



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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-002337
Article Type:	Research
Date Submitted by the Author:	12-Nov-2012
Complete List of Authors:	Fone, David; Cardiff University, Institute of Primary Care & Public Health Farewell, Daniel; Cardiff University, Institute of Primary Care & Public Health White, James; Cardiff University, Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement Lyons, Ronan; Swansea University, College of Medicine Dunstan, Frank; Cardiff University, Institute of Primary Care & Public Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, PREVENTIVE MEDICINE

SCHOLARONE™
Manuscripts

Only

1
2
3 **Socioeconomic patterning of excess alcohol consumption and**
4
5
6 **binge drinking: a cross-sectional study of multilevel associations**
7
8
9 **with neighbourhood deprivation**
10

11
12
13 David L Fone¹ MD

14 Daniel M Farewell¹ PhD

15
16 James White² PhD

17
18 Ronan A Lyons³ MD

19
20 Frank D Dunstan¹ DPhil
21
22
23
24
25

26
27 1. Institute of Primary Care & Public Health, School of Medicine, Heath Park, Cardiff
28 University, Cardiff, CF14 4YS, UK

29
30 2. Centre for the Development and Evaluation of Complex Public Health Interventions,
31 School of Medicine, Cardiff University, Heath Park, Cardiff, CF14 4YS, UK

32
33 3. College of Medicine, Swansea University, Swansea SA2 8PP, UK
34
35
36
37
38

39 Corresponding author:

40 Professor David L Fone

41 Institute of Primary Care & Public Health, School of Medicine, 4th Floor Neuadd

42 Merionnydd, Heath Park, Cardiff University, Cardiff, CF14 4YS, UK

43 Telephone 02920 687241, Fax 02920 687236, e-mail foned@cf.ac.uk
44
45
46
47
48
49
50
51

52 **Keywords**

53 Alcohol, Social epidemiology, multilevel modelling, Public Health
54
55
56
57
58
59
60

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

1
2
3 consumption but less than binge' and 'binge'. The data were analysed using continuation ratio
4
5 ordinal multilevel models with multiple imputation for missing covariates.
6
7

8 9 **Results**

10 Respondents in the most deprived neighbourhoods were more likely to binge drink than in the
11
12 least deprived (adjusted estimates: 17.5% vs. 10.6%; difference = 6.9%, 95% CI: 6.0 to 7.8),
13
14 but were less likely to report excess consumption (17.6% vs. 21.3%; difference = 3.7%, 95%
15
16 CI: 2.6 to 4.8). The effect of deprivation varied significantly with age and gender, but not with
17
18 SES. Younger males in deprived neighbourhoods were most likely to binge drink but the
19
20 largest interaction effect of deprivation on binge drinking was found for middle-aged males
21
22 living in the most deprived areas.
23
24
25
26
27

28 29 **Conclusion**

30 Neighbourhood deprivation is an important factor in the understanding of socio-economic
31
32 patterns of categories of harmful alcohol consumption and for public health policy
33
34 development.
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

- 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
 - 8
 - 9
 - 10
 - 11
 - 12
 - 13
 - 14
 - 15
 - 16
 - 17
 - 18
 - 19
 - 20
 - 21
 - 22
 - 23
 - 24
 - 25
 - 26
 - 27
 - 28
 - 29
 - 30
 - 31
 - 32
 - 33
 - 34
 - 35
 - 36
 - 37
 - 38
 - 39
 - 40
 - 41
 - 42
 - 43
 - 44
 - 45
 - 46
 - 47
 - 48
 - 49
 - 50
 - 51
 - 52
 - 53
 - 54
 - 55
 - 56
 - 57
 - 58
 - 59
 - 60
- 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.

For peer review only

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

1
2
3 harmful alcohol consumption. However, a recent systematic review which included multilevel
4
5 studies of neighbourhood deprivation and alcohol consumption found little evidence to
6
7 support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in
8
9 a quality assessment, one study set in the West of Scotland, UK, found no significant
10
11 association between neighbourhood deprivation and drinking above guideline limits or the
12
13 number of units consumed in the past week.[14] A second study set in California, USA, found
14
15 that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males)
16
17 was significantly higher for people living in the least deprived neighbourhoods with no
18
19 significant variation with individual SES.[15]
20
21
22
23
24

25 The two other studies described an association between high neighbourhood deprivation and
26
27 high consumption.[16,17] Data from the nationally representative Third National Health and
28
29 Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood
30
31 deprivation measure at the level of the census tract was associated with heavy alcohol use,
32
33 defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01,
34
35 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A
36
37 second US study found that higher mean income and income inequality at the larger
38
39 community district level was significantly associated with a higher number of drinks per
40
41 month among drinkers.[17] Four subsequent papers reporting small studies found no
42
43 significant association between alcohol consumption and neighbourhood income,[18,19]
44
45 neighbourhood unemployment,[20] or a composite measure of relative socio-economic
46
47 disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada
48
49 found a small effect of neighbourhood deprivation on the number of drinks consumed per
50
51 week in men, but not in women.[22]
52
53
54
55
56
57
58
59
60

1
2
3 Possible explanations for these inconsistencies in neighbourhood associations found between
4 studies may result from different methods of defining excess, or harmful, consumption, with
5 some choosing definitions based on national guidelines for 'safe' consumption or units,[14]
6 number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations
7 for inconsistent neighbourhood associations may result from different measures of area
8 deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors
9 for excess alcohol consumption.[14-22]
10
11
12
13
14
15
16
17
18
19

20
21 Despite the substantial public health consequences of alcohol consumption and the possible
22 importance of neighbourhood in explaining patterns of consumption, no previous study to our
23 knowledge has investigated multilevel associations with neighbourhood deprivation which
24 distinguish between excess consumption and binge drinking as distinct categories. Little is
25 known on whether any associations vary within population groups. The aim of the present
26 study was to investigate the joint effects of neighbourhood deprivation with age, gender and
27 SES on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a
28 representative sample of the adult population of Wales, UK.
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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).

1
2
3 Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the
4
5 questions on alcohol consumption, and 50 641 had complete covariate information recorded
6
7 in the dataset.
8
9

10 11 12 **Statistical Analysis**

13
14 Since the outcome measure is an ordered categorical variable, the data were analysed using a
15
16 continuation ratio model,[27] which allowed estimation of the association between
17
18 neighbourhood deprivation and the likelihood of moving up one category of alcohol
19
20 consumption, y , (e.g. from excess consumption but less than binge, to binge drinking). This
21
22 continuation ratio approach used a linear predictor, η_k , to explain the probability of continuing
23
24 to a higher category, conditional on reaching a certain ordinal level. The linear predictor was
25
26 modelled by covariates x_k and fixed effects β :
27
28

$$29 \logit p(y > k | y \geq k) = \eta_k = x_k \beta$$

30
31
32 This extends naturally to the multilevel framework, where we adopted the random effects
33
34 model:
35
36

$$37 \logit p(y > k | y \geq k, b) = x_k \beta + z_k b$$

38
39
40 where the linear predictor now has two components: $x_k \beta$ are the fixed effects, and $z_k b$
41
42 described the multilevel structure in the data. Again, in principle the influence of both fixed
43
44 and random effects may vary according to the level k .
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 We estimated the regression coefficients β and the covariance matrix $\text{Var}(\beta)$ and we
4 derived $p(y=k | \beta=0)$, the predicted probabilities of membership of ordinal category k for the
5 median geographical context $\beta=0$ for each quintile of deprivation and category of SES.
6
7
8
9

10
11 The sequential modelling strategy started with the “null” four-level variance components
12 model, with category-specific intercepts and random effects for households, LSOAs and UAs.
13
14 The WIMD2005 categorical variable was fitted to estimate the unadjusted neighbourhood
15 deprivation fixed effects in model 1. NS-SEC3, age group, gender, the interaction between
16 age group and gender, and the potential confounders were then added to form model 2. The
17 final model 3 was fitted with cross-level interactions in separate models for WIMD2005
18 interacting with age group and gender, and WIMD2005 with NS-SEC3. Multiple imputation
19 of five datasets using chained equations in R software was used to account for missing
20 covariates.[28,29]
21
22
23
24
25
26
27
28
29
30
31
32
33

34 The magnitude of the variation between LSOAs and between UAs was estimated using the
35 standard deviation (SD) of their random effects, since these are measured on the same scale as
36 the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/-
37 0.67, and the differences between LSOA and between UA quartiles were computed by
38 1.34*SD to compare with the magnitude of the estimated fixed effects for SES.
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2
3 The two-way cross-level interaction between WIMD2005, age group and gender showed the
4 effect of neighbourhood deprivation on the probability of excess consumption and binge
5 drinking varied significantly between age group and gender. The model outputs are shown on
6 the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-
7 level interaction in females or older age groups was found for either excess consumption or
8 binge drinking. Males had a higher probability of excess consumption in low deprivation
9 quintiles than females. Although the probability of binge drinking in females increased with
10 increasing deprivation quintile, the gradients were significantly steeper in males. The
11 probability of binge drinking was highest at all levels of neighbourhood deprivation in males
12 aged 18 to 34, and the interaction effect was largest in the 35-64 year age groups. The cross-
13 level interaction between WIMD2005 and NS-SEC3 was not significant suggesting that the
14 association of excess consumption and binge drinking with neighbourhood deprivation did
15 not vary with SES.
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

34 Random effects variance

35
36 The majority of the unexplained random variation occurred at the household level (table 4).
37 For LSOAs, in model 2, the SD = 0.156 giving the inter-quartile range = 0.21. This compares
38 to a parameter estimate of -0.33 for the 'never worked' category of NS-SEC3, of -0.15 for
39 'routine' occupations and -0.10 for the 'intermediate' category, compared to the
40 professional/managerial category (table 3). The size of this variation suggests there is
41 important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the
42 inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation,
43 although smaller than LSOA, remains of importance in explaining the spatial pattern of
44 alcohol consumption.
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2
3 neighbourhood disadvantage may make men more vulnerable to psychological distress. This
4
5 then increases the risk that alcohol is used as a coping mechanism.
6
7

8
9
10 Third, the structural hypothesis argues that neighbourhood social norms and institutions
11 define the pattern of health behaviours. Greater availability of cheap alcohol measured as
12 higher alcohol outlet densities might influence harmful drinking rates, although the evidence
13 summarised in systematic reviews of both cross-sectional and longitudinal studies is
14 inconsistent.[30] There is some evidence that high deprivation neighbourhoods have a higher
15 density of alcohol outlets,[15,31,32] and this might provide a mechanism to explain higher
16 consumption in deprived neighbourhoods. However, two studies which found higher outlet
17 densities in more deprived areas found that levels of consumption were highest in less
18 deprived areas.[15,31] A third study found the spatial association between outlet density and
19 deprivation did not vary systematically, suggesting the relationship between deprivation and
20 outlet density may be different in different locations.[32] This deprivation-density hypothesis
21 could not explain the findings of higher rates of excess consumption in the least deprived
22 neighbourhoods in the current study. One possibility is the acceptance of social norms of
23 regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to
24 a different set of social normative binge drinking behaviour in the most deprived areas.
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44

45 **Strengths and limitations**

46
47 Since 2003/04, the Welsh Health Survey has been an annual source of robust population
48 survey data. It has the important strength of a large sampling fraction resulting in a
49 representative response dataset that includes around one in fifty of the socially diverse Welsh
50 adult population, with detailed exposure data linked to the small-area neighbourhood. The
51 study findings from such a comprehensive dataset should be more widely generalisable.
52
53
54
55
56
57
58
59
60

1
2
3 Several limitations should be considered. The alcohol consumption outcome measure was
4 based on a widely used definition published by the UK Department of Health.[25] However,
5 the possibility of social desirability bias resulting in under-reported alcohol consumption
6 should be considered,[33,34] although it is not known whether under-reporting varies
7 between neighbourhoods. The questionnaire responses were consistent year-on-year from four
8 different successive samples, suggesting that responses were reliable. Non-response bias was
9 a possibility but the surveys had a consistently good overall response to the interviewer-led
10 method, from 74% of sampled households and 85% of individuals within responding
11 households in 2003/04,[24] to 74% and 82% respectively in 2010.[35]
12
13
14
15
16
17
18
19
20
21
22
23
24

25 The administratively defined census LSOA was used as a proxy for ‘neighbourhood’.
26 However, the direction of bias from using non-homogeneous administrative areas is towards
27 conservative estimates.[36,37] Therefore it is unlikely that the current study over-estimated
28 the associations between alcohol consumption and neighbourhood deprivation. Finally, no
29 inferences about causal processes can be made. Reverse cause, for example, could suggest
30 that binge drinking causes a decline in social position, but this explanation seems unlikely for
31 excess alcohol consumption in which the associations were in the opposite direction to binge
32 drinking.
33
34
35
36
37
38
39
40
41
42
43
44

45 In conclusion, the socio-economic patterning of excess alcohol consumption and binge
46 drinking was complex. The study findings have implications for enhancing public health
47 alcohol policy development, emphasising the importance of neighbourhood. Further
48 longitudinal research on the spatial relationships between alcohol consumption, outlet density,
49 and socio-economic deprivation at individual and neighbourhood levels is necessary to further
50
51
52
53
54
55
56
57
58
59
60

1
2
3 understand the underlying processes and provide further evidence for local and national
4
5 policies to reduce alcohol-related harm.[38]
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

COMPETING INTERESTS

None

FUNDING

This work was supported by the Office of the Chief Social Research Officer (OCSRO), Welsh Government. [grant number 081218 SAP].

The work was undertaken at The Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement, a UKCRC Public Health Research: Centre of Excellence. Funding from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council (RES-590-28-0005), Medical Research Council, the Welsh Assembly Government and the Wellcome Trust (WT087640MA), under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged.

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.

REFERENCES

- [1] Rehm J, Mathers C, Popova S, et al. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol use disorders. *Lancet* 2009;**373**:2223-33.
- [2] McAlaney J, McMahon J. Establishing rates of binge drinking in the UK : Anomalies in the data. *Alcohol Alcohol* 2006;**41**:355-57.
- [3] Smith L, Foxcroft D. *Drinking in the UK. An exploration of trends*. York: Joseph Rowntree Foundation 2009. ISBN: 978-1-85935-698-2.
- [4] Hayward R, Sharp C. *Young people, crime and anti-social behaviour: findings from the 2003 Crime and Justice Survey. Home Office Research Findings 245*. London: Home Office 2005. ISSN 1473-8406.
- [5] Richardson A, Budd T. *Home Office Research Studies 263. Alcohol, crime and disorder: a study of young adults*. London: Home Office 2003. ISBN-1-84082-961-3.
- [6] Robinson S, Harris H. *Smoking and drinking among adults, 2009. A report on the 2009 General Lifestyle Survey*. London: Office for National Statistics 2011.
- [7] Huckle T, You RQ, Casswell S. Socio-economic status predicts drinking patterns but not alcohol-related consequences independently. *Addiction* 2010;**105**:1192-202.
- [8] Kuntsche E, Rehm J, Gmel G. Characteristics of binge drinkers in Europe. *Soc Sci Med* 2004;**59**:113-27.

