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What impact would tobacco retailer proximity limit have on tobacco availability in New Zealand?

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ABSTRACT

Introduction One policy option to reduce the density of tobacco retailers is to restrict the distance retailers can be located to each other. This study examined the impacts of proximity limits of 150 m, 300 m and 450 m between tobacco retailers in New Zealand and if critical threshold reduction in tobacco retailers of 90%–95% would be achieved.

Methods Using a spatial modelling approach, tobacco retailers were randomly removed based on a minimum distance between retailers until there were zero retailers within each scenario's minimum distance. This was repeated for all three proximity limit scenarios and descriptive statistics are provided for each.

Results Implementation of 150 m, 300 m or 450 m distance restrictions between tobacco retailers would result in an average reduction in availability of 35%, 49% and 58%, respectively. On average, the current median distance to the closest retailer increases from 110 m to 377 m, to 568 m or to 718 m, respectively. The average median distance from a retailer to the closest school also increases across the three proximity limits, from 1017 m to 1087 m, to 1149 m or to 1231 m, respectively. Reduced clustering in deprived areas would be most apparent if a 450 m restriction policy was implemented.

Conclusions A proximity limit of 450 m would reduce retailers by 58%, but would not reach proposed critical behaviour-change threshold of 90%–95% required to reduce smoking prevalence independently. There is a need for a combination of policies, which focus on promoting equity, to achieve this bold endgame goal.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Modelling studies have shown a policy restricting the proximity of tobacco retailers to each other could reduce outlet density, however, policy impact may be context and environment specific.
⇒ A small number of US jurisdictions have implemented this type of policy; none has been evaluated.
⇒ Overall there has been little research to examine the geographical distance between existing tobacco retailers.

WHAT THIS STUDY ADDS

⇒ A proximity limit policy would greatly reduce tobacco retailer availability.
⇒ A proximity limit policy would not reach proposed critical levels of 90-95% reduction in availability required to reduce smoking prevalence on its own.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ There is a need for a combination of policies, which focus on promoting equity, to achieve this bold endgame goal.

INTRODUCTION

New Zealand's Smokefree 2025 goal aims to reduce overall smoking prevalence to below 5%, and to greatly decrease the availability of tobacco.[1] Recently, the New Zealand Government released an action plan for achieving Smokefree Aotearoa 2025, which sets out six focus areas,[2] one of which is to reduce the availability of smoked tobacco products. Tobacco's widespread retail distribution promotes smoking by making cigarettes more accessible and normalised, and by increasing environmental cues to smoke.[3] A recent meta-analysis found that across 37 studies, lower levels of tobacco retailer density and decreased proximity were associated with lower tobacco use among adults.[4] Two recent studies, a systematic review and a meta-analysis, both found a positive association between tobacco retail outlet density and smoking behaviours among youth, particularly for the density near youths' homes.[5 6] The density of tobacco outlets is also greater in areas of higher socioeconomic deprivation,[7–10] where smoking is more prevalent.[11 12] Exposure to tobacco outlets may also undermine quit attempts,[13–16] as simply seeing a tobacco retail outlet is a sufficient cue to stimulate thoughts of smoking and prompt impulse tobacco purchases.[17] The government action plan stipulates that a law change will be developed to restrict who will be able to sell tobacco while also ensuring that retailers are not clustered in the most deprived neighbourhoods; however, no specific policy on how this will be achieved has been specified.[2]

Tobacco retail availability can be reduced through a range of mechanisms. These include area-based or population-based caps, restrictions on types of retailers that can sell tobacco or regulating the location of tobacco retailers such as restricting the distance retailers can be located to each other.[18] The latter type of policy has been implemented in a number of US jurisdictions. In California, Huntington Park restricts outlets from opening within 200 feet of another existing retailer,[19] and in Santa Clara County,[20] San Francisco[21] and Palo Alto,[22] the proximity limit is 500 ft. In Benton County Oregon, retailers are prohibited from opening within 1000 ft of another tobacco retailer.[23] However, constraints apply to some of these regulations. For example, the policy may only

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apply to a subset of retailers such as those in 'unincorporated' areas (a region that is not governed by a local municipal corporation and usually governed as larger administrative divisions), retailers whose primary business is tobacco, or only to new retail outlets. To the best of the authors' knowledge, no evaluations of these policies have been undertaken.

