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ABSTRACT

Introduction: Many neighbourhood characteristics may constrain or enable smoking. This study investigated whether the neighbourhood tobacco retail environment was associated with individual-level smoking and cessation in Scottish adults, and whether inequalities in smoking status were related to tobacco retailing.

Methods: Tobacco outlet density measures were developed for neighbourhoods across Scotland using the September 2012 Scottish Tobacco Retailers Register. The outlet data were cleaned and geocoded (n=10,161) using a Geographic Information System. Kernel density estimation (KDE) was used to calculate an outlet density measure for each postcode. The KDE measures were then appended to data on individuals included in the 2008-11 Scottish Health Surveys (n = 28,751 adults aged >=16), via their postcode. Two-level logistic regression models examined whether neighbourhood density of tobacco retailing was associated with current smoking status and smoking cessation and whether there were differences in the relationship between household income and smoking status, by tobacco outlet density.

Results: After adjustment for individual- and area-level confounders, compared to residents of areas with the lowest outlet densities, those living in areas with the highest outlet densities had a 6% higher chance of being a current smoker, and a 5% lower chance of being an ex-smoker. There was little evidence to suggest that inequalities in either current smoking or cessation were narrower in areas with lower availability of tobacco retailing.

Conclusions: The findings suggest that residents of environments with a greater availability of tobacco outlets are more likely to start and/or sustain smoking, and less likely to quit.

INTRODUCTION

It is increasingly recognised that local geographical context is important in understanding the prevalence of, and inequalities in, smoking,[1-3] as well as the efficacy of tobacco control interventions.[4,5] Neighbourhood-level characteristics such as local social norms, levels of community networks and social capital, and perceptions of crime and disorder can enable or constrain a multitude of health behaviours including the propensity to smoke.[1] Further, place-based constructs may help to explain how socio-economic inequalities in health are created, mediated and maintained. Attention to identifying and understanding these geographical processes is important as it offers significant policy opportunities for reducing the prevalence of smoking and tobacco-related inequalities.

One feature of local context that can affect individual-level smoking behaviours is the neighbourhood availability of tobacco products, particularly the density of tobacco retailers.[6-11] Greater geographical access is likely to enhance the ability to procure tobacco and potentially creates a more competitive local market reducing the price of tobacco products, resulting in higher levels of consumption, and undermining smoking cessation attempts.[1,12] Further, in countries such as the UK, advertising in retail outlets is the primary form of tobacco promotion, particularly when products are positioned in high visibility locations. The visual cues provided by point-of-sale advertising may encourage the purchasing of tobacco products and smoking.[13] The increased availability and heightened visibility of tobacco products are likely to lead to smoking prevalence being perceived as higher and contribute to the local normalisation of smoking.

Most work considering associations between tobacco outlet density and smoking behaviour has taken place in the US and other non-European settings.[9,10] Studies in the US have

tended to find greater neighbourhood availability of tobacco retailing to be associated with higher propensity to smoke,[8] or lower likelihood of continuous abstinence from smoking.[14] A study in New Zealand found that adults residing in the quartile of neighbourhoods with the greatest access to tobacco retailers had an approximately 20% higher odds of being a smoker than those living in the least accessible quartile.[11] Some of this work has found associations to be stronger amongst socially disadvantaged groups or areas.[8,15] The few studies undertaken in Europe have produced mixed results. A study in Finland found that residing within walking distance of a tobacco retailer was associated with a lower likelihood of smoking cessation among males who were moderate or heavy smokers.[16] However, work in two English cities found that sustained quitting was unrelated to the residential proximity to tobacco retailing.[17] Whilst few studies have examined adult smoking, there has been far more attention on the association between the configuration of tobacco retailing around schools and youth smoking. Most studies have tended to note a greater density of tobacco outlets in the vicinity of schools to be associated with a higher prevalence of smoking among students.[18-21] Other work on youth smoking has noted positive associations between overall residential outlet density and adolescent smoking behaviour.[10]

