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# The density of tobacco retailers in home and school environments and relationship with adolescent smoking behaviours in Scotland

N K Shortt,<sup>1</sup> C Tisch,<sup>1</sup> J Pearce,<sup>1</sup> E A Richardson,<sup>1</sup> R Mitchell<sup>2</sup>

<sup>1</sup>Centre for Research on Environment, Society and Health, School of Geosciences, University of Edinburgh, Edinburgh, UK

<sup>2</sup>Centre for Research on Environment, Society and Health, Institute of Health and Wellbeing, University of Glasgow, Glasgow, UK

## Correspondence to

Dr Niamh K Shortt, Centre for Research on Environment, Society and Health, School of Geosciences, University of Edinburgh, Edinburgh, Scotland EH8 9XP, UK; niamh.shortt@ed.ac.uk

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## ABSTRACT

**Background** Neighbourhood retailing of tobacco products has been implicated in affecting smoking prevalence rates. Long-term smoking usually begins in adolescence and tobacco control strategies have often focused on regulating 'child spaces', such as areas in proximity to schools. This cross-sectional study examines the association between adolescent smoking behaviour and tobacco retail outlet density around home and school environments in Scotland.

**Methods** Data detailing the geographic location of every outlet registered to sell tobacco products in Scotland were acquired from the Scottish Tobacco Retailers Register and used to create a retail outlet density measure for every postcode. This measure was joined to individual responses of the Scottish Schools Adolescent Lifestyle and Substance Use Survey (n=20 446). Using logistic regression models, we explored the association between the density of retailers, around both home and school address, and smoking behaviours.

**Results** Those living in the areas of highest density of retailers around the home environment had 53% higher odds of reporting having ever smoked (95% CI 1.27 to 1.85,  $p<0.001$ ) and 47% higher odds of reporting current smoking (95% CI 1.13 to 1.91  $p<0.01$ ). Conversely, those attending schools in areas of highest retail density had lower odds of having ever smoked (OR 0.66, 95% CI 0.50 to 0.86  $p<0.01$ ) and lower odds of current smoking (OR 0.75, 95% CI 0.59 to 0.95,  $p<0.05$ ).

**Conclusions** The density of tobacco retail outlets in residential neighbourhoods is associated with increased odds of both ever smoked and current smoking among adolescents in Scotland. Policymakers may be advised to focus on reducing the overall density of tobacco outlets, rather than concentrating on 'child spaces'.

## INTRODUCTION

Various aspects of the local environment are important factors in explaining health and health-related behaviours,<sup>1 2</sup> including smoking.<sup>3 4</sup> Smoking behaviours and place are linked through two distinct pathways: place-based practices and place-based regulation/policy.<sup>4</sup> Place-based practices that are relevant to understand smoking behaviour include levels of social capital, social practices, contagion and neighbourhood crime, disorder and stress.<sup>4</sup> On the other hand place-based regulations and policy, which shape tobacco control, environmental opportunities and constraints for the availability and advertising of tobacco products, tend to be formed by national-level or state-level policies (eg, 'smoking bans'). One such environmental

opportunity may be the density of tobacco retail outlets in neighbourhoods. A high density of such retailers may increase the ease with which individuals can access tobacco products and the local acceptability and normalisation of tobacco-related behaviours. Research has shown that tobacco outlet density is associated with higher odds of smoking in adults.<sup>5–8</sup> It has also been suggested that the sight of retail outlets is associated with tobacco purchases and smoking frequency.<sup>5</sup> Further research has explored the association between proximity to tobacco outlets and attempts to quit, confirming an association between the distance to outlets and the reduced likelihood of smoking cessation.<sup>9 10</sup>

While most research exploring environmental drivers and smoking has focused on adults, the majority of adult smokers try their first cigarette before the age of 18.<sup>11</sup> This makes tobacco misuse prevention in adolescence a widely endorsed public health goal.<sup>12</sup> Those who start smoking at a younger age are more likely to become regular smokers in adulthood,<sup>13</sup> and those who have not started smoking as a teenager are unlikely to ever become a smoker.<sup>14</sup> Research on the association between tobacco retail density and adolescent smoking is less well established. Exploring tobacco outlet density in the home neighbourhood, research has reported higher odds of smoking over the past month<sup>15</sup> and increased likelihood of smoking initiation<sup>16</sup> associated with increased tobacco outlet density. Higher rates of smoking prevalence among school pupils have been found in those attending schools in neighbourhoods of high tobacco retail outlet density.<sup>17</sup> Further research has found that tobacco retail density around schools was positively associated with ever but not current smoking.<sup>18 19</sup> These findings have prompted calls for new regulations to limit the density of tobacco outlets and the quantity of cigarette advertising in 'child spaces', particularly around schools.<sup>20 21</sup>

