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How has the introduction of point-of-sale legislation affected the presence and visibility of tobacco retailing in Scotland? A longitudinal study

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Abstract

Background

Reducing the local availability of tobacco is identified as the ‘next frontier’ in tobacco control. This paper examines the roles of tobacco retail outlet density and tobacco visibility in changing exposure to tobacco retailing before and after the introduction of Point-of-Sale (POS) legislation in Scotland.

Methods

National tobacco retailer register data were analysed to examine time trends in tobacco retailer density (2012-2017). Results were stratified by local authority, neighbourhood deprivation and urbanity. Next, an annual retail audit using a POS tobacco visibility tool assessed changes in total product visibility in all retail outlets in four study communities between 2013 and 2017. A longitudinal survey (2013-2017) of 5,527 adolescents aged 12-17 in the four study communities enabled the calculation of residential and journey-to-school measures of tobacco retailer exposure. Trends were stratified by deprivation, urbanity and socioeconomic status.

Results

Retail provision of tobacco declined following the introduction of the POS legislation in 2013. However, there were strong geographic differences; nationally one fifth of local authorities have increased provision since 2015. In the four study communities, tobacco retail provision was generally stable over the study period. Although product visibility of tobacco products reduced for adolescents there was growing socioeconomic disparity in the density of tobacco retailers and the visibility of tobacco storage.

Conclusions

The POS ban reduced exposure to tobacco products in communities across Scotland.

However, tobacco products remain widely available, and there is growing socioeconomic disparity in the availability and visibility of tobacco.

What is already known on this subject

- Higher local availability of tobacco products tends to be associated with smoking initiation, greater smoking prevalence, and lower levels of cessation.
- Tobacco retailers are more prevalent in more socially disadvantaged areas.
- Point-of-Sale legislation has led to a reduced visibility of tobacco products in tobacco stores

What important gaps in knowledge exist on this topic

- The effect of the recent legislation in the UK restricting tobacco displays at Point-of-Sale on retail provision of tobacco is unknown.
- How tobacco retail outlet density and retail visibility of tobacco interact to influence changes in overall tobacco retail exposure after the introduction of the Point-of-Sale legislation and how this impacts inequalities has not previously been explored.

What this study adds

- Legislation in Scotland removing Point-of-Sale tobacco displays has reduced overall exposure to tobacco products amongst adolescents but inequalities in availability and visibility have increased.
- The availability of tobacco in Scotland remains ubiquitous. Achieving the tobacco 'endgame' will require strategies that reduce the local provision of tobacco products across the country.

Background

There is widespread acceptance that the ‘next frontier’ of tobacco control is likely to require radical action to reduce the availability of tobacco including the supply of tobacco in local communities [1]. It is feasible that a greater availability of tobacco: increases the opportunities to procure tobacco; creates a more competitive local market; and enhances the visibility of tobacco products [2–6]. Greater availability, reduced price, and higher visibility are all known to encourage initiation, particularly amongst adolescents, and undermine cessation efforts. Retail availability is also an equity concern as tobacco retailers tend to disproportionately locate in more socially disadvantaged neighbourhoods, which may help to explain inequalities in smoking [7]. Recent work in Scotland found that greater neighbourhood density of tobacco retailing is associated with higher odds of having ever smoked or reporting current smoking amongst adolescents [8]. For adults, residents of areas with the higher densities of tobacco retailing had a higher chance of being a current smoker, and a lower chance of being an ex-smoker [9].

There are three important critiques of the work on geographical tobacco retailing density. First, measures of exposure rely on overly simplistic methods such as the density of retailers in a person’s residential neighbourhood. This is problematic because over the course of a day people tend to be highly mobile as they move between different settings (home, school, retail, leisure spaces, friends’ houses etc.) and are, therefore, likely to be exposed to a multitude of different environments. The literature describes the geographical range a person has as their ‘activity space’. Second, and related, most density measures rely on data indicating the simple count of tobacco retailers within a predefined area. This approach assumes all tobacco retailers to be homogenous when of course there are substantial differences in the size and position of tobacco displays, the internal and external signage indicating tobacco is for sale, and the generic and branded messages on display. Third, most previous studies of exposure to

tobacco retailing adopt cross-sectional study designs; there are few examples of longitudinal analyses, especially studies covering periods that include the introduction of major pieces of tobacco control legislation.

