



Is the neighbourhood context important for a tobacco retailer proximity policy?

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ARTICLE INFO

Keywords:

Tobacco availability
Tobacco retail
Health inequity
Social determinants of health

ABSTRACT

A spatial modelling approach was used to explore how a proximity limit (150 m, 300 m, and 450 m) between tobacco retailers may impact different neighbourhoods in New Zealand. Neighbourhoods were categorised into three density groups (0, 1–2, 3+ retailers). As the proximity limit increases, there is a progressive redistribution of neighbourhoods in the three density groups with the 3+ density group incorporating fewer neighbourhoods and the 0 and 1–2 density groups conversely each consisting of more. The differing measures available at the neighbourhood level enabled our study to discern potential inequities. More directed policies targeting these inequities are needed.

1. Introduction

The density of tobacco retail outlets in neighbourhoods is one example of how the built environment can contribute to social determinants of health (SDOH) and health inequities (Diez Roux and Mair, 2010; Barnett et al., 2016). A recent systematic review found evidence of associations between higher tobacco retail density and higher smoking prevalence, higher frequency of smoking, higher susceptibility to smoking, earlier tobacco initiation, shorter time to the first cigarette in the morning, and reduced number of days of abstinence and quit attempts among current smokers (Valiente et al., 2021). In a recent meta-analysis, reduced tobacco retailer density and decreased proximity were found to reduce the risk of tobacco use by 2.5% (Lee et al., 2021). A further systematic review focused on smoking behaviours among youth, found a positive association between tobacco retail outlet density and smoking behaviours among youth, particularly for the density near youths' homes (Marsh et al., 2020). As well as the location of the tobacco retailer, features of the built environment including exposure to tobacco promotion at point-of-sale (POS) are associated with smoking or smoking susceptibility (Robertson et al., 2014, Robertson et al., 2016).

Evidence has shown an association between neighbourhood

demographics and tobacco availability. Tobacco retailer density is higher in areas of greater deprivation (Chaiton et al., 2013; Adibe et al., 2019; Kong et al., 2021; Schneider and Gruber, 2013; Fakunle et al., 2019). Extending this, Glasser et al. (2021) found associations between the SDOH and tobacco use. Tobacco retailer density disparities were positively associated with smoking disparities among adults, but negative among youth (Glasser et al., 2021). There were inconsistent findings for this association in rural and urban areas (Chaiton et al., 2013; Adibe et al., 2019). Kong et al. (2021) also found that in the US, the association between socio-demographics of a census tract are "associated with tobacco retailer density both in that region and also for neighbouring regions" (Kong et al., 2021, 5). A further study found that the association held, despite the populations being similar with respect to race (Fakunle et al., 2019).

Some studies examined household income as a measure of affluence, and found neighbourhoods with lower median household incomes had a higher density of tobacco retailers (Schneider and Gruber, 2013; Mills et al., 2022; Reid et al., 2013; Fakunle et al., 2010, 2021; Lee et al., 2017; Mayers et al., 2012; Siahpush et al., 2010). Several (mainly US) studies examined the association between race and communities with high immigrant populations with the density of tobacco retailers. Studies

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<https://doi.org/10.1016/j.healthplace.2023.103032>

Received 12 February 2023; Received in revised form 19 April 2023; Accepted 20 April 2023

Available online 4 May 2023

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generally reported that areas with a high proportion of African Americans and Hispanics had a greater tobacco retail density (Adibe et al., 2019; Kong et al., 2021; Mills et al., 2022; Reid et al., 2013; Fakunle et al., 2010, 2021; Siahpush et al., 2010) and this was shown to be the case despite similar socio-economic status (Fakunle et al., 2021). Two further studies found a similar association for areas with a high proportion of African American, but not Hispanic, populations (Lee et al., 2017; Mayers et al., 2012).

