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Rapid evidence review: What is the causal link between tobacco outlet density and smoking prevalence?

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About this briefing

This rapid evidence review summarises recent literature which provides insight into the causal association between tobacco outlet density and smoking prevalence.

Key points

- There is a well-established relationship between tobacco outlet density and smoking rates, but this is largely based on correlational evidence which is unable to identify whether outlet density restrictions will lead to reduced smoking rates.

- Three modelling studies predict that reducing tobacco outlet density can lead to small to modest decreases in smoking rates in some situations. However, there is a lack of robust observational evidence that directly evaluates the impact of reducing tobacco outlet density on smoking prevalence.

- Modelling based on US data suggests that policy actions are unlikely to have an effect on smoking prevalence unless they can reduce the density of retailers below a certain threshold. This may particularly limit the effectiveness of weaker retail restrictions in urban areas, however this needs closer examination in the context of outlet density in Scotland.

- There is some evidence that tobacco outlet reduction interventions may modestly reduce smoking prevalence, although none achieved New Zealand's endgame goal of a smoking prevalence of <5%. These interventions could be considered alongside others in a more comprehensive tobacco control programme.

Background

Tobacco use represents the leading preventable cause of morbidity and mortality in Scotland, with around 20% of all deaths attributable to smoking.[1] Although smoking rates have been gradually falling in Scotland, they have stagnated in recent years.[2] If the Scottish Government is to achieve its aim of reducing adult smoking prevalence to 5% or less by 2034, more will need to be done to reduce tobacco use.

Smoking rates are strongly patterned by socioeconomic group in Scotland, with 35% of adults in the most deprived quintile of the Scottish Index of Multiple Deprivation (SIMD) being smokers, compared with 11% in the least deprived quintile.[2] Recent data from the Scottish Health Survey indicate that these inequalities have only marginally narrowed over time.[2] The effectiveness of some existing policies and interventions to reduce smoking and related harms varies across certain population groups, which can act to widen these health inequalities. For example, mass media campaigns may be more effective among those in higher socioeconomic groups.[3, 4] As such, in order to improve population health and reduce health inequalities, it is necessary to consider areas for action that are able to tackle smoking rates without risking lower effectiveness in some socioeconomic groups. This may involve avoiding approaches which require participant opt-in, or the investment of their time or money.

Recent qualitative studies of the views of tobacco control experts[5, 6] concluded that legislation to restrict the availability of tobacco products in Scotland should be explored as a potential further policy action. While it is recognised that availability of tobacco can be defined in many ways, this evidence review focuses on tobacco outlet density – that is, the number of tobacco retailers in a given geographical area.

Scotland has around 10,000 tobacco retailers[7] which means there is approximately one outlet for every 450 persons aged 16 and over, and around one outlet for every 90 smokers. This is higher than in many other countries.

For example, there is approximately one outlet for every 213 smokers in England and one for every 555 smokers in France.[8] Tobacco outlet density is also strongly patterned by socioeconomic status in Scotland, with recent estimates indicating that density in the most deprived areas is double that in the least deprived areas.[7]

It is well established that greater tobacco outlet density is correlated with higher tobacco use.[9, 10, 11, 12, 13] However, it does not necessarily follow from correlational evidence alone that reducing outlet density would cause smoking rates to decline. For instance, it is possible that tobacco outlets gravitate towards areas where smoking rates are already higher, rather than increased availability precipitating higher consumption. Resolving this lack of clarity relies on an understanding of the causal processes involved.

There are several pathways through which greater tobacco outlet density may be linked with higher smoking rates, for instance by directly increasing opportunity for purchase. Higher outlet density may also indirectly influence smoking rates by propagating the perceived normality of smoking[14] or by creating local competition which drives down cost.

This rapid review identifies and synthesises international evidence relating to a causal link between tobacco outlet density and smoking rates (including uptake rates and cessation success) and/or smoking-related morbidity and mortality.

Evidence summary

Systematic review methods were used to identify, critically appraise and synthesise published, peer-reviewed research that examines the link between tobacco outlet density and smoking rates or smoking-related disease. Searches in six bibliographic databases retrieved 973 unique studies, published between 2013 and 2018, of which 15 were relevant to the focus of this review. No robust empirical evaluations of tobacco outlet restrictions (i.e. randomised controlled trials or longitudinal observations of tobacco outlet restrictions) were retrieved.

