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The neighbourhood effects of geographical access to tobacco retailers on individual smoking behaviour

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Abstract

Objective: To investigate whether neighbourhood measures of geographical accessibility to outlets selling tobacco (supermarkets, convenience stores and petrol stations) are associated with individual smoking behaviour in New Zealand.

Methods: Using Geographical Information Systems, travel times from the population-weighted centroid of each neighbourhood to the closest outlet selling tobacco were calculated for all 38,350 neighbourhoods across New Zealand. These measures were appended to the 2002/03 New Zealand Health Survey; a national survey of 12,529 adults. Two-level logistic regression models were fitted to examine the effects of neighbourhood locational access upon individual smoking behaviour after controlling for potential individual- and neighbourhood-level confounding factors, including deprivation and urban/rural status.

Results: After controlling for individual-level demographic and socioeconomic variables, individuals living in the quartiles of neighbourhoods with the best access to supermarkets (OR 1.23, 95% CI 1.06-1.42) and convenience stores (OR 1.19, 95% CI 1.03-1.38) had a higher odds of smoking compared to individuals in the worst access quartiles. However, the association between neighbourhood accessibility to supermarkets and convenience stores was not apparent once other neighbourhood-level variables (deprivation and rurality) were included.

Conclusions: At the national level, there is little evidence to suggest that after adjustment for neighbourhood deprivation better locational access to tobacco retail provision in New Zealand is associated with individual-level smoking behaviour.

Introduction

Smoking is one of the most important public health issues worldwide and is a major determinant of preventable mortality and morbidity in developed and developing countries.[1] Disparities in tobacco consumption between different social and ethnic groups have been noted in a number of countries.[2] Because the environments in which people live influence many health behaviours,[3] there has been an increasing focus on how neighbourhood characteristics may shape the consumption of tobacco, and, by extension, how neighbourhood change might reduce the burden of smoking-related health outcomes and geographical inequalities in health. Recent studies have identified a variety of mechanisms that operate through residential neighbourhoods to effect smoking behaviour after controlling for individual characteristics. Neighbourhood characteristics including area disadvantage,[4-12] social and economic inequality,[13-15] residential segregation,[16] physical stressors such as crime,[10, 17, 18] and urban/rural status,[19-21] have been found to influence individual smoking behaviour.

Although there has been considerable interest in 'place effects' on individual smoking behaviour, most previous studies have relied upon characteristics of neighbourhoods that are provided in routinely collected data sources, particularly the census. This approach can be criticised for failing to identify and measure other important features of neighbourhoods that may partially contribute to the smoking behaviour of local residents. This limitation may be a significant obstacle to successful place-based policy initiatives.

One area characteristic that has received limited attention is the influence of neighbourhood availability of outlets selling tobacco. We hypothesise that retail availability, other things being equal, could increases the likelihood of consumption in a number of ways. First, an effect of neighbourhood access on smoking rates is particularly likely given the international evidence which indicates that outlets selling tobacco are often disproportionately located in more deprived communities.[22] This observation is true in New Zealand where supermarkets and convenience stores (the major retailers of tobacco) are more accessible [23] and more concentrated[24] in socially deprived neighbourhoods. Increased opportunities to procure tobacco thus may affect consumption levels through providing an environment that supports easy access to tobacco products. Research in the alcohol literature suggests that physical neighbourhood availability of alcohol products affects individual consumption and related behaviours,[25, 26] and this could also be true of smoking. The effects of increased access should be particularly important among younger smokers or sole parents in deprived neighbourhoods who are more likely to lack available transport and rely on readily accessible local supplies. Secondly, smokers are price responsive and low income communities are particularly price sensitive,[27] so a more competitive local market may help stimulate increased levels of consumption. Third, the greater concentration of outlets in deprived neighbourhoods may accentuate the scope for addiction, making it harder for people to quit especially when cigarettes are available in the local facilities which they are more likely utilise.

Only one previous study has examined the effect of neighbourhood access to outlets selling tobacco on individual smoking behaviour. In this study of 82 neighbourhoods in four northern Californian cities, neighbourhood measures of convenience store access (distance to and concentration of) were significantly associated with higher levels of individual-level smoking after controlling for individual characteristics.[11] The association between convenience store

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access and individual smoking was modified by individual and neighbourhood socioeconomic status (SES) as the effects of store access were, unexpectedly, only apparent in high SES neighbourhoods. The study considered only one type of tobacco retailer (convenience stores), did not include supermarkets, drug stores and liquor stores, and was limited to a specific sub-national context.

The limited attention to the effects of locational availability of tobacco on individual smoking behaviour is surprising given the considerable attention provided to examining the influence of geographical access to other neighbourhood resources such as green space, food stores and health service provision on various individual health outcomes. For example, there is evidence that the nature of the 'foodscape' influences individual-level nutrition- and obesity-related health outcomes in some,[28-30] but not all,[31, 32] settings.