In Scotland there is little evidence examining the association between neighbourhood tobacco retailing and local smoking. The only study to date found that adolescents living in the areas of highest density of retailers were more likely to report being a current smoker or having ever smoked.[22] There is a need for further work in this area because around 1/4 of Scottish adults continue to smoke (compared to 1/5 in England).[23] Each year in Scotland, smoking is implicated in around 56,000 hospital admissions and 13,000 deaths (one in five of all deaths),[24] and the treatment of smoking-related illnesses is

estimated to cost over £300 million.[24] Further, there is a significant socio-economic gradient in the prevalence of smoking. In 2012, 36% of adults in the most deprived of areas of Scotland compared to 10% in the least deprived fifth of areas were smokers.[25] Historically, Scotland has been amongst the countries with the highest rates of lung cancer in the world (although more recently some Eastern European countries have higher mortality rates).[26] The recent establishment (2011) of a national-level register of tobacco retailers offers a unique opportunity to use purposively collected tobacco outlet data to examine the relationship between outlet density and smoking behaviour at the national-level. Across Scotland, there is a strong relationship between the density of tobacco retailing and area-level social disadvantage, with greater availability in the most deprived neighbourhoods.[22]

The current study is the first to investigate whether tobacco outlet density in neighbourhoods across Scotland is associated with individual-level smoking and ex-smoking patterns in adults. We anticipate smoking prevalence to be highest, and levels of ex-smoking to be lowest, in the highest outlet density areas. Further, we assess whether associations between smoking/ex-smoking and the tobacco retail environment vary across income groups. These questions are important because they may offer options for understanding and addressing social and geographical inequalities in health. Lower socio-economic groups have been shown to be more reliant on their local environment, partly due to fewer assets to afford public or private transport.[27] Therefore we anticipate that associations between smoking/ex-smoking and the tobacco retail environment to be most prominent for the lowest income groups living in areas with the highest tobacco outlet density.

METHODS

Measures of area-level tobacco outlet density were constructed and appended to respondents included in the Scottish Health Surveys between 2008 and 2011. The survey is designed to document trends in the nation's health[28] and detailed survey methodology is described elsewhere.[29] In short, a two-stage clustered sample design was used to collect nationwide data from individuals living in private households selected using a two-stage stratified probability sampling design with datazones (n=6,505 across Scotland) selected at the first stage and addresses at the second. Between 2008 and 2011 the survey was carried out annually providing a large study sample and enabling population subgroup analyses. We examine associations between individual-level smoking, as well as ex-smoking, and the tobacco retail environment. Analyses accounted for sample stratification. Survey non-response was accounted for by the application of sample weights. All analyses were carried out in Stata/IC 12.1.[30]

Measures

Individual-level smoking outcomes

All individual-level smoking measures were derived from the Scottish Health Survey Series. Two binary (yes/no) outcome measures (based on responses to a series of smoking-related questions) categorising each respondent into a 'current smoker' ("Do you smoke cigarettes at all nowadays?") or 'ex-smoker' ("Did you smoke regularly, that is at least one cigarette a day, or did you smoke them occasionally") were selected.

Covariates

The Scottish Health Survey includes a range of established individual (sex, age, ethnicity, education), household (equivalised household income) and area-level covariates

(urban/rural status) known to be associated with tobacco consumption.[11,31] To provide sufficient numbers for subsequent analyses, socio-economic status was measured as tertiles of equivalised household income group: low (<£16,347), medium (£16,347-£31,799), high >£31,799). We assumed a causal relationship between tobacco outlet density and area-level socio-economic deprivation and therefore we did not adjust the analyses for neighbourhood deprivation.