Recent policy initiatives in jurisdictions including Australia, Canada, Ireland and Iceland have targeted the promotion and visibility of tobacco products through policy levers such as restrictions at the Point-of-Sale (POS) [10] and the introduction of plain packaging. In Scotland, POS displays by tobacco retailers were prohibited in large supermarkets in April 2013 and smaller retailers from April 2015. The legislation required that all tobacco and smoking-related products (including prices) to be out of public sight either by concealing tobacco gantries or by storing tobacco products under the counter. Immediately following the implementation of the legislation, compliance was found to be high and tobacco branding was no longer visible [11]. However, it was also found that tobacco products retained a clear presence such as through the tobacco storage units and generic tobacco signage.

The aim of this paper is to examine change in exposure to tobacco retailing over a five-year period that included the introduction of POS legislation in Scotland. The first stage of the analyses considers the change in retail provision at the national-level. This is followed by a more detailed consideration in four communities in Scotland that differ in terms of their deprivation and urban/rural profile. The measures developed are novel as they include information on the local density of tobacco retailers *and* data on within-store tobacco visibility. Importantly, the approach also accounts for the spaces around the homes, schools and journey to school of 5,527 study participants aged 12 to 17 years old (akin to the activity spaces measures used in previous studies). The objectives are to: (i) examine whether there has been a change in geographical availability at national-level between 2012 and 2017; (ii) consider whether these changes vary by geography (local authorities) and area-level measures (deprivation and urban/rural group); and (iii) for a sample of four study communities (defined

as secondary school catchment areas) consider change in exposure over this period to tobacco products and for our sample of individuals residing in the four communities.

Method

National Register Data

The Tobacco and Primary Medical Services (Scotland) Act 2010 established a national register that requires the registration of all retailers selling tobacco products [12]. Tobacco retailers included supermarkets, small grocery/convenience stores, confectioners/tobacconists/newsagents (CTNs), petrol station forecourt stores, off-licences (liquor stores), and fast-food/takeaway outlets. After removing duplicates, the count of premises in the dataset were: 2012 (n=10,161), 2013 (n=10,206), 2014 (n=9,010), 2015 (n=8,847), 2016 (n=9,042) and 2017 (n=9,118) (see Supplementary Table 1). The retailer postcodes were geocoded using a yearly extract of the Ordnance Survey codepoint data product [13].

The national-level mapped retailer data were used to create Kernel Density Estimation (KDE) surfaces for each year. This involved dividing the whole of Scotland into 50m by 50m grid cells, and for each grid cell calculating the number of retailers within an 800m radius. An 800m radius was chosen as it is a plausible walking distance (16 minutes at 3 km/h) and has been commonly adopted in previous studies [7,8]. A density measure is calculated (i.e. number of retailers divided by grid cell area) with the weight of each outlet determined by the quartic kernel function [14]. Applying this distance-decay function means that retailers closer to the grid cell provide more weight towards the density measure than those further away.

In order to integrate the density measures with other area-level data, Geographic Information System (GIS) was used to overlay the boundaries of the Scottish Data Zones (n=6,976) onto each of the density surfaces. Datazones were selected because socioeconomic, urban/rural

status and population data were available at this geography. We used quintiles of the 2016 SIMD income domain rank (percentage of people who are income deprived and receive certain benefits or tax credits) [15] as a marker of socioeconomic deprivation (rather than overall SIMD which includes information on drive times to petrol stations which are often tobacco retailers). The 2013/2014 6-fold urban rural classification [16] was used to distinguish between neighbourhoods in urban and rural areas. Mid-year population estimates from 2012-2017 were used to generate estimates of tobacco retailer rates [17]. The mean of the KDE surface grid cells within each Data Zone was calculated.