A limitation of previous research has been the exclusive focus on one aspect of an adolescent's environment, *either* the home *or* the school neighbourhood. This paper examines the relationship between adolescent smoking behaviours and tobacco retail outlet density in home *and* school neighbourhoods, after adjustment for individual, family-level and area-level variables. This research was conducted in Scotland, and as such makes an interesting comparison with the majority of previous research, which has been largely North American. In Scotland, adolescent smoking rates have fallen from 30% for 15-year-old boys and girls in 1996 to 13% in 2010.<sup>22</sup> The Scottish



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Government has signalled its intent for a 'tobacco-free' Scotland by 2034 through the introduction of plain packaging, a review of smoking cessation services, making hospital grounds smoke-free, a social marketing campaign on secondhand smoke and a peer education programme in schools. The current strategy, *Creating a Tobacco-Free Generation*, includes a focus on limiting the number of young people who take up smoking in the future by creating an environment where young people choose not to smoke.<sup>23</sup> Therefore, it is important to explore the current environmental factors associated with adolescent smoking behaviours.

## METHODOLOGY

This study consists of three stages: creating a tobacco retailer density measure; joining the density measure to individual records in the 2010 Scottish Schools Adolescent Lifestyle and Substance Use Survey (SALSUS); and analysing the association between adolescent behaviours and retail outlet density.

### Outlet data

We obtained the addresses of all premises registered on the Scottish Tobacco Retailers Register as at 30 September 2012 (n=11 449). After cleaning and identifying duplicates, our final data set consisted of 10 161 tobacco outlets.

We used Geographic Information Systems (GIS) to create measures of outlet density for every postcode in Scotland (n=50 466). Postcodes in the UK are based on postal addresses with each postcode corresponding to an average of 15 households. First, we mapped locations of the tobacco outlets based on the coordinates of their postcodes. We then undertook a Kernel Density Estimation (KDE). This transforms the spatial pattern of outlet locations into a continuous surface map which models the density of outlets. In brief, it begins by dividing all of Scotland into 100×100 m grid cells. Next, for each cell, an assessment is made of the number and proximity of outlets within an 800 m radius (we tested the sensitivity of our choice of radius by running further analysis at 400 and 1000 m). This radius was chosen as a plausible walking distance to get to an outlet. Outlets nearer the centre of the search window are given greater weight, with a decay function attributing less weight to outlets further away.<sup>24</sup> Rather than reporting the number of outlets for each postcode, the KDE value represents the smoothed density of outlets. This has an advantage over traditional measures, such as number of outlets per postcode, as the influence of retailers located in adjoining postcodes is included and the measure is not therefore constrained by potential misclassification bias caused by arbitrarily defined boundaries.<sup>25</sup> Postcode centroids were then placed on this density map, allowing us to extract the density value for each postcode. The final output of this process was a data set of proximity-weighted outlets per square kilometre (km<sup>2</sup>) for every postcode in Scotland.

### Survey data

SALSUS is a biennial national survey commissioned by the government to measure progress towards its target reductions of adolescent smoking, drinking and drug use. The 2010 wave was carried out between October 2010 and February 2011 surveying pupils from Secondary 2 (S2) and Secondary 4 (S4), most likely to be aged 13 and 15, respectively. The final nationally representative sample of 37 307 pupils equated to an individual pupil response rate of 91%.

We examined two outcome variables; 'Ever smoked' and 'Current smoking'. The first was used because of evidence

indicating that trying one cigarette in adolescence is one of the strongest predictors of going on to become a smoker.<sup>26</sup> This outcome, referred to as 'ever smoked', has been explored elsewhere.<sup>27–30</sup> In the survey, pupils were asked to select one of six responses related to smoking ranging from 'I have never smoked' to 'I usually smoke more than 6 cigarettes a week'. We merged the five responses which suggested that the respondent had, at one point in time, tried smoking. Our second outcome measured any current smoking regardless of frequency.<sup>15 31–33</sup> This outcome was taken from an affirmative response to the question 'Do you smoke at all nowadays?'