Tobacco outlet density

The tobacco outlet density measures were developed in four steps. First, addresses and postcodes of all premises registered to sell tobacco were obtained from the Scottish Tobacco Retailers Register in September 2012.[32] The data were cleaned to remove all duplicates, and postcodes were added where these were missing. Second, the national-level outlet data were verified by visiting four purposively selected communities (defined as secondary school catchment areas). The communities were chosen to include two large urban areas, a medium sized town, a rural area, as well as varying levels of social disadvantage. Every street in the four communities was traversed to manually record all outlets. A very close match was found between the tobacco register data and the information we collected in the field. Third, the locations of 10,161 outlets were geocoded using ArcMap 10.1 Geographic Information System (GIS) software [33]. It was not possible to geocode 34 outlets and these were removed from the analysis. Fourth, kernel density estimation (KDE) was used to calculate an outlet density measure for each postcode in Scotland. A detailed description of the development of the outlet density measures can be found elsewhere.[22,34] In brief, the KDE technique assesses the presence of, and distance to, outlets in and surrounding 100 x 100 grid cells covering all of Scotland. Search radii around

each cell can be varied, and we tested 400m, 800m, and 1,000m, representing plausible walking distances to an outlet. Outlets closest to the middle of each grid cell receive greater weighting than those near to the edge of the search area. The result is a proximity-weighted estimate of the density of tobacco outlets per km^2 for each postcode in Scotland (n = 152,400). This approach has advantages over standard measures (e.g. the number of outlets per area), because the measure is not subject to possible misclassification bias caused by arbitrarily-defined boundaries (i.e. the influence of retailers located in adjoining postcodes is included). We report results for the 800m buffer, equivalent to a 10-minute walk for adults;[35] using other buffers sizes did not alter the substantive findings.

The tobacco outlet density values were categorised into five groups to minimise disclosure risk. The first density category included all postcodes with zero KDE-values; the remaining KDE-values were then grouped into quartiles. Based on their postcode of residence, these density categories were linked to the Scottish Health Survey respondents (n = 28,785). Due to small numbers the two categories with the lowest density values were combined into a single group. The postcodes of 34 respondents were uniquely identifiable, so they were excluded from subsequent analysis. The linked dataset therefore comprised 28,751 adults aged 16 years and over.

Missing values

Of the adult study sample (n=28,751), some values were missing for household income (n=4,164) and the smoking and ex-smoking outcomes (n=109). A smaller number of missing values were observed for some of the other variables included (sex, age, ethnicity, education and the urban/rural indicator). Excluding the missing values resulted in proportional differences of ≤3% between the variable categories of the original and reduced

sample. As the exclusion of the missing values did not change the composition of the sample considerably, we followed the example of previous research not to impute the missing values to avoid additional bias [36-38] and reported results based on the reduced sample. The final sample size included 24,387 adults aged 16 and above.

Data analysis

We first used descriptive statistics to examine smoking and quitting prevalence amongst health survey respondents, as well as the association of these outcomes with income. Descriptive statistics were also used to examine univariate associations between the dependent variables (smoking and ex-smoking), the tobacco outlet density measure and all covariates. To test associations between the outcomes and the tobacco retail environment, we ran binary logistic regression models for each dependent variable applying the complex survey design function accounting for the clustered sampling design and weighting for non-response. The modelling procedure comprised three steps. First, we included the measure of tobacco outlet density and all individual-level demographic variables. We then adjusted the models for the individual- and household-level socio-economic variables. Finally, the models were also adjusted for neighbourhood urban/rural status. Additionally, we tested for trends in associations across the categories of tobacco outlet density by treating the categorical variable as a continuous variable. This stepwise approach allowed for an assessment of the effect of each group of covariates on the association between smoking and ex-smoking in relation to tobacco outlet density.

After each modelling step, Stata's margins command was used to estimate levels of smoking / ex-smoking for each combination of tobacco outlet density and equivalised household income. This approach accounts for the different distribution of confounders in each

combination. Finally, to analyse whether the effects of tobacco outlet density on individual-level smoking differed by equivalised household income, we ran fully-adjusted interaction models including a post-estimation Wald test.

RESULTS

Descriptive statistics

Of the total sample, 25.0% of respondents identified as current smokers, and 27.3% reported to be ex-smokers (Table 1). There was a clear gradient in the prevalence of smoking across the household income groups, with the lowest income group having the highest percentage of smokers (35.4%). In comparison, there was no clear income gradient for ex-smoking, and the middle income group had the highest percentage of ex-smokers (29.0%). The relationship between smoking, as well as ex-smoking, and the four tobacco outlet density categories showed the expected gradient, with the highest prevalence of current smoking (29.8%) and the lowest prevalence of ex-smoking (25.7%) in the highest outlet density areas. All univariate associations between the smoking as well as ex-smoking outcomes and the covariates reached statistical significance ($p < 0.05$).