DISPLAY Study

The ‘Determining the impact of smoking point of sale legislation among youth’ (DISPLAY) study is a mixed method, longitudinal study (2013 to 2017) in four study communities (the catchment areas around four secondary schools) designed to assess the impacts of the tobacco POS display ban in Scotland [18]. The communities were chosen to provide two levels of social deprivation (high vs medium-low) and urbanity (urban vs semi-urban). To minimise the influence of other school-level factors, we selected only non-denominational local authority schools on mainland Scotland with an ethnic minority population of less than 10% of the school roll. An upper limit was placed on schools’ ethnic minority population, as in Scotland ethnic minorities represent only 4% of the total Scottish population [19].

DISPLAY Audit Data

For each year from 2013, data on the visibility of tobacco products were collected using discreet audits of all retail outlets across the four study communities (n=95 in 2013, and n=93 in 2017). Full details of the development of the audit tool are available elsewhere [20] but briefly, observers worked in pairs to measure product and storage visibility collected by the discreet audits of all outlets selling tobacco in the four study communities. Measures included

the visibility of tobacco storage units at point of purchase; proximity of the tobacco sales counter to customer traffic flows; size of tobacco storage units; and conspicuousness of tobacco storage units within the surrounding retail environment. There was considerable agreement across all 12 items, with 100% agreement on 8 items and 92% agreement on 4 items. The Cohen's Kappa (k) for each item, range: 0.76 – 1.00, were above the suggested 0.60 threshold for moderate to strong reliability. In the current analyses we used the total product visibility score for each store; higher scores are interpreted as greater visibility of tobacco storage or products.

DISPLAY School Survey Data

As part of the DISPLAY study annual school surveys were conducted each year (February and March) of pupils (aged 11–18) in the four schools. Consenting students undertook the surveys under examination conditions, supervised by class teachers. Parental opt-out consent was provided in advance of the survey and students could withdraw from the survey on the day. Ethics approval was granted by the University of St Andrew's School of Medicine Ethics Committee and the Child Panel & School Liaison Representative. The overall response rate ranged from 86% to 87% over five years. The Family Affluence Scale (FAS) was used as an assessment of individual family material well-being. The FAS includes information on material circumstances and consists of four questions relating to information on whether the participant has their own bedroom, number of cars in the family, number of computers, and number of holidays abroad per year [21] [22]. Participants who supplied their postcode of residence were eligible for the current analysis (N=5,527). In Scotland, postcode units correspond to an average of 15 households. Postcodes were missing for 267 (18%) of pupils in 2013, 300 (21.4%) in 2014, 816 (21.4%) in 2015, 900 (23.7%) in 2016 and 913 (23.6%) in 2017. Using survey information about participants' mode of transport to school ("walking", "bicycle", "bus, train, tram, underground or boat", "car, motorcycle or moped",

or “other means”) we determined the optimal route to school from residential postcode to school with Google Maps Directions Application Programming Interface. . If responses could not be matched we assumed “walking” directions as this was the most popular mode of transport.

Data Analysis

To examine the geographic variability between 2012 and 2017 we calculated the number of retailers per 10,000 people (dividing the total number of outlets by the total population and multiplying by 10,000) at the national and local authority level (n=32). The mean density and 95% CIs were calculated and then stratified by local authority, SIMD income domain quintile and 6-fold urban rural classification group.

For each participant in the school surveys we estimated a series of overall tobacco retailing exposure scores based on (for each year) the retailing environments (a) in their residential neighbourhood and b) along their likely route to school. First, for each study participant we calculated the mean tobacco retailers KDE values of their neighbourhood and presented the summary for the four study communities. Second, the analyses were repeated but with the KDE estimates weighted by the total product visibility score (i.e. stores where tobacco products were more visible had a higher weighting). Third, steps one and two were repeated but rather than determine exposure based on the participant’s neighbourhood, the measure was calculated using the participant’s estimated route to school. This was achieved by calculating the sum of all the grid cells (weighted and unweighted) through which the participant passed. Finally, to assess how change in exposure related to socioeconomic status, steps one to three were repeated but instead of stratifying the results by study community, the density measures were stratified by participant’s FAS tertile. A sensitivity analysis was undertaken on the individual level estimates using a radius of 400 m and 1,200 m, but did not

alter the main conclusion, therefore we have presented the analysis for the 800 m. All analyses were undertaken in R version 3.3.2.