This paper addresses this knowledge gap for tobacco consumption through the provision of a national level study. Our focus is New Zealand where smoking is responsible for approximately 15% of all deaths,[33] and there is a strong and rising social gradient in tobacco consumption, with higher rates among lower socioeconomic groups,[34] among Māori,[35] and for those living in more socially deprived neighbourhoods.[36] A study of two large national cohorts found that the contribution of tobacco smoking to inequalities in mortality increased between 1984 and 1999 from 16 to 21 percent for males and 3 to 11 percent for females.[34] Prevalence rates are approximately twice as high in the most deprived quintile of neighbourhoods compared to the least deprived,[37] probably contributing to increasing geographical inequalities in health in New Zealand.[38, 39] A high priority is, for these reasons, placed on reducing the prevalence of smoking.[40] We examine whether access to outlets selling tobacco in neighbourhoods across New Zealand is associated with individual-level smoking behaviour after adjustment for potential individual- and neighbourhood-level confounders.

Methods

Data on the addresses of each supermarket and local convenience store (including small corner stores, petrol stations and mini-markets) were collected during 2004 from all 74 Territorial Authorities (TAs) across New Zealand. TAs have regulatory responsibility for the hygiene inspection of all premises in their region used in the manufacture, preparation or storage of food for sale. To allow the food outlet data to be geocoded, information was requested on the street address. There were a total of 661 supermarkets and 3681 convenience stores. Geographical access to supermarkets and convenience stores was calculated separately for all 38,350 census meshblocks (average population 100), or what we refer to as 'neighbourhoods'. Each neighbourhood was represented by its population-weighted centroid and the travel time (by car) taken to the nearest supermarket and convenience store along the road network was calculated using the network functionality in a Geographical Information System (GIS). All segments in the road system were adjusted to account for variations in speed limits, type of road surface, sinuosity and differences in the topography across the network.[41]

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New Zealand Health Survey data

The 2002/03 New Zealand Health Survey (NZHS) is a national survey of the health status of 12,529 adults aged 15 years and over living in non-institutional permanent dwellings (target population 2.6 million) posing a range of questions that include smoking behaviour.[37] The 12,529 respondents were distributed across 1,178 meshblock neighbourhoods and there were between 1 and 83 respondents per neighbourhood, although in most neighbourhoods there were less than 20 respondents. Each individual in the survey was defined as a 'smoker' or 'non smoker' depending on their response to the question 'Do you smoke one or more tobacco cigarettes a day?'. Each smoker was categorised as a 'light' or 'heavy' (>10 cigarettes per day) smoker. The neighbourhood measures of tobacco outlet access were divided into quartiles (for confidentiality reasons) and appended to each respondent in the survey based on the neighbourhood that they lived in. The individual-level variables from the Health Survey and the neighbourhood-level measures that were examined in this study are summarised in Table 1 (the NZHS deliberately over-sampled ethnic minority populations and furthermore has a complex sampling frame. Therefore, the figures in the table relate only to the survey and cannot be extrapolated to the New Zealand population).

Analyses

Two-level logistic regression models with a random intercept were fitted in MLWin using second order penalised quasilikelihood (PQL) estimation methods. Our two dependent variables were examined separately in view of the different processes underpinning the decision to smoke, and the extent of smoking. First, we considered whether there were neighbourhood effects on all 'smokers' compared to 'non-smokers'. Second, we examined the effects on 'heavy smokers' versus all other respondents (i.e. light and non-smokers).

Variables were added in four stages. First, we included, sex, age, and design variables (ethnic composition of the neighbourhood, number of respondents from the neighbourhood, number of adults in the household, and respondent prioritised ethnicity) to account for the sample stratification and oversampling of ethnic minorities. Second, individual-level socioeconomic variables were added: education (none, school, post-school), social class (professional/managerial, other non-manual, skilled manual, semi and unskilled manual, and unavailable), receipt of poverty-related benefits (family support, domestic purposes or unemployment) in the last year (recipient or not), and household income (<$25k, $25-50k, >$50k). Two potential ecological confounders (at the neighbourhood-level) were added in the third and fourth stages respectively: area deprivation measured using the 2001 New Zealand Deprivation Index (NZDep)[42] divided into quintiles, and the 2001 Urban–Rural Area Classification, (main urban area, secondary urban area, minor urban area, rural centre, highly rural).[43] Due to multicollinearity we could not include both supermarkets and convenience stores in the same model; therefore, results are reported separately. There was also a substantive justification for this decision in that tobacco purchases at supermarkets are generally the result of a multipurpose shopping trip where many other products may be bought. Trips to convenience stores are usually for one or two purchases. This distinction indicates that convenience store purchases of tobacco might be more likely to be subject to access constraints. In order to examine whether SES moderated the relationship between locational access and

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individual smoking behaviour, potential interactions between the main effects (access to supermarkets and convenience stores) and the socioeconomic variables were also examined.

Table 1. Summary information for individuals in the 2002-03 New Zealand Health Survey (n=12,529).