Multivariate models

Adjusted models showing predicted probabilities of current smoking in relation to tobacco outlet density are presented in Table 2. The results of Model 1 adjusting for demographic variables show that in comparison to those living in areas with the lowest tobacco outlet density (Tobacco Outlet Density (TOD) 1), the chance of being a current smoker increases by 6% in TOD 2, and 10% in areas with highest outlet densities (TOD 3 & 4). Further adjustment

slightly attenuates the effects observed, and the fully adjusted Model 3 shows a positive

gradient in the probability of smoking, ranging from 3% in TOD 2 to 7% in the highest outlet

density areas (TOD 4). All of the results reach statistical significance ($p < 0.01$) and all trends

are positive and statistically significant ($p < 0.01$).

Adjusted models showing predicted probabilities of ex-smoking in relation to

tobacco outlet density are presented in Table 3. The results of Model 1 adjusting for

demographic variables show that in comparison to those living in areas with the lowest

tobacco outlet density, the chance of being an ex-smoker decreases by 10% in areas with

the highest outlet density. However, there was no evidence of a gradient in the probability

of ex-smoking between the two highest outlet density areas (TOD 3 & 4). The addition of

further covariates slightly attenuates the associations observed, and the fully adjusted

Model 3 shows a negative gradient in the probability of ex-smoking, decreasing from -2% in

TOD 2 to -6% (TOD 3) and then rising to -5% (TOD 4) in the higher outlet density areas. The

results reach statistical significance ($p < 0.01$) in both of the higher outlet density groups

(TOD 3 & 4); all trends are negative and statistically significant ($p < 0.01$).

Interaction models

In order to examine whether income inequalities in smoking were smaller in areas

with the lowest density of tobacco retailing, we examined the interaction between tobacco

outlet density and current smoking, stratified by household income (Figure 1). Across all

outlet density groups, the chance of being a current smoker (compared to non-smokers) is

lowest in the highest income group, and highest in the lowest income group. Most of the

differences between the income groups reach statistical significance (95% CIs do not

overlap). The probability of being a current smoker increases from 14.5% for the highest

income tertile of respondents living in areas with the lowest tobacco outlet density to 38.1%

for the lowest income respondents living in areas with the highest outlet density. For all

three income groups there was a gradient in the probability of being a current smoker

across the outlet density categories with higher probabilities in the areas with the greatest

outlet densities. For example, within the lowest income group the probability of being a

current smoker ranged from 29.7% in the lowest outlet density group to 38.1% in the group

of areas with the highest density of tobacco outlets. In the highest income group the

corresponding values were 14.5% and 21.3%. The differences between the tobacco outlet

density groups within household income group tertiles do not, however, reach statistical

significance (95% CIs overlap).

Figure 2 shows adjusted associations between tobacco outlet density and ex-

smoking, stratified by household income. Across all outlet density groups, the chance of

being an ex-smoker (compared to smokers) is highest in the highest income group, and

lowest in the lowest income group. Most of the differences between the income groups

reach statistical significance. The probability of being an ex-smoker decreases from 64.5% in

the richest respondents living in areas with the lowest tobacco outlet density to 41.2% in

the poorest respondents living in areas with the highest outlet density. For all three income

groups there was a gradient in the probability of being an ex-smoker across the four tobacco

outlet density categories with higher probabilities in areas with the lowest densities

(although the trend was non-linear in the middle income group). In the lowest income group

the predicted probability of being an ex-smoker ranged from 46.4% to 41.2% between the

lowest and highest outlet density groups. The corresponding values for the highest income

group were 64.5% and 58.5%. The differences between the tobacco outlet density groups do not, however, reach statistical significance (95% CIs overlap).