- 1
2
3 [9] Jefferis BJ, Manor O, Power C. Social gradients in binge drinking and abstaining: trends
4 in a cohort of British adults. *J Epidemiol Community Health* 2007;**61**:150-3.
5
6
7
8
9
10 [10] Marmot M. Inequality, deprivation and alcohol use. *Addiction* 1997;**92**:S13-S20.
11
12
13
14 [11] Van Oers J. Alcohol consumption, alcohol-related problems, problem drinking, and
15 socioeconomic status. *Alcohol Alcoholism* 1999;**34**:78-88.
16
17
18
19
20 [12] Hart C, Ecob R, Smith GD. People, places and coronary heart disease risk factors: a
21 multilevel analysis of the Scottish Heart Health Study archive. *Soc Sci Med* 1997;**45**:893-902.
22
23
24
25
26
27 [13] Karriker-Jaffe KJ. Areas of disadvantage: a systematic review of effects of area-level
28 socioeconomic status on substance use outcomes. *Drug Alcohol Rev* 2011;**30**:84-95.
29
30
31
32
33
34 [14] Ecob R, Macintyre S. Small area variations in health related behaviours; do these depend
35 on the behaviour itself, its measurement, or on personal characteristics? *Health Place*
36 2000;**6**:261-74.
37
38
39
40
41
42 [15] Pollack CE, Cubbin C, Ahn D, et al. Neighbourhood deprivation and alcohol
43 consumption: does the availability of alcohol play a role? *Int J Epidemiol* 2005;**34**:772-80.
44
45
46
47
48
49 [16] Stimpson JP, Ju H, Raji MA, et al. Neighborhood deprivation and health risk behaviors
50 in NHANES III. *Am J Health Behav* 2007;**31**:215-22.
51
52
53
54
55
56
57
58
59
60

1
2
3 [17] Galea S, Ahern J, Tracy M, et al. Neighborhood income and income distribution and the
4 use of cigarettes, alcohol, and marijuana. *Am J Prev Med* 2007;**32**:S195-202.
5
6

7
8
9 [18] Cornaz S, Taffe P, Santos-Eggimann B. Life-course socioeconomic environment and
10 health risk behaviours. A multilevel small-area analysis of young-old persons in an urban
11 neighbourhood in Lausanne, Switzerland. *Health Place* 2009;**15**:273-83.
12
13

14
15
16 [19] Giskes K, Turrell G, Bentley R, et al. Individual and household-level socioeconomic
17 position is associated with harmful alcohol consumption behaviours among adults. *Aust NZ J*
18 *Publ Heal* 2011;**35**:270-7.
19
20
21
22
23

24
25
26 [20] Dzurova D, Spilkova J, Pikhart H. Social inequalities in alcohol consumption in the
27 Czech Republic: a multilevel analysis. *Health Place* 2010;**16**:590-7.
28
29
30

31
32
33 [21] Adams RJ, Howard N, Tucker G, et al. Effects of area deprivation on health risks and
34 outcomes: a multilevel cross-sectional, Australian population study. *Int J Public Health*
35 2009;**54**:183-92.
36
37
38

39
40
41 [22] Matheson FI, White HL, Moineddin R, et al. Drinking in context: the influence of gender
42 and neighbourhood deprivation on alcohol consumption. *J Epidemiol Community Health*
43 2012;**66**:e4. Epub 2011 Feb 17.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 [23] Doyle-Francis M, Sadler K, Kingdon A, et al. *Welsh Health Survey User Guide*. National
4
5 Centre for Social Research, Welsh Assembly Government 2011.

6
7 <http://wales.gov.uk/docs/statistics/2011/110127surveyguideen.pdf> (accessed 22 October
8
9 2012).

10
11
12
13
14 [24] McGee A, Jotangia D, Prescott A, et al. *Welsh Health Survey - Year One Technical*
15
16 *Report*. National Centre for Social Research 2005.

17
18 <http://wales.gov.uk/docs/statistics/2005/050701healthsurvey0304techen.pdf> (accessed 22
19
20 October 2012).

21
22
23
24
25 [25] Department of Health, Home Office, Department for Education and Skills and
26
27 Department for Culture, Media and Sport. *Safe. Sensible. Social. The next steps in the*
28
29 *National Alcohol Strategy*. London: DH Publications 2007:3.

30
31 http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital
32
33 [asset/dh_075219.pdf](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital) (accessed 22 October 2012).

34
35
36
37
38 [26] Welsh Assembly Government. *Welsh Index of Multiple Deprivation 2005: Technical*
39
40 *report*

41
42 <http://wales.gov.uk/cisd/publications/statspubs/wimd2005technical/en.pdf?lang=en> (accessed
43
44 22 October 2012).

45
46
47
48
49 [27] Agresti A. *An introduction to categorical data analysis*. 2nd ed. Hoboken, New Jersey:
50
51 John Wiley & Sons, Inc 2007.

52
53
54
55
56
57
58
59
60

1
2
3 [28] White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues
4 and guidance for practice. *Stat Med* 2010;**30**:377-99.
5
6

7
8
9 [29] van Buuren S, Groothuis-Oudshoorn K. mice: Multivariate Imputation by Chained
10 Equations in R. *Journal of Statistical Software* 2011;**45**:1-67.
11
12

13
14
15 [30] Popova S, Giesbrecht N, Bekmuradov D, et al. Hours and days of sale and density of
16 alcohol outlets: Impacts on alcohol consumption and damage: A systematic review. *Alcohol*
17 *Alcohol* 2009;**44**:500-16.
18
19
20
21

22
23
24 [31] Huckle T, Huakau J, Sweetsur P, et al. Density of alcohol outlets and teenage drinking:
25 Living in an alcogenic environment is associated with higher consumption in a metropolitan
26 setting. *Addiction* 2008;**103**:1614-21.
27
28
29
30

31
32
33 [32] Ellaway A, Macdonald L, Forsyth A, et al. The socio-spatial distribution of alcohol
34 outlets in Glasgow city. *Health Place* 2010;**16**:167-72.
35
36
37

38
39
40 [33] Embree BG, Whitehead PC. Validity and reliability of self-reported drinking behavior:
41 dealing with the problem of response bias. *J Stud Alcohol* 1993;**54**:334-44.
42
43
44

45
46
47 [34] Stockwell T, Donath S, Cooper-Stanbury M, et al.
48 Under-reporting of alcohol consumption in household surveys: a comparison of quantity-
49 frequency, graduated-frequency and recent recall. *Addiction* 2004;**99**:1024-33.
50
51
52
53
54
55
56
57
58
59
60

1
2
3 [35] Fuller E, Heeks F. *Welsh Health Survey 2007 Technical Report*. National Centre for
4 Social Research 2005.

5
6
7 <http://wales.gov.uk/topics/statistics/publications/publication->
8
9 [archive/healthsurvey2007tech/?lang=en](http://wales.gov.uk/topics/statistics/publications/publication-archive/healthsurvey2007tech/?lang=en) (accessed 22 October 2012).

10
11
12
13
14 [36] Blakely TA, Woodward AJ. Ecological effects in multi-level studies. *J Epidemiol*
15 *Community Health* 2000;**54**:367-74.

16
17
18
19
20
21 [37] Stafford M, Duke-Williams O, Shelton N. Small area inequalities in health: Are we
22 underestimating them? *Soc Sci Med* 2008;**67**:891-9.

23
24
25
26
27 [38] Fone DL, Dunstan FD, Webster C, et al. Change in alcohol outlet density and alcohol-
28 related harm to population health (CHALICE). *BMC Public Health* 2012;**12**:428
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

For peer review only

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

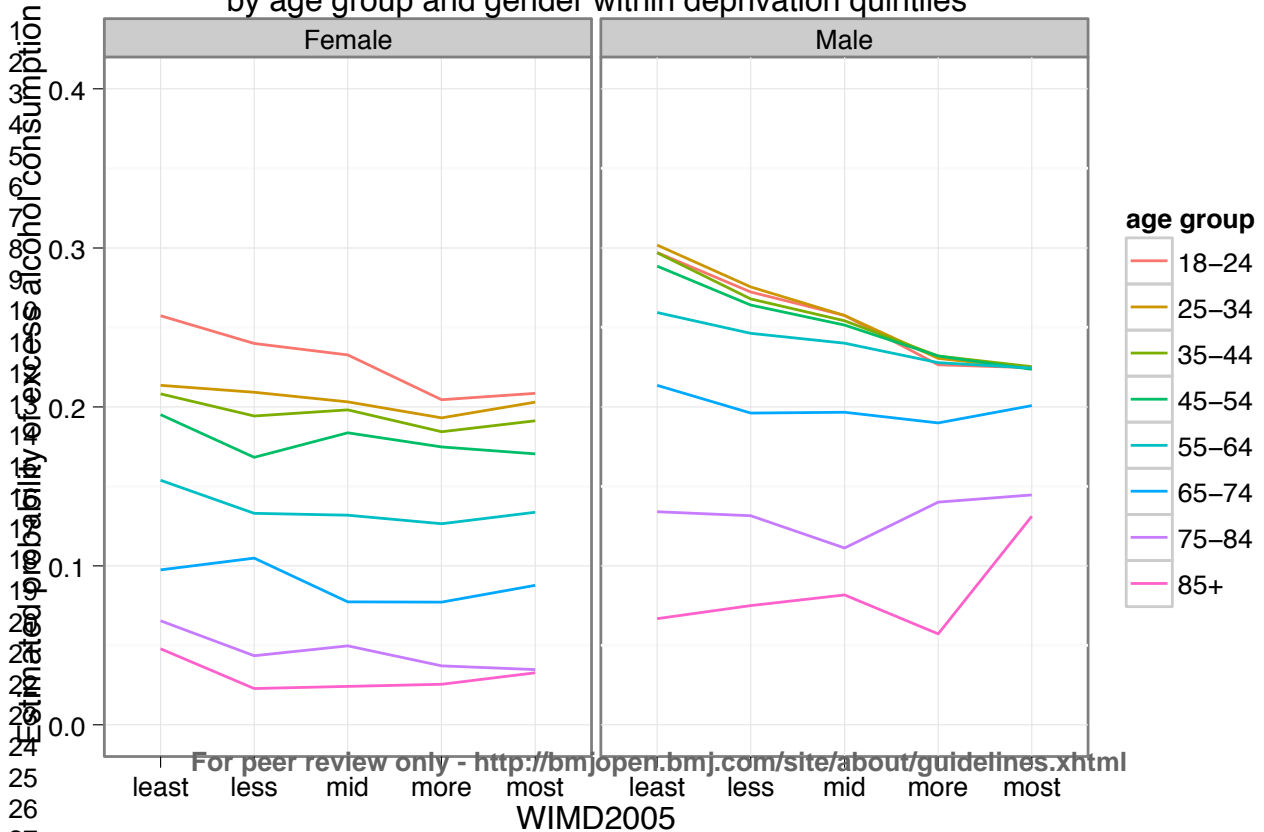
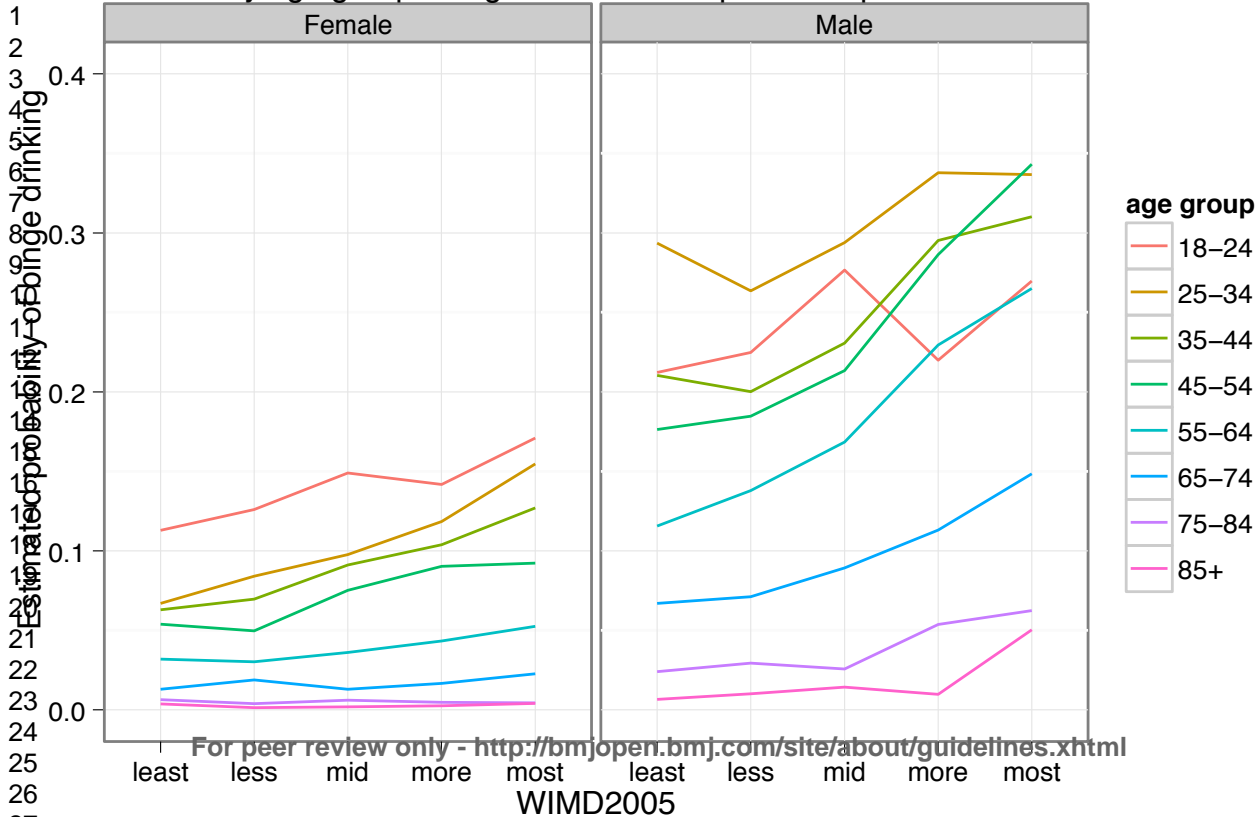


Figure 2: Estimated probabilities of binge drinking by age group and gender within deprivation quintiles



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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-002337.R1
Article Type:	Research
Date Submitted by the Author:	17-Jan-2013
Complete List of Authors:	Fone, David; Cardiff University, Institute of Primary Care & Public Health Farewell, Daniel; Cardiff University, Institute of Primary Care & Public Health White, James; Cardiff University, Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement Lyons, Ronan; Swansea University, College of Medicine Dunstan, Frank; Cardiff University, Institute of Primary Care & Public Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, PREVENTIVE MEDICINE

SCHOLARONE™
Manuscripts

Only

1
2
3 **Socioeconomic patterning of excess alcohol consumption and**
4
5
6 **binge drinking: a cross-sectional study of multilevel associations**
7
8
9 **with neighbourhood deprivation**
10

11
12
13 David L Fone¹ MD

14 Daniel M Farewell¹ PhD

15
16 James White² PhD

17
18 Ronan A Lyons³ MD

19
20 Frank D Dunstan¹ DPhil
21
22
23
24
25

26 1. Institute of Primary Care & Public Health, School of Medicine, Heath Park, Cardiff
27
28 University, Cardiff, CF14 4YS, UK

29
30 2. Centre for the Development and Evaluation of Complex Public Health Interventions,
31
32 School of Medicine, Cardiff University, Heath Park, Cardiff, CF14 4YS, UK

33
34 3. College of Medicine, Swansea University, Swansea SA2 8PP, UK
35
36
37
38

39 Corresponding author:

40 Professor David L Fone

41
42 Institute of Primary Care & Public Health, School of Medicine, 4th Floor Neuadd

43
44 Merionnydd, Heath Park, Cardiff University, Cardiff, CF14 4YS, UK

45
46 Telephone 02920 687241, Fax 02920 687236, e-mail foned@cf.ac.uk
47
48
49
50
51

52 **Keywords**

53
54 Alcohol, Social epidemiology, multilevel modelling, Public Health
55
56
57
58
59
60

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.