In New Zealand (NZ), smoking is the leading cause of morbidity and mortality (Blakely et al., 2015). Over the last 10 years, daily smoking prevalence has decreased from 16.4% to 8.0%; however, this decline hides the inequities that exist. Māori are 2.9 times as likely to smoke than non-Māori, and Pacific peoples are 2.3 times as likely to smoke than non-Pacific (Ministry of Health, 2022). It has been estimated that 23% of deaths are attributable to smoking among Māori, compared with 12% among non-Māori (Walsh and Wright, 2020). Tobacco retailers are more densely located in more deprived areas (Marsh et al., 2013), where smoking is also shown to be three times as high as in the least deprived areas (Ministry of Health, 2022). A high proportion of Māori also live in these highly deprived areas (Stats NZ, 2014), which is a factor likely to contribute to health inequities (Bécares et al., 2013). Exploring the effects of the density of tobacco retailers on the health and smoking behaviours of people in different neighbourhoods, may provide evidence for policy intervention to reduce these health disparities.

NZ's Smokefree 2025 goal aims to reduce overall smoking prevalence to below 5%, and decrease tobacco availability (New Zealand Government, 2011). In December 2021, the NZ Government released an action plan for achieving Smokefree Aotearoa 2025, which sets out six key focus areas, one of which is to reduce the availability of smoked tobacco products (Ministry of Health, 2021). In December 2022, amendments to the Smokefree Environments and Regulated Products Act (the Act) were passed in Parliament (Smokefree Environments And Regulated Products Amendment Act, 2023). Under the amended Act, from July 1, 2024 smoked tobacco products will only be able to be sold in a maximum number of retail premises across the country (Ministry of Health, 2023). The Act requires the Director-General of Health to consider the geographic nature of the area and the estimated average travel time to purchase smoked tobacco products as well as the population size in the area and estimated number of people who smoke. The proposals, which are currently open for consultation, are based on availability in urban and rural areas, and do not specifically address the deprivation level of an area.

One policy option to reduce the density of tobacco retailers is to restrict the distance retailers can be located to each other, also called a proximity limit policy. A greater distance to a tobacco retail outlet is hypothesized to reduce smoking prevalence via increased search and purchase costs (Schneider et al., 2005). This type of policy has been implemented in several US jurisdictions (City Of Huntington Park California, 2011; County Of Santa Clara, 2015; San Francisco Department Of Public Health, 2015; Benton County Oregon, 2018; City of Palo Alto, 2018), and potential impacts have also been modelled in US studies (Myers et al., 2015; Luke et al., 2017; Combs et al., 2019). A recent NZ study found that a proximity limit of 450 m would reduce retailers by 58%, with a 6% reduction in retailers in the most deprived communities, but would not reach the proposed critical behaviour-change threshold of 90–95% required to reduce smoking prevalence (Marsh et al., 2022a).

Several studies examining policies for reducing tobacco availability have found that policies reduce the overall density of tobacco, but not necessarily inequities in smoking or tobacco availability (Marsh et al., 2020; Caryl et al., 2020; Ribisl et al., 2017; Tucker-Seeley et al., 2016). Geospatial analysis can be employed to inform efforts to address the social determinants of smoking. In this study, we use a geospatial approach to explore how a proximity limit between tobacco retailers may impact different neighbourhoods to inform policy development for reducing tobacco availability. The specific aims of the study are.

- 1) To examine the impact of a proximity limit of 150 m, 300 m, and 450 m between tobacco retailers on the number of retailers located in differing neighbourhoods (SA2) in NZ.
- 2) To capture the sociodemographic and economic characteristics of neighbourhood with (i) 0 tobacco retailers (ii) 1 or 2 retailers, and (iii) 3 or more retailers based on the imposed distance limits.

2. Methods

We used a spatial modelling approach to simulate the impact of a policy that limited the proximity between tobacco retailers on neighbourhoods. Neighbourhoods were defined by Statistical Area 2 units (SA2) which reflect communities that interact together socially and economically, and which have been used as a suitable approximation for neighbourhoods (Pearson et al., 2013). While SA2 areas aim to capture similar size populations, their area can vary depending on their location (Stats NZ, 2017). We excluded SA2's with nil or nominal populations (12 or less), and any SA2s representing bodies of water, consistent with previous NZ research (Wiki et al., 2021). This reduced eligible SA2 areas by 108 neighbourhoods, to the 2145 investigated.