DISCUSSION

We examined whether the local density of tobacco retailing in neighbourhoods across Scotland was associated with adults' propensity to be a current smoker as well as whether they had quit. After full adjustment for individual-level confounders and urban/rural status at the area-level, compared to participants living in areas with the lowest outlet densities, those living in areas with the highest outlet densities had a 6% higher chance of being a current smoker, and a 5% lower chance of being an ex-smoker. The findings therefore suggest that residents of environments with a greater availability of tobacco outlets are more likely to start and/or sustain smoking, and less likely to quit. To our knowledge, this is the first study to examine whether the tobacco retailer environment might disproportionately affect low income communities. We found that there was little evidence to suggest that inequalities in smoking or cessation were narrower in areas with lower availability of tobacco retailing.

These findings are broadly consistent with work in North America which has tended to find that people are more likely to be smokers in areas with a greater availability of tobacco retailing.[8] The results are also consistent with a study in the US which found that sustained quit attempts (over 6 months) were less likely among those living closest to a tobacco outlet.[14] Our Scottish study is among the first in Europe to demonstrate smoking or cessation among adults to be associated with the local retailing environment. The only other

comparable study in the UK which was based on 611 smokers in two English cities found

that sustained quitting at six months was unrelated to residential proximity to tobacco

outlets.[17] The findings are also consistent with international evidence which suggests that

local environments can constrain or enable a multitude of health behaviours including

physical activity, nutrition and alcohol consumption.[39-41]

The main contributions of our study are threefold. Our analyses are at the national

and not the local scale and include environments across Scotland; we have used a national

register of tobacco outlets which has been verified for accuracy; and we have separately

examined current smokers and smoking cessation. However, there are limitations. First, the

Scottish Tobacco Retailers Register was established in 2011 and locational data on tobacco

retailers prior to this date are not available which meant that longitudinal analyses were not

possible. In the near future it will be feasible to improve upon our cross-sectional study

design. Second, and related, there is a temporal mismatch between the outlet density

measure (2012) and health survey data (2008-11). Whilst it is not possible to ascertain the

change in outlet density between 2008 and 2012, if anything it is likely that due to the

economic recession in the UK there may have been a small reduction in the number of

outlets selling tobacco in Scotland. Between 2012 and 2014 the number of outlets in the

tobacco register fell from 10,161 to 9010. If this trend were replicated during the earlier

period then it is feasible that the results presented in this paper understate the association

between the density of tobacco retailers and individual-level smoking-related outcomes.

Third tobacco retailing in Scotland is ubiquitous and it is plausible that there was insufficient

variation in our exposure measure to fully recognise the strength of association between

retail availability and smoking. Fourth, people are also influenced by environments other

than their residential spaces. Future work could usefully consider multiple exposures, such as around homes, workplaces, and schools (for adolescents).

The findings have implications for tobacco control policy, especially in the context of the Scottish Government's ambition for a 'tobacco-free' Scotland by 2034.[42] The findings emphasise that a greater availability of local tobacco retailing not only increase supply but also provide an important vehicle for the tobacco industry to market tobacco products. Greater prominence of tobacco products encourages impulse purchases and also affects perceived prevalence of smoking and hence the local social norms regarding its acceptability. A ban on point-of-sale advertising in Scotland will apply to all tobacco outlets from April 2015.[43] It will be important to monitor the influence of this legislation on smoking knowledge, attitudes and behaviours but also new tactics adopted by the tobacco industry to counter these changes.[44] The UK government has recently drafted regulations for the introduction of plain, standardised packaging for tobacco products.[45] It might be anticipated that alongside point-of-sale legislation these measures will help dilute any causal relationships between retailing and smoking. Future tobacco control policy should consider the utility of reducing the neighbourhood density of tobacco outlets.

In conclusion, this study has shown that at the national level amongst adults in Scotland the density of neighbourhood tobacco retailing is associated with smoking and cessation. The uneven geography of tobacco retailing in Scotland is likely to be a factor in explaining spatial differences in smoking.