For peer review only

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

1
2
3 harmful alcohol consumption. However, a recent systematic review which included multilevel
4
5 studies of neighbourhood deprivation and alcohol consumption found little evidence to
6
7 support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in
8
9 a quality assessment, one study set in the West of Scotland, UK, found no significant
10
11 association between neighbourhood deprivation and drinking above guideline limits or the
12
13 number of units consumed in the past week.[14] A second study set in California, USA, found
14
15 that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males)
16
17 was significantly higher for people living in the least deprived neighbourhoods with no
18
19 significant variation with individual SES.[15]
20
21
22
23
24

25 The two other studies described an association between high neighbourhood deprivation and
26
27 high consumption.[16,17] Data from the nationally representative Third National Health and
28
29 Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood
30
31 deprivation measure at the level of the census tract was associated with heavy alcohol use,
32
33 defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01,
34
35 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A
36
37 second US study found that higher mean income and income inequality at the larger
38
39 community district level was significantly associated with a higher number of drinks per
40
41 month among drinkers.[17] Four subsequent papers reporting small studies found no
42
43 significant association between alcohol consumption and neighbourhood income,[18,19]
44
45 neighbourhood unemployment,[20] or a composite measure of relative socio-economic
46
47 disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada
48
49 found a small effect of neighbourhood deprivation on the number of drinks consumed per
50
51 week in men, but not in women.[22]
52
53
54
55
56
57
58
59
60

1
2
3 Possible explanations for these inconsistencies in neighbourhood associations found between
4 studies may result from different methods of defining excess, or harmful, consumption, with
5 some choosing definitions based on national guidelines for 'safe' consumption or units,[14]
6 number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations
7 for inconsistent neighbourhood associations may result from different measures of area
8 deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors
9 for excess alcohol consumption.[14-22]
10
11
12
13
14
15
16
17
18
19

20
21 Despite the substantial public health consequences of alcohol consumption and the possible
22 importance of neighbourhood in explaining patterns of consumption, no previous study to our
23 knowledge has investigated multilevel associations with neighbourhood deprivation which
24 distinguish between excess consumption and binge drinking as distinct categories. Little is
25 known on whether any associations vary within population groups. The aim of the present
26 study was to investigate the effect of neighbourhood deprivation with age, gender and SES on
27 (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a
28 representative sample of the adult population of Wales, UK.
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2 residential areas, post-industrial valley towns, market towns and rural, farming areas.

3
4 Respondents were linked to their neighbourhood of residence by the data owners (the Welsh
5
6 Government) and the dataset included individuals living in 1839 LSOAs, nested within the 22
7
8 unitary authorities (UA) in Wales. Each LSOA was assigned to one of five ordinal categories
9
10 of WIMD2005 scores with equal counts of LSOAs in each quintile.
11
12

13 14 15 16 17 18 **Measures of individual SES and potential confounding variables**

19
20 The principal measure of SES defined for the analysis was the National Statistics Socio-
21
22 economic Classification (NS-SEC3) variable for the head of household. This is a measure of
23
24 occupational social class with the following categories: professional/managerial, intermediate,
25
26 routine and manual occupations, and never worked/long-term unemployed. Age was analysed
27
28 in 10-year bands by gender. We considered other available measures of SES that were
29
30 associated with alcohol consumption in the dataset as confounding variables: individual
31
32 employment status (employed, seeking work, training/student, retired, permanently sick or
33
34 disabled, at home), highest educational qualification (degree, intermediate, none), ethnicity
35
36 (White, Black and minority ethnic) and housing tenure (owner occupier, social and private
37
38 renting) (table 2).
39
40
41
42
43
44

45 Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the
46
47 questions on alcohol consumption, and 50 641 had complete covariate information recorded
48
49 in the dataset.
50
51
52
53
54
55
56
57
58
59
60

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, η_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:

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

where the linear predictor now has two components: $x_k \beta$ are the fixed effects, and $z_k b$ 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 β and the covariance matrix $\text{Var}(b)$ and we derived $p(y=k \mid b=0)$, 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

1
2
3 model, with category-specific intercepts and random effects for households, LSOAs and UAs.
4
5 The WIMD2005 categorical variable was fitted to estimate the unadjusted neighbourhood
6
7 deprivation fixed effects in model 1. To allow increased flexibility in understanding the
8
9 effects of deprivation on alcohol consumption, interactions between the change in alcohol
10
11 consumption category and deprivation quintile were included in the continuation ratio models.
12
13 The predicted probabilities of excess consumption and binge drinking are derived from the
14
15 sum of the additive main effect and interaction coefficients.
16
17
18
19

20
21 Social class, age group, gender, the interaction between age group and gender, and the
22
23 potential confounders were then added to form model 2. The final model 3 was fitted with
24
25 cross-level interactions in separate models for WIMD2005 interacting with age group and
26
27 gender, and WIMD2005 with social class. Multiple imputation of five datasets using chained
28
29 equations in R software was used to account for missing covariates.[31,32]
30
31
32
33

34
35 The magnitude of the variation between LSOAs and between UAs was estimated using the
36
37 standard deviation (SD) of their random effects, since these are measured on the same scale as
38
39 the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/-
40
41 0.67, and the differences between LSOA and between UA quartiles were computed by
42
43 $1.34*SD$ to compare with the magnitude of the estimated fixed effects for social class.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2
3 The two-way cross-level interaction between WIMD2005, age group and gender showed the
4 effect of neighbourhood deprivation on the probability of excess consumption and binge
5 drinking varied significantly between age group and gender. The model outputs are shown on
6 the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-
7 level interaction in females or older age groups was found for either excess consumption or
8 binge drinking. Males had a higher probability of excess consumption in low deprivation
9 quintiles than females. Although the probability of binge drinking in females increased with
10 increasing deprivation quintile, the gradients were significantly steeper in males. The
11 probability of binge drinking was highest at all levels of neighbourhood deprivation in males
12 aged 18 to 34, and the interaction effect was largest in the 35-64 year age groups. The cross-
13 level interaction between WIMD2005 and social class was not significant suggesting that the
14 association of excess consumption and binge drinking with neighbourhood deprivation did
15 not vary with SES.
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

34 Random effects variance

35
36 The majority of the unexplained random variation occurred at the household level (table 4).
37 For LSOAs, in model 2, the SD = 0.156 giving the inter-quartile range of the distribution of
38 the LSOA variance = 0.21. This compares to a parameter estimate of -0.33 for the 'never
39 worked' category of social class, of -0.15 for 'routine' occupations and -0.10 for the
40 'intermediate' category, compared to the professional/managerial category (table 3). The size
41 of this variation is of similar magnitude to the social class estimates, which suggests there is
42 important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the
43 inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation,
44 although smaller than LSOA, remains of importance in explaining the spatial pattern of
45 alcohol consumption.
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2
3 neighbourhood disadvantage may make men more vulnerable to psychological distress. This
4
5 then increases the risk that alcohol is used as a coping mechanism.
6
7

8
9
10 Third, the structural hypothesis argues that neighbourhood social norms and institutions
11
12 define the pattern of health behaviours. Greater availability of cheap alcohol measured as
13
14 higher alcohol outlet densities might influence harmful drinking rates, although the evidence
15
16 summarised in systematic reviews of both cross-sectional and longitudinal studies is
17
18 inconsistent.[33] There is some evidence that high deprivation neighbourhoods have a higher
19
20 density of alcohol outlets,[15,34,35] and this might provide a mechanism to explain higher
21
22 consumption in deprived neighbourhoods. However, two studies which found higher outlet
23
24 densities in more deprived areas found that levels of consumption were highest in less
25
26 deprived areas.[15,34] A third study found the spatial association between outlet density and
27
28 deprivation did not vary systematically, suggesting the relationship between deprivation and
29
30 outlet density may be different in different locations.[35] This deprivation-density hypothesis
31
32 could not explain the findings of higher rates of excess consumption in the least deprived
33
34 neighbourhoods in the current study. One possibility is the acceptance of social norms of
35
36 regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to
37
38 a different set of social normative binge drinking behaviour in the most deprived areas.
39
40
41
42
43
44

45 **Strengths and limitations**

46
47 Since 2003/04, the Welsh Health Survey has been an annual source of robust population
48
49 survey data. It has the important strength of a large sampling fraction resulting in a
50
51 representative response dataset that includes around one in fifty of the socially diverse Welsh
52
53 adult population, with detailed exposure data linked to the small-area neighbourhood. The
54
55 study findings from such a comprehensive dataset should be widely generalisable. Several
56
57
58
59
60

1
2
3 limitations should be considered. The alcohol consumption outcome measure was based on a
4
5 widely used definition published by the UK Department of Health.[26] However, the
6
7 possibility of social desirability bias resulting in under-reported alcohol consumption should
8
9 be considered,[36,37] although it is not known whether under-reporting varies between
10
11 neighbourhoods. The questionnaire responses were consistent year-on-year from four
12
13 different successive samples, suggesting that responses were reliable. Non-response bias was
14
15 a possibility but the surveys had a consistently good overall response to the interviewer-led
16
17 method,[24,25]
18
19

20
21
22 The administratively defined census LSOA was used as a proxy for 'neighbourhood'.
23
24 However, the direction of bias from using non-homogeneous administrative areas is towards
25
26 conservative estimates.[38,39] Therefore it is unlikely that the current study over-estimated
27
28 the associations between alcohol consumption and neighbourhood deprivation. Finally, no
29
30 inferences about causal processes can be made. Reverse cause, for example, could suggest
31
32 that binge drinking causes a decline in social position, but this explanation seems unlikely for
33
34 excess alcohol consumption in which the associations were in the opposite direction to binge
35
36 drinking. A further limitation was that the dataset did not permit investigation of the possible
37
38 mechanisms for our study findings.
39
40
41
42
43
44

45 In conclusion, the socio-economic patterning of excess alcohol consumption and binge
46
47 drinking was complex. The study findings have implications for enhancing public health
48
49 alcohol policy development, emphasising the importance of neighbourhood. Further
50
51 longitudinal research on the spatial relationships between alcohol consumption, outlet density,
52
53 and socio-economic deprivation at individual and neighbourhood levels is necessary to further
54
55
56
57
58
59
60

1
2
3 understand the underlying processes and provide further evidence for local and national
4
5 policies to reduce alcohol-related harm.[40]
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

COMPETING INTERESTS

None

FUNDING

This work was supported by the Office of the Chief Social Research Officer (OCSRO), Welsh Government. [grant number 081218 SAP].

The work was undertaken at The Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement, a UKCRC Public Health Research: Centre of Excellence. Funding from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council (RES-590-28-0005), Medical Research Council, the Welsh Assembly Government and the Wellcome Trust (WT087640MA), under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged.

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.

REFERENCES

- [1] Rehm J, Mathers C, Popova S, et al. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol use disorders. *Lancet* 2009;**373**:2223-33.
- [2] McAlaney J, McMahon J. Establishing rates of binge drinking in the UK : Anomalies in the data. *Alcohol Alcohol* 2006;**41**:355-57.
- [3] Smith L, Foxcroft D. *Drinking in the UK. An exploration of trends*. York: Joseph Rowntree Foundation 2009. ISBN: 978-1-85935-698-2.
- [4] Hayward R, Sharp C. *Young people, crime and anti-social behaviour: findings from the 2003 Crime and Justice Survey. Home Office Research Findings 245*. London: Home Office 2005. ISSN 1473-8406.
- [5] Richardson A, Budd T. *Home Office Research Studies 263. Alcohol, crime and disorder: a study of young adults*. London: Home Office 2003. ISBN-1-84082-961-3.
- [6] Robinson S, Harris H. *Smoking and drinking among adults, 2009. A report on the 2009 General Lifestyle Survey*. London: Office for National Statistics 2011.
- [7] Huckle T, You RQ, Casswell S. Socio-economic status predicts drinking patterns but not alcohol-related consequences independently. *Addiction* 2010;**105**:1192-202.
- [8] Kuntsche E, Rehm J, Gmel G. Characteristics of binge drinkers in Europe. *Soc Sci Med* 2004;**59**:113-27.

1
2
3 [9] Jefferis BJ, Manor O, Power C. Social gradients in binge drinking and abstaining: trends
4
5 in a cohort of British adults. *J Epidemiol Community Health* 2007;**61**:150-3.
6
7

8
9 [10] Marmot M. Inequality, deprivation and alcohol use. *Addiction* 1997;**92**:S13-S20.
10
11

12
13 [11] Van Oers J. Alcohol consumption, alcohol-related problems, problem drinking, and
14
15 socioeconomic status. *Alcohol Alcoholism* 1999;**34**:78-88.
16
17

18
19 [12] Hart C, Ecob R, Smith GD. People, places and coronary heart disease risk factors: a
20
21 multilevel analysis of the Scottish Heart Health Study archive. *Soc Sci Med* 1997;**45**:893-902.
22
23

24
25 [13] Karriker-Jaffe KJ. Areas of disadvantage: a systematic review of effects of area-level
26
27 socioeconomic status on substance use outcomes. *Drug Alcohol Rev* 2011;**30**:84-95.
28
29

30
31 [14] Ecob R, Macintyre S. Small area variations in health related behaviours; do these depend
32
33 on the behaviour itself, its measurement, or on personal characteristics? *Health Place*
34
35 2000;**6**:261-74.
36
37

38
39 [15] Pollack CE, Cubbin C, Ahn D, et al. Neighbourhood deprivation and alcohol
40
41 consumption: does the availability of alcohol play a role? *Int J Epidemiol* 2005;**34**:772-80.
42
43

44
45 [16] Stimpson JP, Ju H, Raji MA, et al. Neighborhood deprivation and health risk behaviors
46
47 in NHANES III. *Am J Health Behav* 2007;**31**:215-22.
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 [17] Galea S, Ahern J, Tracy M, et al. Neighborhood income and income distribution and the
4 use of cigarettes, alcohol, and marijuana. *Am J Prev Med* 2007;**32**:S195-202.
5
6

7
8
9 [18] Cornaz S, Taffe P, Santos-Eggimann B. Life-course socioeconomic environment and
10 health risk behaviours. A multilevel small-area analysis of young-old persons in an urban
11 neighbourhood in Lausanne, Switzerland. *Health Place* 2009;**15**:273-83.
12
13

14
15
16 [19] Giskes K, Turrell G, Bentley R, et al. Individual and household-level socioeconomic
17 position is associated with harmful alcohol consumption behaviours among adults. *Aust NZ J*
18 *Publ Heal* 2011;**35**:270-7.
19
20
21
22
23

24
25
26 [20] Dzurova D, Spilkova J, Pikhart H. Social inequalities in alcohol consumption in the
27 Czech Republic: a multilevel analysis. *Health Place* 2010;**16**:590-7.
28
29
30

31
32
33 [21] Adams RJ, Howard N, Tucker G, et al. Effects of area deprivation on health risks and
34 outcomes: a multilevel cross-sectional, Australian population study. *Int J Public Health*
35 2009;**54**:183-92.
36
37
38
39

40
41
42 [22] Matheson FI, White HL, Moineddin R, et al. Drinking in context: the influence of gender
43 and neighbourhood deprivation on alcohol consumption. *J Epidemiol Community Health*
44 2012;**66**:e4. Epub 2011 Feb 17.
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 [23] Doyle-Francis M, Sadler K, Kingdon A, et al. *Welsh Health Survey User Guide*. National
4
5 Centre for Social Research, Welsh Assembly Government 2011.

6
7 <http://wales.gov.uk/docs/statistics/2011/110127surveyguideen.pdf> (accessed 15 January
8
9 2013).

10
11
12
13
14 [24] McGee A, Jotangia D, Prescott A, et al. *Welsh Health Survey - Year One Technical*
15
16 *Report*. National Centre for Social Research 2005.

17
18 <http://wales.gov.uk/docs/statistics/2005/050701healthsurvey0304techen.pdf> (accessed 15
19
20 January 2013).

21
22
23
24
25 [25] Fuller E, Heeks F. *Welsh Health Survey 2007 Technical Report*. National Centre for
26
27 Social Research 2005.

28
29 <http://wales.gov.uk/topics/statistics/publications/publication->
30
31 [archive/healthsurvey2007tech/?lang=en](http://wales.gov.uk/topics/statistics/publications/publication-) (accessed 15 January 2013).

32
33
34
35
36 [26] Department of Health, Home Office, Department for Education and Skills and
37
38 Department for Culture, Media and Sport. *Safe. Sensible. Social. The next steps in the*
39
40 *National Alcohol Strategy*. London: DH Publications 2007:3.

41
42 http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital
43
44 [asset/dh_075219.pdf](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital) (accessed 15 January 2013).

45
46
47
48
49 [27] Welsh Assembly Government. *Welsh Index of Multiple Deprivation 2005: Technical*
50
51 *report*

52
53 <http://wales.gov.uk/cisd/publications/statspubs/wimd2005technical/en.pdf?lang=en> (accessed
54
55 15 January 2013).

1
2
3 [28] Office for National Statistics (2011). *Super Output Areas (SOAs)*.