Three US modelling studies have assessed the impact of a proximity limit between tobacco retailers on tobacco retailer density. Myers *et al* used a Python script to randomly remove retailers within 500 ft of each other.[24] This resulted in a 22% reduction in tobacco retailer density at the state level. Luke *et al* used an agent-based simulation model to examine four types of retail reduction policies; one of these involved limiting proximity of retailers to each other.[25] This policy reduced tobacco retailer density across all towns examined, however, the impact varied by town type. The results indicate that reduction of retailer density has the potential to decrease accessibility of tobacco products by driving up search and purchase costs such as time, distance and travel. The third study used an additional agent-based simulation model.[26] They found that a 2000 ft buffer between retailers had minor effects on reducing density, total (direct and indirect) costs and indirect (travel and opportunity) costs. The effects may be enhanced when coupled with a policy of only selling tobacco through specialty tobacco stores.

Kong and Henriksen highlight the overabundance, and inequitable distribution, of tobacco retailers across communities.[27] A number of studies examining policies for reducing tobacco availability have found that the policies reduce overall density of tobacco, but inequities in tobacco availability remain;[28–31] emphasising the need for equity promoting policies.[27] A recent Scottish study simulated the impact of 12 potential policies designed to reduce tobacco outlet density, including their impact on socioeconomic inequalities.[29] The study found a policy limiting the minimum spacing between tobacco retailers to 300 m had a mean tobacco outlet density reduction of 41%, and was considered 'equity promoting' as it reduced socioeconomic inequalities in the availability of tobacco when compared with the baseline. A reduction in inequities may also be dependent on neighbourhood sociodemographic characteristics,[8] illustrating policy impact may be context and environment specific.

Many retail reduction policies have aimed specifically at trying to reduce access to tobacco products by school-aged children. The reason for this focus is threefold: first, New Zealand evidence shows that smoking initiation and uptake usually occurs before 25 years of age,[32] and may lead to long-term tobacco use. Second, evidence shows that greater retail outlet density is associated with increased youth smoking prevalence.[5 6] Third, there is high public support for policies which reduce tobacco retailers around schools and youth-oriented areas.[33–36]

A number of studies have identified that a threshold or critical level of reduction in outlet density is needed to have an effect on smoking behaviour. US modelling concluded that retailer density needs to reduce to less than four retailers per square mile (1.6 per square kilometre) to reach a threshold effect on the total cost of acquiring cigarettes (travel and purchase costs).[25] They make the point that the impact of any policy would depend on the starting point of retailer density. In New Zealand, modelling research suggests that a reduction of around 90%–95% of retailers is required to influence smoking prevalence.[37–39]

Overall, there has been little research to examine the distance between existing tobacco retailers, nor on the impacts of a policy limiting the proximity of tobacco retailers to each other, including in New Zealand. It is hypothesised that a greater distance to a tobacco retail outlet would reduce smoking prevalence via increased search and purchase costs, reduce socioeconomic inequities in the availability of tobacco, reduce smoking initiation among young people who are susceptible to smoking and increase abstinence during and after a cessation attempt. This study uses a geospatial approach to (1) examine the impact of a proximity limit of 150 m, 300 m and 450 m between tobacco retailers on the tobacco retail landscape in New Zealand, in particular, clustering of tobacco retailers in deprived communities, distance to closest secondary schools and urban and rural access to tobacco and (2) to determine if the proposed proximity policy would be sufficient to achieve a threshold reduction in tobacco retailers.

METHODS

We use a spatial modelling approach to simulate the impact of a policy that limits the proximity between tobacco retailers. The study uses geographic classifications at the statistical area 1 level, the second smallest geographic unit for which statistical data are collected in New Zealand and which generally represents between 100 and 200 residents.[40] This geographic classification was selected to give the most detailed information about the location of tobacco retailers, their socioeconomic deprivation classification and their rural/urban categorisation.

Measures

Proximity limits: proximity limit scenarios (150 m, 300 m and 450 m) were selected to be consistent with previous modelling work by Luke *et al*[25] and Caryl *et al*.[29] The proximity limit of 150 m also corresponds with 500 ft minimum distance between retailers used by Myers *et al*[24] and in policies implemented in Santa Clara, San Francisco and Palo Alto Counties.[20–22]

Identification of known tobacco retailers: we developed a national database of tobacco retailers between 2012 and 2017, which included 5131 retailers.[7 28] Types of retailers included convenience stores, petrol stations, supermarkets and liquor stores. Retailers that allow alcohol consumption on their premises, such as bars and clubs, were excluded. Duplicate listings were removed, and missing or incomplete physical addresses were resolved through online searches and Google Street View. This is a reliable method that can be used in place of field audits to measure key characteristics of the built environment important to public health.[41] Once the retailer addresses were confirmed, geocoding allowed the addresses in the database to be translated to spatial locations and mapped using ArcGIS Pro software.[42] Accuracy of the geocoding results was first checked by confirming that each retailer had been correctly located at the city or region level. Those that were in the wrong city or region were manually relocated to their correct street address. Over 90% of the mapped points were reviewed manually to ensure proper placement. Where possible, points were relocated as close to a premise's entrance as possible.