### Linking outlet density data with survey data

When responding to the survey, pupils were asked to include their home and school postcodes. Of the 37 307 pupils who completed the survey, 15 963 did not include valid home and school postcodes. Pupils who did not provide both postcodes had to be removed from the analysis as it was not possible to assign a density value to these adolescents. Using the postcode identifiers on the SALSUS survey and our derived density data set, ISD Scotland attached a density value to every pupil with a legitimate home and school postcode, 57.2% of the entire sample (n=21 344). A further 898 (4.2%) of the matched pupils were excluded as they did not respond to the outcome variables included in the analysis, resulting in a final sample of 20 446 pupils.

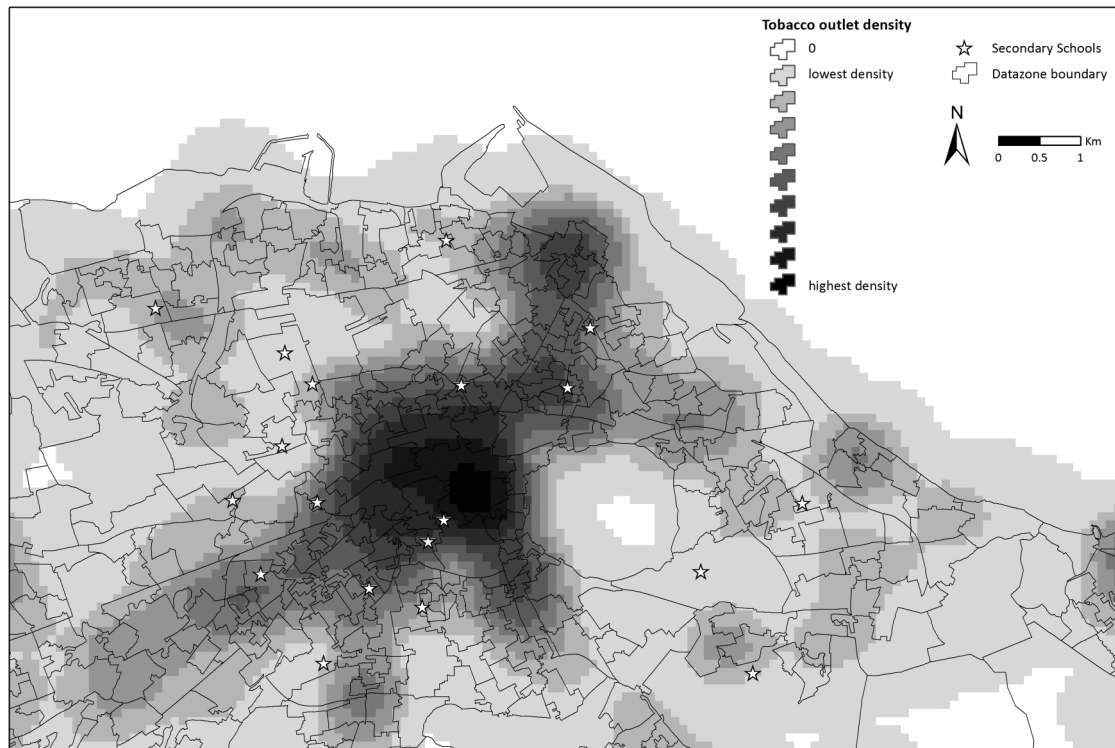
We found that those excluded from the sample (16 861) were slightly more likely to be male (53.7% vs 48.1%,  $p<0.001$ ), younger (52.2% vs 51.7%,  $p>0.05$ ) and non-white (7.6% vs 5.5%,  $p<0.001$ ). The overall rate of having ever smoked was higher among the excluded pupils compared with the included respondents (36.1% vs 28.1%,  $p<0.05$ ). This was also the case for current smoking (15.4% among excluded pupils vs 9.8% for included pupils,  $p<0.05$ ). Furthermore, we ran models on a subset of our included pupils with characteristics corresponding to those of our missing group (young, non-white males) to see whether or not this group had a different relationship between smoking and outlet density compared to the rest of the sample. There was no significant difference, implying that the exclusion of this group is unlikely to have radically altered our models.