Tobacco retailers were identified from a 2020 national database of tobacco retailers which included 5131 retailers (Marsh et al., 2013, Marsh et al., 2020). Eight of these were excluded as they were located in ineligible SA2s. Types of retailers included convenience stores, petrol stations, supermarkets, and liquor stores. Retailers that allow alcohol consumption on their premises were excluded; only 6.5% of on-license premises sold tobacco in NZ (Marsh et al., 2022b). Duplicate listings were removed and missing or incomplete physical addresses were resolved through online searches and Google Street View. Addresses were then translated to spatial locations and mapped using ArcGIS Pro software (Environmental Systems Research Institute, 2011). The accuracy of the geocoding results was first checked by confirming that each retailer had been correctly located at the city or region level. Those in the wrong city or region were manually relocated to their correct street address. All of the mapped points were reviewed manually to ensure proper placement. Points were relocated as close to a premise's entrance as possible.

Proximity limit scenarios (150 m, 300 m, and 450 m) were selected to be consistent with previous modelling work by Luke et al. (2017) and Caryl et al. (2020). The proximity limit of 150 m also corresponds with 500 feet minimum distance between retailers used by Myers et al. (2015) and in policies implemented in Santa Clara, San Francisco and Palo Alto Counties (County of Santa Clara, 2015, San Francisco Department Of Public Health, 2015; City of Palo Alto, 2018).

2.1. Measures

A brief description of the main measures, including tobacco outlet exposure (distance to next closest retailer, density of tobacco retailers), geographic variables (rural/urban, population), demographics (deprivation, ethnicity, age, sex and ethnicity), smoking status, and economic variables (personal income and participation in the workforce) are shown in Table 1. For the analysis, all measures are represented at the SA2 neighbourhood level with the demographic, smoking status, and economic variables reflecting proportions of a specific SA2 population within the relevant subgroups. (Stats NZ, 2020).

2.2. Analysis

The potential effects on tobacco retailer density of a proximity limit between retailers were explored following the methods used by (Myers et al., 2015). An iterative Python script was used to randomly remove tobacco retailers based on a minimum distance between retailers for each of the three proximity scenarios examined (150 m, 300 m and 450 m). Independently, this process continued for all three scenario's minimum distance. Furthermore, as each process is a random analysis

Table 1
Measures.

Variable	Description	Coding
Tobacco retailer variables		
Distance to the closest tobacco retailer	Distance to the closest retailer was measured using the straight-line method using the Near tool in ArcGIS.	Continuous
Density of tobacco retailers	The number of retailers per SA2	0 = 0 tobacco retailers 1 = 1 or 2 tobacco retailers 2 = 3+ tobacco retailers
Geographic variables		
Rural/urban	Each SA2 was categorised as being located in an Major urban area (Large/Major Urban - population greater than 30,000), semi-urban area (Small/Medium Urban - population between 1,000 and 29,999) or rural area (Rural settlement/Rural other - population of less than 1,000) at the SA2 level based on classifications obtained from the 2018 census as published by Stats NZ.	Large/Major Urban Small/Medium Urban Rural Other
Population size	Census usually resident population count	Continuous
Demographic variables		
Age	Age in years	Under 15 years 15–29 years 30–64 years 65 years +
Sex	Biological sex	Female Male
Deprivation	NZDep2018 index was used to measure socioeconomic deprivation (Atkinson J et al., 2019). This index combines nine variables from the census that reflect eight dimensions of material deprivation, and is presented as an ordinal score from 1 to 10. This was combined into three groups: Low (1–3) Medium (4–7) High (8–10).	Low (1–3) Medium (4–7) High (8–10).
Ethnicity	Self-reported ethnicity where an individual could select multiple responses	Māori Pacific European Asian MELAA Other
Smoking variable		
Smoking status	Cigarette smoking refers to the active smoking of one or more manufactured or hand-rolled tobacco cigarettes, from purchased or home-grown tobacco, per day, by a person aged 15 years and over.	Regular smoker (smoke one or more cigarettes at least daily) Ex-smoker Never smoker
Economic variables		
Personal income	Personal annual income from all sources in the 12 months ending March 6, 2018, for the usually resident population aged 15 years and over. This excludes any income that is not money.	Loss or zero \$1–15,000 \$15,001 – \$50,000 \$50,001 – \$70,000 \$70,001 – \$150,000 \$150,001+
Workforce	Workforce status classifies a person aged 15 years and over by their inclusion in or exclusion from the labour force. A person is considered unemployed if, during the week ended 4 March 2018, was without a paid job but was available for work, and had actively sought work in the four weeks ended 4 March 2018. A	Employed Unemployed Not in the labour force