Tobacco retail availability was measured as the number of retailers in New Zealand. Straight-line distance to the closest retailer was measured using the Near tool in ArcGIS. This method was used as it is computationally efficient, conceptually uncomplicated and commonly used in other studies.

Distance to the closest secondary school: school locations were obtained from the online data portal Koordinates.com. The GPS position of each school (n=522) was confirmed by visual inspection using Google maps and was relocated if necessary. The straight-line distance between tobacco retailer and secondary schools was measured using the Near tool in ArcGIS.

Socioeconomic deprivation: NZDep2018 index was used to measure socioeconomic deprivation of the geographic location of the retailer.[43] This index combines nine variables from the census that reflect eight dimensions of material deprivation (communication, income, employment, qualifications, owned home, support, living space, living condition), and is presented as an ordinal score from 1 to 10. This was collapsed into three groups: low (1–3), medium (4–7), high (8–10), consistent with use in other NZ studies.[44]

Rural/Urban classification: each tobacco retailer was categorised as being located in an large/major urban area (population >30 000), small/medium urban area (population between 1000 and 29 999) or rural area (population of <1000) based on classifications obtained from the 2018 census as published by Statistics NZ.[40]

Analysis

The potential effects on tobacco retailer availability of a proximity limit between retailers were explored following the methods used by Myers *et al*.[24] An iterative Python script was developed to randomly remove tobacco retailers based on a minimum distance between retailers for each of the three proximity scenarios being examined (150 m, 300 m and 450 m). Independently, for all three scenarios, this process continued until there were zero retailers present within each scenario's minimum distance. Furthermore, as this is a random simulation, which means each run produces different results, the script was run 100 times for each scenario to maximise validity.

For each of the three different proximity limit scenarios (150 m, 300 m and 450 m), retailer availability, percentage reduction in retailer availability, median distance to closest tobacco retailer, median distance to closest school, socioeconomic distribution and rural/urban status distribution were estimated as the mean of the 100 Python script simulations.

RESULTS

Implementation of a 150 m distance restriction between tobacco retailers would decrease retailer availability to an average 3317 retailers (range: 3292, 3973), a reduction in availability of 35.3% (range: 22.6, 35.8) (table 1). A 300 m limit would further lower retailer numbers to an average 2604 (range: 2588, 2617) corresponding to 49.3% reduction (range: 49.0, 49.6). The higher distance restriction of 450 m would remove an average of 2955 tobacco retailers, leaving 2176 (range: 2149, 2202), and reducing availability by 57.6% (range: 57.1, 58.1).

Adopting the increasing proximity limits of 150 m, 300 m and 450 m would, on average, increase the current median distance to the closest retailer from 109.6 m to 377.2 m (range: 255.2, 387.6), to 568.0 m (range: 559.5, 580.2) or to 718.2 m (range: 699.5, 735.4), respectively. In a similar way, although to a lesser degree, the average median distance to the closest school also increases across the three proximity limits. Specifically, the current median distance of 1017.2 m would increase to 1087.4 m (range: 1034.9, 1094.0), to 1149.2 m (range: 1139.5, 1158.8) or to 1230.6 m (range: 1214.0, 1250.2), respectively.

Change in distribution of the socioeconomic areas that tobacco retailers are located would be most apparent if a 450 m distance restriction policy was implemented. In this context, the percentage of retail outlets in each of the low, medium and high socioeconomic deciles would change from 10.2%, 38.7% and 51.1% to an average of 13.3% (range: 12.7, 13.9), 41.7% (range: 40.8, 42.9) and 45.0% (range: 44.1, 45.8), respectively. Based on the current retailer context (n=5131) and the average number of remaining retailers (n=2176), this would correspond to a change in numbers from n=521, n=1971 and n=2607 to approximately n=290, n=907 and n=979, respectively. Although, on average, there are somewhat subtle proportion increases in the low and medium socioeconomic categories as the proximity restriction between tobacco retailers increases (with a correlating decrease in the proportion located in high-deprived