### Data analysis

We ran a series of logistic regression models in STATA/IC V.12.0 (StataCorp, College Station, Texas, USA) to explore the association between our outcome variables and exposure to outlets after controlling for various covariates. To account for clustering of pupils within schools, we used the survey (svy) command. Pupils living in areas of zero density were used as the reference category in all of our models. The remaining pupils were divided into quartiles of density, both for the home (>0–1.65, 1.66–3.30, 3.31–5.62, >5.63) and the school (>0–1.93, 1.94–3.78, 3.79–6.71, >6.72). Model 1 included the density measure and individual level demographic variables (age group (by class year), sex and ethnicity). Model 2 added family variables: whether the individual received free school meals; self-perceived family wealth (1=very/quite well off, 2=average—not at all well off); family structure (eg, family with both parents, single parent family, etc) and parental smoking status. Finally, model 3 included two area-level measures: the Carstairs deprivation score (based on four census indicators: low social class, lack of car ownership, overcrowding and male unemployment) quintiles (–4.58 to 1.60, –1.59 to 0.33, 0.34 to 2.09, 2.10 to 4.69, 4.70 to 15.11) and an indicator of rurality (urban areas are classified by government as those settlements over 3000 people) (see

**Table 1** Descriptive statistics of Scottish Schools Adolescent Lifestyle and Substance Use Survey: 2010

			Tobacco outcomes			
			Ever smoked		Current smokers	
	All pupils		Yes		Yes	
	n	Per cent	n	Per cent	n	Per cent
All pupils	20 446	100	5745	28.1	2009	9.8
Tobacco outlet density: school						
1 (density=0)	620	3.0	206	33.2	73	11.8
2 (lowest density)	5069	24.7	1418	28.0	495	9.8
3	5337	26.1	1386	26.0	477	8.9
4	4786	23.4	1401	29.3	512	10.7
5 (highest density)	4634	22.7	1334	28.8	452	9.8
Tobacco outlet density: home						
1 (density=0)	2539	12.4	570	22.4	200	7.9
2 (lowest density)	4488	22.0	1145	25.5	399	8.9
3	4457	21.8	1252	28.1	447	10.0
4	4501	22.0	1352	30.0	477	10.6
5 (highest density)	4461	21.8	1426	32.0	486	10.9
Class year						
Secondary 2	10 563	51.7	1725	16.3	394	3.7
Secondary 4	9883	48.3	4020	40.7	1615	16.3
Sex						
Male	9844	48.1	2677	27.2	859	8.7
Female	10 580	51.7	3058	28.9	1145	10.8
Not stated	22	0.1	10	45.5	5	22.7
Ethnicity						
White	19 146	93.6	5350	27.9	1856	9.7
Non-white	1133	5.5	332	29.3	131	11.6
Not stated	167	0.8	63	37.7	22	13.2
Free school meals						
Yes	1889	9.2	780	41.3	306	16.2
No	16 293	79.7	4274	26.2	1422	8.7
Not stated	2264	11.1	691	30.5	281	12.4
Self-perceived family wealth						
Very/quite well off	10 068	49.2	2431	24.1	824	8.2
Average—not at all well off	9597	46.9	3055	31.8	1092	11.4
Not stated	781	3.8	259	33.2	93	11.9
Family structure						
Single parent	3845	18.8	1456	37.9	552	14.4
Step-parent (and one parent)	1830	9.0	732	40.0	288	15.7
Both parents	14 017	68.6	3294	23.5	1071	7.6
Other	426	2.1	167	39.2	71	16.7
Not stated	328	1.6	96	29.3	27	8.2
Parental smoking status						
No parent smokes	11 184	54.7	2153	19.3	590	5.3
At least one parent smokes daily	6426	31.4	2829	44.0	1160	18.1
Not stated	2836	13.9	763	26.9	259	9.1
Urban/rural status						
Urban	15 670	76.6	4367	27.9	1491	9.5
Rural	4738	23.2	1366	28.8	512	10.8
Missing	38	0.2	12	31.6	6	15.8
Carstairs quintile						
1 (least deprived)	4791	23.4	999	20.9	341	7.1
2	4159	20.3	1087	26.1	382	9.2
3	4394	21.5	1302	29.6	468	10.7
4	3906	19.1	1218	31.2	411	10.5
5 (most deprived)	3173	15.5	1131	35.6	403	12.7
Missing	23	0.1	8	34.8	4	17.4



**Figure 1** Map of tobacco outlet density in Edinburgh.

breakdown for all variables in [table 1](#)). In further analyses, we stratified the models by age and sex.