Of the 15 relevant articles, three modelling studies[15, 16, 17] represent the best-available evidence for the focus of this review. A further 12 articles did not provide direct insight into the existence of a causal relationship between tobacco outlet density and tobacco consumption, but provide useful context, and these are therefore briefly summarised at the end of this section.

Modelling studies

Luke et al[15]

Key points

- This study involved computer simulating individuals' tobacco purchasing behaviour, using a composite measure of cost inclusive of travel as an outcome variable (a proxy of tobacco consumption).
- A range of interventions were simulated, including a cap on the number of retailers, cordons around schools or other retailers, store type bans, and combinations of all of these approaches.
- Simulated interventions varied in their ability to lower the density of tobacco outlets, with specific policies being more effective in different settings. For example, a 1,500 foot school buffer substantially reduced outlet density in urban deprived areas, but was less successful in suburban areas.

- Total tobacco purchase cost does not appear to be associated with outlet density in a straightforward linear fashion. Reducing the number of outlets in areas with high outlet density may have little effect on smoking rates unless they reduce density below a critical level.

One of the retrieved articles[15] utilised an agent based modelling approach to predict the outcome of various tobacco outlet restriction policies. Broadly, this approach involves computer simulations of individuals' behaviour in order to determine the overall impact of actions or policies. In this particular study, a virtual city/town environment was modelled, within which individuals are able to travel and perform simplified actions including purchasing and smoking cigarettes.

The computer simulation was built using a large number of parameters based on previous real-world observations. Four environments were simulated (urban rich, urban poor, suburban rich and suburban poor), with key model parameters for these environments reflecting real-world counterparts in California. Individuals in this model were defined by fixed parameters reflecting their smoking rate, salary, method of transport (walking, bicycle or car), home and work place/school location and the usual route between them.

The outcome of interest in this model was an abstract composite measure, which combines the retail cost of cigarettes, plus the fuel and/or time costs associated with travelling to obtain them. This measure is an appropriate proxy of tobacco use given the strong association between price and consumption.[18]

Various tobacco retail restrictions were simulated and compared to a baseline simulation with no restrictions:

1 Eliminate sales from outlets within 500, 1,000 or 1,500 feet of another retailer.
2 Eliminate sales from outlets within 500, 1,000 or 1,500 feet of a school.

3 Random cap on the number of retailers (ranging from 90% of the current number to 50%).
4 Ban tobacco sales at pharmacies or convenience stores.
5 Combinations of restrictions 1–4 were also modelled once with moderate versions of each policy, and again with the most restrictive.

The imposition of retail restriction policies was largely successful in reducing retailer density, with more restrictive policies achieving substantial reductions. For example, the average density of tobacco outlets in urban poor simulated environments was 12.03 per square mile, which reduced to 3.23 when all retailers within 1,500 feet of a school were closed. The 500-foot buffer to schools, in contrast, was only able to reduce the average density to 11.27 retailers per square mile in urban poor environments. School and retailer proximity buffers were markedly less effective in reducing tobacco retailer density in suburban areas, with even the most restrictive school proximity buffer only able to reduce retailer density to 74% of its baseline level in suburban rich areas, versus 27% in urban poor areas.

The total cost of cigarettes (retail price plus associated travel costs) does not appear to be associated with retailer density in a straightforward linear fashion. Rather, in the US-based simulated environments there appears to be a threshold effect at around three retailers per square mile. Retailer reductions in high-density areas do not appear to influence total costs unless they are able to reduce the number of outlets to fewer than three per square mile. The only approach able to achieve this in the simulated urban environments was a combination of a 50% retailer cap, 1,500-foot school and retailer proximity buffers and a convenience store ban.

The simulation results indicate that the effectiveness of any one policy is contingent on the environment in question. Capping the number of retailers as a percentage of the current number was less effective in urban areas, even when halving the current number. This is likely because these environments start with higher retailer densities. In contrast, school and retailer proximity buffers achieved the greatest percentage increases in total tobacco price

(around 3–5%) in urban areas, potentially because of a greater density of schools and retailers. Pharmacy sales restrictions were predicted to have little effect in any environment, however banning tobacco sales at convenience stores had a comparatively large effect on total price in suburban areas. This is potentially due to a reduced starting density and diversity of tobacco retailers in these environments.