Results

National-level change in tobacco retailers

There was a marked change in the number of tobacco retailers in Scotland from 2012 to 2017 (S1). The number of tobacco retailers per 10,000 people increased slightly between 2012 (19.12) and 2013 (19.16) and then dropped sharply from 2013 to 2014 (16.85). The lowest figure was recorded in 2015 (16.47), but then increased again to 16.73 in 2016 and 16.81 in 2017. Across the 32 local authorities in Scotland, the highest rate of retailers was found in Highland in 2012 (74.61 per 10,000), compared to the lowest rate in Eilean Siar in 2013 (3.75 per 10,000) (Supplementary Table 2).

Retailer density. At the national-level, the trend in mean neighbourhood density reflected the patterns noted for the number of retailers with a reduction between 2012 and 2015, followed by a slight increase between 2015 and 2017. Time trends in tobacco retailer density in Scotland and the 32 Scottish local authorities are presented in Figure 1 and Supplementary Figure 1. Three trajectories emerged: stable with very low density, variable then an increase since 2015, and decrease then stable since 2015. Moray was an outlier due to the steepness of decline from 2013 to 2014. Among the major cities, Edinburgh, Glasgow and Aberdeen follow the national pattern, whereas Dundee did not record a post-2015 increase.

Neighbourhood deprivation. Neighbourhoods in the most deprived quintile had the highest tobacco retailer density throughout the study period (Figure 2). The reduction in density found at the national-level between 2012 and 2015 was apparent across all of the deprivation quintiles, although the drop was less marked in the most deprived quintile (Supplementary Figure 2). The increase in density towards the end of the study period (2015-17) was also

apparent in all deprivation quintiles but with a much sharper increase in the two highest-deprivation quintiles. This suggests that the overall increase noted at the national level was driven substantially by an increase in availability in the most disadvantaged 40 percent of neighbourhoods. The ratio between the most deprived and least deprived quintile increased from 2.01:1 in 2012 to 2.17:1 in 2017.

Urbanity. As anticipated, we found pronounced differences in the change in tobacco retailer density by urban/rural status (Figure 3). Neighbourhoods in “Large urban areas” had more than double the retailer density of “other urban areas”, “accessible small towns” and “remote small towns” which all have moderate levels of tobacco retailer density. “Accessible rural” and “remote rural” have very low tobacco retailer densities. Between 2012 and 2015 there was a marked reduction in retailer density in all urban/rural categories. However, after 2015 the trends in retailer density diverged with a substantial increase in “large urban areas” and “other urban areas” (Supplementary Figure 3). In “accessible small towns”, “remote small towns” and “accessible rural” there was little change in retailer density between 2015 and 2017. For neighbourhoods in the “remote rural” retailer density fell slightly in this latter period.

Community-level change in tobacco retailer density

The next phase of the research provided a more detailed analysis of the provision of tobacco retailing in the four DISPLAY school communities. Between 2013 and 2017, there were few changes (≤ 2 retailers) in the number of tobacco retailers within the four communities, and these were predominantly openings and closures of small retailers (under 280 m²).

Individual-level change. The descriptive characteristics of the school survey sample are presented in Table 1. The percentage of adolescents from the urban/high deprivation community declined and the semi-urban/medium-low deprivation community increased

marginally. Little change in mode of transport was observed over the time period, with the majority of children walking to school.