Table 1 (continued)

Variable	Description	Coding
	person is considered to not be in the labour force if they were not employed and were not actively seeking work, or not available for work.	

producing different results, the script was run 100 times within each minimum proximity scenario to maximize validity.

For each of the 100 simulations, SA2s were separated into three density groups: SA2s with no tobacco retailers in the current simulation, those with 1 or 2 (from here referred to as '1–2'), and those with 3+ retailers. The three density groups were defined based on having zero retailers in a neighbourhood as the benchmark, while the average number of retailers per SA2 (2.39) defined the mid category (1–2 retailers), and 3+ retailers was viewed as harmful. Then, for each density group, we collected summary statistics at the SA2 level for the measures detailed above, including median population sizes and distances between tobacco retailers, and proportions of demographics and smoking status. The results for each density group were estimated as the mean of the 100 Python script simulations for each of the three proximity limit scenarios.

3. Results

Please refer to [Tables 2–5](#) which collectively present the results.

3.1. Tobacco retailers

Currently, of the 2145 SA2s, a higher proportion are located in the 1–2 tobacco retailers density group ($n = 801 = 37\%$). This is followed by the 3+ density group ($n = 714 = 33\%$) then the 0 density group ($n = 630 = 29\%$). As the distance limit increases, there is an obvious decrease in the average number of SA2s that include 3+ tobacco retailers, and an overall redistribution to the 0 and 1–2 density groups. Implementing the 450 m distance restriction corresponded to a greatly reduced $n = 163 = 8\%$ in the 3+ density group and an increased $n = 757 = 35\%$ and $n = 1225 = 57\%$ in the 0 and 1–2 density groups, respectively. [Fig. 1](#) provides an example of how the imposed distance limits affect the tobacco retailer distribution in the Auckland region.

As anticipated, there is an evident difference in the status quo median distance to the closest tobacco retailer: 559 m for the 1–2 density group and just 89 m for the 3+ density group. As the proximity limit increases, there is a consistent increase in this distance across the two relevant density groups. The increase is most evident in the 3+ density group where eventually, the average median distance becomes more similar to that of the status quo 1–2 density group: 559 to 651 to 702 to 796 in the 1–2 density group and 89 to 272 to 448 to 599 in the 3+ density group.

Although there were no discernible patterns in age, sex, or workforce status across the three density groups and the three distance limit contexts, there were for the rurality, deprivation, ethnicity, smoking status, and personal income variables.

3.2. Geographic

Currently, the distribution of the rurality categories in the 1–2 density group reflects that of all 2145 SA2s (dominated by large/major urban neighbourhoods.). This remains broadly consistent as the proximity limit increases ([Tables 3–5](#)). However, compared to all SA2, large/major urban areas are underrepresented and rural areas are over-represented in the 0 density group (41% versus 55% and 41% versus 25% respectively). The converse is true for the 3+ density group (65% versus 55% and 11% versus 25% respectively). These disparities

Table 2
Current distribution of characteristics in number-of-retailer groups.