Table 1 Sample distribution and prevalence of tobacco consumption (weighted), Scottish Health Survey 2008-2011

	$^{†}n_{weighted}$	% of sample	$^{†}n_{weighted}$	% current smokers	$^{†}n_{weighted}$	% ex-smokers
Sex						
Male	11,778	48.3	3,013	25.6	3,318	28.2
Female	12,609	51.7	3,076	24.4	3,348	26.6
Total	*24,387*	*100.0*	*6,090*	*25.0*	*6,666*	*27.3*
Missing	0	0.0	0	0.0	0	0.0
Design-based F-statistic (*p*-value)			4.6	($p<0.05$)	8.1	($p<0.01$)
Age group						
16-24	3,232	13.3	874	27.1	322	10.0
25-34	3,906	16.0	1,189	30.4	853	21.8
35-44	4,498	18.4	1,297	28.8	1,040	23.1
45-54	4,534	18.6	1,214	26.8	1,167	25.7
55-64	3,748	15.4	897	23.9	1,285	34.3
65+	4,469	18.3	620	13.9	2,000	44.8
Total	*24,387*	*100.0*	*6,090*	*25.0*	*6,666*	*27.3*
Missing	0	0.0	0	0.0	0	0.0
Design-based F-statistic (*p*-value)			53.6	($p<0.01$)	104.6	($p<0.01$)
Ethnicity						
Non-White	657	2.7	120	18.2	108	16.5
White	23,708	97.3	5,961	25.1	6,553	27.6
Total	*24,365*	*100.0*	*6,081*	*25.0*	*6,661*	*27.3*
Missing	22	0.1	9	<1.0	5	<1.0
Design-based F-statistic (*p*-value)			5.4	($p<0.01$)	13.3	($p<0.01$)
Equivalised household income (tertiles)						
<£16,347	7,706	31.6	2,726	35.4	1,980	25.7
£16,347-£31,799	8,080	33.1	1,920	23.8	2,343	29.0
>£31,799	8,601	35.3	1,444	16.8	2,343	27.2
Total	*8,601*	*35.3*	*1,444*	*25.0*	*2,343*	*27.3*
Missing	0	0.0	0	0.0	0	0.0
Design-based F-statistic (*p*-value)			218.1	($p<0.01$)	130.5	($p<0.01$)
Highest educational qualification						
None or other school	6,287	25.8	1,961	31.2	2,135	34.0
Standard or higher grade	9,028	37.1	2,669	29.6	2,006	22.2
Higher National Diploma or higher	9,030	37.1	1,446	16.0	2,516	27.9
Total	*24,345*	*100.0*	*6,076*	*25.0*	*6,657*	*27.3*
Missing	42	0.2	14	<1.0	9	<1.0
Design-based F-statistic (*p*-value)			136.7	($p<0.01$)	123.2	($p<0.01$)
Urban/rural status						
Urban areas & primary cities (population >10,000)	16,649	68.3	4,360	26.2	4,292	25.8

Small towns (population >3,000 & ≤10,000)	3,098	12.7	787	25.4	901	29.1
Rural areas (population <3,000)	4,639	19.0	943	20.3	1,473	31.8
Total	*24,387*	*100.0*	*6,090*	*25.0*	*6,666*	*27.3*
Missing	0	0.0	0	0.0	0	0.0
Design-based F-statistic *(p*-value)			19.1	*(p<0.01)*	15.6	*(p<0.01)*
Tobacco outlet density (TOD)*						
TOD 1 (lowest)	7,988	32.8	1,540	19.3	2,285	28.6
TOD 2	6,154	25.2	1,518	24.7	1,722	28.0
TOD 3	5,790	23.7	1,704	29.4	1,514	26.2
TOD 4 (highest)	4,454	18.3	1,328	29.8	1,145	25.7
Total	*24,387*	*100.0*	*6,090*	*25.0*	*6,666*	*27.3*
Missing	0	0.0	0	0.0	0	0.0
Design-based F-statistic *(p*-value)			45.3	*(p<0.01)*	26.0	*(p<0.01)*

[†]Totals and percentages account for sample stratification and non-response.

[*]TOD 1: median of Kernel Density Estimation values (KDE) = 0.3/km^2; TOD 2: median KDE = 3.2/km^2; TOD 3: median KDE = 6.1/km^2; TOD 4: median KDE = 15.3/km^2.