4
5 [http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-](http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-areas--soas-/index.html)
6
7 [areas--soas-/index.html](http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-areas--soas-/index.html) (accessed 15 January 2013).
8
9

10
11 [29] Townsend P, Phillimore P, Beattie A. *Health and deprivation: inequality and the North*.
12
13 London: Routledge, 1988.
14

15
16 [30] Agresti A. *An introduction to categorical data analysis*. 2nd ed. Hoboken, New Jersey:
17
18 John Wiley & Sons, Inc 2007.
19
20

21
22 [31] White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues
23
24 and guidance for practice. *Stat Med* 2010;**30**:377-99.
25
26
27

28
29 [32] van Buuren S, Groothuis-Oudshoorn K. mice: Multivariate Imputation by Chained
30
31 Equations in R. *Journal of Statistical Software* 2011;**45**:1-67.
32
33

34
35 [33] Popova S, Giesbrecht N, Bekmuradov D, et al. Hours and days of sale and density of
36
37 alcohol outlets: Impacts on alcohol consumption and damage: A systematic review. *Alcohol*
38
39 *Alcohol* 2009;**44**:500-16.
40
41
42

43
44 [34] Huckle T, Huakau J, Sweetsur P, et al. Density of alcohol outlets and teenage drinking:
45
46 Living in an alcogenic environment is associated with higher consumption in a metropolitan
47
48 setting. *Addiction* 2008;**103**:1614-21.
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 [35] Ellaway A, Macdonald L, Forsyth A, et al. The socio-spatial distribution of alcohol
4 outlets in Glasgow city. *Health Place* 2010;**16**:167-72.
5
6

7
8 [36] Embree BG, Whitehead PC. Validity and reliability of self-reported drinking behavior:
9 dealing with the problem of response bias. *J Stud Alcohol* 1993;**54**:334-44.
10
11

12
13 [37] Stockwell T, Donath S, Cooper-Stanbury M, et al. Under-reporting of alcohol
14 consumption in household surveys: a comparison of quantity-frequency, graduated-frequency
15 and recent recall. *Addiction* 2004;**99**:1024-33.
16
17
18
19
20

21
22 [38] Blakely TA, Woodward AJ. Ecological effects in multi-level studies. *J Epidemiol*
23 *Community Health* 2000;**54**:367-74.
24
25
26
27

28
29 [39] Stafford M, Duke-Williams O, Shelton N. Small area inequalities in health: Are we
30 underestimating them? *Soc Sci Med* 2008;**67**:891-9.
31
32
33
34

35
36 [40] Fone DL, Dunstan FD, Webster C, et al. Change in alcohol outlet density and alcohol-
37 related harm to population health (CHALICE). *BMC Public Health* 2012;**12**:428
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

For peer review only

1
2
3
4
5
6
7 **Socioeconomic patterning of excess alcohol consumption and**
8
9 **binge drinking: a cross-sectional study of multilevel associations**
10
11 **with neighbourhood deprivation**
12
13

14
15
16 David L Fone¹ MD

17 Daniel M Farewell¹ PhD

18 James White² PhD

19 Ronan A Lyons³ MD

20 Frank D Dunstan¹ DPhil

21
22
23
24
25
26
27 1. Institute of Primary Care & Public Health, School of Medicine, Heath Park, Cardiff

28 University, Cardiff, CF14 4YS, UK

29
30 2. Centre for the Development and Evaluation of Complex Public Health Interventions,

31 School of Medicine, Cardiff University, Heath Park, Cardiff, CF14 4YS, UK

32
33 3. College of Medicine, Swansea University, Swansea SA2 8PP, UK

34
35
36
37
38 Corresponding author:

39 Professor David L Fone

40 Institute of Primary Care & Public Health, School of Medicine, 4th Floor Neuadd

41 Merionnydd, Heath Park, Cardiff University, Cardiff, CF14 4YS, UK

42 Telephone 02920 687241, Fax 02920 687236, e-mail foned@cf.ac.uk

43
44
45
46
47
48
49 **Keywords**

50 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 survey of 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~~ee~~t for public health policy development.

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

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

- 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
 - 8
 - 9
 - 10
 - 11
 - 12
 - 13
 - 14
 - 15
 - 16
 - 17
 - 18
 - 19
 - 20
 - 21
 - 22
 - 23
 - 24
 - 25
 - 26
 - 27
 - 28
 - 29
 - 30
 - 31
 - 32
 - 33
 - 34
 - 35
 - 36
 - 37
 - 38
 - 39
 - 40
 - 41
 - 42
 - 43
 - 44
 - 45
 - 46
 - 47
 - 48
 - 49
 - 50
 - 51
 - 52
 - 53
 - 54
 - 55
 - 56
 - 57
 - 58
 - 59
 - 60
- 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

1
2
3
4
5
6
7 harmful alcohol consumption. However, a recent systematic review which included multilevel
8
9 studies of neighbourhood deprivation and alcohol consumption found little evidence to
10
11 support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in
12
13 a quality assessment, one study set in the West of Scotland, UK, found no significant
14
15 association between neighbourhood deprivation and drinking above guideline limits or the
16
17 number of units consumed in the past week.[14] A second study set in California, USA, found
18
19 that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males)
20
21 was significantly higher for people living in the least deprived neighbourhoods with no
22
23 significant variation with individual SES.[15]

24
25
26 The two other studies described an association between high neighbourhood deprivation and
27
28 high consumption.[16,17] Data from the nationally representative Third National Health and
29
30 Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood
31
32 deprivation measure at the level of the census tract was associated with heavy alcohol use,
33
34 defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01,
35
36 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A
37
38 second US study found that higher mean income and income inequality at the larger
39
40 community district level was significantly associated with a higher number of drinks per
41
42 month among drinkers.[17] Four subsequent papers reporting small studies found no
43
44 significant association between alcohol consumption and neighbourhood income,[18,19]
45
46 neighbourhood unemployment,[20] or a composite measure of relative socio-economic
47
48 disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada
49
50 found a small effect of neighbourhood deprivation on the number of drinks consumed per
51
52 week in men, but not in women.[22]

1
2
3
4
5
6
7 Possible explanations for these inconsistencies in neighbourhood associations found between
8 studies may result from different methods of defining excess, or harmful, consumption, with
9 some choosing definitions based on national guidelines for 'safe' consumption or units,[14]
10 number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations
11 for inconsistent neighbourhood associations may result from different measures of area
12 deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors
13 for excess alcohol consumption.[14-22]
14
15
16
17
18
19
20

21
22 Despite the substantial public health consequences of alcohol consumption and the possible
23 importance of neighbourhood in explaining patterns of consumption, no previous study to our
24 knowledge has investigated multilevel associations with neighbourhood deprivation which
25 distinguish between excess consumption and binge drinking as distinct categories. Little is
26 known on whether any associations vary within population groups. The aim of the present
27 study was to investigate the joint-effects of neighbourhood deprivation with age, gender and
28 SES on (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a
29 representative sample of the adult population of Wales, UK.
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.[23,245] The adult population of Wales is approximately ~~3.2~~ 2.2 million (2001 Census) and the dataset available included ~~s~~ 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]

Formatted: Font: 12 pt

Formatted: Line spacing: Double, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers

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 <u>one</u> 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 256

Neighbourhood deprivation measure

The Welsh Index of Multiple Deprivation 2005 (WIMD2005) was used as the measure of neighbourhood deprivation.[276] 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

Formatted: Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers

1
2
3
4
5
6
7 levels of socioeconomic disadvantage, including deprived urban inner-city areas, less
8 deprived city sub-urban residential areas, post-industrial valley towns, market towns and
9 rural, farming areas. Respondents were linked to their LSOA-neighbourhood of residence by
10 the data owners (the Welsh Government) and the dataset included individuals living in 1839
11 LSOAs, nested within the 22 unitary authorities (UA) local government areas (UA) in
12 Wales. Each LSOA was assigned to one of five ordinal categories of WIMD2005 scores with
13 equal counts of LSOAs in each quintile.
14
15
16
17
18
19
20
21
22
23

24 **Measures of individual SES and potential confounding variables**

25
26 The principal measure of SES defined for the analysis was the National Statistics Socio-
27 economic Classification (NS-SEC3) variable for the head of household. This is a measure of
28 occupational social class with the following, defined as the person with the highest income.
29 The categories were: professional/managerial, intermediate, routine and manual occupations,
30 and never worked/long-term unemployed. Age was analysed in 10-year bands by gender. We
31 considered other available measures of SES that were associated with alcohol consumption in
32 the dataset as confounding variables: individual employment status (employed, seeking work,
33 training/student, retired, permanently sick or disabled, at home), highest educational
34 qualification (degree, intermediate, none), ~~and~~ ethnicity (White, Black and minority ethnic)
35 and housing tenure (owner occupier, social and private renting) (table †2).
36
37
38
39
40
41
42
43
44
45

46
47 Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the
48 questions on alcohol consumption, and 50 641 had complete covariate information recorded
49 in the dataset.
50
51
52
53
54
55
56
57
58
59
60

Statistical Analysis

Since the outcome measure is an ordered categorical variable, the data were analysed using a continuation ratio model,^[2730] 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, η_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:

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

where the linear predictor now has two components: $x_k \beta$ are the fixed effects, and $z_k b$ 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 β and the covariance matrix $\text{Var}(b)$ and we derived $p(y=k \mid b=0)$, 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

1
2
3
4
5
6
7 model, with category-specific intercepts and random effects for households, LSOAs and UAs.

8
9 The WIMD2005 categorical variable was fitted to estimate the unadjusted neighbourhood
10 deprivation fixed effects in model 1. To allow increased flexibility in understanding the
11 effects of deprivation on alcohol consumption, interactions between the change in alcohol
12 consumption category and deprivation ~~###~~quintile were included in the continuation ratio
13 models. The predicted probabilities of excess consumption and binge drinking are derived
14 from the sum of the additive main effect and interaction coefficients.

15
16
17
18
19
20
21 Social classNS-SEC3, age group, gender, the interaction between age group and gender, and
22 the potential confounders were then added to form model 2. The final model 3 was fitted with
23
24 cross-level interactions in separate models for WIMD2005 interacting with age group and
25
26 gender, and WIMD2005 with social classNS-SEC3. Multiple imputation of five datasets
27
28 using chained equations in R software was used to account for missing covariates.^[2831,329]

29
30
31
32
33 The magnitude of the variation between LSOAs and between UAs was estimated using the
34
35 standard deviation (SD) of their random effects, since these are measured on the same scale as
36
37 the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/-
38
39 0.67, and the differences between LSOA and between UA quartiles were computed by
40
41 1.34*SD to compare with the magnitude of the estimated fixed effects for social classSES.

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
<u>Social class:</u>						
<u>NS-SEC3:</u>						
<u>SES</u>						
	Professional and managerial occupations	3850	19.5	3354	17.0	19699
	Intermediate occupations	1742	16.1	1873	17.3	10811
	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^{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~~

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

1
2
3
4
5
6
7 apparent paradox of increasingly negative main effect deprivation coefficients leading to
8 decreasing excess consumption probabilities but increasing binge probabilities (table 3) is
9 explained by the inclusion of interaction terms between the change in alcohol consumption
10 category and deprivation. The coefficients are additive and the predicted probabilities are
11 derived from the sum of the main effect and interaction coefficients. Even without
12 interactions, however, linear contrasts can result in non-linear (and non-monotonic) changes
13 in the probabilities associated with different alcohol consumption categories. This underlines
14 the importance of the estimated marginal probabilities in table 3 being more easily
15 interpretable and more revealing of the complexities of the relationship between deprivation
16 and alcohol consumption.
17
18
19
20
21
22
23
24
25
26
27

28 Table 3 also shows the predicted probabilities of consumption for the social class NS-SEC3
29 categories in the fully adjusted model 2. There was little difference-variation in excess
30 consumption with social class SES. The descriptive analysis finding of a higher probability of
31 binge drinking in the three higher social class SES groups compared to the never
32 worked/long-term unemployed category remained after adjustment.
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

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

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

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

1
2
3
4
5
6
7 | b Model 2 included NS-SEC3, age group, gender, age group*gender, and adjusted for
8 | employment status, highest educational qualification, ethnicity, and housing tenure
9 | * p<0.001
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1
2
3
4
5
6
7 The two-way cross-level interaction between WIMD2005, age group and gender showed the
8 effect of neighbourhood deprivation on the probability of excess consumption and binge
9 drinking varied significantly between age group and gender. The model outputs are shown on
10 the probability scale for ease of interpretation in figures 1 and 2. Little evidence of a cross-
11 level interaction in females or older age groups was found for either excess consumption or
12 binge drinking. Males had a higher probability of excess consumption in low deprivation
13 quintiles than females. Although the probability of binge drinking in females increased with
14 increasing deprivation quintile, the gradients were significantly steeper in males. The
15 probability of binge drinking was highest at all levels of neighbourhood deprivation in males
16 aged 18 to 34, and the interaction effect was largest in the 35-64 year age groups. The cross-
17 level interaction between WIMD2005 and social class NS-SEC3 was not significant
18 suggesting that the association of excess consumption and binge drinking with neighbourhood
19 deprivation did not vary with SES.
20
21
22
23
24
25
26
27
28
29
30
31
32

33 Random effects variance

34
35 The majority of the unexplained random variation occurred at the household level (table 4).
36
37 For LSOAs, in model 2, the SD = 0.156 giving the inter-quartile range of the distribution of
38 the LSOA variance = 0.21. This compares to a parameter estimate of -0.33 for the 'never
39 worked' category of social class NS-SEC3, of -0.15 for 'routine' occupations and -0.10 for the
40 'intermediate' category, compared to the professional/managerial category (table 3). The size
41 of this variation is of similar magnitude to the social class estimates, which suggests there is
42 important unexplained variation that can be attributed to LSOAs. Similarly, for UAs, the
43 inter-quartile range = 0.16, suggesting that the magnitude of the UA random variation,
44 although smaller than LSOA, remains of importance in explaining the spatial pattern of
45 alcohol consumption.
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 4 Random effects variance in sequential multilevel models

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

Formatted Table
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt
Formatted: Font: (Default) Times New Roman, 12 pt

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

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 classSES. 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 classSES. 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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.^[303] There is some evidence that high deprivation neighbourhoods have a higher density of alcohol outlets,^[15,314,325] 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.^[15,314] 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.^[325] 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

1
2
3
4
5
6
7 study findings from such a comprehensive dataset should be ~~more~~-widely generalisable.
8
9 Several limitations should be considered. The alcohol consumption outcome measure was
10
11 based on a widely used definition published by the UK Department of Health.[265] However,
12
13 the possibility of social desirability bias resulting in under-reported alcohol consumption
14
15 should be considered,[336,347] although it is not known whether under-reporting varies
16
17 between neighbourhoods. The questionnaire responses were consistent year-on-year from four
18
19 different successive samples, suggesting that responses were reliable. Non-response bias was
20
21 a possibility but the surveys had a consistently good overall response to the interviewer-led
22
23 method,[24,25]Non response bias was a possibility but the surveys had a consistently good
24
25 overall response to the interviewer led method, from 74% of sampled households and 85% of
26
27 individuals within responding households in 2003/04,[24] to 74% and 82% respectively in
28
29 2010.[535]

30
31 The administratively defined census LSOA was used as a proxy for 'neighbourhood'.
32
33 However, the direction of bias from using non-homogeneous administrative areas is towards
34
35 conservative estimates.[368,379] Therefore it is unlikely that the current study over-estimated
36
37 the associations between alcohol consumption and neighbourhood deprivation. Finally, no
38
39 inferences about causal processes can be made. Reverse cause, for example, could suggest
40
41 that binge drinking causes a decline in social position, but this explanation seems unlikely for
42
43 excess alcohol consumption in which the associations were in the opposite direction to binge
44
45 drinking. A further limitation was that the dataset did not permit investigation of the possible
46
47 mechanisms for our study findings.
48
49

50
51 In conclusion, the socio-economic patterning of excess alcohol consumption and binge
52
53 drinking was complex. The study findings have implications for enhancing public health
54
55
56
57
58
59
60

1
2
3
4
5
6 alcohol policy development, emphasising the importance of neighbourhood. Further
7
8 longitudinal research on the spatial relationships between alcohol consumption, outlet density,
9
10 and socio-economic deprivation at individual and neighbourhood levels is necessary to further
11
12 understand the underlying processes and provide further evidence for local and national
13
14 policies to reduce alcohol-related harm.^[4038]
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

COMPETING INTERESTS

None

FUNDING

This work was supported by the Office of the Chief Social Research Officer (OCSRO), Welsh Government. [grant number 081218 SAP].