Variable	Count	%		Count	%
Sex			*Benefits*		
Female	7658	61.1	Non-recipient	9784	78.1
Male	4871	38.9	Recipient	2745	21.9
Total	12529	100.0			
Age group			*Household income(NZ$)*		
65+	2206	17.6	>50,000	3948	31.5
45-64	3718	29.7	25,000-50,000	3842	30.7
25-44	5039	40.2	< 25,000	4730	37.8
15-24	1566	12.5			
Ethnicity			*Education*		
Other	6329	50.5	Tertiary qualifications	5581	44.6
Māori	4120	32.9	School qualifications only	3257	26.0
Pacific	908	7.2	No qualifications	3681	29.4
Asian	1172	9.4			
Social Class			*Current smoker*		
Managerial	2594	20.7	Yes	3739	29.9
Other non-manual	3084	24.6	No	8785	70.1
Skilled manual	1699	13.6	*Heavy smoker (>10 cigarettes per day)*		
Semi & unskilled manual	1958	15.6	Yes	1789	14.3
Unavailable	3194	25.5	No	10719	85.7

Neighbourhood-level variables

Variable	Count	%		Count	%
Neighbourhood Deprivation			*Neighbourhood Access to Supermarkets(mins)*		
1 (least deprived)	1705	13.6	Worst 6.54	2733	21.9
2	1573	12.6	Worse 3.22-6.54	3387	27.1
3	1854	14.8	Better 1.89-3.22	3444	27.6
4	2389	19.1	Best <1.89	2933	23.5
5 (most deprived)	4979	39.8			
Neighbourhood Urban/Rural Status			*Neighbourhood Access to Convenience Stores (mins)*		
Main urban	7650	61.1	Worst 3.89+	2409	19.3
Secondary urban	724	5.8	Worse 1.65-3.89	3173	25.4
Minor urban	1501	12.0	Better 0.98-1.65	3520	28.2
Rural centre	706	5.6	Best <0.98	3371	27.0
Highly rural	1948	15.5			

The figures in the table relate only to the survey and cannot be extrapolated to the New Zealand population

Odds ratios and 95% confidence intervals were calculated for quartile measures of access to supermarkets and access to convenience stores. The three quartiles with the best access to a supermarket or convenience store were compared to the worst access quartile (greatest travel time).

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Results

Supermarkets

We found that in the baseline model (that controlled for the design variables, age and sex) smoking was moderately associated with neighbourhood access to supermarkets (Model 1, Table 2). Compared to the reference category (worst access), the odds ratios for each quartile increased with better levels of access in an approximately linear fashion. However, the confidence intervals suggest that access only affects smoking for respondents in the two most accessible quartiles of neighbourhoods. The odds ratio in the quartile of neighbourhoods with the best access to a supermarket compared to the base category suggests that residents of these neighbourhoods had a 22 percent higher odds of being a smoker. The modest association between supermarket accessibility and smoking remained once individual-level socioeconomic status was controlled for (Model 2). However, any gradient relationship between access and smoking weakened on the addition of neighbourhood deprivation (Model 3) and disappeared when rurality was included (Model 4). At the same time controlling for area deprivation (Model 3) and area type (Model 4) removed any suggestion of statistical significance in the relationship between smoking and supermarket access.

Similar findings were noted for heavy smokers compared to light and non-smokers (Table 3). In the baseline model the odds ratio of being a heavy smoker was higher in neighbourhoods with better access to supermarkets (Model 1). Relative to the base category (worst access), the odds ratio increased from 1.05 in quartile 2 to 1.28 in quartile 4 (neighbourhoods with the best access), although the confidence intervals for all quartiles (except for the most accessible quartile of neighbourhoods) included 1.0. This pattern of relationship persisted in Models 2 and 3; in Model 4 even the confidence interval for the most accessible quartile overlapped 1.0, although the odds ratios for the accessibility quartiles continued to exhibit a small gradient ranging from 1.04 in quartile 2 to 1.15 in quartile 4.

To probe this finding further, we explored additional models (not shown). Both outcomes were modelled with access omitted. No significant change was observed for the individual or neighbourhood socio-economic deprivation coefficients, confirming that access represents a minor, non-significant attenuation or compounding of stronger relationships with socio-economic deprivation, mainly at an area level. Second, we considered possible interactions between access to supermarkets and individual- or area-level socioeconomic variables. There was some suggestion in the heavy smoking model of significant interaction between supermarket access and individual educational qualification and between supermarket access and neighbourhood deprivation. In both cases, however, confidence intervals overlapped extensively and there was no coherent patterning to the results. Finally, we examined the relationship between neighbourhood access to supermarkets and smoking status/heavy smoking for urban areas only. The results were consistent with the national findings.

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Table 2. Odds ratio of being a smoker (95% confidence intervals) and random variance estimates predicted from access to supermarkets in the 2002-03 New Zealand Health Survey (n=12,529).