Given, the modest changes in the number of tobacco retailers over the study period, it is unsurprising that there was very little change in the unweighted individual exposure scores with only small declines in exposure amongst individuals from the semi-urban communities (Figure 4A). However, once the retailers were weighted by the total product visibility score, it is clear that there was a large reduction in the participants' neighbourhood exposure following the phased implementation of the POS legislation in 2013 (large supermarkets) and 2015 (small retailers), with a particularly marked reduction between 2014 and 2016 (Figure 4B). Between 2013 and 2017 the absolute difference between mean total product exposure scores for the participants in the highest (urban/high deprivation) and lowest (semi-urban/medium-low deprivation) community reduced over twofold from 0.047 in 2013 to 0.020 in 2017. With the exception of one case, the differences between the four communities were significant (i.e. with non-overlapping confidence intervals). Similar findings were apparent when using the journey-to-school exposure measure was assessed with a reduction in exposure for the urban communities (Figure 4C-D), however there was a marked difference in estimates in the semi-urban/high deprivation and semi-urban/medium-low deprivation communities, which switched in rank (Figure 4D). The semi-urban/high deprivation community had higher density surrounding the participants' residence compared with the journey-to-school exposure measure; whereas the semi-urban/medium-low deprivation community had a lower density surrounding the participants' residence compared to the higher journey-to-school measure. Again, the differences between the four study communities over the study period were mostly significant.

Socioeconomic status. When the exposure results were stratified by individual-level SES, we found that in the unweighted measure the reductions in retailer density were confined to the

least disadvantaged tertile (Figure 5A). Therefore, the level of inequality between the most deprived and least deprived FAS tertiles increased over the time period; by the end of the study period the difference between the least deprived tertile and the other tertiles was statistically significant. These results were slightly more pronounced using the journey-to-school measures (Figure 5C). For density weighted by total product visibility, it was apparent that there was a substantial reduction in exposure for individuals in each FAS tertile (Figure 5B and 5C); by the end of the study period, although there was still a significant gradient in total product exposure between high and low SES individuals, the absolute difference between FAS1 and FAS3 mean scores had reduced almost fivefold (0.032 to 0.007).

Discussion

This study provides a longitudinal assessment of the presence and visibility of tobacco retailing following the introduction of POS legislation designed to restrict the promotion and marketing of tobacco products. At the national-level, the findings demonstrate a reduction in the density of tobacco retailing across Scotland but with pronounced geographical differences in availability across regions. Of concern is that the overall reduction in availability at the start of the study period was then followed by a slight increase in more recent years. The national-level analyses also demonstrate that the increase in tobacco retailer density has been largely driven by the increase in retailers in the most disadvantaged neighbourhoods, which in more recent years has resulted in an increase in inequalities in density. In the four study communities, changes in availability were stable but differed by deprivation and urbanity profile. At the individual-level, visibility of tobacco products was dramatically reduced due to compliance with the POS legislation but there was growing socioeconomic disparity in the availability and visibility of tobacco products.

Strengths and limitations

Our study has three key advantages over existing work. First, although other studies have investigated the effectiveness of POS bans on smoking prevalence [10], there is little research on the spatial changes in exposure to tobacco retailers and marketing. Previous tobacco outlet availability studies have been limited by their geographical extent (e.g. city level) [23] and/or by their temporal coverage (i.e. data from a single year) [7,24]. The only previous longitudinal study, conducted using four years of tobacco outlet data (2003, 2009, 2012, 2015) and three years of audit data (2009, 2012, 2015), documented a reduction in the availability and advertising of tobacco [25]. Ours is the first study to investigate national-level tobacco retailer availability continuously over five years, spanning the introduction of a POS ban, and linked to area and individual estimates of socioeconomic status.

Second, previous studies on retailer density have also been limited by failing to incorporate information about the marketing of tobacco in individual retailers. In 2014, a systematic review found that 88 store audit studies had been published with some also measuring density within their study area. However, there were opportunities to better combine tobacco retailer density and proximity with audit-based information on tobacco marketing [26]. By applying audit weightings to our kernel density estimates ours is the first study to combine both sets of information. Our yearly verification of retailers in the four catchments ensured a robust measure of tobacco retailer availability. Finally, previous work has shown that compared to traditional methods, tobacco outlet exposure can be estimated more accurately when the participant's journey-to-school exposure is accounted for [27,28]. Our work is the first to report differences in availability and marketing by geographical exposure assessment (i.e. residential compared to measures capturing residential, school and journey-to-school environments).