Combinations of the individual retailer restriction policies were projected to achieve total tobacco price increases of 7–17%, which, assuming a price elasticity of tobacco demand to be –0.4[18], would result in an approximate reduction in smoking prevalence of 3–7%. It is important to reiterate, however, that this work is based on urban and suburban contexts in the USA, with substantial differences to the diverse geography, tobacco control policies and social factors in Scotland.

Pearson et al[16, 17]

Key points

- Two related modelling studies estimated the effect of four tobacco retail outlet reduction interventions on smoking prevalence, quality of life and health system costs in New Zealand.
- Limiting sales to only 50% of liquor stores was the most effective tobacco outlet intervention, leading to the highest increases in the notional cost of a pack of cigarettes (including travel), the lowest national smoking prevalence, the largest healthcare savings and greatest estimated impact on health gains as well as reducing health inequalities among indigenous populations. Eliminating sales within 2km of schools also showed modest benefits.
- Geographical heterogeneity may influence the effectiveness of retailer outlet restrictions.
- Although the results should be interpreted cautiously, reducing tobacco outlets could be a potential component of an endgame strategy.

Two modelling studies by Pearson et al[16, 17] reported the estimated impact of tobacco retail restrictions in New Zealand on smoking prevalence, quality of life and health system costs. In the 2015 study[16] a dynamic forecasting model was used to estimate future smoking prevalence, assuming continuation of contemporary trends in smoking uptake and cessation. Like the Luke et al study[15], the effects of each intervention were evaluated by estimating increases in time and travel resulting from there being fewer tobacco outlets. This study also took into account the geographical heterogeneity of travel costs. Age-group specific price elasticities for tobacco demand were then used to estimate the changes in smoking behaviour. Unlike the Luke et al study[15], which modelled individuals' behaviour, the unit of analysis in this study is at the neighbourhood level.

The 2017 Pearson et al study[17] evaluated the impact of the same outlet restriction policies on tobacco-related diseases (e.g. quality-adjusted life years, or QALYs) and healthcare costs net of implementing new legislation. The model also evaluated scenarios for variable discount rates*, price elasticities and the potential growth of an illicit market when calculating QALYs gained and health system costs. To account for higher rates of morbidity and mortality among the Maori population, an equity analysis was undertaken.

The four hypothetical retail reduction interventions tested in each study were:

1. Reduce total number of outlets by 95%
2. Permit sales at half of the liquor stores and nowhere else
3. Eliminate sales from outlets within 1km of all schools
4. Eliminate sales from outlets within 2km of all schools.

* Costs and health benefits incurred today are usually assumed to have a higher value than costs and benefits occurring in the future. Therefore costs (and benefits) occurring at different points in time need to be adjusted. This process is called discounting. The lower the value attached to costs and benefits occurring in the future, the higher the discount rate.

All interventions were underpinned by the following explicit assumptions:

- Outlets should be licensed.
- Any legislation would:
  - limit sales to one 20-pack of cigarettes per person per day
  - ban online or mail-order tobacco sales
  - ban tobacco outlets in any new locations.

It was also assumed that these interventions would be phased in over a 10-year period, starting in 2011.

All four legally mandated interventions were projected to achieve at least an 89% reduction in tobacco outlets after 10 years[16], however none of the strategies achieved an endgame goal of a smoking prevalence of <5%. Restricting sales to 50% of liquor stores led to the lowest projected smoking prevalence at 9.1% (compared with the business-as-usual prevalence of 9.9%) and highest notional travel-inclusive cost of a pack of 20 cigarettes (e.g. NZ$58.98 in rural areas compared with the baseline cost of NZ$22.92). Eliminating sales from outlets within 2km of all schools was the next most effective intervention, reducing smoking prevalence to an estimated 9.3% and increasing costs of cigarettes by over 20% in all areas.

For all interventions, geographical heterogeneity influenced total pack price (including travel costs). Some of the largest effects of retailer restrictions were seen in rural areas. For example, for the intervention that reduced outlets by 95%, there was a 20% increase in the notional pack cost in rural areas compared with around 10% increase in semi-urban and urban areas. Permitting sales to only 50% of liquor stores increased costs of cigarettes by 60% and 71% in urban and semi-urban areas respectively and as much as 157% in rural areas.