## RESULTS

Density measures for tobacco outlets were created for each Scottish postcode. An example of our tobacco outlet density maps for the City of Edinburgh can be seen in [figure 1](#). The darker shaded areas are those with the highest density in the city centre and smaller pockets further out.

There was an overall prevalence rate of ever smoked of 28.1%: 16.3% of 13-year-olds (S2) rising to 40.7% in 15-year-olds (S4). 9.8% of pupils were current smokers, with this also increasing with age from 3.7% in S2 pupils to 16.3% in S4 pupils ([table 1](#)).

In model 1, adjusting for individual level variables, there was a significant dose-response relationship between the density of tobacco retailers around the home environment and both current smoking and ever smoked ([tables 2](#) and [3](#)). The odds of current smoking ranged from 1.16 (CI 0.98 to 1.37;  $p > 0.05$ ) in the areas of lowest density to 1.44 (CI 1.19 to 1.73;  $p < 0.01$ ) in the areas of highest density ([table 2](#)). While not significant in the lowest density quartile, the results in all remaining quartiles were significant. Similar patterns are evident for ever smoked, ranging from 1.20 (CI 1.05 to 1.37;  $p < 0.001$ ) in areas of lowest density to 1.67 (CI 1.46 to 1.90;  $p < 0.001$ ) in areas of highest density around the home ([table 3](#)). After further controlling for family and area level variables, a significant relationship remained for both ever smoked and current smoking and retail density around the home. For current smoking, the odds were 47% higher in the highest density quartile compared to having no outlets in the area (OR 1.47, CI 1.13 to 1.91;  $p < 0.01$ ). For ever smoked, those in areas with the highest density had 53% higher odds (OR 1.53, CI 1.27 to 1.85;  $p < 0.001$ ) of having ever tried smoking compared with those with no retail outlets in their immediate vicinity.

The relationship with the school environment was in the opposite direction. In model 1 (again controlling for individual level variables), an increased density of tobacco retailers near schools was associated with lower odds of having ever smoked and current smoking, but neither model was significant. After controlling for all confounders, we see significantly lower odds of having ever smoked (OR 0.66, CI 0.50 to 0.86;  $p < 0.01$ ). Furthermore, in the fully adjusted model, pupils attending schools in the highest density had significantly lower odds (OR 0.75, CI 0.59 to 0.95,  $p < 0.05$ ) of being a current smoker compared with those with no retail outlets around their school.

It is important to note that in the models we have added variables which, following a review of the literature, have been identified as important predictors of adolescent smoking. In all of our models, for both home and school density, two variables (having both parents living at home and not receiving free school meals) were consistently related with lower odds of adolescent smoking and one variable, having a parent who smokes daily, with higher odds.

To examine whether tobacco retail density had differential effects among younger or older populations and males or females, we further stratified our analysis by age and sex. For both 13-year-olds and 15-year-olds, the general patterns remained the same for both home and school environments.

## DISCUSSION

This is the first UK study to examine the association between the neighbourhood density of tobacco retailers and adolescent smoking behaviours at a national level. We found the anticipated relationship surrounding an adolescent's home; a higher density of tobacco retailers was associated with higher odds of an adolescent engaging in both having ever smoked and current smoking. These findings are consistent with the majority of previous studies, mostly from North America, considering the



