443)		
Excess to binge: Mid deprived	0.7054* (0.0554)		
Within to excess: More deprived	0.9931* (0.0459)		
Excess to binge: More deprived	1.1510* (0.0563)		
Within to excess: Most deprived	1.3587* (0.0489)		
Excess to binge: Most deprived	1.3692* (0.0584)		
Model 2[b]			
~~**WIMD2005:**~~			
Neighbourhood deprivation quintiles:			
Least deprived	Reference	21.3	10.6
Less deprived	-0.1973* (0.0387)	19.5	11.1
Mid deprived	-0.3879* (0.0386)	18.8	13.0
More deprived	-0.6073* (0.0395)	17.5	15.3
Most deprived	-0.7142* (0.0421)	17.6	17.5
Interaction: ~~WIMD2005*change in alcohol consumption category:~~			
Within to excess: Less deprived	0.1954* (0.0470)		
Excess to binge: Less deprived	0.3282* (0.0588)		
Within to excess: Mid deprived	0.5720* (0.0467)		
Excess to binge: Mid deprived	0.7296* (0.0577)		
Within to excess: More deprived	1.0157* (0.0483)		
Excess to binge: More deprived	1.2033* (0.0586)		
Within to excess: Most deprived	1.3996* (0.0514)		
Excess to binge: Most deprived	1.4615* (0.0608)		
~~**NS-SEC3:**~~ **SES**			
Professional/managerial	Reference	19.8	14.6
Intermediate	-0.0973* (0.0265)	19.0	13.0

Routine occupations	-0.1519* (0.0226)	18.6	12.2
Never worked/long-term unemployed	-0.3339* (0.0614)	17.1	9.7

a Model 1 included fixed effects terms for ~~WIMD2005~~ neighbourhood deprivation quintiles and the interaction with the binary transition explanatory variable for change in category of consumption, and random effects terms for household, LSOA and unitary authority

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

* p<0.001

The two-way cross-level interaction between neighbourhood deprivation~~WIMD2005~~, age group and gender showed the effect of neighbourhood deprivation on the probability of excess consumption and binge drinking varied significantly between age group and gender. These model outputs are shown on the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-level interaction in females or older age groups was found for either excess consumption or binge drinking. Males had a higher probability of excess consumption in less~~ow~~ deprivat~~ioned~~ neighbourhoods ~~quintiles~~ than females. Although the probability of binge drinking in females increased with increasing deprivation quintile, the gradients were significantly steeper in males. The probability of binge drinking was highest at all levels of neighbourhood deprivation in males aged ~~18~~ 25 to 34. The interaction effects suggested that males in the 35-64 year age groups showed the steepest increase in the probability of binge drinking associated with increasing neighbourhood deprivation, while the interaction effect in the 18-24 year age group suggested a weaker association of increasing binge drinking with increasing deprivation~~, and the interaction effect was largest in the 35-64 year age groups~~. The cross-level interaction between neighbourhood deprivation~~WIMD2005~~ and social class was not significant suggesting that the association of excess consumption and binge drinking with neighbourhood deprivation did not vary with SES.

Random effects variance

The values for the intra-class correlation coefficients (%) given in table 4 show that the majority of the unexplained random variation occurred at the household level, suggesting that, as expected, drinking behaviour tends to cluster more within households than within neighbourhoods or within the larger-area UA~~(table 4)~~. To examine the magnitude of the variation between neighbourhoods in comparison to the fixed-effect estimates for SES, ~~For LSOAs, in model 2,~~ the SD for LSOAs in model 2 = 0.156, giving the inter-quartile range of

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the distribution of the LSOA variance = 0.21. This compares to a parameter estimate of -0.33 for the 'never worked' category of social class, of -0.15 for 'routine' occupations and -0.10 for the 'intermediate' category, compared to the professional/managerial category (table 3). The size of this variation is of similar magnitude to the social class estimates, which suggests there is important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation, although smaller than LSOA, remains of importance in explaining the spatial pattern of alcohol consumption.