	Model 1[a] Baseline	Model 2[b] Individual socio-economic status	Model 3[c] Area deprivation	Model 4[d] Urban/rural
Neighbourhood Access (mins)				
Worst >6.54	1	1	1	1
Worse 3.22-6.54	1.08 (0.93-1.25)	1.12 (0.97-1.29)	1.08 (0.94-1.24)	1.03 (0.86-1.24)
Better 1.89-3.22	1.17 (1.01-1.35)	1.19 (1.04-1.38)	1.12 (0.97-1.29)	1.07 (0.89-1.29)
Best <1.89	1.22 (1.05-1.42)	1.23 (1.06-1.42)	1.12 (0.97-1.29)	1.06 (0.88-1.28)
Sex				
Male	1	1	1	1
Female	1.04 (0.95-1.14)	1.10 (1.00-1.21)	1.10 (1.00-1.22)	1.11 (1.01-1.22)
Age group				
65+	1	1	1	1
45-64	4.31 (3.57-5.21)	3.77 (3.06-4.64)	3.68 (2.99-4.52)	3.67 (2.99-4.52)
25-44	4.57 (3.91-5.33)	4.38 (3.64-5.27)	4.26 (3.54-5.13)	4.26 (3.54-5.13)
15-24	2.86 (2.44-3.36)	2.85 (2.38-3.40)	2.78 (2.33-3.31)	2.78 (2.33-3.32)
Ethnicity				
Other	1	1	1	1
Māori	2.94 (2.62-3.29)	2.44 (2.17-2.74)	2.22 (1.97-2.50)	2.22 (1.98-2.50)
Pacific	1.52 (1.27-1.82)	1.28 (1.06-1.53)	1.12 (0.93-1.35)	1.13 (0.94-1.36)
Asian	0.37 (0.29-0.46)	0.38 (0.31-0.48)	0.37 (0.30-0.46)	0.38 (0.30-0.47)
Education				
Tertiary qualifications		1	1	1
School qualifications only		0.98 (0.87-1.09)	0.98 (0.87-1.09)	0.98 (0.87-1.09)
No qualifications		1.51 (1.35-1.69)	1.49 (1.34-1.67)	1.49 (1.33-1.67)
Social Class				
Managerial/Professional		1	1	1
Other non-manual		1.26 (1.10-1.45)	1.24 (1.08-1.42)	1.24 (1.08-1.42)
Skilled manual		1.81 (1.55-2.13)	1.77 (1.51-2.08)	1.78 (1.52-2.09)
Semi & unskilled manual		1.71 (1.46-2.00)	1.64 (1.41-1.92)	1.64 (1.40-1.91)
Unavailable		1.11 (0.94-1.31)	1.07 (0.91-1.26)	1.07 (0.91-1.26)
Benefits				
Non-recipient		1	1	1
Recipient		1.53 (1.37-1.70)	1.51 (1.36-1.68)	1.51 (1.36-1.68)
Household income				
>50,000		1	1	1
25,000-50,000		1.20 (1.07-1.35)	1.13 (1.00-1.27)	1.12 (1.00-1.26)
< 25,000		1.48 (1.30-1.68)	1.36 (1.19-1.55)	1.36 (1.19-1.55)
Neighbourhood Deprivation				
1 (least deprived)			1	1
2			1.15 (0.94-1.41)	1.15 (0.94-1.42)
3			1.22 (1.00-1.49)	1.22 (1.00-1.49)
4			1.64 (1.36-1.98)	1.65 (1.36-1.99)
5 (most deprived)			1.87 (1.53-2.29)	1.86 (1.52-2.28)
Neighbourhood Urban/Rural Status				
Main urban				1

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Secondary urban				1.12 (0.91-1.37)
Minor urban				1.02 (0.88-1.19)
Rural centre				1.08 (0.85-1.35)
Highly rural				0.92 (0.76-1.11)
Level 2 variance[e] (Std err)	0.13 (0.03)	0.07 (0.02)	0.05 (0.02)	0.05 (0.02)

a. Models include design (to account for sample stratification and oversampling of ethnic minorities), and individual-level sex and age variables.

b. Individual-level socio-economic variables included in models containing design, sex and age variables.

c. Neighbourhood-level deprivation included in models containing individual-level design, sex, age and socio-economic variables.

d. Neighbourhood-level urban area classification included in models containing neighbourhood-level deprivation and individual-level design, sex, age and socio-economic variables.

e. Variance at the neighbourhood-level

Table 3. Odds ratio of being a heavy smoker (95% confidence intervals) and random variance estimates predicted from access to supermarkets in the 2002-03 New Zealand Health Survey (n=12,529).