Our study has limitations. First, although there may be tobacco retailers that did not register, fieldwork in the four study communities suggested high compliance. Second, geocoding of

tobacco retailers was completed at the postcode unit level (rather than for households), which might result measurement error in the individual density measures. Third, mode of transport to school was not available in 2013 and therefore for this year we assumed all participants walked to school. This is unlikely to have been the case and may restrict the comparability of the journey to school measures between 2013 and the other years. Finally, it is likely that the participants will traverse a multitude of spaces over the course of their daily lives, including those that distal from their residential neighbourhoods and schools. Previous work using GPS data to capture people's geographical range has shown the types places likely to be important in understanding their health and related behaviours, including the use of tobacco [28]. It is therefore feasible that our journey to school measures using optimal routes may not precisely replicate the actual route taken and/or fully capture the extent of the places visited over the course of a day [29].

Conclusion

POS legislation successfully reduced exposure to tobacco products in communities in Scotland. However, whilst there has been a modest reduction in the number of tobacco retailers around the introduction of the POS legislation, since 2015 there has been a slight increase. Furthermore, there is growing socioeconomic disparity in the availability and visibility of tobacco. Future work can usefully assess the longitudinal relationships between tobacco outlet availability/visibility and intermediary outcomes such as attitudes to smoking, brand awareness and perceived ease of access to tobacco products. These findings are important from a policy perspective as they emphasise that despite the progress being made in tobacco control in Scotland, tobacco products remain widely available. Scotland's recently published tobacco control action plan [30] highlights the interconnections between tobacco consumption and the substantial inequities in health across the country. The findings of the current study emphasise that policies intended to reduce smoking prevalence and address

health inequalities must consider the uneven geography of the availability and visibility of tobacco products in Scotland. If Scotland is to be successful in its ambitions to achieve the tobacco endgame then policy options that reduce the availability of tobacco retailers are likely to be essential.

Ethics

Ethical approval for the school survey was obtained from the University of St Andrews, School of Medical Ethics Committee. The Ethics Committee approved the use of parental opt-out consent, as is the norm for national school surveys in Scotland, and pupils provided active consent on the day of completing the survey.

References

- 1 Smyth C, Freeman B, Maag A. Tobacco retail regulation: the next frontier in tobacco control? *Public Heal Res Pract* 2015;**25**. doi:10.17061/phrp2531529
- 2 Pearce J, Hiscock R, Moon G, *et al*. The neighbourhood effects of geographical access to tobacco retailers on individual smoking behaviour. *J Epidemiol Community Health* 2009;**63**:69–77. doi:10.1136/jech.2007.070656
- 3 Lipperman-Kreda S, Grube JW, Friend KB. Local Tobacco Policy and Tobacco Outlet Density: Associations With Youth Smoking. *J Adolesc Heal* 2012;**50**:547–52. doi:10.1016/j.jadohealth.2011.08.015
- 4 Lipperman-Kreda S, Paschall MJ, Grube JW. Perceived enforcement of school tobacco policy and adolescents' cigarette smoking. *Prev Med (Baltim)* 2009;**48**:562–6. doi:10.1016/j.ypmed.2009.03.008
- 5 Henriksen L, Feighery EC, Schleicher NC, *et al*. Is adolescent smoking related to the density and proximity of tobacco outlets and retail cigarette advertising near schools? *Prev Med (Baltim)* 2008;**47**:210–4. doi:10.1016/j.ypmed.2008.04.008
- 6 Schleicher NC, Johnson TO, Fortmann SP, *et al*. Tobacco outlet density near home and school: Associations with smoking and norms among US teens. *Prev Med (Baltim)* 2016;**91**:287–93. doi:10.1016/j.ypmed.2016.08.027
- 7 Shortt NK, Tisch C, Pearce J, *et al*. A cross-sectional analysis of the relationship between tobacco and alcohol outlet density and neighbourhood deprivation. *BMC Public Health* 2015;**15**:1014. doi:10.1186/s12889-015-2321-1
- 8 Shortt NK, Tisch C, Pearce J, *et al*. The density of tobacco retailers in home and school environments and relationship with adolescent smoking behaviours in Scotland.