Table 4 Random effects variance in sequential multilevel models

	Level	Variance	SD	Intra-class correlation (%)
Null model	HH	0.809	0.899	74.4
	LSOA	0.032	0.179	14.8
	UA	0.017	0.130	10.8
Model 1[a]	HH	0.824	0.908	74.8
	LSOA	0.028	0.167	13.8
	UA	0.019	0.139	11.4
Model 2[b]	HH	0.867	0.931	77.1
	LSOA	0.024	0.156	12.9
	UA	0.015	0.121	10.0
Model 3[c]	HH	0.866	0.931	77.3
	LSOA	0.023	0.153	12.7
	UA	0.014	0.120	10.0

a Model 1 included fixed effects terms for neighbourhood deprivation quintiles and the interaction with the binary transition explanatory variable for change in category of consumption, and random effects terms for household, LSOA and unitary authority~~Model 1 included fixed effects terms for WIMD2005 deprivation quintiles and the interaction with change in category of consumption, and random effects terms for household, LSOA and unitary authority~~

b Model 2 added social class, age group, gender, age group*gender, and adjusted for employment status, highest educational qualification, ethnicity, and housing tenure

c Model 3 further included the two-way cross-level interaction between ~~WIMD2005~~ neighbourhood deprivation quintile, age group and gender

DISCUSSION

Main results

The current study has investigated the difference in associations between neighbourhood deprivation and excess alcohol consumption and binge drinking as ordinal categories, based on the UK definition~~.~~ [26] This is because~~since~~ it has been suggested that it is more appropriate to set benchmarks for daily than for weekly consumption of alcohol following greater concern about the health and social risks associated with single episodes of intoxication.[6] Excess consumption was more common in less deprived neighbourhoods. In contrast, binge drinking was more common in deprived neighbourhoods. These findings add to the previous US and Canadian studies which showed a significant neighbourhood effect,[16,17,22] by further assessing the complex interacting effects of neighbourhood deprivation with consumption category, age and gender, and social class. The interaction effect of neighbourhood deprivation with age and gender ~~was greatest for~~showed the steepest increase in binge drinking with deprivation was in middle-aged males with no significant interaction with social class. We also found a substantial variation between neighbourhoods, since the magnitude of the unexplained variance in alcohol consumption was similar to the effect sizes of individual SES.

Possible mechanisms linking neighbourhood deprivation to harmful alcohol consumption

Three mechanisms have been proposed to explain how neighbourhood deprivation might exert an independent effect on the risk of harmful alcohol consumption, and a differential effect on middle-aged males.[16] First, the contagion hypothesis suggests that health behaviours are spread by social exchange and particularly social networks of personal friends. [33] Thus, binge drinking may be more acceptable in middle-aged men resident in deprived

neighbourhoods than in the non-deprived. Second, the stress of living in areas of high neighbourhood disadvantage may make men more vulnerable to psychological distress.[34,35] This then increases the risk that alcohol is used as a coping mechanism.

Third, the structural hypothesis argues that neighbourhood social norms and institutions define the pattern of health behaviours.[36] Greater availability of cheap alcohol measured as higher alcohol outlet densities might influence harmful drinking rates, although the evidence summarised in systematic reviews of both cross-sectional and longitudinal studies is inconsistent.[373] There is some evidence that high deprivation neighbourhoods have a higher density of alcohol outlets,[15,348,359] and this might provide a mechanism to explain higher consumption in deprived neighbourhoods. However, two studies which found higher outlet densities in more deprived areas found that levels of consumption were highest in less deprived areas.[15,348] A third study found the spatial association between outlet density and deprivation did not vary systematically, suggesting the relationship between deprivation and outlet density may be different in different locations.[359] This deprivation-density hypothesis could not explain the findings of higher rates of excess consumption in the least deprived neighbourhoods in the current study. One possibility is the acceptance of social norms of regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to a different set of social normative binge drinking behaviour in the most deprived areas.