It is not possible to comment on the effect of rurality on smoking prevalence for all of the modelled interventions as prevalence data were only presented for the 95% outlet reduction intervention. For this intervention, smoking prevalence was projected to be lower in rural areas in 2025 (around 9%)

compared with more urbanised areas and the estimated national prevalence of 9.6% which is due to the majority of the New Zealand population (84%) residing in urban areas. Therefore reducing outlets in urban areas is likely to have the biggest impact on population-level smoking prevalence.

In terms of evaluating the effect of these interventions on tobacco-related diseases and healthcare costs, limiting sales of tobacco to 50% of liquor stores represents the intervention offering the greatest potential health gains at 129,000 QALYs and savings of NZ$1.82 billion.[17] This was followed by eliminating sales from outlets within 2km of all schools at 84,800 QALYs gained and savings of NZ$1.2 billion. All interventions led to healthcare cost savings, and this finding was upheld under variable discount rates. The most effective intervention (limiting sales to 50% of liquor stores) remained cost saving under the assumption of a growing illicit market and varying price elasticity. The 50% liquor only intervention showed potential to reduce health inequalities, yielding per-capita QALY gains about five times greater for Maori populations compared with non-Maori population (93.7 versus 17.7 per 1,000 population respectively).

Limitations of modelling studies

In the absence of experimental studies, modelling studies allow examination of policies that would otherwise take years to enact and evaluate. However, there are a number of key limitations to the studies summarised above which may affect the validity of their findings and limit the confidence with which they can be applied to the Scottish context.

One of the main shortcomings of modelling studies is that by design they oversimplify human behaviour and the complex system within which this sits. For example, the Luke et al study[15] assumes that all tobacco purchases are made by individuals on the way to or from work but does not consider travel for other reasons. This study also neglects to consider ways in which consumers may attempt to circumvent increases in tobacco-purchase time and travel costs, including bulk buying or online sales.

A further key limitation of these studies concerns the various assumptions that underpin the models used, many of which would require substantial changes in legislation to replicate in Scotland. For example, the Pearson et al studies[16, 17] both made an assumption that online sales of tobacco would be prohibited and that sales would be restricted to one pack of cigarettes per adult per day. Both of these restrictions would be challenging to enforce in practice and are likely to experience significant opposition from tobacco manufacturers and retailers.[19]

Additional assumptions made by these studies mean that there is substantial uncertainty in the true effects of outlet reduction. For example, in the Luke et al study[15] for certain types of policy, the models assume retailers are closed at random. This may be unreasonable in reality, and will depend on the way in which retail closures are achieved. If retailers do close in a non-random way, this may influence the efficacy of actions taken to reduce outlet density or create a greater inequality gap between affluent and deprived neighbourhoods. It is important to note, however, that this approach could be adopted in Scotland without necessarily requiring retailers to close; rather they would only need to stop selling tobacco products. A positive rather than punitive approach could be taken, whereby retailers are given incentives to stop selling tobacco.

An auctioning system for licences was assumed in two of the interventions in the Pearson studies[16, 17] with the most densely populated areas likely being successful in winning the licence; indeed the authors note that if different criteria were used, the study results would vary. The Luke et al study[15] also assumed that individuals make optimal tobacco purchasing and travel decisions to minimise total tobacco costs. While this assumption is in line with economic theory, in reality it is likely that there is substantial variability in individual's tobacco-related knowledge, both between individuals and within individuals over time.

Limiting the ability of this work to be extrapolated to Scotland, these studies examined potential interventions in countries with distinct geographies and fundamentally different tobacco retail environments. These studies also did not account for the diversity of contemporary tobacco control policies currently employed in Scotland, including plain packaging, display bans and smoke-free environments.