Table 1 Distribution of characteristics by differing minimum proximity limits

	All current retailers (n=5131)		150 m proximity limit		300 m proximity limit		450 m proximity limit	
Characteristic		**IQR**	**Mean (SD)**	**Min, max**	**Mean (SD)**	**Min, max**	**Mean (SD)**	**Min, max**
Remaining retailers								
Number			3317 (66.59)	3292, 3973	2604 (6.86)	2588, 2617	2176 (9.50)	2149, 2202
% Reduction			35.34 (1.30)	22.57, 35.84	49.26 (0.13)	49.56, 49.00	57.59 (0.19)	58.12, 57.08
Distance to closest retailer								
Median (m)	109.61	45.99, 343.22	377.22 (12.92)	255.23, 387.62	568.03 (4.34)	559.48. 580.19	718.16 (6.74)	699.54, 735.36
Distance to closest school								
Median (m)	1017.21	627.78, 1676.74	1087.41 (5.95)	1034.91, 1094.02	1149.24 (4.64)	1139.48, 1158.81	1230.64 (9.08)	1214.00, 1250.15
	N	**%**	**% (SD)**	**Min, max**	**% (SD)**	**Min, max**	**% (SD)**	**Min, max**
Socioeconomic deprivation*								
Low	521	10.22	11.21 (0.13)	10.66, 11.52	12.76 (0.19)	12.34, 13.30	13.34 (0.23)	12.70, 13.92
Medium	1971	38.65	39.70 (0.21)	38.95, 40.11	40.71 (0.33)	39.69, 41.55	41.68 (0.39)	40.84, 42.86
High	2607	51.13	49.09 (0.23)	48.69, 50.39	46.53 (0.27)	45.97, 47.36	44.98 (0.36)	44.05, 45.76
Urban rural								
Rural	568	11.07	13.63 (0.15)	12.21, 13.77	16.15 (0.06)	15.98, 16.29	18.71 (0.10)	18.44, 18.99
Small/Medium urban	1247	24.30	24.67 (0.13)	23.91, 24.96	22.84 (0.16)	22.50, 23.16	22.67 (0.17)	22.17, 23.04
Large/Major urban	3316	64.63	61.71 (0.25)	61.42, 63.88	61.01 (0.16)	60.64, 61.37	58.62 (0.18)	58.25, 59.16

*Socioeconomic deprivation classification was unavailable for 32 of the 5131 current tobacco retailers (0.6%).
IQR, Interquartile Range.

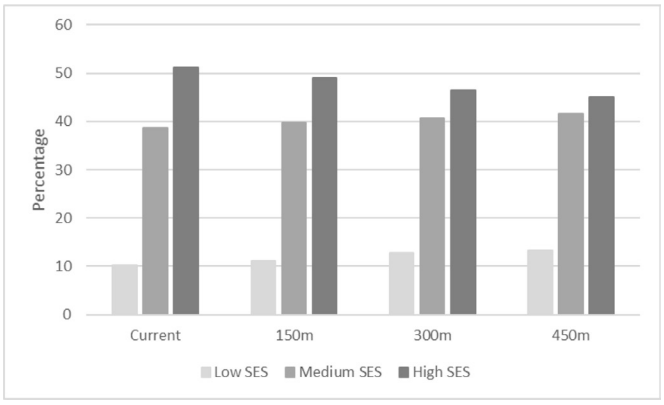

Figure 1 Socioeconomic status (SES) distribution of tobacco retailers under each proximity limit scenario.

areas), a difference from the current distribution is evident at the potential 450 m distance limit (figure 1).

Regarding population density status, the proportion of tobacco retailers situated in a small/medium urban area would remain relatively consistent under all three proximity scenarios with the current distribution of retailers (a maximum difference of only just over 1.5%). There is, however, a progressive increase in the proportion of retailers located in rural areas as the proximity limit increases (a maximum difference of just over 7.6%), corresponding to a decrease in those located in large/major urban areas.

DISCUSSION

Threshold reduction

This study sought to examine the impact of proximity limits of 150 m, 300 m and 450 m between tobacco retailers on the tobacco retail landscape. Modelling research suggests that a reduction of around 90%–95% of retailers is required to influence smoking prevalence.[37–39] Our study found that the availability of tobacco retailers would decrease from the status quo under each of the proximity limit scenarios examined in this study. The largest distance of 450 m would make a significant contribution to reducing access to tobacco in New Zealand and would increase the median distance between tobacco retailers by 608 m (from 109.61 m to 718.16 m). This policy (450 m) would reduce retailers by 58% but would not, as a standalone policy, reach the threshold effects of a 90%–95% reduction in retailers.