Table 2 Predicted probabilities of current smoking^ in relation to tobacco outlet density, Scottish Health Survey 2008-2011

	Model 1[†] ($n_{weighted}$ = 24,364)			Model 2[‡] ($n_{weighted}$ = 24,338)			Model 3[+] ($n_{weighted}$ = 24,338)		
		95% CI			95% CI			95% CI	
	dy/dx[§]	lower	upper	dy/dx[§]	lower	upper	dy/dx[§]	lower	upper
Tobacco outlet density (TOD)*									
TOD 1 (lowest) [reference group]									
TOD 2	**0.06**	0.04	0.07	**0.03**	0.01	0.04	**0.03**	0.01	0.04
TOD 3	**0.10**	0.08	0.12	**0.06**	0.04	0.08	**0.06**	0.04	0.08
TOD 4 (highest)	**0.10**	0.08	0.13	**0.08**	0.06	0.10	**0.07**	0.05	0.10
Trend	**0.04**	0.03	0.04	**0.03**	0.02	0.03	**0.03**	0.02	0.03
Sex									
Female [reference group]									
Male	0.01	0.00	0.02	*0.01*	0.00	0.03	*0.01*	0.00	0.03
Age group									
16-24 [reference group]									
25-34	*0.03*	0.00	0.07	**0.10**	0.07	0.13	**0.10**	0.07	0.13
35-44	0.03	0.00	0.05	**0.07**	0.04	0.10	**0.07**	0.04	0.10
45-54	0.01	-0.02	0.03	*0.03*	0.01	0.06	*0.03*	0.01	0.06
55-64	-0.02	-0.05	0.00	*-0.03*	-0.06	-0.01	*-0.03*	-0.06	-0.01
65+	**-0.13**	-0.15	-0.10	**-0.16**	-0.18	-0.14	**-0.16**	-0.18	-0.14
Ethnicity									
White [reference group]									
Non-White	**-0.12**	-0.17	-0.08	**-0.13**	-0.17	-0.08	**-0.13**	-0.17	-0.08
Highest educational qualification									
Higher National Diploma or higher [reference group]									
Standard or higher grade				**0.10**	0.08	0.11	**0.10**	0.08	0.11
None or other school				**0.19**	0.17	0.21	**0.19**	0.17	0.21
Equivalised household income (tertiles)									
>£31,799 [reference group]									
£16,347-£31,799				**0.06**	0.04	0.07	**0.06**	0.04	0.07
<£16,347				**0.16**	0.14	0.18	**0.16**	0.14	0.18
Neighbourhood urban/rural status									
Urban areas & primary cities (population >10,000) [reference group]									
Small towns (population >3,000)							0.00	-0.02	0.02
Rural areas (population <3,000)							-0.01	-0.03	0.01

^Reference group: non-smokers, including participants who never smoked and ex-smokers.

[†]Model includes design (to account for sample stratification and non-response) and individual-level demographic variables.

[‡]Individual- and household-level socio-economic variables included in models containing design and demographic variables.

+Neighbourhood-level urban/rural classification included in models containing design, demographic and socio-economic variables.

§Predicted probabilities: **p < 0.01; *p < 0.05***

*TOD 1: median of Kernel Density Estimation values (KDE) = 0.3/km^2; TOD 2: median KDE = 3.2/km^2; TOD 3: median KDE = 6.1/km^2; TOD 4: median KDE = 15.3/km^2.

Table 3 Predicted probabilities of ex-smoking^ in relation to tobacco outlet density,
Scottish Health Survey 2008-2011