Characteristic	ALL SA2		SA2 with 0 Retailers		SA2 with 1 or 2 Retailers		SA2 with 3 or more Retailers	
		%/IQR/sd ^a		%/IQR/sd ^a		%/IQR/sd ^a		%/IQR/sd ^a
SA2 (number)	2145	100	630	29.37	801	37.34	714	33.29
Distance to closest Retailer								
Median (metres)	211.61	65.43, 662.67	N/A	N/A	558.97	231.01, 1392.24	88.80	42.85, 181.93
Urban Rural (number)								
Large/Major Urban	1186	55.29	259	41.11	464	57.93	463	64.85
Small/Medium Urban	410	19.11	107	16.98	133	16.60	170	23.81
Rural	542	25.27	258	40.95	204	25.47	80	11.20
Other	7	0.33	6	0.95	0	0.00	1	0.14
Deprivation (number)								
Low	638	29.98	302	48.79	227	28.41	109	15.35
Medium	851	39.99	219	35.38	336	42.05	296	41.69
High	639	30.03	98	15.83	236	29.94	305	42.96
Age (%)								
Under 15 Years	19.11	5.00	19.56	4.49	19.65	4.45	18.12	5.80
15–29 Years	19.90	8.37	17.96	6.50	19.51	7.82	22.05	9.84
30–64 Years	45.32	5.64	46.88	5.28	45.22	5.55	44.06	5.71
65 Years +	15.67	7.35	15.60	7.09	15.63	6.98	15.77	7.97
Sex (%)								
Male	49.94	3.45	50.28	3.89	49.63	2.93	49.99	3.56
Female	50.06	3.45	49.72	3.89	50.37	2.93	50.01	3.56
Ethnicity (%)								
European	73.42	20.59	78.60	19.53	73.73	19.99	68.50	21.03
Māori	17.13	14.46	15.40	14.44	17.09	13.74	18.71	15.10
Pasifika	6.48	10.81	4.46	8.61	6.62	10.97	8.10	12.02
Asian	12.68	14.26	10.23	13.85	12.58	13.85	14.96	14.72
MELAA	1.34	1.81	1.06	1.24	1.28	1.32	1.66	2.51
Other	1.28	0.67	1.37	0.77	1.30	0.65	1.18	0.58
Smoking Status (%)								
Regular Smoker	13.81	6.57	11.98	6.49	13.92	6.27	15.29	6.59
ExSmoker	23.01	5.64	23.38	5.65	23.11	5.37	22.57	5.90
Never Smoked	63.18	9.45	64.64	9.25	62.97	9.16	62.13	9.79
Workforce Status (%)								
Employed	65.27	8.57	67.42	8.80	65.20	8.10	63.44	8.47
Unemployed	3.85	2.10	3.22	1.97	3.88	1.99	4.37	2.20
Not in the labour force	30.88	7.81	29.36	8.04	30.91	7.40	32.18	7.83
Personal Income (%)								
Loss or Zero								
\$1-\$15,000	7.10	3.02	7.20	2.95	7.06	2.31	7.04 (3.70)	3.70
\$15,001-\$50,000	17.19	5.32	16.06	4.55	17.02	5.16	18.36 (5.86)	5.86
\$50,001-\$70,000	44.49	8.40	42.37	7.83	44.64	8.14	46.18 (8.76)	8.76
\$70,001-\$150,000	14.44	3.06	14.98	2.90	14.69	3.05	13.69 (3.08)	3.08
\$150,000+	13.91	5.93	15.83	5.69	13.86	5.87	12.30 (5.73)	5.73
	2.87	3.16	3.56	3.13	2.72	3.07	2.42 (3.18)	3.18

^a If the characteristic is represented by (number) this column will correspond to the %, by (metres) this column will correspond to the IQR, by (%) this column will correspond to the sd.

gradually lessen with the increasing proximity limits (Tables 3–5). The exception is the rural category in the 3+ density group which initially extends. By adoption of the 450 m restriction policy, the distributions are more aligned: 41%–49% for the large/major urban area and 41%–34% for the rural areas in the 0 density group; and correspondingly, 65%–53% and 11%–19% in the 3+ density group.