	Model 1[a] Baseline	Model 2[b] Individual socio-economic status	Model 3[c] Area deprivation	Model 4[d] Urban/rural
Neighbourhood Access (mins)				
Worst >6.54	1	1	1	1
Worse 3.22-6.54	1.05 (0.88-1.25)	1.12 (0.94-1.33)	1.08 (0.91-1.27)	1.04 (0.84-1.30)
Better 1.89-3.22	1.16 (0.97-1.38)	1.22 (1.03-1.44)	1.14 (0.96-1.35)	1.10 (0.88-1.38)
Best <1.89	1.28 (1.07-1.52)	1.33 (1.12-1.58)	1.20 (1.01-1.43)	1.15 (0.92-1.44)
Sex				
Male	1	1	1	1
Female	0.79 (0.71-0.88)	0.87 (0.77-0.98)	0.87 (0.78-0.98)	0.87 (0.78-0.98)
Age group				
65+	1	1	1	1
45-64	3.60 (2.88-4.50)	4.01 (3.15-5.11)	3.89 (3.06-4.96)	3.90 (3.07-4.97)
25-44	4.57 (3.68-5.69)	5.06 (3.93-6.50)	4.90 (3.81-6.29)	4.91 (3.82-6.31)
15-24	2.70 (2.06-3.53)	2.64 (1.98-3.53)	2.56 (1.92-3.42)	2.57 (1.93-3.43)
Ethnicity				
Other	1	1	1	1
Māori	1.93 (1.68-2.23)	1.60 (1.38-1.84)	1.43 (1.24-1.65)	1.43 (1.24-1.65)
Pacific	0.83 (0.64-1.07)	0.68 (0.53-0.88)	0.58 (0.45-0.75)	0.59 (0.45-0.77)
Asian	0.17 (0.11-0.25)	0.17 (0.11-0.26)	0.16 (0.11-0.25)	0.17 (0.11-0.25)
Education				
Tertiary qualifications		1	1	1
School qualifications only		0.99 (0.85-1.14)	0.99 (0.85-1.14)	0.99 (0.86-1.14)
No qualifications		1.48 (1.29-1.69)	1.46 (1.28-1.67)	1.46 (1.27-1.67)
Social Class				
Managerial/Professional		1	1	1
Other non-manual		1.31 (1.09-1.57)	1.28 (1.06-1.54)	1.28 (1.06-1.53)
Skilled manual		2.16 (1.77-2.63)	2.10 (1.72-2.56)	2.09 (1.71-2.55)
Semi & unskilled manual		1.80 (1.48-2.19)	1.71 (1.41-2.08)	1.70 (1.40-2.07)
Unavailable		1.37 (1.11-1.70)	1.31 (1.06-1.63)	1.31 (1.06-1.62)
Benefits				
Non-recipient		1	1	1
Recipient		1.26 (1.11-1.44)	1.25 (1.09-1.42)	1.25 (1.09-1.42)
Household income				
>50,000		1	1	1
25,000-50,000		1.30 (1.12-1.51)	1.21 (1.04-1.40)	1.20 (1.04-1.40)
< 25,000		1.50 (1.27-1.76)	1.36 (1.15-1.61)	1.35 (1.15-1.60)
Neighbourhood Deprivation				
1 (least deprived)			1	1
2			1.22 (0.93-1.60)	1.22 (0.93-1.60)
3			1.17 (0.90-1.52)	1.18 (0.90-1.53)
4			1.72 (1.34-2.20)	1.72 (1.35-2.20)
5 (most deprived)			2.06 (1.59-2.68)	2.06 (1.59-2.67)
Neighbourhood Urban/Rural Status				
Main urban				1

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Secondary urban				1.24 (0.98-1.57)
Minor urban				1.09 (0.92-1.30)
Rural centre				1.06 (0.81-1.38)
Highly rural				0.98 (0.78-1.24)
Level 2 variance[e] (Std err)	0.13 (0.04)	0.07 (0.03)	0.05 (0.03)	0.04 (0.03)

a. Models include design (to account for sample stratification and oversampling of ethnic minorities), and individual-level sex and age variables.
b. Individual-level socio-economic variables included in models containing design, sex and age variables.
c. Neighbourhood-level deprivation included in models containing individual-level design, sex, age and socio-economic variables.
d. Neighbourhood-level urban area classification included in models containing neighbourhood-level deprivation and individual-level design, sex, age and socio-economic variables.
e. Variance at the neighbourhood-level

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Table 4. Odds ratio of being a smoker (95% confidence intervals) and random variance estimates predicted from access to convenience stores in the 2002-03 New Zealand Health Survey (n=12,529).