Multiple policies needed

The need to meet a threshold reduction in tobacco retailer availability to have an effect on smoking rates indicates the need for a combination of retail reduction policies to achieve the Smokefree 2025 goal, a strategy that has been recommended by a number of authors. For a policy specifically designed to prohibit tobacco sales in outlet types that are over-represented in the most deprived areas, Coombs *et al* suggest that a combination of policies is needed to equalise the average distance travelled to purchase tobacco and reduce tobacco use.[26] Luke *et al* also suggest that multiple policies 'can decrease tobacco retailer density and increase costs more than a single policy at a higher, or its highest feasible intensity'.[25] The policy combination of a 50% retailer cap of initial levels, 1500 ft school and retailer proximity buffers and a convenience store ban were able to achieve this in their simulated study. A recent review of retail reduction policies also concluded that a combination of policies was most effective for reducing retail density.[18]

Socioeconomic equity

A reduction in the availability of tobacco retailers can have an impact on smoking rates by increasing the cost of tobacco, which is strongly associated with declining smoking prevalence and reduced tobacco consumption.[45 46] A portion of the cost of tobacco comprises the costs associated with obtaining the product, including search and purchase costs such as the time and distance travelled to the retail outlet. It is therefore expected that decreasing tobacco retail availability will increase the search and purchase costs through increased travel distance between the consumer and the retail outlet.[47]

In New Zealand, tobacco retailers are more densely located in areas of greater deprivation,[7] where rates of smoking are also three times higher.[11] This is likely because disadvantaged areas tend to be located in more heavily populated urban areas, therefore closer to shopping centres and high-traffic areas where tobacco retail outlets are likely to be more prevalent. A proximity limit between tobacco retailers of 450 m would reduce the availability of tobacco in these highly deprived areas by 6.2%. Although 45% of the tobacco retailers would still be located in highly deprived areas, it would now be more similar to that of the medium deprivation areas (41.7%), low deprivation neighbourhoods would still include a conspicuously smaller 13.3%. Caryl *et al* found that a minimum spacing policy was equity-promoting, but not to a statistically significant level.[29] These authors found that the policy designed to prohibit tobacco sales in outlet types that are over-represented in the most deprived areas (reduced clusters) was the only policy which reduced tobacco retailer density to achieve equity between the least and most deprived areas.[29] This policy could be something New Zealand could consider for improving health equity.

However, a consequence of this is the potential for inequities to increase for those living in more deprived areas in terms of greater time and travel costs (ie, these people would now have to spend more to acquire tobacco and would have less to spend on other items). Further research is needed to determine the search and purchase costs for New Zealand 'consumers', which would involve acquiring the price elasticity of demand in New Zealand for different groups, for example, deprivation, ethnicity, age as well as information about tobacco purchasing behaviour in New Zealand. As Kong and Henriksen note, it is important to asses and evaluate any implemented policies to ensure that inequities in the availability of tobacco are not unintentionally exacerbated.[27]

Access to tobacco in rural areas

Having equal proportion of retailers in each level of disadvantage would improve health equity, however, striving for equity between rural and urban areas may not achieve health equity. Rural and urban areas are different communities, and although there is no evidence that smoking rates in rural areas are any different to those in urban areas, there is complexity in all aspects of smoking for those in rural areas.[44] This proximity policy has the highest efficacy in urban areas, where density of retailers is currently highest. It also ensures that (1) retailers are not removed from more rural and remote areas and (2) that rural areas do not have multiple retailers (within 450 m) in small towns.

Proximity to schools

New Zealand modelling studies predicted that a 2 km school buffer policy would result in a 96% reduction in outlets and a lower smoking prevalence of 9.3%.[48] In this current study, a

proximity limit between tobacco retailers would have limited impact on reducing the distance of tobacco retailers to schools to a level needed to have a large impact, with a maximum median reduction of 213 m with a 450 m proximity limit. Policies which limit the distance that retailers can be located to schools was reviewed by Glasser and Roberts.[18] Myers *et al* found that a 1000 ft school buffer implemented at the state level in North Carolina would reduce density by 17.8%.[24] Ribisl *et al* also examined the impact of a 1000 ft school buffer in Missouri and New York and found that density reduction occurred primarily in lower income areas,[30] indicating potential for this type of policy to have an impact on current socioeconomic inequities in retailer density. Our findings may differ from this US research because the New Zealand context and neighbourhoods may not be similar to that of the USA. For example, a recent systematic review[5] and meta-analysis[6] found evidence of a relationship between density of tobacco retail outlets and smoking behaviours, particularly for the density near youths' home rather than schools. Limited or inconsistent findings for the relationship between tobacco retail outlet proximity to schools and youth smoking behaviours was found in the systematic review.[5] It may be that in New Zealand, the neighbourhoods where children live are more important than the location of the school they attend. However, it is important not to discount the high public support that has been found in studies for tobacco retail reduction policies, which reduce tobacco retailers around schools and youth-oriented areas.[33–36]