Strengths and limitations

Since 2003/04, the Welsh Health Survey has been an annual source of robust population survey data. It has the important strength of a large sampling fraction resulting in a representative response dataset that includes around one in fifty of the socially diverse Welsh

adult population, with detailed exposure data linked to the small-area neighbourhood. The study findings from such a comprehensive dataset should be widely generalisable. Several limitations should be considered. The alcohol consumption outcome measure was based on a widely used definition published by the UK Department of Health.[26] However, the possibility of social desirability bias resulting in under-reported alcohol consumption should be considered,[~~36~~40,~~37~~41] although it is not known whether under-reporting varies between neighbourhoods. The questionnaire responses were consistent year-on-year from four different successive samples, suggesting that responses were reliable. Non-response bias was a possibility but the surveys had a consistently good overall response to the interviewer-led method,[24,25]

The administratively defined census LSOA was used as a proxy for 'neighbourhood'. However, the direction of bias from using non-homogeneous administrative areas is towards conservative estimates.[~~38~~42,4~~9~~] Therefore it is unlikely that the current study over-estimated the associations between alcohol consumption and neighbourhood deprivation. Finally, no inferences about causal processes can be made. Reverse cause, for example, could suggest that binge drinking causes a decline in social position, but this explanation seems unlikely for excess alcohol consumption in which the associations were in the opposite direction to binge drinking. A further limitation was that the dataset did not permit investigation of the possible mechanisms for our study findings.

In conclusion, the socio-economic patterning of excess alcohol consumption and binge drinking was complex. The study findings have implications for enhancing public health alcohol policy development, emphasising the importance of neighbourhood deprivation, as measured primarily by levels of low income and unemployment, as a determinant of harmful

levels of consumption. Further longitudinal research on the spatial relationships between alcohol consumption, outlet density, and socio-economic deprivation at individual and neighbourhood levels is necessary to further understand the underlying processes and provide further evidence for local and national policies to reduce alcohol-related harm.[404]

COMPETING INTERESTS

None

FUNDING

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Information Governance and data sharing

A formal data access agreement was signed with the Welsh Government in order to receive the dataset with the geographical variables for analysis. These data can only be accessed under such an agreement. There are no additional data available. Ethical approval was not required for this secondary analysis of an anonymised dataset.

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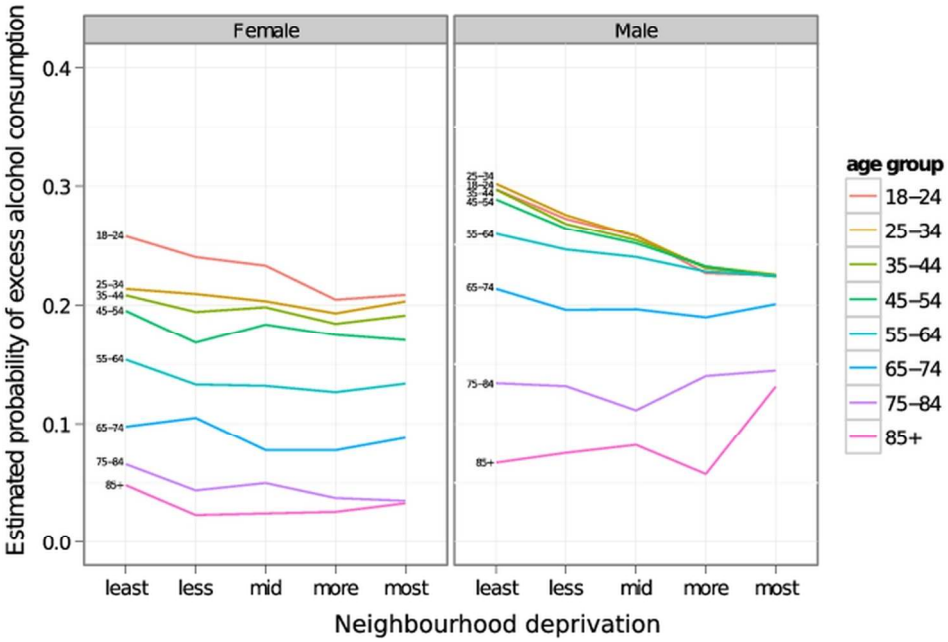
LIST OF TITLES FOR FIGURES