	Model 1[a] Baseline	Model 2[b] Individual socio-economic status	Model 3[c] Area deprivation	Model 4[d] Urban/rural
Neighbourhood Access (mins)				
Worst >3.89	1	1	1	1
Worse 1.65-3.89	1.10 (0.95-1.28)	1.12 (0.97-1.29)	1.07 (0.93-1.23)	0.97 (0.82-1.15)
Better 0.98-1.65	1.13 (0.97-1.32)	1.15 (0.99-1.33)	1.05 (0.91-1.22)	0.95 (0.79-1.13)
Best <0.98	1.18 (1.01-1.37)	1.19 (1.03-1.38)	1.05 (0.91-1.22)	0.95 (0.80-1.13)
Sex				
Male	1	1	1	1
Female	1.04 (0.96-1.14)	1.11 (1.00-1.22)	1.11 (1.01-1.22)	1.11 (1.01-1.22)
Age group				
65+	1	1	1	1
45-64	2.86 (2.44-3.35)	2.84 (2.38-3.39)	2.77 (2.32-3.31)	2.78 (2.33-3.32)
25-44	4.53 (3.88-5.29)	4.35 (3.61-5.23)	4.24 (3.53-5.10)	4.25 (3.53-5.11)
15-24	4.27 (3.53-5.15)	3.74 (3.03-4.60)	3.66 (2.97-4.50)	3.65 (2.97-4.50)
Ethnicity				
Other	1	1	1	1
Māori	2.93 (2.61-3.28)	2.43 (2.16-2.73)	2.21 (1.96-2.49)	2.22 (1.97-2.50)
Pacific	1.52 (1.27-1.82)	1.28 (1.07-1.54)	1.12 (0.93-1.35)	1.13 (0.94-1.36)
Asian	0.37 (0.29-0.46)	0.38 (0.31-0.48)	0.37 (0.30-0.47)	0.38 (0.30-0.47)
Education				
Tertiary qualifications		1	1	1
School qualifications only		0.97 (0.87-1.09)	0.97 (0.87-1.09)	0.97 (0.87-1.09)
No qualifications		1.49 (1.33-1.67)	1.48 (1.32-1.65)	1.48 (1.32-1.66)
Social Class				
Managerial/Professional		1	1	1
Other non-manual		1.27 (1.10-1.45)	1.24 (1.08-1.43)	1.24 (1.08-1.43)
Skilled manual		1.83 (1.56-2.15)	1.78 (1.52-2.09)	1.79 (1.53-2.11)
Semi & unskilled manual		1.73 (1.48-2.02)	1.66 (1.42-1.94)	1.65 (1.42-1.93)
Unavailable		1.12 (0.95-1.32)	1.08 (0.92-1.28)	1.08 (0.91-1.28)
Benefits				
Non-recipient		1	1	1
Recipient		1.52 (1.37-1.70)	1.50 (1.35-1.68)	1.50 (1.35-1.68)
Household income				
>50,000		1	1	1
25,000-50,000		1.20 (1.07-1.35)	1.13 (1.00-1.27)	1.12 (1.00-1.26)
< 25,000		1.48 (1.30-1.68)	1.36 (1.19-1.55)	1.36 (1.19-1.55)
Neighbourhood Deprivation				
1 (least deprived)			1	1
2			1.15 (0.94-1.41)	1.16 (0.94-1.42)
3			1.24 (1.02-1.52)	1.25 (1.02-1.53)
4			1.67 (1.39-2.02)	1.69 (1.40-2.04)
5 (most deprived)			1.91 (1.56-2.35)	1.91 (1.56-2.35)
Neighbourhood Urban/Rural Status				
Main urban				1

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Secondary urban				1.10 (0.90-1.34)
Minor urban				1.01 (0.87-1.18)
Rural centre				1.04 (0.84-1.28)
Highly rural				0.85 (0.71-1.02)
Level 2 variance^e (Std err)	0.14 (0.03)	0.08 (0.02)	0.05 (0.02)	0.05 (0.02)

a. Models include design (to account for sample stratification and oversampling of ethnic minorities), and individual-level sex and age variables.
b. Individual-level socio-economic variables included in models containing design, sex and age variables.
c. Neighbourhood-level deprivation included in models containing individual-level design, sex, age and socio-economic variables.
d. Neighbourhood-level urban area classification included in models containing neighbourhood-level deprivation and individual-level design, sex, age and socio-economic variables.
e. Variance at the neighbourhood-level

Convenience stores

With regards to access to convenience stores, in the baseline model there was a significant association only between individual smoking behaviour and neighbourhoods with the best accessibility (Model 1, Table 4). The odds ratio in the most accessible quartile of neighbourhoods compared to the reference category (worst access) was 1.18 (95% CI 1.01-1.37). This association remained once individual socioeconomic status was controlled for (Model 2). However, the inclusion of neighbourhood variables (deprivation and rurality) attenuated the relationship and the 95% confidence intervals included 1.0 (Models 3 and 4).

There was little evidence of an association between access to convenience stores and individual-level *heavy* smoking (Table 5). In the baseline model (Model 1), although the quartile of neighbourhoods with better access to outlets selling tobacco each had odds ratios over 1.0, there was not a convincing dose-response relationship. Further, all of the 95% confidence intervals included the null. Once individual-level socioeconomic status as well as neighbourhood-level deprivation and urban/rural status were included in the model the odds ratios were all close to 1.0 (Model 4).

These findings were probed using the same approach as that used in the analysis of supermarket access. Results were similar suggesting that more complex modelling does not reinstate significant evidence for store access having any independent effect on smoking behaviour.

Table 5. Odds ratio of being a heavy smoker (95% confidence intervals) and random variance estimates predicted from access to convenience stores in the 2002-03 New Zealand Health Survey (n=12,529).