Tob Control 2016;**25**. doi:10.1136/tobaccocontrol-2013-051473

- 9 Pearce J, Rind E, Shortt N, *et al*. Tobacco Retail Environments and Social Inequalities in Individual-Level Smoking and Cessation Among Scottish Adults. *Nicotine Tob Res* 2016;;138–46. doi:10.1093/ntr/ntv089
- 10 He Y, Shang C, Huang J, *et al*. Global evidence on the effect of point-of-sale display bans on smoking prevalence. *Tob Control* 2018;;tobaccocontrol-2017-053996. doi:10.1136/tobaccocontrol-2017-053996
- 11 Eadie D, Stead M, Mackintosh AM, *et al*. Are retail outlets complying with national legislation to protect children From exposure to tobacco displays at point of sale? Results From the first compliance study in the UK. *PLoS One* 2016;**11**. doi:10.1371/journal.pone.0152178
- 12 The Scottish Government. Register of Tobacco and Nicotine Vapour Product Retailers. 2018.<https://www.tobaccoregisterscotland.org/> (accessed 16 May 2018).
- 13 Ordnance Survey. Code-Point. 2018.<https://www.ordnancesurvey.co.uk/business-and-government/products/code-point.html> (accessed 16 May 2018).
- 14 Silverman BW. *Density estimation for statistics and data analysis*. Chapman and Hall 1986. <https://www.crcpress.com/Density-Estimation-for-Statistics-and-Data-Analysis/Silverman/p/book/9780412246203> (accessed 16 May 2018).
- 15 The Scottish Government. The Scottish Index of Multiple Deprivation. 2016.<http://www.gov.scot/Topics/Statistics/SIMD> (accessed 16 May 2018).
- 16 The Scottish Government. Defining Scotland by Rurality. <http://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification> (accessed 16 May 2018).

- 17 Scotland NR of. Mid-Year Population Estimates.
<https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/population/population-estimates/mid-year-population-estimates> (accessed 16 May 2018).
- 18 Haw S, Amos A, Eadie D, *et al.* Determining the impact of smoking point of sale legislation among youth (Display) study: a protocol for an evaluation of public health policy. *BMC Public Health* 2014;**14**:251. doi:10.1186/1471-2458-14-251
- 19 The National Records of Scotland. 2011 Census: Key Results on Population, Ethnicity, Identity, Language, Religion, Health, Housing and Accommodation in Scotland - Release 2A. Edinburgh: 2013. <https://www.scotlandscensus.gov.uk/statistical-bulletins>
- 20 Eadie D, Best CS, M S, *et al.* Assessing Change in Tobacco Visibility at Point-of-Sale Following a Display Ban. *Tob Regul Sci* 2018;**4**:10–28. doi:10.18001/TRS.4.3.2
- 21 Currie C, Molcho M, Boyce W, *et al.* Researching health inequalities in adolescents: The development of the Health Behaviour in School-Aged Children (HBSC) Family Affluence Scale. *Soc Sci Med* 2008;**66**:1429–36. doi:10.1016/j.socscimed.2007.11.024
- 22 Torsheim T, Cavallo F, Levin KA, *et al.* Psychometric Validation of the Revised Family Affluence Scale: a Latent Variable Approach. *Child Indic Res* 2016;**9**:771–84. doi:10.1007/s12187-015-9339-x
- 23 Han T, Alexander M, Niggebrugge A, *et al.* Impact of tobacco outlet density and proximity on smoking cessation: A longitudinal observational study in two English cities. 2014. doi:10.1016/j.healthplace.2014.01.008
- 24 Kirchner TR, Anesetti-Rothermel A, Bennett M, *et al.* Tobacco outlet density and converted versus native non-daily cigarette use in a national US sample. *Tob Control*