**Table 2** Odds of current smoking in school and home environments

	Model 1		Model 2		Model 3	
	Home OR 95% CI	School OR 95% CI	Home OR 95% CI	School OR 95% CI	Home OR 95% CI	School OR 95% CI
Tobacco outlet density						
1 (density=0)	1.00	1.00	1.00	1.00	1.00	1.00
2 (lowest density)	1.16 (0.98 to 1.37)	0.85 (0.54 to 1.34)	1.10 (0.90 to 1.34)	0.77 (0.58 to 1.04)	1.35 (1.10 to 1.67)*	0.77 (0.61 to 0.98)*
3	1.32 (1.11 to 1.58)*	0.77 (0.49 to 1.23)	1.11 (0.91 to 1.37)	0.69 (0.51 to 0.92)*	1.41 (1.11 to 1.79)*	0.70 (0.55 to 0.89)*
4	1.42 (1.19 to 1.70)*	0.92 (0.58 to 1.47)	1.14 (0.93 to 1.39)	0.73 (0.54 to 0.99)*	1.41 (1.11 to 1.79)*	0.73 (0.56 to 0.94)*
5 (highest density)	1.44 (1.19 to 1.73)*	0.83 (0.52 to 1.32)	1.14 (0.93 to 1.41)	0.74 (0.55 to 0.99)*	1.47 (1.13 to 1.91)*	0.75 (0.59 to 0.95)*
Trend	1.09 (1.05 to 1.13)*	1.00 (0.94 to 1.06)	1.02 (0.98 to 1.07)	0.97 (0.91 to 1.04)	1.06 (1.00 to 1.12)*	0.98 (0.92 to 1.04)
Class year						
Secondary 2 (age 13)	1.00	1.00	1.00	1.00	1.00	1.00
Secondary 4 (age 15)	5.06 (4.37 to 5.87)*	5.05 (4.36 to 5.85)*	5.48 (4.65 to 6.47)*	5.48 (4.64 to 6.47)*	5.49 (4.65 to 6.49)*	5.50 (4.66 to 6.50)*
Sex						
Female	1.00	1.00	1.00	1.00	1.00	1.00
Male	1.30 (1.16 to 1.47)*	1.30 (1.15 to 1.46)*	1.40 (1.22 to 1.61)*	1.40 (1.22 to 1.60)*	1.39 (1.21 to 1.60)*	1.38 (1.21 to 1.59)*
Ethnicity						
White	1.00	1.00	1.00	1.00	1.00	1.00
Non-white	1.28 (1.04 to 1.56)*	1.30 (1.06 to 1.59)*	1.32 (1.00 to 1.74)*	1.32 (1.00 to 1.75)*	1.37 (1.04 to 1.80)*	1.37 (1.04 to 1.80)*
Free school meals						
Yes			1.00	1.00	1.00	1.00
No			0.72 (0.60 to 0.86)*	0.71 (0.60 to 0.85)*	0.73 (0.61 to 0.88)*	0.73 (0.61 to 0.87)*
Self-perceived family wealth						
Very /quite well off			1.00	1.00	1.00	1.00
Average—not at all well off			1.01 (0.89 to 1.14)	1.01 (0.89 to 1.14)	1.00 (0.88 to 1.13)	1.00 (0.88 to 1.13)
Family structure						
Single parent			1.00	1.00	1.00	1.00
Step-parent (and one parent)			1.04 (0.87 to 1.25)	1.04 (0.87 to 1.24)	1.04 (0.87 to 1.25)	1.03 (0.86 to 1.24)
Both parents			0.68 (0.59 to 0.78)*	0.67 (0.58 to 0.77)*	0.68 (0.59 to 0.78)*	0.67 (0.58 to 0.77)*
Other			1.32 (0.88 to 1.97)	1.30 (0.87 to 1.95)	1.29 (0.86 to 1.93)	1.26 (0.84 to 1.89)
Parental smoking status						
No parent smokes			1.00	1.00	1.00	1.00
At least one parent smokes daily			3.39 (2.99 to 3.85)*	3.42 (3.01 to 3.89)*	3.31 (2.91 to 3.77)*	3.33 (2.92 to 3.78)*
Urban/rural status						
Urban					1.00	1.00
Rural					1.52 (1.28 to 1.81)*	1.33 (1.14 to 1.55)*
Carstairs quintile						
1 (least deprived)					1.00	1.00
2					1.03 (0.81 to 1.30)	1.04 (0.83 to 1.31)
3					1.26 (1.01 to 1.58)*	1.30 (1.05 to 1.60)*
4					1.14 (0.90 to 1.45)	1.20 (0.96 to 1.51)
5 (most deprived)					1.27 (0.99 to 1.62)	1.35 (1.07 to 1.69)*

95% CIs in brackets, \*p&lt;0.05.

importance of the local retailing environment and smoking behaviour.<sup>34 35</sup> However, our findings did not support earlier work which tended to find a higher density of tobacco retailers around schools to be positively associated with smoking behaviour<sup>15 17–19</sup>; indeed, we found lower odds of having ever smoked and current smoking in pupils attending schools in areas with the highest density of tobacco retailers. This finding might be explained by higher levels of surveillance (and compliance) among retailers in proximity to schools. Adolescents in the UK attempting to purchase tobacco in proximity to schools are likely to be dressed in school uniform (unlike adolescents in North America) which indicates to retailers that they are underage.