The work was undertaken at The Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement, a UKCRC Public Health Research: Centre of Excellence. Funding from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council (RES-590-28-0005), Medical Research Council, the Welsh Assembly Government and the Wellcome Trust (WT087640MA), under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged.

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.

REFERENCES

- [1] Rehm J, Mathers C, Popova S, et al. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol use disorders. *Lancet* 2009;**373**:2223-33.
- [2] McAlaney J, McMahon J. Establishing rates of binge drinking in the UK : Anomalies in the data. *Alcohol Alcohol* 2006;**41**:355-57.
- [3] Smith L, Foxcroft D. *Drinking in the UK. An exploration of trends*. York: Joseph Rowntree Foundation 2009. ISBN: 978-1-85935-698-2.
- [4] Hayward R, Sharp C. *Young people, crime and anti-social behaviour: findings from the 2003 Crime and Justice Survey. Home Office Research Findings 245*. London: Home Office 2005. ISSN 1473-8406.
- [5] Richardson A, Budd T. *Home Office Research Studies 263. Alcohol, crime and disorder: a study of young adults*. London: Home Office 2003. ISBN-1-84082-961-3.
- [6] Robinson S, Harris H. *Smoking and drinking among adults, 2009. A report on the 2009 General Lifestyle Survey*. London: Office for National Statistics 2011.
- [7] Huckle T, You RQ, Casswell S. Socio-economic status predicts drinking patterns but not alcohol-related consequences independently. *Addiction* 2010;**105**:1192-202.
- [8] Kuntsche E, Rehm J, Gmel G. Characteristics of binge drinkers in Europe. *Soc Sci Med* 2004;**59**:113-27.

[9] Jefferis BJ, Manor O, Power C. Social gradients in binge drinking and abstaining: trends in a cohort of British adults. *J Epidemiol Community Health* 2007;**61**:150-3.

[10] Marmot M. Inequality, deprivation and alcohol use. *Addiction* 1997;**92**:S13-S20.

[11] Van Oers J. Alcohol consumption, alcohol-related problems, problem drinking, and socioeconomic status. *Alcohol Alcoholism* 1999;**34**:78-88.

[12] Hart C, Ecob R, Smith GD. People, places and coronary heart disease risk factors: a multilevel analysis of the Scottish Heart Health Study archive. *Soc Sci Med* 1997;**45**:893-902.

[13] Karriker-Jaffe KJ. Areas of disadvantage: a systematic review of effects of area-level socioeconomic status on substance use outcomes. *Drug Alcohol Rev* 2011;**30**:84-95.

[14] Ecob R, Macintyre S. Small area variations in health related behaviours; do these depend on the behaviour itself, its measurement, or on personal characteristics? *Health Place* 2000;**6**:261-74.

[15] Pollack CE, Cubbin C, Ahn D, et al. Neighbourhood deprivation and alcohol consumption: does the availability of alcohol play a role? *Int J Epidemiol* 2005;**34**:772-80.

[16] Stimpson JP, Ju H, Raji MA, et al. Neighborhood deprivation and health risk behaviors in NHANES III. *Am J Health Behav* 2007;**31**:215-22.

Formatted: English (U.K.)

Field Code Changed

[17] Galea S, Ahern J, Tracy M, et al. Neighborhood income and income distribution and the use of cigarettes, alcohol, and marijuana. *Am J Prev Med* 2007;**32**:S195-202.

[18] Cornaz S, Taffé P, Santos-Eggimann B. Life-course socioeconomic environment and health risk behaviours. A multilevel small-area analysis of young-old persons in an urban neighbourhood in Lausanne, Switzerland. *Health Place* 2009;**15**:273-83.

[19] Giskes K, Turrell G, Bentley R, et al. Individual and household-level socioeconomic position is associated with harmful alcohol consumption behaviours among adults. *Aust NZ J Publ Heal* 2011;**35**:270-7.

[20] Dzurova D, Spilkova J, Pikhart H. Social inequalities in alcohol consumption in the Czech Republic: a multilevel analysis. *Health Place* 2010;**16**:590-7.

[21] Adams RJ, Howard N, Tucker G, et al. Effects of area deprivation on health risks and outcomes: a multilevel cross-sectional, Australian population study. *Int J Public Health* 2009;**54**:183-92.

[22] Matheson FI, White HL, Moineddin R, et al. Drinking in context: the influence of gender and neighbourhood deprivation on alcohol consumption. *J Epidemiol Community Health* 2012;**66**:e4. Epub 2011 Feb 17.

Formatted: English (U.K.)

Field Code Changed

1
2
3
4
5
6 [23] Doyle-Francis M, Sadler K, Kingdon A, et al. *Welsh Health Survey User Guide*. National
7
8 Centre for Social Research, Welsh Assembly Government 2011.

9
10 <http://wales.gov.uk/docs/statistics/2011/110127surveyguideen.pdf> (accessed 15 January
11
12 ~~2013~~ accessed 22 October 2012).

13
14
15
16 [24] McGee A, Jotangia D, Prescott A, et al. *Welsh Health Survey - Year One Technical*
17
18 *Report*. National Centre for Social Research 2005.

19
20 <http://wales.gov.uk/docs/statistics/2005/050701healthsurvey0304techen.pdf> (accessed 15
21
22 January 2013 ~~22 October 2012~~).

23
24
25
26 [25] Fuller E, Heeks F. *Welsh Health Survey 2007 Technical Report*. National Centre for
27
28 Social Research 2005.

29
30 [http://wales.gov.uk/topics/statistics/publications/publication-
33
34 archive/healthsurvey2007tech/?lang=en](http://wales.gov.uk/topics/statistics/publications/publication-
31
32 archive/healthsurvey2007tech/?lang=en) (accessed 15 January 2013).

35
36 [26] Department of Health, Home Office, Department for Education and Skills and
37
38 Department for Culture, Media and Sport. *Safe. Sensible. Social. The next steps in the*
39
40 *National Alcohol Strategy*. London: DH Publications 2007:3.

41
42 [http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital
45
46 asset/dh_075219.pdf](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital
43
44 asset/dh_075219.pdf) (accessed 15 January 2013 ~~accessed 22 October 2012~~).

47
48 [26] Welsh Assembly Government. *Welsh Index of Multiple Deprivation 2005: Technical*
49
50 *report*

51
52 <http://wales.gov.uk/cisd/publications/statspubs/wimd2005technical/en.pdf?lang=en> (accessed
53
54 ~~22-15 October~~ January 2012).

[28] Office for National Statistics (2011). *Super Output Areas (SOAs)*.

<http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-areas--soas-/index.html> (accessed 15 January 2013).

Formatted: Font: Italic

Formatted: Font: 12 pt

[239] Townsend P, Phillimore P, Beattie A. *Health and deprivation: inequality and the North*. London: Routledge, 1988.

[2730] Agresti A. *An introduction to categorical data analysis*. 2nd ed. Hoboken, New Jersey: John Wiley & Sons, Inc 2007.

[2831] White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Stat Med* 2010;**30**:377-99.

[2932] van Buuren S, Groothuis-Oudshoorn K. mice: Multivariate Imputation by Chained Equations in R. *Journal of Statistical Software* 2011;**45**:1-67.

[330] Popova S, Giesbrecht N, Bekmuradov D, et al. Hours and days of sale and density of alcohol outlets: Impacts on alcohol consumption and damage: A systematic review. *Alcohol* 2009;**44**:500-16.

[344] Huckle T, Huakau J, Sweetsur P, et al. Density of alcohol outlets and teenage drinking: Living in an alcogenic environment is associated with higher consumption in a metropolitan setting. *Addiction* 2008;**103**:1614-21.

[325] Ellaway A, Macdonald L, Forsyth A, et al. The socio-spatial distribution of alcohol outlets in Glasgow city. *Health Place* 2010;**16**:167-72.

[336] Embree BG, Whitehead PC. Validity and reliability of self-reported drinking behavior: dealing with the problem of response bias. *J Stud Alcohol* 1993;**54**:334-44.

[347] Stockwell T, Donath S, Cooper-Stanbury M, et al.

Under-reporting of alcohol consumption in household surveys: a comparison of quantity-frequency, graduated-frequency and recent recall. *Addiction* 2004;**99**:1024-33.

[35] Fuller E, Heeks F. *Welsh Health Survey 2007 Technical Report*. National Centre for Social Research 2005.

<http://wales.gov.uk/topics/statistics/publications/publication-archive/healthsurvey2007tech/?lang=en> (accessed 22 October 2012).

[368] Blakely TA, Woodward AJ. Ecological effects in multi-level studies. *J Epidemiol Community Health* 2000;**54**:367-74.

[379] Stafford M, Duke-Williams O, Shelton N. Small area inequalities in health: Are we underestimating them? *Soc Sci Med* 2008;**67**:891-9.

Formatted

Formatted: Normal, Line spacing: single

Formatted: Normal

Field Code Changed

Formatted: Font: Bold

1
2
3
4
5
6
7 [4038] Fone DL, Dunstan FD, Webster C, et al. Change in alcohol outlet density and alcohol-
8 related harm to population health (CHALICE). *BMC Public Health* 2012;**12**:428
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

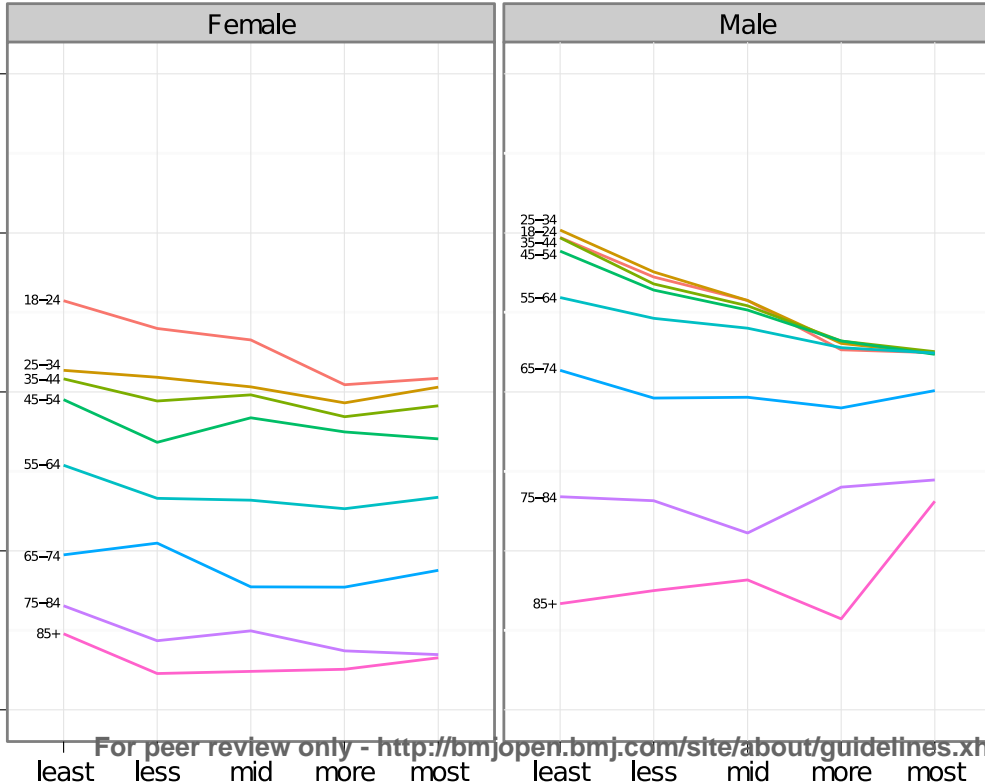
LIST OF TITLES FOR FIGURES

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

For peer review only

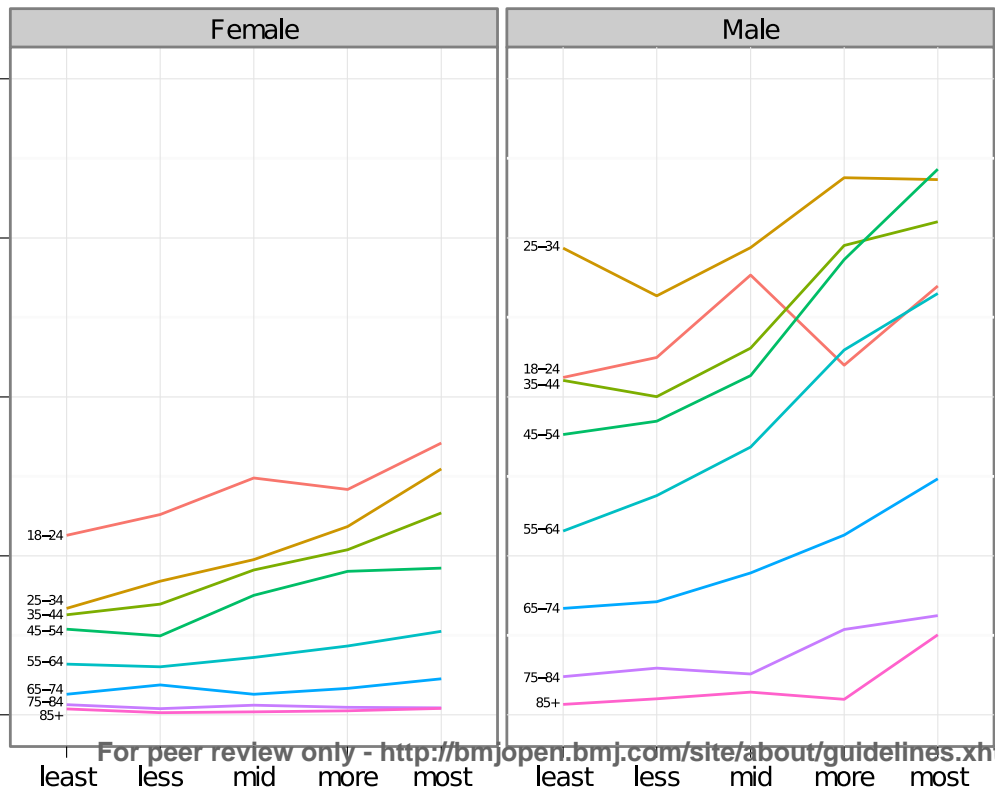
21
22
23
24
25
26
27



For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

WIMD2005

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27



For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

WIMD2005

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

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2012-002337.R2
Article Type:	Research
Date Submitted by the Author:	08-Mar-2013
Complete List of Authors:	Fone, David; Cardiff University, Institute of Primary Care & Public Health Farewell, Daniel; Cardiff University, Institute of Primary Care & Public Health White, James; Cardiff University, Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement Lyons, Ronan; Swansea University, College of Medicine Dunstan, Frank; Cardiff University, Institute of Primary Care & Public Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Addiction, Sociology
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, PREVENTIVE MEDICINE

SCHOLARONE™
Manuscripts

Only

1
2
3 **Socioeconomic patterning of excess alcohol consumption and**
4
5
6 **binge drinking: a cross-sectional study of multilevel associations**
7
8
9 **with neighbourhood deprivation**
10

11
12
13 David L Fone¹ MD

14 Daniel M Farewell¹ PhD

15
16 James White² PhD

17
18 Ronan A Lyons³ MD

19
20 Frank D Dunstan¹ DPhil
21
22
23
24
25

26 1. Institute of Primary Care & Public Health, School of Medicine, Heath Park, Cardiff
27 University, Cardiff, CF14 4YS, UK
28

29 2. Centre for the Development and Evaluation of Complex Public Health Interventions,
30 School of Medicine, Cardiff University, Heath Park, Cardiff, CF14 4YS, UK
31
32

33 3. College of Medicine, Swansea University, Swansea SA2 8PP, UK
34
35
36
37
38

39 Corresponding author:

40 Professor David L Fone

41 Institute of Primary Care & Public Health, School of Medicine, 4th Floor Neuadd

42 Merionnydd, Heath Park, Cardiff University, Cardiff, CF14 4YS, UK

43 Telephone 02920 687241, Fax 02920 687236, e-mail foned@cf.ac.uk
44
45
46
47
48
49
50
51

52 **Keywords**

53 Alcohol, Social epidemiology, multilevel modelling, Public Health
54
55
56
57
58
59
60

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

- 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
 - 8
 - 9
 - 10
 - 11
 - 12
 - 13
 - 14
 - 15
 - 16
 - 17
 - 18
 - 19
 - 20
 - 21
 - 22
 - 23
 - 24
 - 25
 - 26
 - 27
 - 28
 - 29
 - 30
 - 31
 - 32
 - 33
 - 34
 - 35
 - 36
 - 37
 - 38
 - 39
 - 40
 - 41
 - 42
 - 43
 - 44
 - 45
 - 46
 - 47
 - 48
 - 49
 - 50
 - 51
 - 52
 - 53
 - 54
 - 55
 - 56
 - 57
 - 58
 - 59
 - 60
- 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.