Figure 1 Estimated probabilities of excess alcohol consumption by age group and gender within neighbourhood deprivation quintiles

Figure 2 Estimated probabilities of binge drinking by age group and gender within neighbourhood deprivation quintiles



Estimated probabilities of excess alcohol consumption by age group and gender within neighbourhood deprivation quintiles
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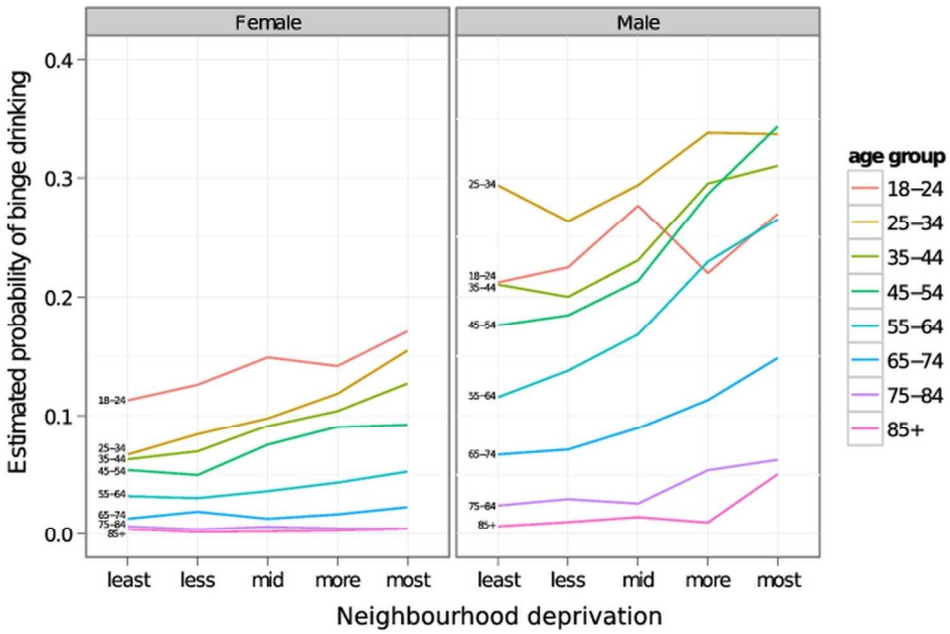

Estimated probabilities of binge drinking by age group and gender within neighbourhood deprivation quintiles
125x90mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	DONE?	Item No	Recommendation
Title and abstract	√	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
	√		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
	Introduction		
Background/rationale	√	2	Explain the scientific background and rationale for the investigation being reported
Objectives	√	3	State specific objectives, including any prespecified hypotheses
	Methods		
Study design	√	4	Present key elements of study design early in the paper
Setting	√	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	√	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	√	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	√	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	√	9	Describe any efforts to address potential sources of bias
Study size	√	10	Explain how the study size was arrived at
Quantitative variables	√	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	√	12	(*a*) Describe all statistical methods, including those used to control for confounding
	√		(*b*) Describe any methods used to examine subgroups and interactions
	√		(*c*) Explain how missing data were addressed
	√		(*d*) If applicable, describe analytical methods taking account of sampling strategy
	√		(*e*) Describe any sensitivity analyses
	Results		
Participants	√	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
	N/Known		(b) Give reasons for non-participation at each stage
	Would add little		(c) Consider use of a flow diagram
Descriptive data	√	14*	(a) Give characteristics of study participants (eg demographic,

			clinical, social) and information on exposures and potential confounders
	√		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	√	15*	Report numbers of outcome events or summary measures
Main results	√	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
	√ (equal count method for small-area boundaries)		(*b*) Report category boundaries when continuous variables were categorized
	N/A		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	√	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion			
Key results	√	18	Summarise key results with reference to study objectives
Limitations	√	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	√	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	√	21	Discuss the generalisability (external validity) of the study results
Other information			
Funding	√	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.