Our research responds to calls for more evidence on the association between retail outlets and adolescent smoking

behaviours.<sup>27</sup> Consistent with previous research, we acknowledge the importance of individual-level and family-level risk factors on adolescent smoking, including family structure, poverty (as measured through Free School Meals) and parental smoking status, but also emphasise significant area-level effects in the form of tobacco outlet density. We recognise that there are other smoking-related outcomes which could be altered by the density of outlets in a neighbourhood. An increased density of outlets in a neighbourhood may shape normative structures of behaviour including attitudes towards tobacco and subjective norms. Such attitudes and norms in adolescents have been shown to predict smoking in the future.<sup>36 37</sup> More research is required to explore the impact of such density on adolescent behaviour more indirectly through the formation of social norms, the social acceptability of smoking and local attitudes to risky behaviours.

**Table 3** Odds of having ever smoked in school and home environments

	Model 1		Model 2		Model 3	
	Home OR 95% CI	School OR 95% CI	Home OR 95% CI	School OR 95% CI	Home OR 95% CI	School OR 95% CI
Tobacco outlet density						
1 (density=0)	1.00	1.00	1.00	1.00	1.00	1.00
2 (lowest density)	1.20 (1.05 to 1.37)*	0.80 (0.48 to 1.32)	1.19 (1.03 to 1.38)*	0.72 (0.51 to 1.00)	1.42 (1.20 to 1.67)*	0.70 (0.53 to 0.93)*
3	1.38 (1.21 to 1.57)*	0.72 (0.43 to 1.19)	1.22 (1.05 to 1.41)*	0.64 (0.46 to 0.90)*	1.45 (1.22 to 1.71)*	0.63 (0.47 to 0.83)*
4	1.53 (1.35 to 1.74)*	0.83 (0.50 to 1.38)	1.23 (1.05 to 1.43)*	0.67 (0.48 to 0.94)*	1.42 (1.19 to 1.69)*	0.63 (0.48 to 0.84)*
5 (highest density)	1.67 (1.46 to 1.90)*	0.82 (0.50 to 1.35)	1.31 (1.13 to 1.52)*	0.68 (0.49 to 0.95)*	1.53 (1.27 to 1.85)*	0.66 (0.50 to 0.86)*
Trend	1.13 (1.10 to 1.16)*	1.01 (0.96 to 1.06)	1.05 (1.02 to 1.09)*	0.97 (0.92 to 1.02)	1.06 (1.02 to 1.11)*	0.96 (0.91 to 1.01)
Class year						
Secondary 2 (age 13)	1.00	1.00	1.00	1.00	1.00	1.00
Secondary 4 (age 15)	3.55 (3.24 to 3.88)*	3.52 (3.22 to 3.85)*	3.84 (3.49 to 4.24)*	3.84 (3.49 to 4.23)*	3.85 (3.50 to 4.25)*	3.86 (3.51 to 4.26)*
Sex						
Female	1.00	1.00	1.00	1.00	1.00	1.00
Male	1.11 (1.02 to 1.20)*	1.10 (1.02 to 1.20)*	1.15 (1.05 to 1.26)*	1.14 (1.04 to 1.25)*	1.14 (1.04 to 1.25)*	1.14 (1.04 to 1.25)*
Ethnicity						
White	1.00	1.00	1.00	1.00	1.00	1.00
Non-white	1.10 (0.95 to 1.27)	1.12 (0.97 to 1.30)	1.18 (0.99 to 1.41)	1.20 (1.00 to 1.43)*	1.22 (1.02 to 1.45)*	1.22 (1.02 to 1.45)*
Free school meals						
Yes			1.00	1.00	1.00	1.00
No			0.70 (0.61 to 0.80)*	0.69 (0.60 to 0.78)*	0.72 (0.63 to 0.83)*	0.72 (0.63 to 0.82)*
Self-perceived family wealth						
Very/quite well off			1.00	1.00	1.00	1.00
Average—not at all well off			1.08 (1.01 to 1.17)*	1.08 (1.01 to 1.17)*	1.07 (0.99 to 1.15)	1.07 (0.99 to 1.15)
Family structure						
Single parent			1.00	1.00	1.00	1.00
Step-parent (and one parent)			1.04 (0.91 to 1.20)	1.04 (0.90 to 1.19)	1.04 (0.91 to 1.20)	1.03 (0.90 to 1.19)
Both parents			0.65 (0.59 to 0.73)*	0.65 (0.58 to 0.72)*	0.65 (0.59 to 0.73)*	0.65 (0.58 to 0.72)*
Other			1.36 (1.06 to 1.74)*	1.34 (1.04 to 1.72)*	1.32 (1.03 to 1.70)*	1.30 (1.01 to 1.67)*
Parental smoking status						
No parent smokes			1.00	1.00	1.00	1.00
At least one parent smokes daily			2.95 (2.69 to 3.23)*	3.00 (2.74 to 3.28)*	2.83 (2.59 to 3.10)*	2.85 (2.60 to 3.11)*
Urban/rural status						
Urban					1.00	1.00
Rural					1.43 (1.27 to 1.62)*	1.23 (1.09 to 1.37)*
Carstairs quintile						
1 (least deprived)					1.00	1.00
2					1.11 (0.94 to 1.30)	1.13 (0.97 to 1.32)
3					1.27 (1.07 to 1.49)*	1.31 (1.12 to 1.54)*
4					1.32 (1.12 to 1.56)*	1.40 (1.20 to 1.64)*
5 (most deprived)					1.43 (1.23 to 1.67)*	1.54 (1.31 to 1.79)*