	Model 1[a] Baseline	Model 2[b] Individual socio-economic status	Model 3[c] Area deprivation	Model 4[d] Urban/rural
Neighbourhood Access (mins)				
Worst >3.89	1	1	1	1
Worse 1.65-3.89	1.13 (0.95-1.35)	1.17 (0.98-1.38)	1.10 (0.93-1.31)	1.01 (0.82-1.24)
Better 0.98-1.65	1.14 (0.95-1.37)	1.19 (0.99-1.42)	1.07 (0.90-1.28)	0.98 (0.78-1.21)
Best <0.98	1.12 (0.94-1.34)	1.15 (0.97-1.37)	1.01 (0.85-1.20)	0.93 (0.75-1.15)
Sex				
Male	1	1	1	1
Female	0.79 (0.71-0.88)	0.87 (0.77-0.98)	0.87 (0.77-0.98)	0.87 (0.78-0.99)
Age group				
65+	1	1	1	1
45-64	3.56 (2.85-4.45)	3.99 (3.14-5.09)	3.87 (3.04-4.92)	3.89 (3.06-4.95)
25-44	4.50 (3.62-5.59)	5.03 (3.91-6.46)	4.87 (3.79-6.26)	4.89 (3.81-6.28)
15-24	2.64 (2.02-3.45)	2.62 (1.96-3.49)	2.54 (1.91-3.39)	2.55 (1.91-3.39)
Ethnicity				
Other	1	1	1	1
Māori	1.93 (1.67-2.22)	1.59 (1.37-1.83)	1.41 (1.22-1.63)	1.42 (1.23-1.64)
Pacific	0.83 (0.64-1.07)	0.68 (0.52-0.88)	0.57 (0.44-0.75)	0.59 (0.45-0.76)
Asian	0.17 (0.11-0.26)	0.17 (0.11-0.26)	0.16 (0.11-0.25)	0.17 (0.11-0.26)
Education				
Tertiary qualifications		1	1	1
School qualifications only		0.98 (0.84-1.13)	0.98 (0.85-1.13)	0.98 (0.85-1.13)
No qualifications		1.46 (1.27-1.67)	1.45 (1.26-1.66)	1.45 (1.26-1.66)
Social Class				
Managerial/Professional		1	1	1
Other non-manual		1.31 (1.09-1.58)	1.28 (1.06-1.54)	1.28 (1.06-1.54)
Skilled manual		2.16 (1.77-2.63)	2.08 (1.71-2.54)	2.09 (1.71-2.54)
Semi & unskilled manual		1.82 (1.49-2.21)	1.73 (1.42-2.10)	1.72 (1.41-2.09)
Unavailable		1.40 (1.13-1.74)	1.33 (1.07-1.65)	1.33 (1.07-1.65)
Benefits				
Non-recipient		1	1	1
Recipient		1.26 (1.10-1.44)	1.24 (1.09-1.42)	1.24 (1.09-1.41)
Household income				
>50,000		1	1	1
25,000-50,000		1.32 (1.14-1.53)	1.22 (1.05-1.42)	1.21 (1.04-1.41)
< 25,000		1.51 (1.28-1.79)	1.37 (1.16-1.62)	1.37 (1.15-1.62)
Neighbourhood Deprivation				
1 (least deprived)			1	1
2			1.23 (0.94-1.61)	1.23 (0.94-1.61)
3			1.21 (0.93-1.58)	1.22 (0.94-1.59)
4			1.80 (1.41-2.31)	1.80 (1.41-2.31)
5 (most deprived)			2.17 (1.67-2.83)	2.16 (1.66-2.81)
Neighbourhood Urban/Rural Status				
Main urban				1

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Secondary urban				1.20 (0.95-1.53)
Minor urban				1.10 (0.93-1.31)
Rural centre				1.04 (0.81-1.33)
Highly rural				0.90 (0.72-1.12)
Level 2 variance^e (Std err)	0.14 (0.04)	0.09 (0.03)	0.06 (0.03)	0.04 (0.03)

a. Models include design (to account for sample stratification and oversampling of ethnic minorities), and individual-level sex and age variables.
b. Individual-level socio-economic variables included in models containing design, sex and age variables.
c. Neighbourhood-level deprivation included in models containing individual-level design, sex, age and socio-economic variables.
d. Neighbourhood-level urban area classification included in models containing neighbourhood-level deprivation and individual-level design, sex, age and socio-economic variables.
e. Variance at the neighbourhood-level

Discussion

This paper presents the results of the first national study of the effects of neighbourhood access to outlets selling tobacco on individual smoking behaviour. Two findings are of particular interest. First, we confirmed that, after adjustment for potentially confounding individual-level variables, neighbourhood access to both supermarkets and convenience stores showed a modest association with smoking rates, but this was less evident with respect to the intensity of smoking. Second, although it has previously been noted that tobacco outlets are preferentially located in more deprived New Zealand neighbourhoods[23], after adjustment for neighbourhood variables, residents of neighbourhoods with better geographical access to supermarkets and convenience stores were *not* more likely to smoke or to be a heavy smoker. Our findings concur with the only similar previous study that also found that after controlling for individual level characteristics high convenience store density remained positively associated with individual smoking but not when neighbourhood SES was taken into account, except in the case of higher income residents.[11]