Some specific limitations of the reviewed studies may serve to underestimate the impact of outlet reduction on smoking prevalence. For example reduced outlet density may contribute to denormalisation of smoking and tobacco purchasing, particularly among young people if the implemented policy actively eliminates sales near schools. The modelling studies also did not consider how tobacco outlet density influences smokers' (or recent ex-smokers') responses to cravings or withdrawal symptoms.[20]

These studies also focused largely on current smokers, and did not consider the effects on non-smokers. However, it may be the case that tobacco retail restrictions have larger effects on preventing tobacco uptake, rather than on promoting cessation among current smokers.[9]

Contextual literature

Six of the retrieved studies[21, 22, 23, 24, 25, 26] investigated proximity to and/or density of tobacco outlets and the relationship to smoking cessation. Three of these studies[21, 24, 25] found a negative association between proximity of tobacco outlets and smoking cessation, i.e. the nearer the tobacco outlet to the person's home the less likely they were able to quit. A Finnish study[21] also found that, for men who were moderate or heavy smokers, having one or more tobacco stores within half a kilometre of their home meant that they were less likely to successfully stop smoking. However, one longitudinal study conducted in the UK did not find a relationship between proximity and quitting smoking after six months.[22]

In addition, one study[23] found that the density of tobacco outlets and their proximity to young peoples' homes was associated with the intention of smoking, which can predict future smoking. Two further studies[27, 28] also found that young people's smoking behaviour trajectory and intention to smoke is associated with neighbourhood exposure (i.e. venues that permit smoking) and the presence of tobacco outlets.

Some studies[20, 29, 30] utilised technologies such as ecological momentary assessments (EMA) and global positioning systems (GPS) to investigate the relationship between tobacco retail environments and smoking urges or smoking cues such as point-of-sale marketing and smoking cessation interventions. EMA provides information on the experiences and behaviours of smokers in real-time, e.g. smoking cravings, and GPS provides information on the location of these participants during those experiences. Both these pieces of information can be linked to the contextual environment or exposures that smokers might encounter, i.e. the density of tobacco retail outlets or current proximity to these outlets. This approach provides a different avenue of investigation into the relationship between the tobacco retail environment and smoking behaviours. One of these studies,[29] conducted in the USA, found that there was an association between closer proximity to tobacco retail outlets and stronger smoking urges. However this association was only found when an individual's home was less than a mile from the tobacco outlet. Another study found that the sight of tobacco retail outlets can prompt thoughts about smoking and may induce smokers to purchase cigarettes.[31] The 12 studies reviewed in this section were of varying methodological quality with some limitations. The main limitation was that the studies could only find associations or correlations rather than causal relationships due to the type of study or data they were utilising. A further key limitation was that, like the modelling studies reviewed above, the studies were primarily conducted outside the UK (11 of 12), meaning the generalisability of these results to Scotland is not clear.

Conclusion

The most robust evidence on the causal impact of tobacco outlet restrictions on smoking prevalence comes from modelling studies. Policy changes to restrict tobacco outlets have the potential to decrease availability of tobacco products by increasing the search and purchase costs, reducing smoking prevalence, offering health gains and incurring savings to the healthcare system. This resonates with a more substantial literature on the causal association between alcohol retailer density and alcohol use.[32] This includes interrupted time-series designs which largely find that reductions in alcohol outlet density can lead to reductions in alcohol use and harmful drinking.

Some of the modelled benefits were greater for certain interventions, for policies combining multiple interventions and among different areas of population density. Given the modest estimated effects of individual tobacco control interventions in advancing tobacco control, changes to tobacco availability may need to be part of a more comprehensive tobacco control programme, which may include a multifaceted approach in terms of combining tobacco outlet density interventions or with other measures, such as tobacco pricing interventions.

Further research is needed in this area. In the first instance, modelling studies need to be undertaken in Scotland to take account of tobacco retail structure and geography; this should be followed by robust empirical research. Interventions which aim to reduce tobacco outlet density should be robustly evaluated to determine their impacts on smoking prevalence and their ability to improve health and narrow health inequalities.

About NHS Health Scotland evidence briefings

NHS Health Scotland evidence briefings are produced by the organisation's Evidence for Action (EfA) team. They use systematic methods* to review the most appropriate evidence to provide a robust, quality assured and balanced assessment of interventions and approaches likely to be effective in improving health and reducing health inequalities. As such, users can have a high degree of confidence that the conclusions/recommendations are valid. Supporting literature reviews and other relevant background papers are often available. Please contact the person named at the start of this briefing for further details.

Scottish policy link(s)

Scottish Government. Tobacco Control Strategy – Creating a Tobacco-Free Generation (2013) www.gov.scot/Publications/2013/03/3766

* The highest degree of confidence can be drawn from the review of existing evidence already critically appraised and quality-assured and/or systematic overview and synthesis of existing research evidence from primary and/or review level studies. Protocols for each of these methods have been produced and are available on request.

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