Implementation

Jurisdictions which have implemented tobacco retailer proximity limit policies have done so by protecting existing retailers, and restrictions only applying to new business or permits. However, the decline in number of retailers may be slow as this method relies on businesses closing down and new businesses not being able to sell tobacco. Our spatial modelling assumes that a policy would be implemented by randomly removing the ability to sell tobacco from existing retailers. This approach would likely be met with opposition from retailers who believe that any reduction in retail availability must be fair to all existing retailers[35] and could potentially breach competition laws.[49] New Zealand's recent Smokefree Action Plan to introduce legislation for the reduction in tobacco availability, will require the enactment of bold policy. Amortisation rather than protected status, would accelerate reductions in tobacco retailers.[50] This would give existing retailers a certain period of time that they could continue to sell tobacco, but after which they would no longer be able to sell tobacco and no new businesses would be permitted to sell tobacco. As Robertson and Marsh note, this would provide retailers with sufficient time to adapt and transition.[50] Assistance may be needed for tobacco retailers to divest themselves of tobacco and transition to other higher-profit margin products, while preventing 'food swamp' communities (neighbourhoods saturated with unhealthy food, beverages, tobacco and alcohol) from arising.[51] Initiatives, such as an intervention transforming neighbourhood corner stores into healthy retailers in San Francisco, illustrate how this may be a viable method to consider.[52]

Strengths and limitations

Spatial research has shown that the effectiveness of any one policy is contingent on the environment in question, including the geographic and policy environment.[18 24 25] One of the strengths of this study is that it provides local information for New Zealand, a jurisdiction in a 'dark market' with heavy restrictions on marketing tobacco products, on the potential effectiveness of a proximity limit between tobacco retailers and the impact this would have on the availability and location of retailers in New Zealand. Being a national study, all areas of the country were able to be included. These findings may only apply to the New Zealand context, since the distance between retailers varies widely across countries and regions,[53–57] however, modelling could be helpful for other contexts or jurisdictions.

Taking a geospatial approach to this analysis allowed the spatial configuration of existing tobacco retailers to be explicitly modelled. The use of straight-line distances, however, while computationally efficient, may under-represent the actual distances between retailers and associated costs. The method to simulate implementation of the policy was replicated 100 times for each scenario to reduce the chance of producing different results with this method. A further limitation of this research is that the random tobacco retailer removal process (to simulate implementation of a proximity limit policy) produces a different result per simulation. The use of the 100 replicates per scenario, however, enables the calculation of mean estimates as well as corresponding measures of variability. An additional consequence of this process is that the research only has the capacity to investigate estimated impacts of distance restricted policy. The real-world policy implementation, however, could logically involve a more targeted strategy.

CONCLUSION

The New Zealand Government is committed to reducing tobacco availability as part of its plan to achieve Smokefree 2025, and intends introducing legislation to enable this to occur. Our research provides information on how one type of policy option, a proximity limit between tobacco retailers, would impact on the reduction in tobacco retail outlets in New Zealand. A proximity limit of 450 m would reduce retailers by 58%, but would not reach proposed critical levels of 90%–95% required to reduce smoking prevalence on its own. There is a need for a combination of policies, which focus on promoting equity, to achieve this bold endgame goal.

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Contributors LM, CD, MT and RQ conceptualised the project. CD undertook all GIS analysis. EI was involved in refining the analysis approach, undertook the statistical analysis and prepared the results. LM (guarantor) conducted the literature review and drafted the manuscript. All authors provided feedback on subsequent drafts of the manuscript. All authors have seen and approved the final version.