3.3. Demographic

Analogous to the rurality variable, the deprivation distribution in the 1–2 density group is relatively similar across the current and proposed proximity limit contexts to the entire SA2 population. However, compared to the population distribution, there are apparent discrepancies in both the 0 and 3+ density groups, with the 0 density group being conspicuously comprised of more low-deprivation neighbourhoods (49% versus 30%) and fewer high-deprivation neighbourhoods (16% versus 30%); and in contrast, the 3+ density group comprised of

less low deprivation SA2s (15% versus 30%) and more high deprivation areas (43% versus 30%). Although in the 0 density group, there is a tendency for the proportions in the low and high deprivation categories to assimilate towards the population distributions across the three increasing proximity limits, the discrepancies remain pronounced. Furthermore, inconsistencies in the 3+ density group are progressively exacerbated: 15%–12% to 9%–8% and 43%–45% to 49%–51% for the low deprivation and high deprivation groups, respectively.

Mirroring the NZ's SA2 population, each density group currently predominantly consists of individuals of European ethnicity. Although the current ethnicity distribution in the 1–2 density group aligns with the corresponding distribution in the SA2 population, there are more European and slightly fewer Māori, Pasifika, and Asian in the 0 density group. The opposite is evident in the 3+ density group, where there are fewer European and redistribution to Māori, Pasifika, and Asian ethnicities. These ethnicity patterns remain consistent across the 150 m, 300 m, and 450 m distance restrictions.

Table 3
Distribution of Characteristics by Number-of-Retailer Groups in the 150 m proximity Limit.