For peer review only

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

1
2
3 harmful alcohol consumption. However, a recent systematic review which included multilevel
4
5 studies of neighbourhood deprivation and alcohol consumption found little evidence to
6
7 support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in
8
9 a quality assessment, one study set in the West of Scotland, UK, found no significant
10
11 association between neighbourhood deprivation and drinking above guideline limits or the
12
13 number of units consumed in the past week.[14] A second study set in California, USA, found
14
15 that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males)
16
17 was significantly higher for people living in the least deprived neighbourhoods with no
18
19 significant variation with individual SES.[15]
20
21
22
23
24

25 The two other studies described an association between high neighbourhood deprivation and
26
27 high consumption.[16,17] Data from the nationally representative Third National Health and
28
29 Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood
30
31 deprivation measure at the level of the census tract was associated with heavy alcohol use,
32
33 defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01,
34
35 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A
36
37 second US study found that higher mean income and income inequality at the larger
38
39 community district level was significantly associated with a higher number of drinks per
40
41 month among drinkers.[17] Four subsequent papers reporting small studies found no
42
43 significant association between alcohol consumption and neighbourhood income,[18,19]
44
45 neighbourhood unemployment,[20] or a composite measure of relative socio-economic
46
47 disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada
48
49 found a small effect of neighbourhood deprivation on the number of drinks consumed per
50
51 week in men, but not in women.[22]
52
53
54
55
56
57
58
59
60

1
2
3 Possible explanations for these inconsistencies in neighbourhood associations found between
4 studies may result from different methods of defining excess, or harmful, consumption, with
5 some choosing definitions based on national guidelines for 'safe' consumption or units,[14]
6 number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations
7 for inconsistent neighbourhood associations may result from different measures of area
8 deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors
9 for excess alcohol consumption.[14-22]
10
11
12
13
14
15
16
17
18
19

20
21 Despite the substantial public health consequences of alcohol consumption and the possible
22 importance of neighbourhood in explaining patterns of consumption, no previous study to our
23 knowledge has investigated multilevel associations with neighbourhood deprivation which
24 distinguish between excess consumption and binge drinking as distinct categories. Little is
25 known on whether any associations vary within population groups. The aim of the present
26 study was to investigate the effect of neighbourhood deprivation with age, gender and SES on
27 (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a
28 representative sample of the adult population of Wales, UK.
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2 residential areas, post-industrial valley towns, market towns and rural, farming areas.
3
4 Respondents were linked to their neighbourhood of residence by the data owners (the Welsh
5
6 Government) and the dataset included individuals living in 1839 LSOAs, nested within the 22
7
8 unitary authorities (UA) in Wales. Each LSOA was assigned to one of five ordinal categories
9
10 of neighbourhood deprivation with equal counts of LSOAs in each quintile.
11
12
13

14 15 16 17 18 **Measures of individual SES and potential confounding variables** 19

20 The principal measure of SES defined for the analysis was the National Statistics Socio-
21
22 economic Classification (NS-SEC3) variable for the head of household. This is a measure of
23
24 occupational social class with the following categories: professional/managerial, intermediate,
25
26 routine and manual occupations, and never worked/long-term unemployed. Age was analysed
27
28 in 10-year bands by gender. We considered other available measures of SES that were
29
30 associated with alcohol consumption in the dataset as confounding variables: individual
31
32 employment status (employed, seeking work, training/student, retired, permanently sick or
33
34 disabled, at home), highest educational qualification (degree, intermediate, none), ethnicity
35
36 (White, Black and minority ethnic) and housing tenure (owner occupier, social and private
37
38 renting) (table 2).
39
40
41
42
43
44

45 Of the 60 555 respondents, 58 282 individuals living within 32 692 households completed the
46
47 questions on alcohol consumption, and 50 641 had complete covariate information recorded
48
49 in the dataset.
50
51
52
53
54
55
56
57
58
59
60

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, η_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:

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

where the linear predictor now has two components: $x_k \beta$ are the fixed effects, and $z_k b$ 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 β and the covariance matrix $\text{Var}(b)$ and we derived $p(y=k \mid b=0)$, 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

1
2
3 continuation ratio model, we defined three additional binary explanatory variables, one for
4
5 each transition between the alcohol outcome categories to indicate the level at which the
6
7 transition was occurring. The sequential modelling strategy started with the “null” four-level
8
9 variance components model, with category-specific intercepts and random effects for
10
11 households, LSOAs and UAs. The neighbourhood deprivation categorical variable was fitted
12
13 to estimate the unadjusted neighbourhood deprivation fixed effects in model 1. To allow a
14
15 better understanding of the effects of deprivation on alcohol consumption, we fitted
16
17 interactions between the neighbourhood deprivation quintiles and each additional explanatory
18
19 variable indicating the relevant binary transition. The predicted probabilities of excess
20
21 consumption and binge drinking were derived from the sum of these main effects and relevant
22
23 interaction coefficients.
24
25
26
27
28

29
30 Social class, age group, gender, the interaction between age group and gender, and the
31
32 potential confounders were then added to form model 2. The final model 3 was fitted with
33
34 cross-level interactions in separate models for neighbourhood deprivation interacting with age
35
36 group and gender, and neighbourhood deprivation with social class. Multiple imputation of
37
38 five datasets using chained equations in R software was used to account for missing
39
40 covariates.[31,32]
41
42
43
44

45
46 The magnitude of the variation between LSOAs and between UAs was estimated using the
47
48 standard deviation (SD) of their random effects, since these are measured on the same scale as
49
50 the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/-
51
52 0.67, and the differences between LSOA and between UA quartiles were computed by
53
54 1.34*SD to compare with the magnitude of the estimated fixed effects for social class.
55
56
57
58
59
60

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).

1
2
3 Table 3 finally shows the predicted probabilities of consumption for the SES categories in the
4 fully adjusted model 2. There was little variation in excess consumption with SES. The
5
6
7 descriptive analysis finding of a higher probability of binge drinking in the three higher social
8
9
10 class groups compared to the never worked/long-term unemployed category remained after
11
12 adjustment.
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

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

1
2
3 a Model 1 included fixed effects terms for neighbourhood deprivation quintiles and the
4
5 interaction with the binary transition explanatory variable for change in category of
6
7 consumption, and random effects terms for household, LSOA and unitary authority
8

9
10 b Model 2 added social class, age group, gender, age group*gender, and adjusted for
11
12 employment status, highest educational qualification, ethnicity, and housing tenure
13

14 * p<0.001
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1
2
3 The two-way cross-level interaction between neighbourhood deprivation, age group and
4 gender showed the effect of neighbourhood deprivation on the probability of excess
5 consumption and binge drinking varied significantly between age group and gender. These
6 model outputs are shown on the probability scale for ease of interpretation in figures 1 and 2.
7
8 Little evidence of a cross-level interaction in females or older age groups was found for either
9 excess consumption or binge drinking. Males had a higher probability of excess consumption
10 in less deprived neighbourhoods than females. Although the probability of binge drinking in
11 females increased with increasing deprivation quintile, the gradients were significantly
12 steeper in males. The probability of binge drinking was highest at all levels of neighbourhood
13 deprivation in males aged 25 to 34. The interaction effects suggested that males in the 35-64
14 year age groups showed the steepest increase in the probability of binge drinking associated
15 with increasing neighbourhood deprivation, while the interaction effect in the 18-24 year age
16 group suggested a weaker association of increasing binge drinking with increasing
17 deprivation. The cross-level interaction between neighbourhood deprivation and social class
18 was not significant suggesting that the association of excess consumption and binge drinking
19 with neighbourhood deprivation did not vary with SES.
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

41 Random effects variance

42 The values for the intra-class correlation coefficients (%) given in table 4 show that the
43 majority of the unexplained random variation occurred at the household level, suggesting that,
44 as expected, drinking behaviour tends to cluster more within households than within
45 neighbourhoods or within the larger-area UA. To examine the magnitude of the variation
46 between neighbourhoods in comparison to the fixed-effect estimates for SES, the SD for
47 LSOAs in model 2 = 0.156, giving the inter-quartile range of the distribution of the LSOA
48 variance = 0.21. This compares to a parameter estimate of -0.33 for the 'never worked'
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2
3 neighbourhoods than in the non-deprived. Second, the stress of living in areas of high
4
5 neighbourhood disadvantage may make men more vulnerable to psychological
6
7 distress.[34,35] This then increases the risk that alcohol is used as a coping mechanism.
8
9

10
11 Third, the structural hypothesis argues that neighbourhood social norms and institutions
12
13 define the pattern of health behaviours.[36] Greater availability of cheap alcohol measured as
14
15 higher alcohol outlet densities might influence harmful drinking rates, although the evidence
16
17 summarised in systematic reviews of both cross-sectional and longitudinal studies is
18
19 inconsistent.[37] There is some evidence that high deprivation neighbourhoods have a higher
20
21 density of alcohol outlets,[15,38,39] and this might provide a mechanism to explain higher
22
23 consumption in deprived neighbourhoods. However, two studies which found higher outlet
24
25 densities in more deprived areas found that levels of consumption were highest in less
26
27 deprived areas.[15,38] A third study found the spatial association between outlet density and
28
29 deprivation did not vary systematically, suggesting the relationship between deprivation and
30
31 outlet density may be different in different locations.[39] This deprivation-density hypothesis
32
33 could not explain the findings of higher rates of excess consumption in the least deprived
34
35 neighbourhoods in the current study. One possibility is the acceptance of social norms of
36
37 regular drinking to excess, but not episodic binge drinking, in less deprived areas compared to
38
39 a different set of social normative binge drinking behaviour in the most deprived areas.
40
41
42
43
44
45
46

47 **Strengths and limitations**

48
49 Since 2003/04, the Welsh Health Survey has been an annual source of robust population
50
51 survey data. It has the important strength of a large sampling fraction resulting in a
52
53 representative response dataset that includes around one in fifty of the socially diverse Welsh
54
55 adult population, with detailed exposure data linked to the small-area neighbourhood. The
56
57
58
59
60

1
2
3 study findings from such a comprehensive dataset should be widely generalisable. Several
4
5 limitations should be considered. The alcohol consumption outcome measure was based on a
6
7 widely used definition published by the UK Department of Health.[26] However, the
8
9 possibility of social desirability bias resulting in under-reported alcohol consumption should
10
11 be considered,[40,41] although it is not known whether under-reporting varies between
12
13 neighbourhoods. The questionnaire responses were consistent year-on-year from four
14
15 different successive samples, suggesting that responses were reliable. Non-response bias was
16
17 a possibility but the surveys had a consistently good overall response to the interviewer-led
18
19 method,[24,25]
20
21
22
23
24

25 The administratively defined census LSOA was used as a proxy for ‘neighbourhood’.
26
27 However, the direction of bias from using non-homogeneous administrative areas is towards
28
29 conservative estimates.[42,43] Therefore it is unlikely that the current study over-estimated
30
31 the associations between alcohol consumption and neighbourhood deprivation. Finally, no
32
33 inferences about causal processes can be made. Reverse cause, for example, could suggest
34
35 that binge drinking causes a decline in social position, but this explanation seems unlikely for
36
37 excess alcohol consumption in which the associations were in the opposite direction to binge
38
39 drinking. A further limitation was that the dataset did not permit investigation of the possible
40
41 mechanisms for our study findings.
42
43
44
45
46

47 In conclusion, the socio-economic patterning of excess alcohol consumption and binge
48
49 drinking was complex. The study findings have implications for enhancing public health
50
51 alcohol policy development, emphasising the importance of neighbourhood deprivation, as
52
53 measured primarily by levels of low income and unemployment, as a determinant of harmful
54
55 levels of consumption. Further longitudinal research on the spatial relationships between
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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]

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2012-002337 on 15 April 2013. Downloaded from <http://bmjopen.bmj.com/> on April 17, 2024 by guest. Protected by copyright.

COMPETING INTERESTS

None

FUNDING

This work was supported by the Office of the Chief Social Research Officer (OCSRO), Welsh Government. [grant number 081218 SAP].

The work was undertaken at The Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement, a UKCRC Public Health Research: Centre of Excellence. Funding from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council (RES-590-28-0005), Medical Research Council, the Welsh Assembly Government and the Wellcome Trust (WT087640MA), under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged.

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.

REFERENCES

- [1] Rehm J, Mathers C, Popova S, et al. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol use disorders. *Lancet* 2009;**373**:2223-33.
- [2] McAlaney J, McMahon J. Establishing rates of binge drinking in the UK : Anomalies in the data. *Alcohol Alcohol* 2006;**41**:355-57.
- [3] Smith L, Foxcroft D. *Drinking in the UK. An exploration of trends*. York: Joseph Rowntree Foundation 2009. ISBN: 978-1-85935-698-2.
- [4] Hayward R, Sharp C. *Young people, crime and anti-social behaviour: findings from the 2003 Crime and Justice Survey. Home Office Research Findings 245*. London: Home Office 2005. ISSN 1473-8406.
- [5] Richardson A, Budd T. *Home Office Research Studies 263. Alcohol, crime and disorder: a study of young adults*. London: Home Office 2003. ISBN-1-84082-961-3.
- [6] Robinson S, Harris H. *Smoking and drinking among adults, 2009. A report on the 2009 General Lifestyle Survey*. London: Office for National Statistics 2011.
- [7] Huckle T, You RQ, Casswell S. Socio-economic status predicts drinking patterns but not alcohol-related consequences independently. *Addiction* 2010;**105**:1192-202.
- [8] Kuntsche E, Rehm J, Gmel G. Characteristics of binge drinkers in Europe. *Soc Sci Med* 2004;**59**:113-27.