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REFERENCES

1 Government NZ. *Government response to the report of the Māori Affairs Committee on its inquiry into the tobacco industry in Aotearoa and the consequences of tobacco use for Māori (final response)*. Wellington: New Zealand Parliament, 2011.
2 Ministry of Health. *Smokefree Aotearoa 2025 action plan*. Wellington: Ministry of Health, New Zealand, 2021.
3 Henriksen L. Comprehensive tobacco marketing restrictions: promotion, packaging, price and place. *Tob Control* 2012;21:147–53.
4 Lee JGL, Kong AY, Sewell KB, *et al*. Associations of tobacco retailer density and proximity with adult tobacco use behaviours and health outcomes: a meta-analysis. *Tob Control* 2022;31:e189–200.
5 Marsh L, Vaneckova P, Robertson L, *et al*. Association between density and proximity of tobacco retail outlets with smoking: a systematic review of youth studies. *Health Place* 2021;67:102275.
6 Finan LJ, Lipperman-Kreda S, Abadi M, *et al*. Tobacco outlet density and adolescents' cigarette smoking: a meta-analysis. *Tob Control* 2019;28:27–33.
7 Marsh L, Doscher C, Robertson LA. Characteristics of tobacco retailers in New Zealand. *Health Place* 2013;23:165–70.
8 Kong AY, Delamater PL, Gottfredson NC, *et al*. Neighborhood inequities in tobacco Retailer density and the presence of Tobacco-Selling pharmacies and tobacco shops. *Health Educ Behav* 2022;49:478–87.
9 Rodriguez D, Carlos HA, Adachi-Mejia AM, *et al*. Predictors of tobacco outlet density nationwide: a geographic analysis. *Tob Control* 2013;22:349–55.
10 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.
11 Ministry of Health. *Annual update of key results 2020/21: new Zealand health survey*. Wellington, New Zealand: Ministry of Health, 2021.
12 The Scottish Government. *Scottish health survey 2019: volume 1: main report*. Edinburgh: The Scottish Government.
13 Reitzel LR, Cromley EK, Li Y, *et al*. The effect of tobacco outlet density and proximity on smoking cessation. *Am J Public Health* 2011;101:315–20.
14 Pulakka A, Halonen JI, Kawachi I, *et al*. Association between distance from home to tobacco outlet and smoking cessation and relapse. *JAMA Intern Med* 2016;176:1512–9.
15 Valiente R, Escobar F, Urtasun M, *et al*. Tobacco retail environment and smoking: a systematic review of geographic exposure measures and implications for future studies. *Nicotine Tob Res* 2021;23:1263–73.
16 Halonen JI, Kivimäki M, Kouvonen A, *et al*. Proximity to a tobacco store and smoking cessation: a cohort study. *Tob Control* 2014;23:146–51.
17 Burton S, Hoek J, Nesbit P, *et al*. "Smoking is bad, it's not cool…yet I'm still doing it": Cues for tobacco consumption in a 'dark' market. *J Bus Res* 2015;68:2067–74.
18 Glasser AM, Roberts ME. Retailer density reduction approaches to tobacco control: a review. *Health Place* 2021;67:102342.
19 City of Huntington Park California. *Huntington Park municipal code: 4-19.03 limits on eligibility for a tobacco retailer license*. Huntingon Park, Califorina: City of Huntington Park California, 2011.
20 County of Santa Clara. *County of Sanata Clara Ordinance Cose: CHAPTER XXIII. - PERMITS FOR RETAILERS OF TOBACCO PRODUCTS*. Santa Clara, California: County of Santa Clara, 2015.
21 San Francisco Department of Public Health. *Article 19H: permits for the sale of tobacco*. San Francisco, California: San Francisco Department of Public Health, 2015.
22 City of Palo Alto. *Palo Alto municipal code chapter 4.64: permits for retailers of tobacco products*. Alto CoP, 2018.
23 Benton County Oregan. *Benton County, or municipal code chapter 17 sale of tobacco administration*. Oregan BC, ed, 2018.
24 Myers AE, Hall MG, Isgett LF, *et al*. A comparison of three policy approaches for tobacco retailer reduction. *Prev Med* 2015;74:67–73.
25 Luke DA, Hammond RA, Combs T, *et al*. Tobacco town: computational modeling of policy options to reduce tobacco retailer density. *Am J Public Health* 2017;107:740–6.
26 Combs TB, McKay VR, Ornstein J, *et al*. Modelling the impact of menthol sales restrictions and retailer density reduction policies: insights from tobacco town Minnesota. *Tob Control* 2020;29:502–9.
27 Kong AY, Henriksen L. Retail endgame strategies: reduce tobacco availability and visibility and promote health equity. *Tob Control* 2022;31:243–9.
28 Marsh L, Doscher C, Cameron C, *et al*. How would the tobacco retail landscape change if tobacco was only sold through liquor stores, petrol stations or pharmacies? *Aust N Z J Public Health* 2020;44:34–9.
29 Caryl FM, Pearce J, Reid G, *et al*. Simulating the density reduction and equity impact of potential tobacco retail control policies. *Tob Control* 2021;30:138–43.