Characteristic	150 m					
	SA2 with 0 Retailers		SA2 1 or 2 Retailers		SA2 3 or more Retailers	
	mean (sd)	min, max	mean (sd)	min,max	mean (sd)	min,max
SA2						
Number	662.46 (3.86)	646, 673	1050.79 (11.24)	955, 1073	431.75 (11.91)	418, 544
% of 2145 SA2	30.88 (0.18)	30.12, 31.38	48.99 (0.52)	44.52, 50.02	20.13 (0.56)	19.49, 25.36
Distance to closest Retailer						
Median (metres)	N/A	N/A	651.18 (7.44)	610.93, 663.96	272.13 (7.92)	199.76, 280.25
	mean % (sd)	min, max	mean % (sd)	min, max	mean % (sd)	min, max
Urban Rural						
Large/Major Urban	43.19 (0.31)	41.80, 43.98	60.58 (0.25)	59.83, 61.27	60.98 (0.49)	59.76, 63.24
Small/Medium Urban	16.87 (0.21)	16.34, 17.52	16.45 (0.21)	16.00, 17.07	29.04 (0.48)	26.47, 29.88
Rural	39.03 (0.22)	38.48, 40.09	22.97 (0.15)	22.55, 23.87	9.76 (0.17)	9.45, 10.12
Other	0.91 (0.01)	0.89, 0.93	0.00 (0.00)	0.00, 0.00	0.23 (0.01)	0.18, 0.24
Deprivation						
Low	47.62 (0.31)	46.95, 48.46	26.47 (0.23)	25.95, 27.44	11.81 (0.40)	10.60, 13.05
Medium	35.30 (0.26)	34.62, 35.94	41.68 (0.28)	41.19, 42.33	42.98 (0.53)	41.76, 44.26
High	17.09 (0.32)	16.22, 17.84	31.84 (0.27)	31.17, 32.41	45.21 (0.49)	44.10, 46.41
Age						
Under 15 Years	19.50 (0.03)	19.42, 19.59	19.65 (0.04)	19.55, 19.73	17.22 (0.07)	17.07, 17.61
15–29 Years	18.19 (0.05)	18.05, 18.35	20.03 (0.07)	19.70, 20.19	22.19 (0.13)	21.87, 22.49
30–64 Years	46.74 (0.03)	46.67, 46.84	44.87 (0.04)	44.76, 45.01	44.26 (0.06)	44.10, 44.40
65 Years +	15.58 (0.04)	15.46, 15.67	15.45 (0.04)	15.35, 15.59	16.34 (0.09)	15.86, 16.59
Sex						
Male	50.24 (0.02)	50.21, 50.28	49.66 (0.02)	49.62, 49.71	50.18 (0.04)	50.07, 50.26
Female	49.76 (0.02)	49.72, 49.79	50.34 (0.02)	50.29, 50.38	49.82 (0.04)	49.74, 49.93
Ethnicity						
European	78.01 (0.14)	77.64, 78.52	72.31 (0.15)	71.97, 73.08	69.08 (0.25)	67.95, 69.63
Māori	15.33 (0.05)	15.20, 15.46	17.82 (0.06)	17.67, 17.97	18.22 (0.12)	17.95, 18.55
Pasifika	4.67 (0.07)	4.54, 4.80	7.16 (0.06)	6.95, 7.28	7.59 (0.10)	7.36, 7.95
Asian	10.69 (0.10)	10.32, 10.92	12.87 (0.11)	12.40, 13.15	15.27 (0.19)	14.90, 15.99
MELAA	1.11 (0.01)	1.07, 1.15	1.39 (0.01)	1.35, 1.42	1.57 (0.02)	1.53, 1.65
Other	1.36 (0.00)	1.35, 1.37	1.26 (0.00)	1.25, 1.27	1.23 (0.01)	1.21, 1.25
Smoking Status						
Regular Smoker	12.04 (0.03)	11.96, 12.12	14.21 (0.03)	14.12, 14.28	15.55 (0.06)	15.39, 15.74
ExSmoker	23.26 (0.03)	23.17, 23.33	22.94 (0.04)	22.85, 23.10	22.81 (0.07)	22.48, 22.96
Never Regularly Smoked	64.70 (0.05)	64.58, 64.79	62.85 (0.05)	62.72, 63.00	61.64 (0.12)	61.34, 62.13
Workforce Status						
Employed	67.24 (0.05)	67.15, 67.37	64.86 (0.04)	64.71, 64.96	63.24 (0.08)	63.07, 63.44
Unemployed	3.27 (0.01)	3.23, 3.30	4.03 (0.01)	3.97, 4.05	4.33 (0.02)	4.27, 4.37
Not in the labour force	29.49 (0.04)	29.36, 29.59	31.12 (0.04)	31.03, 31.27	32.43 (0.08)	32.20, 32.60
Personal Income						
Loss or Zero	7.21 (0.01)	7.19, 7.24	7.17 (0.01)	7.13, 7.21	6.74 (0.03)	6.66, 6.92
\$1–\$15,000	16.14 (0.02)	16.07,16.21	17.34 (0.03)	17.21, 17.40	18.43 (0.06)	18.29, 18.54
\$15,001–\$50,000	42.71 (0.05)	42.60, 42.85	44.79 (0.05)	44.65, 44.89	46.89 (0.10)	46.45, 47.19
\$50,001–\$70,000	14.95 (0.02)	14.92, 14.98	14.48 (0.05)	14.41, 14.57	13.79 (0.11)	13.59, 13.96
\$70,001–\$150,000	15.79 (0.08)	15.63, 15.93	13.68 (0.06)	13.56, 13.84	12.04 (0.06)	11.86, 12.18
\$150,000+	3.53 (0.02)	3.47, 3.58	2.71 (0.02)	2.67, 2.77	2.24 (0.03)	2.15, 2.31

3.4. Smoking

For smoking status distribution, the proportions in the 1–2 density group reflect the overall SA2 population currently and in all proximity limit contexts (regular smoker = 14%, ex-smoker = 23%, and never smoked = 63%). There do, however, appear to be slightly more regular smokers in the 3+ density group compared to the 0 density group. This is most extreme at 5% in the 450 m proximity limit scenario (17% versus 12%).

3.5. Economic

Income levels for SA2s with 1–2 tobacco retailers generally reflect the overall SA2 population. There are proportionally fewer SA2s with an

income level from \$1 to \$70,000 in the 0 density group and somewhat more in the 3+ density group. The reverse pattern is seen for incomes over \$70,000, where the proportion of retailers in the 0 density group increases, and the proportion in the 3+ density group decreases. This is most exaggerated at the 450 m proximity limit, where there is a 6% difference between 0 and 3+ density neighbourhoods with an income between \$1 and \$70,000 (74% versus 80%). The reciprocal being that the proportion comparison for incomes of more than \$70,000, between the 0 and 3+ density groups, was also 6% (19% versus 13%).