1
2
3 [9] Jefferis BJ, Manor O, Power C. Social gradients in binge drinking and abstaining: trends
4 in a cohort of British adults. *J Epidemiol Community Health* 2007;**61**:150-3.
5
6

7
8
9 [10] Marmot M. Inequality, deprivation and alcohol use. *Addiction* 1997;**92**:S13-S20.
10
11

12
13
14 [11] Van Oers J. Alcohol consumption, alcohol-related problems, problem drinking, and
15 socioeconomic status. *Alcohol Alcoholism* 1999;**34**:78-88.
16
17

18
19
20 [12] Hart C, Ecob R, Smith GD. People, places and coronary heart disease risk factors: a
21 multilevel analysis of the Scottish Heart Health Study archive. *Soc Sci Med* 1997;**45**:893-902.
22
23

24
25
26 [13] Karriker-Jaffe KJ. Areas of disadvantage: a systematic review of effects of area-level
27 socioeconomic status on substance use outcomes. *Drug Alcohol Rev* 2011;**30**:84-95.
28
29

30
31
32 [14] Ecob R, Macintyre S. Small area variations in health related behaviours; do these depend
33 on the behaviour itself, its measurement, or on personal characteristics? *Health Place*
34 2000;**6**:261-74.
35
36

37
38
39 [15] Pollack CE, Cubbin C, Ahn D, et al. Neighbourhood deprivation and alcohol
40 consumption: does the availability of alcohol play a role? *Int J Epidemiol* 2005;**34**:772-80.
41
42

43
44
45 [16] Stimpson JP, Ju H, Raji MA, et al. Neighborhood deprivation and health risk behaviors
46 in NHANES III. *Am J Health Behav* 2007;**31**:215-22.
47
48

49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 [17] Galea S, Ahern J, Tracy M, et al. Neighborhood income and income distribution and the
4 use of cigarettes, alcohol, and marijuana. *Am J Prev Med* 2007;**32**:S195-202.
5
6

7
8
9 [18] Cornaz S, Taffe P, Santos-Eggimann B. Life-course socioeconomic environment and
10 health risk behaviours. A multilevel small-area analysis of young-old persons in an urban
11 neighbourhood in Lausanne, Switzerland. *Health Place* 2009;**15**:273-83.
12
13

14
15
16 [19] Giskes K, Turrell G, Bentley R, et al. Individual and household-level socioeconomic
17 position is associated with harmful alcohol consumption behaviours among adults. *Aust NZ J*
18 *Publ Heal* 2011;**35**:270-7.
19
20
21
22
23

24
25
26 [20] Dzurova D, Spilkova J, Pikhart H. Social inequalities in alcohol consumption in the
27 Czech Republic: a multilevel analysis. *Health Place* 2010;**16**:590-7.
28
29
30

31
32
33 [21] Adams RJ, Howard N, Tucker G, et al. Effects of area deprivation on health risks and
34 outcomes: a multilevel cross-sectional, Australian population study. *Int J Public Health*
35 2009;**54**:183-92.
36
37
38
39

40
41
42 [22] Matheson FI, White HL, Moineddin R, et al. Drinking in context: the influence of gender
43 and neighbourhood deprivation on alcohol consumption. *J Epidemiol Community Health*
44 2012;**66**:e4. Epub 2011 Feb 17.
45
46
47
48

49
50
51 [23] Doyle-Francis M, Sadler K, Kingdon A, et al. *Welsh Health Survey User Guide*. National
52 Centre for Social Research, Welsh Assembly Government 2011.
53
54
55
56
57
58
59
60

1
2
3 <http://wales.gov.uk/docs/statistics/2011/110127surveyguideen.pdf> (accessed 28 February
4
5 2013).

6
7
8
9 [24] McGee A, Jotangia D, Prescott A, et al. *Welsh Health Survey - Year One Technical*
10
11 *Report*. National Centre for Social Research 2005.

12
13 <http://wales.gov.uk/docs/statistics/2005/050701healthsurvey0304techen.pdf> (accessed 28
14
15 February 2013).

16
17
18
19 [25] Fuller E, Heeks F. *Welsh Health Survey 2007 Technical Report*. National Centre for
20
21 Social Research 2005.

22
23 [http://wales.gov.uk/topics/statistics/publications/publication-](http://wales.gov.uk/topics/statistics/publications/publication-archive/healthsurvey2007tech/?lang=en)
24
25 [archive/healthsurvey2007tech/?lang=en](http://wales.gov.uk/topics/statistics/publications/publication-archive/healthsurvey2007tech/?lang=en) (accessed 28 February 2013).

26
27
28
29 [26] Department of Health, Home Office, Department for Education and Skills and
30
31 Department for Culture, Media and Sport. *Safe. Sensible. Social. The next steps in the*
32
33 *National Alcohol Strategy*. London: DH Publications 2007:3.

34
35 [http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital-asset/dh_075219.pdf)
36
37 [asset/dh_075219.pdf](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital-asset/dh_075219.pdf) (accessed 28 February 2013).

38
39
40
41 [27] Welsh Assembly Government. *Welsh Index of Multiple Deprivation 2005: Technical*
42
43 *report*

44
45
46 <http://wales.gov.uk/cisd/publications/statspubs/wimd2005technical/en.pdf?lang=en> (accessed
47
48 28 February 2013).

49
50
51 [28] Office for National Statistics (2011). *Super Output Areas (SOAs)*.

1
2
3 [http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-](http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-areas--soas-/index.html)
4 [areas--soas-/index.html](http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-areas--soas-/index.html) (accessed 28 February 2013).
5
6
7

8
9
10 [29] Townsend P, Phillimore P, Beattie A. *Health and deprivation: inequality and the North*.
11 London: Routledge, 1988.
12

13
14
15
16 [30] Agresti A. *An introduction to categorical data analysis*. 2nd ed. Hoboken, New Jersey:
17 John Wiley & Sons, Inc 2007.
18
19

20
21
22
23 [31] White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues
24 and guidance for practice. *Stat Med* 2010;**30**:377-99.
25
26

27
28
29
30 [32] van Buuren S, Groothuis-Oudshoorn K. mice: Multivariate Imputation by Chained
31 Equations in R. *Journal of Statistical Software* 2011;**45**:1-67.
32
33

34
35
36 [33] Boardman JD, Finch BK, Ellison CG, et al. Neighborhood disadvantage, stress, and drug
37 use among adults. *J Health Soc Behav* 2001;**42**:151-65.
38
39

40
41
42 [34] Hill TD, Ross CE, Angel RJ. Neighborhood disorder, psychophysiological distress, and
43 health. *J Health Soc Behav* 2005;**46**:170-86.
44
45

46
47
48 [35] Elliott M. The stress process in neighbourhood context. *Health Place* 2000;**6**:287-99.
49
50

51
52
53
54 [36] Morland K, Wing S, Diez Roux A, et al. Neighborhood characteristics associated with
55 the location of food stores and food service places. *Am J Prev Med* 2002;**22**:23-9.
56
57
58
59
60

1
2
3
4
5 [37] Popova S, Giesbrecht N, Bekmuradov D, et al. Hours and days of sale and density of
6 alcohol outlets: Impacts on alcohol consumption and damage: A systematic review. *Alcohol*
7
8
9
10 *Alcohol* 2009;**44**:500-16.

11
12
13
14 [38] Huckle T, Huakau J, Sweetsur P, et al. Density of alcohol outlets and teenage drinking:
15
16 Living in an alcogenic environment is associated with higher consumption in a metropolitan
17
18 setting. *Addiction* 2008;**103**:1614-21.

19
20
21
22
23 [39] Ellaway A, Macdonald L, Forsyth A, et al. The socio-spatial distribution of alcohol
24
25 outlets in Glasgow city. *Health Place* 2010;**16**:167-72.

26
27
28 [40] Embree BG, Whitehead PC. Validity and reliability of self-reported drinking behavior:
29
30 dealing with the problem of response bias. *J Stud Alcohol* 1993;**54**:334-44.

31
32
33
34
35 [41] Stockwell T, Donath S, Cooper-Stanbury M, et al. Under-reporting of alcohol
36
37 consumption in household surveys: a comparison of quantity-frequency, graduated-frequency
38
39 and recent recall. *Addiction* 2004;**99**:1024-33.

40
41
42
43
44 [42] Blakely TA, Woodward AJ. Ecological effects in multi-level studies. *J Epidemiol*
45
46 *Community Health* 2000;**54**:367-74.

47
48
49
50
51 [43] Stafford M, Duke-Williams O, Shelton N. Small area inequalities in health: Are we
52
53 underestimating them? *Soc Sci Med* 2008;**67**:891-9.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

[44] Fone DL, Dunstan FD, Webster C, et al. Change in alcohol outlet density and alcohol-related harm to population health (CHALICE). *BMC Public Health* 2012;**12**:428

For peer review only

BMJ Open: first published as 10.1136/bmjopen-2012-002337 on 15 April 2013. Downloaded from <http://bmjopen.bmj.com/> on April 17, 2024 by guest. Protected by copyright.

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

For peer review only

1
2
3
4
5
6
7 **Socioeconomic patterning of excess alcohol consumption and**
8
9 **binge drinking: a cross-sectional study of multilevel associations**
10
11 **with neighbourhood deprivation**
12
13

14
15
16 David L Fone¹ MD

17 Daniel M Farewell¹ PhD

18 James White² PhD

19 Ronan A Lyons³ MD

20 Frank D Dunstan¹ DPhil

21
22
23
24
25
26
27 1. Institute of Primary Care & Public Health, School of Medicine, Heath Park, Cardiff

28 University, Cardiff, CF14 4YS, UK

29
30 2. Centre for the Development and Evaluation of Complex Public Health Interventions,

31 School of Medicine, Cardiff University, Heath Park, Cardiff, CF14 4YS, UK

32
33 3. College of Medicine, Swansea University, Swansea SA2 8PP, UK

34
35
36
37
38 Corresponding author:

39 Professor David L Fone

40 Institute of Primary Care & Public Health, School of Medicine, 4th Floor Neuadd

41 Merionnydd, Heath Park, Cardiff University, Cardiff, CF14 4YS, UK

42 Telephone 02920 687241, Fax 02920 687236, e-mail foned@cf.ac.uk

43
44
45
46
47
48
49 **Keywords**

50 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). 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.

Formatted: Line spacing: Double

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 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.

For peer review only

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

1
2
3
4
5
6
7 harmful alcohol consumption. However, a recent systematic review which included multilevel
8
9 studies of neighbourhood deprivation and alcohol consumption found little evidence to
10
11 support this hypothesis.[13] Of the four multilevel studies which were classified as rigorous in
12
13 a quality assessment, one study set in the West of Scotland, UK, found no significant
14
15 association between neighbourhood deprivation and drinking above guideline limits or the
16
17 number of units consumed in the past week.[14] A second study set in California, USA, found
18
19 that the odds of heavy alcohol consumption (>7 drinks/week for females and >14 for males)
20
21 was significantly higher for people living in the least deprived neighbourhoods with no
22
23 significant variation with individual SES.[15]

24
25
26 The two other studies described an association between high neighbourhood deprivation and
27
28 high consumption.[16,17] Data from the nationally representative Third National Health and
29
30 Nutrition Examination Survey (NHANES III, USA) found that a composite neighbourhood
31
32 deprivation measure at the level of the census tract was associated with heavy alcohol use,
33
34 defined as consuming five or more drinks almost every day (odds ratio 1.18; 95% CI: 1.01,
35
36 1.38), but it was not reported whether this association varied with age, gender or SES.[16] A
37
38 second US study found that higher mean income and income inequality at the larger
39
40 community district level was significantly associated with a higher number of drinks per
41
42 month among drinkers.[17] Four subsequent papers reporting small studies found no
43
44 significant association between alcohol consumption and neighbourhood income,[18,19]
45
46 neighbourhood unemployment,[20] or a composite measure of relative socio-economic
47
48 disadvantage,[21] while a further large-scale study of over 90 000 subjects set in Canada
49
50 found a small effect of neighbourhood deprivation on the number of drinks consumed per
51
52 week in men, but not in women.[22]

1
2
3
4
5
6
7 Possible explanations for these inconsistencies in neighbourhood associations found between
8 studies may result from different methods of defining excess, or harmful, consumption, with
9 some choosing definitions based on national guidelines for 'safe' consumption or units,[14]
10 number of drinks,[15-19,21,22] or frequency of consumption.[19,20] Additional explanations
11
12 for inconsistent neighbourhood associations may result from different measures of area
13 deprivation, sizes of neighbourhood, and adjustment for different individual-level risk factors
14
15 for excess alcohol consumption.[14-22]
16
17
18
19
20

21
22 Despite the substantial public health consequences of alcohol consumption and the possible
23 importance of neighbourhood in explaining patterns of consumption, no previous study to our
24 knowledge has investigated multilevel associations with neighbourhood deprivation which
25 distinguish between excess consumption and binge drinking as distinct categories. Little is
26 known on whether any associations vary within population groups. The aim of the present
27 study was to investigate the effect of neighbourhood deprivation with age, gender and SES on
28
29 (1) excess alcohol consumption above guideline limits, and (2) binge drinking, in a
30
31 representative sample of the adult population of Wales, UK.
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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, η_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:

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

where the linear predictor now has two components: $x_k \beta$ are the fixed effects, and $z_k b$ 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 β and the covariance matrix $\text{Var}(b)$ and we derived $p(y=k \mid b=0)$, 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](#)

1
2
3
4
5
6
7 continuation ratio model, we first re-express this ordinal outcome in terms of defined three
8 additional -binary explanatory variables-, one for each -yes/no- transitions between the alcohol
9 outcome categories to indicate the level at which the transition was occurring non-drinking
10 and drinking within guidelines,
11 between drinking within guidelines and exceeding guidelines, and between exceeding
12 guidelines and binge drinking. This necessitates the inclusion of an additional explanatory
13 variable indicating which transition is being referred to. The advantage of this transformation
14 is that standard software for logistic regression and its extensions to random effects
15 models can be used to analyse the ordinal data.
16
17
18
19
20
21
22
23

24
25
26 The sequential modelling strategy started with the “null” four-level variance components
27 model, with category-specific intercepts and random effects for households, LSOAs and UAs.

28
29 The neighbourhood deprivation-WIMD2005 categorical variable was fitted to estimate the
30 unadjusted neighbourhood deprivation fixed effects in model 1. To allow increased flexibility
31 in a better understanding of the effects of deprivation on alcohol consumption, we fitted
32 interactions between the neighbourhood deprivation quintiles and the each additional
33 explanatory variable indicating the relevant binary transition. in question were included in the
34 continuation ratio models to allow the use of completely flexible models for our ordinal
35 data To allow increased flexibility in understanding the effects of deprivation on alcohol
36 consumption, interactions between the change in alcohol consumption category and
37 deprivation quintile were included in the continuation ratio models. The predicted
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
probabilities of excess consumption and binge drinking we are derived from the sum of these
51
52
53
54
55
56
57
58
59
60
additive main effects s and relevant interaction coefficients.

1
2
3
4
5
6
7 Social class, age group, gender, the interaction between age group and gender, and the
8 potential confounders were then added to form model 2. The final model 3 was fitted with
9 cross-level interactions in separate models for [neighbourhood deprivation WIMD2005](#)
10 interacting with age group and gender, and [neighbourhood deprivation WIMD2005](#) with social
11 class. Multiple imputation of five datasets using chained equations in R software was used to
12 account for missing covariates.[31,32]
13
14
15
16
17
18
19
20
21

22 The magnitude of the variation between LSOAs and between UAs was estimated using the
23 standard deviation (SD) of their random effects, since these are measured on the same scale as
24 the fixed effects for observed covariates. The quartiles of a standard normal variable lie at +/-
25 0.67, and the differences between LSOA and between UA quartiles were computed by
26 1.34*SD to compare with the magnitude of the estimated fixed effects for social class.
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

43 RESULTS

44 Descriptive analysis

45 Overall, 22 218 (38.1%) of the total 58 282 respondents reported their levels of alcohol
46 consumption as 'none or never drinks', 16 059 (27.6%) reported 'within guidelines', 9664
47 (16.6%) reported 'excess consumption but less than binge' and 10 341 (17.7%) reported
48 'binge' drinking. Both excess consumption and particularly binge drinking were higher in
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7 males than females. Excess consumption was highest in the 35-64 year age groups and binge
8 drinking was highest in 18-34 year olds, declining with increasing age (table 2). The 'never
9 worked and long-term unemployed' group and respondents with no educational qualifications
10 showed substantially lower levels of both excess consumption and binge drinking than the
11 three higher social class groups and those with some educational achievement. For
12 employment status, the economically active who were employed or seeking work had higher
13 levels of excess and binge consumption than economically inactive respondents. The
14 proportion of respondents drinking to excess decreased with increasing neighbourhood
15 deprivation but binge drinking showed the opposite pattern of increasing with higher
16 deprivation (table 2).
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

		Excess consumption, less than binge	%	Binge	%	
Gender*	Female	4702	15.0	3482	11.1	31261
	Male	4962	18.4	6859	25.1	31261
Age group**	18-24	1001	14.5	2041	29.1	7029
	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
Social class:**	85+	32	2.7	19	1.6	1189
	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	18.1	42222
	Black and minority ethnic	108	8.8	100	8.2	1222
<u>Neighbourhood deprivation WIMD2005 quintile</u> ^{**} <u>Deprivation quintile</u>	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. 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 including 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). 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).

1
2
3
4
5
6
7
8
9 Table 3 also finally shows the predicted probabilities of consumption for the social classSES
10 categories in the fully adjusted model 2. There was little variation in excess consumption with
11 social classSES. The descriptive analysis finding of a higher probability of binge drinking in
12
13
14 the three higher social class groups compared to the never worked/long-term unemployed
15
16 category remained after adjustment.
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

19

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 deprived 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.