30 Ribisl KM, Luke DA, Bohannon DL, *et al*. Reducing disparities in tobacco retailer density by banning tobacco product sales near schools. *Nicotine Tob Res* 2017;19:239–44.
31 Tucker-Seeley RD, Bezold CP, James P, *et al*. Retail pharmacy policy to end the sale of tobacco products: what is the impact on disparity in neighborhood density of tobacco outlets? *Cancer Epidemiol Biomarkers Prev* 2016;25:1305–10.
32 Edwards R, Carter K, Peace J, *et al*. An examination of smoking initiation rates by age: results from a large longitudinal study in New Zealand. *Aust N Z J Public Health* 2013;37:516–9.
33 Whyte G, Gendall P, Hoek J. Advancing the retail endgame: public perceptions of retail policy interventions. *Tob Control* 2014;23:160–6.
34 Farley SM, Coady MH, Mandel-Ricci J, *et al*. Public opinions on Tax and retail-based tobacco control strategies. *Tob Control* 2015;24:e10–13.
35 Robertson L, Marsh L, Hoek J, *et al*. Regulating the sale of tobacco in New Zealand: a qualitative analysis of retailers' views and implications for advocacy. *Int J Drug Policy* 2015;26:1222–30.
36 Robertson L, Marsh L, Hoek J, *et al*. New Zealand tobacco control experts' views towards policies to reduce tobacco availability. *N Z Med J* 2017;130:27–35.
37 Pearson AL, Cleghorn CL, van der Deen FS, *et al*. Tobacco retail outlet restrictions: health and cost impacts from multistate life-table modelling in a national population. *Tob Control* 2017;26:579–85.
38 van der Deen FS, Wilson N, Cleghorn CL, *et al*. Impact of five tobacco endgame strategies on future smoking prevalence, population health and health system costs: two modelling studies to inform the tobacco endgame. *Tob Control* 2018;27:278–86.
39 Petrović-van der Deen FS, Wilson N. Restricting tobacco sales to only pharmacies as an endgame strategy: are pharmacies likely to opt in? *Aust N Z J Public Health* 2018;42:219–20.
40 Stats NZ. *Statistical standard for geographic areas 2018*. Wellington: Stats NZ, 2017.
41 Wilson JS, Kelly CM, Schootman M, *et al*. Assessing the built environment using omnidirectional imagery. *Am J Prev Med* 2012;42:193–9.
42 Environmental Systems Research Institute. *ArcGIS desktop: release 10*. Redlands, CA: Environmental Systems Research Institute, 2011.
43 Atkinson J, Salmond C PC. *NZDep2018 index of deprivation, interim research report, December 2019*. Wellington: University of Otago, 2019.
44 Griffin E, Moon G, Barnet R. Examining the significance of urban-rural context in tobacco Quitline use: does rurality matter? *Int J Public Health* 2015;60:327–33.
45 International Agency for Research on Cancer. *Effectiveness of Tax and price policies for tobacco control. handbooks of cancer prevention*. Lyon France: International Agency for Research on Cancer, 2011.
46 Wakefield MA, Durkin S, Spittal MJ, *et al*. Impact of tobacco control policies and mass media campaigns on monthly adult smoking prevalence. *Am J Public Health* 2008;98:1443–50.
47 Schneider JE, Reid RJ, Peterson NA, *et al*. Tobacco outlet density and demographics at the tract level of analysis in Iowa: implications for environmentally based prevention initiatives. *Prev Sci* 2005;6:319–25.
48 Pearson AL, van der Deen FS, Wilson N, *et al*. Theoretical impacts of a range of major tobacco retail outlet reduction interventions: modelling results in a country with a smoke-free nation goal. *Tob Control* 2015;24:e32–8.
49 Commerce Act. New Zealand, 1986.
50 Robertson L, Marsh L. Estimating the effect of a potential policy to restrict tobacco retail availability in New Zealand. *Tob Control* 2019;28:466–8.
51 Sushil Z, Vandevijvere S, Exeter DJ, *et al*. Food swamps by area socioeconomic deprivation in New Zealand: a national study. *Int J Public Health* 2017;62:869–77.
52 San Francisco Tobacco-Free. Healthy retail San Francisco San Francisco: San Francisco tobacco-free, 2016. Available: https://sanfranciscotobaccofreeproject.org/case-studies/healthy-retail-san-francisco-2016/ [Accessed 02 June 2020].
53 Chaiton MO, Mecredy GC, Cohen JE, *et al*. Tobacco retail outlets and vulnerable populations in Ontario, Canada. *Int J Environ Res Public Health* 2013;10:7299–309.
54 Gong T, Lv J, Liu Q, *et al*. Audit of tobacco retail outlets in Hangzhou, China. *Tob Control* 2013;22:245–9.
55 Salloum RG, Nakkash RT, Myers AE, *et al*. Surveillance of tobacco retail density in Beirut, Lebanon using electronic tablet technology. *Tob Induc Dis* 2014;12:3.
56 Astuti PAS, Mulyawan KH, Sebayang SK, *et al*. Cigarette retailer density around schools and neighbourhoods in Bali, Indonesia: a GIS mapping. *Tob Induc Dis* 2019;17:55.
57 Henriksen L, Andersen-Rodgers E, Zhang X, *et al*. Neighborhood variation in the price of cheap tobacco products in California: results from healthy stores for a healthy community. *Nicotine Tob Res* 2017;19:1330–7.