95% CIs in brackets, \*p&lt;0.05.

Our study has limitations. First, we use cross-sectional data and hence can only infer association, rather than causation. Second, we do not have data on adolescent purchasing patterns, and as such we do not know whether these adolescents are using retail outlets to purchase their tobacco or are relying on informal networks as their main source. Third, our final sample included 54.8% of SALSUS respondents as we did not include those without a spatial identifier (postcode), and those that did not respond to the smoking questions. The deletion of these results may have resulted in either overstating or understating our final results. We did, however, assess whether pupils in our sample who had characteristics associated with missing postcode data (younger non-white males) seemed to have different relationships between smoking status and tobacco environment, compared

with the rest of the sample. They did not—which implies that the exclusion of pupils with missing postcodes is unlikely to have radically altered or biased our models. Finally, there are various factors that may influence whether or not an adolescent chooses to smoke, with the density of outlets being just one. As far as possible, we have tried to control for these at the individual, family and area level, but recognise that there may be other factors shaping young people's smoking behaviour.

There is increased interest in the ways in which our environment may influence our behaviours, and this is particularly important in adolescence when such behaviours are formed. In particular, this is the first study that has included a measure of home and school environments. In doing so, we offer a better conceptualisation of the environment by acknowledging that

adolescents are exposed to place-based characteristics in a range of settings. This research indicates the importance of the retail environment more generally, not just that around schools or in so-called child spaces, but across the total environment.

The results of this research are important from a public policy and public health perspective. A 2012 report, published by the Royal College of Physicians and the UK Centre for Tobacco Control Studies, reported little or no evidence base for retail interventions but suggested that restricting the number/density of outlets in a locality could have an impact on smoking uptake and perpetuation. These findings support this suggestion and confirm that in Scotland the density of tobacco outlets in a neighbourhood is positively associated with increased odds of related risky behaviours in adolescents. The fact that adolescents in areas with the greatest density of outlets in their home environment are more likely to try smoking is critical, particularly when we consider the strength of evidence suggesting that these adolescents, who even try smoking once, are more likely to establish habitual risky behaviours. This evidence does not support a reduction of retailers solely in 'child spaces', such as school neighbourhoods. Instead, tobacco control policy should consider regulating the density of tobacco outlets across all neighbourhoods to reduce the likelihood of smoking and smoking initiation in adolescents.

### What this paper adds

#### What is already known on the subject

- Research has shown that tobacco retail outlet density in residential neighbourhoods is associated with higher odds of smoking.
- Further research has demonstrated higher rates of smoking among pupils attending schools in neighbourhoods of high tobacco retail outlet density.

#### What important gaps exist in knowledge on this subject

- A limitation of previous research has been the exclusive focus on one aspect of an adolescent's environment, *either* the home *or* the school neighbourhood.

#### What this study adds

- This national level study explores the association between tobacco outlet density and adolescent smoking behaviours in home *and* school neighbourhoods.
- Adolescents living in areas of high tobacco outlet density have higher odds of both having ever smoked and current smoking.
- In contrast, adolescents attending schools in areas of highest density had lower odds of having ever smoked and current smoking.
- This evidence does not support a reduction of retailers solely in 'child spaces', such as school neighbourhoods. Instead, tobacco control policy should consider regulating the density of tobacco outlets across all neighbourhoods to reduce the likelihood of smoking and smoking initiation in adolescents.

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**Data sharing statement** The density measures used in this study are available from the corresponding author.

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