- 2017;**26**:85–91. doi:10.1136/tobaccocontrol-2015-052487
- 25 Hosler AS, Done DH, Michaels IH, *et al.* Longitudinal Trends in Tobacco Availability, Tobacco Advertising, and Ownership Changes of Food Stores, Albany, New York, 2003–2015. *Prev Chronic Dis* 2016;**13**:160002. doi:10.5888/pcd13.160002
- 26 Lee JGL, Henriksen L, Myers AE, *et al.* A systematic review of store audit methods for assessing tobacco marketing and products at the point of sale. *Tob Control* 2014;**23**:98–106. doi:10.1136/tobaccocontrol-2012-050807
- 27 Lipperman-Kreda S, Morrison C, Grube JW, *et al.* Youth activity spaces and daily exposure to tobacco outlets. *Health Place* 2015;**34**:30–3. doi:10.1016/j.healthplace.2015.03.013
- 28 Shareck M, Kestens Y, Vallée J, *et al.* The added value of accounting for activity space when examining the association between tobacco retailer availability and smoking among young adults. *Tob Control* 2015;**25**:1–7. doi:10.1136/tobaccocontrol-2014-052194
- 29 Dalton A, Jones A, Panter J, *et al.* Are GIS-modelled routes a useful proxy for the actual routes followed by commuters? *J Transp Heal* 2015;**2**:219–29. doi:10.1016/J.JTH.2014.10.001
- 30 Scottish Government. Improving Scotland's Health: Raising Scotland's Tobacco-free Generation. Edinburgh: 2018. <https://beta.gov.scot/publications/raising-scotlands-tobacco-free-generation-tobacco-control-action-plan-2018/>

Tables and Figures

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Figure 5: Tobacco Retailer Density Estimates for participant's neighbourhood and journey to school, for the Four DISPLAY communities, by total product visibility weighting and FAS tertile (2013-2017)

Table 1: Descriptive characteristics of participants by year (number and percentage in brackets)

Variable	Year				
	2013 (N=1226)	2014 (N=1104)	2015 (N=3005)	2016 (N=2889)	2017 (N=2963)
School^a					
Urban/High dep.	313 (26)	280 (25)	683 (23)	613 (21)	667 (23)
Urban/medium-low dep.	277 (23)	264 (24)	717 (24)	757 (26)	768 (26)
Semi-urban/high dep.	305 (25)	259 (23)	724 (24)	722 (25)	711 (24)
Semi-urban/medium-low dep.	331 (25)	301 (27)	881 (29)	797 (28)	817 (28)
Mode of transport					
Walking	-	571 (52)	1520 (51)	1424 (49)	1496 (50)
Car, motorcycle or moped	-	146 (13)	395 (13)	413 (14)	437 (15)
Bus, train, tram, UG or boat	-	359 (33)	1027 (34)	994 (34)	960 (32)
Bicycle	-	5 (0)	11 (0)	8 (0)	11 (0)
Other means	-	8 (0)	11 (0)	9 (0)	12 (0)
Incorrect Response	-	-	-	27 (0)	-
Missing	1226 (100)	15 (0)	41 (0)	14 (0)	47 (0)
Family affluence Score^b					
Low	405 (33)	347 (31)	975 (32)	924 (32)	952 (32)
Medium	397 (32)	359 (33)	974 (32)	926 (32)	980 (33)
High	434 (35)	398 (36)	1056 (35)	1036 (36)	1031 (35)

- a. Community-level deprivation categories were derived from the population-weighted mean Scottish Index of Multiple Deprivation (SIMD) score for all census Data Zones (500-1000 residents) located within the school catchment areas, and the proportion of children from each school receiving free school meals
- b. FAS raw scores were transformed through categorical principal component analysis into single-dimensional scores that were then divided into tertiles of low, medium and high affluence.

Supplementary Materials

Supplementary Table 1: The Number of Tobacco Retailers in Scotland, by local authority (2012-2017)

Supplementary Table 2: The Number of Tobacco Retailers per 10,000 people in Scotland, by local authority (2012-2017)

Supplementary Figure 1: Tobacco retailer density estimates for Scottish Data Zones, by local authority (2012-2017)

Supplementary Figure 2: Tobacco Retailer Density Estimates for Scottish Data Zones, by SIMD income deprivation quintile (2012-2017)

Supplementary Figure 3: Tobacco Retailer Density Estimates for Scottish Data Zones, by Urban/rural group (2012-2017)