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

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

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.~~

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

For peer review only

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 ~~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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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,^[15,348,359] 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

1
2
3
4
5
6
7 adult population, with detailed exposure data linked to the small-area neighbourhood. The
8 study findings from such a comprehensive dataset should be widely generalisable. Several
9 limitations should be considered. The alcohol consumption outcome measure was based on a
10 widely used definition published by the UK Department of Health.[26] However, the
11 possibility of social desirability bias resulting in under-reported alcohol consumption should
12 be considered,[[3640,3741](#)] although it is not known whether under-reporting varies between
13 neighbourhoods. The questionnaire responses were consistent year-on-year from four
14 different successive samples, suggesting that responses were reliable. Non-response bias was
15 a possibility but the surveys had a consistently good overall response to the interviewer-led
16 method,[24,25]

17
18
19
20
21
22
23
24
25
26
27
28 The administratively defined census LSOA was used as a proxy for 'neighbourhood'.
29 However, the direction of bias from using non-homogeneous administrative areas is towards
30 conservative estimates.[[3842,439](#)] Therefore it is unlikely that the current study over-
31 estimated the associations between alcohol consumption and neighbourhood deprivation.
32
33 Finally, no inferences about causal processes can be made. Reverse cause, for example, could
34 suggest that binge drinking causes a decline in social position, but this explanation seems
35 unlikely for excess alcohol consumption in which the associations were in the opposite
36 direction to binge drinking. A further limitation was that the dataset did not permit
37 investigation of the possible mechanisms for our study findings.
38
39
40
41
42
43
44
45
46

47 In conclusion, the socio-economic patterning of excess alcohol consumption and binge
48 drinking was complex. The study findings have implications for enhancing public health
49 alcohol policy development, emphasising the importance of neighbourhood deprivation, as
50 measured primarily by levels of low income and unemployment, as a determinant of harmful
51
52
53
54

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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]

For peer review only

COMPETING INTERESTS

None

FUNDING

This work was supported by the Office of the Chief Social Research Officer (OCSRO), Welsh Government. [grant number 081218 SAP].

The work was undertaken at The Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement, a UKCRC Public Health Research: Centre of Excellence. Funding from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council (RES-590-28-0005), Medical Research Council, the Welsh Assembly Government and the Wellcome Trust (WT087640MA), under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged.

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.

REFERENCES

- [1] Rehm J, Mathers C, Popova S, et al. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol use disorders. *Lancet* 2009;**373**:2223-33.
- [2] McAlaney J, McMahon J. Establishing rates of binge drinking in the UK : Anomalies in the data. *Alcohol Alcohol* 2006;**41**:355-57.
- [3] Smith L, Foxcroft D. *Drinking in the UK. An exploration of trends*. York: Joseph Rowntree Foundation 2009. ISBN: 978-1-85935-698-2.
- [4] Hayward R, Sharp C. *Young people, crime and anti-social behaviour: findings from the 2003 Crime and Justice Survey. Home Office Research Findings 245*. London: Home Office 2005. ISSN 1473-8406.
- [5] Richardson A, Budd T. *Home Office Research Studies 263. Alcohol, crime and disorder: a study of young adults*. London: Home Office 2003. ISBN-1-84082-961-3.
- [6] Robinson S, Harris H. *Smoking and drinking among adults, 2009. A report on the 2009 General Lifestyle Survey*. London: Office for National Statistics 2011.
- [7] Huckle T, You RQ, Casswell S. Socio-economic status predicts drinking patterns but not alcohol-related consequences independently. *Addiction* 2010;**105**:1192-202.
- [8] Kuntsche E, Rehm J, Gmel G. Characteristics of binge drinkers in Europe. *Soc Sci Med* 2004;**59**:113-27.

1
2
3
4
5
6 [9] Jefferis BJ, Manor O, Power C. Social gradients in binge drinking and abstaining: trends
7 in a cohort of British adults. *J Epidemiol Community Health* 2007;**61**:150-3.
8
9

10
11
12 [10] Marmot M. Inequality, deprivation and alcohol use. *Addiction* 1997;**92**:S13-S20.
13
14

15
16 [11] Van Oers J. Alcohol consumption, alcohol-related problems, problem drinking, and
17 socioeconomic status. *Alcohol Alcoholism* 1999;**34**:78-88.
18
19

20
21
22 [12] Hart C, Ecob R, Smith GD. People, places and coronary heart disease risk factors: a
23 multilevel analysis of the Scottish Heart Health Study archive. *Soc Sci Med* 1997;**45**:893-902.
24
25

26
27
28 [13] Karriker-Jaffe KJ. Areas of disadvantage: a systematic review of effects of area-level
29 socioeconomic status on substance use outcomes. *Drug Alcohol Rev* 2011;**30**:84-95.
30
31

32
33 [14] Ecob R, Macintyre S. Small area variations in health related behaviours; do these depend
34 on the behaviour itself, its measurement, or on personal characteristics? *Health Place*
35 2000;**6**:261-74.
36
37

38
39
40 [15] Pollack CE, Cubbin C, Ahn D, et al. Neighbourhood deprivation and alcohol
41 consumption: does the availability of alcohol play a role? *Int J Epidemiol* 2005;**34**:772-80.
42
43

44
45
46 [16] Stimpson JP, Ju H, Raji MA, et al. Neighborhood deprivation and health risk behaviors
47 in NHANES III. *Am J Health Behav* 2007;**31**:215-22.
48
49

1
2
3
4
5
6
7 [17] Galea S, Ahern J, Tracy M, et al. Neighborhood income and income distribution and the
8 use of cigarettes, alcohol, and marijuana. *Am J Prev Med* 2007;**32**:S195-202.
9

10
11
12 [18] Cornaz S, Taffé P, Santos-Eggimann B. Life-course socioeconomic environment and
13 health risk behaviours. A multilevel small-area analysis of young-old persons in an urban
14 neighbourhood in Lausanne, Switzerland. *Health Place* 2009;**15**:273-83.
15
16
17

18
19
20 [19] Giskes K, Turrell G, Bentley R, et al. Individual and household-level socioeconomic
21 position is associated with harmful alcohol consumption behaviours among adults. *Aust NZ J*
22 *Publ Heal* 2011;**35**:270-7.
23
24
25

26
27
28 [20] Dzurova D, Spilkova J, Pikhart H. Social inequalities in alcohol consumption in the
29 Czech Republic: a multilevel analysis. *Health Place* 2010;**16**:590-7.
30
31

32
33
34 [21] Adams RJ, Howard N, Tucker G, et al. Effects of area deprivation on health risks and
35 outcomes: a multilevel cross-sectional, Australian population study. *Int J Public Health*
36 2009;**54**:183-92.
37
38
39

40
41 [22] Matheson FI, White HL, Moineddin R, et al. Drinking in context: the influence of gender
42 and neighbourhood deprivation on alcohol consumption. *J Epidemiol Community Health*
43 2012;**66**:e4. Epub 2011 Feb 17.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

[23] Doyle-Francis M, Sadler K, Kingdon A, et al. *Welsh Health Survey User Guide*. National Centre for Social Research, Welsh Assembly Government 2011.

<http://wales.gov.uk/docs/statistics/2011/110127surveyguideen.pdf>

<http://wales.gov.uk/docs/statistics/2011/110127surveyguideen.pdf> (accessed ~~15 January~~ 28 February 2013).

[24] McGee A, Jotangia D, Prescott A, et al. *Welsh Health Survey - Year One Technical Report*. National Centre for Social Research 2005.

<http://wales.gov.uk/docs/statistics/2005/050701healthsurvey0304techen.pdf> (accessed ~~28 February~~ 15 January 2013).

[25] Fuller E, Heeks F. *Welsh Health Survey 2007 Technical Report*. National Centre for Social Research 2005.

<http://wales.gov.uk/topics/statistics/publications/publication-archive/healthsurvey2007tech/?lang=en> (accessed ~~28 February~~ 15 January 2013).

[26] Department of Health, Home Office, Department for Education and Skills and Department for Culture, Media and Sport. *Safe. Sensible. Social. The next steps in the National Alcohol Strategy*. London: DH Publications 2007:3.

http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_075219.pdf (accessed ~~28 February~~ 15 January 2013).

[27] Welsh Assembly Government. *Welsh Index of Multiple Deprivation 2005: Technical report*

Field Code Changed

1
2
3
4
5
6
7 <http://wales.gov.uk/cisd/publications/statspubs/wimd2005technical/en.pdf?lang=en> (accessed

8 [28 February 15 January](#) 2013).

9
10 [28] Office for National Statistics (2011). *Super Output Areas (SOAs)*.

11 [12 \[areas--soas-/index.html\]\(#\) \(accessed \[28 February 15 January\]\(#\) 2013\).](http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/census/super-output-</p></div><div data-bbox=)

Formatted: Font: 12 pt

13
14
15
16
17
18 [29] Townsend P, Phillimore P, Beattie A. *Health and deprivation: inequality and the North*.

19 London: Routledge, 1988.

20
21
22
23 [30] Agresti A. *An introduction to categorical data analysis*. 2nd ed. Hoboken, New Jersey:

24 John Wiley & Sons, Inc 2007.

25
26
27
28 [31] White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues

29 and guidance for practice. *Stat Med* 2010;**30**:377-99.

30
31
32
33 [32] van Buuren S, Groothuis-Oudshoorn K. mice: Multivariate Imputation by Chained

34 Equations in R. *Journal of Statistical Software* 2011;**45**:1-67.

35
36
37
38
39
40 [33] Boardman JD, Finch BK, Ellison CG, et al. Neighborhood disadvantage, stress, and drug

41 [use among adults](#). *J Health Soc Behav* 2001;**42**:151-65.

Formatted: Font: Italic

Formatted: Font: Bold

42
43
44
45 [34] Hill TD, Ross CE, Angel RJ. Neighborhood disorder, psychophysiological distress, and

46 [health](#). *J Health Soc Behav* 2005;**46**:170-86.

47
48
49
50 [35] Elliott M. The stress process in neighbourhood context. *Health Place* 2000;**6**:287-99.

Formatted: Font: Italic

Formatted: Font: Bold

[36] Morland K, Wing S, Diez Roux A, et al. Neighborhood characteristics associated with the location of food stores and food service places. *Am J Prev Med* 2002;**22**:23-9.

Formatted: Font: Italic

Formatted: Font: Bold

[337] Popova S, Giesbrecht N, Bekmuradov D, et al. Hours and days of sale and density of alcohol outlets: Impacts on alcohol consumption and damage: A systematic review. *Alcohol Alcohol* 2009;**44**:500-16.

Formatted: English (U.K.)

[384] Huckle T, Huakau J, Sweetsur P, et al. Density of alcohol outlets and teenage drinking: Living in an alcogenic environment is associated with higher consumption in a metropolitan setting. *Addiction* 2008;**103**:1614-21.

[395] Ellaway A, Macdonald L, Forsyth A, et al. The socio-spatial distribution of alcohol outlets in Glasgow city. *Health Place* 2010;**16**:167-72.

[4036] Embree BG, Whitehead PC. Validity and reliability of self-reported drinking behavior: dealing with the problem of response bias. *J Stud Alcohol* 1993;**54**:334-44.

[4137] Stockwell T, Donath S, Cooper-Stanbury M, et al. Under-reporting of alcohol consumption in household surveys: a comparison of quantity-frequency, graduated-frequency and recent recall. *Addiction* 2004;**99**:1024-33.

[4238] Blakely TA, Woodward AJ. Ecological effects in multi-level studies. *J Epidemiol Community Health* 2000;**54**:367-74.

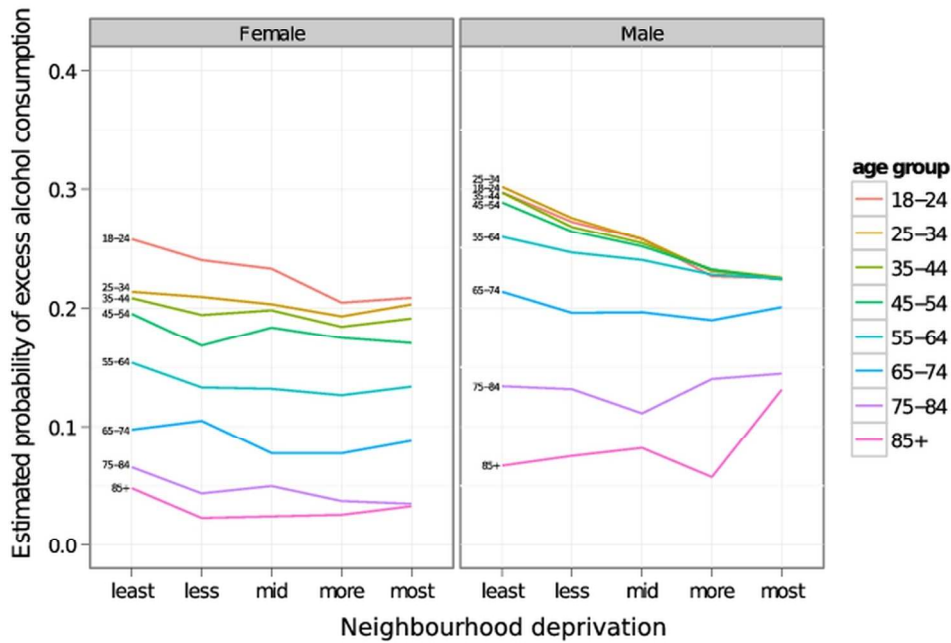
1
2
3
4
5
6
7 | [4339] Stafford M, Duke-Williams O, Shelton N. Small area inequalities in health: Are we
8 underestimating them? *Soc Sci Med* 2008;**67**:891-9.
9

10
11
12 | [440] Fone DL, Dunstan FD, Webster C, et al. Change in alcohol outlet density and alcohol-
13 related harm to population health (CHALICE). *BMC Public Health* 2012;**12**:428
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7 **LIST OF TITLES FOR FIGURES**
8
9

10 Figure 1 Estimated probabilities of excess alcohol consumption by age group and gender
11 within neighbourhood deprivation quintiles
12
13

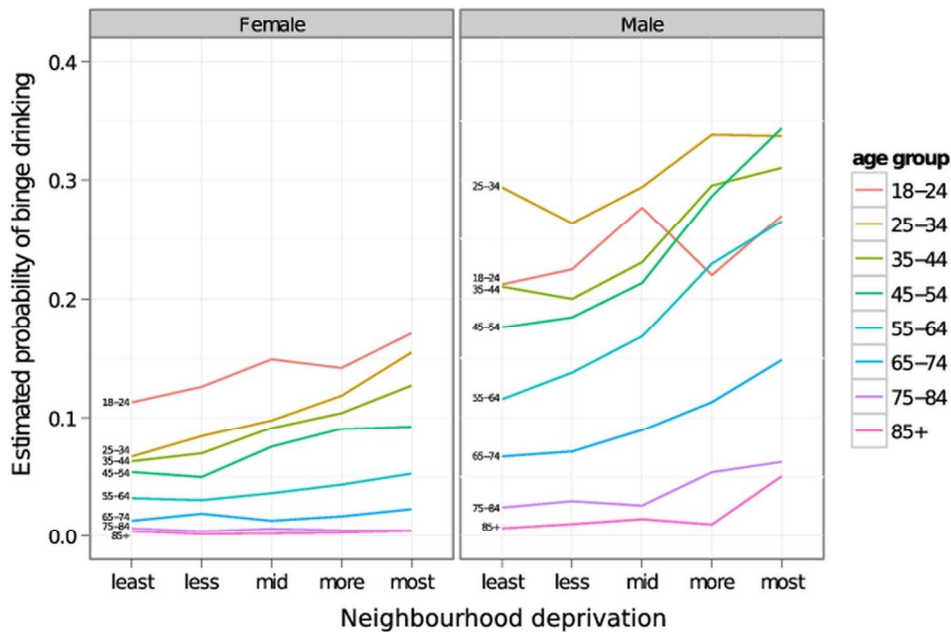
14
15
16 Figure 2 Estimated probabilities of binge drinking by age group and gender within
17 neighbourhood deprivation quintiles
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Estimated probabilities of excess alcohol consumption by age group and gender within neighbourhood deprivation quintiles
 125x90mm (300 x 300 DPI)

ew only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



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

Review only

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.