The main contributions of our study are threefold. Our findings are based on the national and not the local scale, we have captured most outlets selling tobacco, not only convenience stores but also supermarkets and we have separately examined the effects of neighbourhood access on all smokers *and* heavy smokers. However, our study has a number of limitations. First, there are other sources for procuring tobacco that are not captured in our neighbourhood accessibility measure, including liquor stores and hotels, restaurants, petrol stations that do not sell food, duty free shops, mail order, the internet and other illegal sources. Nonetheless, over 90 percent of smokers in New Zealand acquire their tobacco products from supermarkets, convenience stores or petrol stations.[44] Second, without information on shopping habits there is no validation that people actually purchase tobacco products from their closest supermarket or convenience store. Third, tobacco purchasing may link not only to residential neighbourhood, but also to workplace and other locations. Fourth, the neighbourhood measure of access to tobacco outlets is based on travel times by car but access to a car is itself patterned by neighbourhood socioeconomic characteristics. Finally, the differences in travel time between each quartile are not large, suggesting that few neighbourhoods have substantial distances to travel to an outlet selling tobacco.

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These limitations acknowledged, our results confirm that the effects of access to tobacco outlets on smoking behaviour largely reflect the impact of neighbourhood deprivation. This is not unsurprising given the higher concentration of outlets selling tobacco in disadvantaged neighbourhoods. This association between neighbourhood deprivation and individual smoking is consistent with the findings from a number of countries. Research has persistently found neighbourhood SES or deprivation to be associated with individual smoking, even after individual-level adjustments.[7, 8, 45-47] Previous studies in New Zealand have also found this independent association.[4, 13, 14, 36]

Our findings have a number of important theoretical and policy implications. First, the fact that controls for neighbourhood deprivation effectively removed the relationship between access to tobacco outlets and tobacco consumption confirms the importance of this factor in disadvantaged communities. However, since neighbourhood access is just one contextual feature, more nuanced analyses of the significance of different types of area effects, including neighbourhood incivilities,[17] social capital[48] or local stigma and alienation,[15] are needed in order to more fully understand the key environmental influences which mediate the well known independent relationship between area deprivation and smoking.

Second, although our findings suggest that neighbourhood access to tobacco outlets was not a significant factor in determining individual smoking behaviour, it would be premature to argue against area-based policies restricting the availability of tobacco. First, it remains unclear whether more severe restrictions on the number of tobacco outlets would significantly influence consumption rates, especially if people had to travel longer distances to purchase tobacco. Further analyses involving different travel time thresholds are required. Second, given that many people purchase tobacco from non-neighbourhood outlets (e.g. near workplaces), then the access effects could also be mitigated by restrictions on locating outlets selling cigarettes within important employment nodes (e.g. city centres). Third, in the absence of national-level restrictions on the retail displays of tobacco products, greater local restrictions on tobacco retailing in more deprived areas remain a possibility. Fourth, our cross-sectional analyses have not explored the relationship between access to tobacco products and smoking initiation especially among younger persons in deprived neighbourhoods. Thus further research might usefully examine the relations between smoking stages and sources of cigarettes. Finally, local restrictions on the availability of tobacco could be effective for certain groups, such as solo parents or older people who are more likely to face mobility constraints. Such a possibility may, for example, be one way of reducing the high rates of smoking by Māori women in disadvantaged areas.

Continued research on the pathways linking local area disadvantage to smoking behaviour is warranted. Despite the correspondence between our findings and the earlier (Californian) research, the potential importance of national context should encourage researchers in other countries to examine the influence of neighbourhood resources, such as retail provision, on individual health in their own countries.

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What this paper adds

What is already known on this subject?

- Higher levels of smoking are associated with a range of adverse health outcomes.
- Smoking behaviour is strongly patterned by socioeconomic circumstances with people on lower incomes, lower educational attainment and living in areas of high social deprivation tending to smoke more.
- Neighbourhood access to shops selling tobacco has been suggested as one explanation for the social gradient in tobacco consumption.

What does this study add?

This paper adds to the understanding of the contextual explanations for smoking behaviour. At the national level, we found little evidence that better geographical access to retailers selling tobacco is associated with higher consumption of cigarettes. The findings of this analysis suggest that area-based restrictions on the availability of outlets selling tobacco alone may not reduce the prevalence of smoking in New Zealand.

Policy Implications

This study does not find evidence to suggest that restrictions on the neighbourhood availability of tobacco products will be an effective policy instrument in reducing the prevalence of smoking in New Zealand. However, before arguing against area-based policies that restrict the local availability of tobacco, further research is required. In particular, more severe restrictions on the number of tobacco outlets in residential neighbourhoods, and area-based restrictions in non-residential settings (e.g. close to workplaces) may influence the consumption of tobacco. Further, local restrictions on the availability of cigarettes could be effective for certain groups, such as solo parents or older people who are more likely to face mobility constraints.

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