	Model 1[†]			Model 2[‡]			Model 3[+]		
	($n_{weighted}$ = 12,742)			($n_{weighted}$ = 12,728)			($n_{weighted}$ = 12,728)		
		95% CI			95% CI			95% CI	
	dy/dx[§]	lower	upper	dy/dx[§]	lower	upper	dy/dx[§]	lower	upper
Tobacco outlet density (TOD)*									
TOD 1 (lowest) [reference group]									
TOD 2	**-0.06**	-0.09	-0.03	***0.03***	-0.06	0.00	-0.02	-0.05	0.01
TOD 3	**-0.12**	-0.14	-0.09	**-0.07**	-0.10	-0.05	**-0.06**	-0.09	-0.03
TOD 4 (highest)	**-0.10**	-0.13	-0.07	**-0.07**	-0.10	-0.04	**-0.05**	-0.09	-0.02
Trend	**-0.04**	-0.05	-0.03	**-0.03**	-0.04	-0.02	**-0.02**	-0.03	-0.01
Sex									
Female [reference group]									
Male	0.00	-0.02	0.01	-0.01	-0.03	0.00	-0.01	-0.03	0.00
Age group									
16-24 [reference group]									
25-34	**0.15**	0.10	0.19	**0.08**	0.04	0.13	**0.09**	0.04	0.13
35-44	**0.17**	0.13	0.21	**0.12**	0.08	0.16	**0.12**	0.08	0.17
45-54	**0.21**	0.17	0.25	**0.17**	0.13	0.22	**0.17**	0.13	0.22
55-64	**0.31**	0.27	0.35	**0.31**	0.26	0.35	**0.31**	0.26	0.35
65+	**0.49**	0.45	0.53	**0.51**	0.47	0.55	**0.51**	0.47	0.55
Ethnicity									
White [reference group]									
Non-White	0.05	-0.03	0.13	0.03	-0.04	0.11	0.03	-0.04	0.11
Highest educational qualification									
Higher National Diploma or higher [reference group]									
Standard or higher grade				**-0.12**	-0.14	-0.10	**-0.12**	-0.14	-0.10
None or other school				**-0.19**	-0.22	-0.16	**-0.19**	-0.21	-0.16
Equivalised household income (tertiles)									
>£31,799 [reference group]									
£16,347-£31,799				**-0.06**	-0.09	-0.04	**-0.06**	-0.09	-0.04
<£16,347				**-0.17**	-0.20	-0.15	**-0.17**	-0.20	-0.15
Neighbourhood urban/rural status									
Urban areas & primary cities (population >10,000) [reference group]									
Small towns (population >3,000)							0.01	-0.02	0.04
Rural areas (population <3,000)							**0.04**	0.02	0.07

^Reference group: current smokers.

†Model includes design (to account for sample stratification and non-response) and individual-level demographic variables.

‡Individual- and household-level socio-economic variables included in models containing design and demographic variables.

+Neighbourhood-level urban/rural classification included in models containing design, demographic and socio-economic variables.

§Predicted probabilities: **p < 0.01;** *p < 0.05*

*TOD 1: median of Kernel Density Estimation values (KDE) = 0.3/km^2; TOD 2: median KDE = 3.2/km^2; TOD 3: median KDE = 6.1/km^2; TOD 4: median KDE = 15.3/km^2.

Figure 1 Adjusted* interactive effects of tobacco outlet density on individual-level smoking^ by household income, Scottish Health Survey 2008-2011 ($n_{weighted}$ = 24,338)

*Model includes design variables (to account for sample stratification and non-response), tobacco outlet density and equivalised household income, controlling for sex, age, ethnicity, education, and urban/rural status.
^Reference group: non-smokers, including participants who never smoked and ex-smokers.
[†]TOD 1: median of Kernel Density Estimation values (KDE) = 0.3/km^2; TOD 2: median KDE = 3.2/km^2; TOD 3: median KDE = 6.1/km^2; TOD 4: median KDE = 15.3/km^2.

Figure 2 Adjusted* interactive effects of tobacco outlet density on individual-level ex-smoking^ by household income, Scottish Health Survey 2008-2011 ($n_{weighted}$ = 12,728)

*Model includes design variables (to account for sample stratification and non-response), tobacco outlet density and equivalised household income, controlling for sex, age, ethnicity, education, and urban/rural status.
^Reference group: current smokers.
†TOD 1: median of Kernel Density Estimation values (KDE) = 0.3/km^2; TOD 2: median KDE = 3.2/km^2; TOD 3: median KDE = 6.1/km^2; TOD 4: median KDE = 15.3/km^2.

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