4. Discussion

This paper contributes further knowledge about the impact a tobacco retailer proximity limit would have on neighbourhoods in NZ. Our

Table 4
Distribution of Characteristics by Number-of-Retailer Groups in the 300 m proximity Limit.

Characteristic	300 m					
	SA2 with 0 Retailers		SA2 1 or 2 Retailers		SA2 3 or more Retailers	
	mean (sd)	min, max	mean (sd)	min,max	mean (sd)	min,max
SA2						
Number	698.27 (4.89)	687, 713	1171.18 (7.33)	1149, 1187	275.55 (4.84)	267, 289
% of 2145 SA2	32.55 (0.23)	32.03, 33.24	54.60 (0.34)	53.57, 55.34	12.85 (0.23)	12.45, 13.47
Distance to closest Retailer						
Median (metres)	N/A	N/A	702.11 (5.85)	687.45, 717.39	448.11 (5.52)	435.76, 465.96
	<i>mean % (sd)</i>	<i>min, max</i>	<i>mean % (sd)</i>	<i>min, max</i>	<i>mean % (sd)</i>	<i>min, max</i>
Urban Rural						
Large/Major Urban	45.28 (0.35)	44.41, 46.56	60.38 (0.30)	59.74, 61.20	59.03 (0.91)	56.68, 60.87
Small/Medium Urban	16.70 (0.26)	16.13, 17.36	18.32 (0.26)	17.52, 18.94	28.61 (0.82)	26.81, 30.69
Rural	37.16 (0.25)	36.47, 37.85	21.30 (0.14)	20.99, 21.67	11.99 (0.33)	11.31, 12.73
Other	0.86 (0.01)	0.84, 0.87	0.00 (0.00)	0.00, 0.00	0.36 (0.01)	0.35, 0.37
Deprivation						
Low	46.72 (0.32)	45.81, 47.57	24.96 (0.26)	24.32, 25.53	9.45 (0.72)	7.66, 10.94
Medium	35.49 (0.37)	34.69, 36.51	42.37 (0.32)	41.56, 43.04	41.12 (1.06)	38.81, 43.75
High	17.79 (0.41)	16.86, 18.76	32.68 (0.37)	31.87, 33.50	49.43 (1.11)	47.08, 51.87
Age						
Under 15 Years	19.37 (0.05)	19.22, 19.49	19.37 (0.04)	19.25, 19.47	17.40 (0.12)	17.13, 17.71
15–29 Years	18.59 (0.10)	18.34, 18.85	20.33 (0.07)	19.18, 20.52	21.38 (0.16)	20.96, 21.77
30–64 Years	46.55 (0.05)	46.42, 46.72	44.74 (0.04)	44.66, 44.86	44.65 (0.12)	44.39, 44.93
65 Years +	15.50 (0.06)	15.35, 15.67	15.56 (0.05)	15.42, 15.69	16.57 (0.15)	16.17, 16.90
Sex						
Male	50.19 (0.02)	50.14, 50.24	49.67 (0.02)	49.61, 49.72	50.49 (0.09)	50.23, 50.72
Female	49.81 (0.02)	49.76, 49.86	50.33 (0.02)	50.28, 50.39	49.51 (0.09)	49.28, 49.77
Ethnicity						
European	77.39 (0.18)	77.01, 77.79	72.15 (0.16)	71.69, 72.47	68.78 (0.41)	67.70, 70.13
Māori	15.24 (0.08)	15.03, 15.43	17.74 (0.08)	17.53, 17.90	19.35 (0.26)	18.71, 20.02
Pasifika	4.73 (0.08)	4.56, 4.92	7.19 (0.08)	7.02, 7.39	7.86 (0.23)	7.37, 8.43
Asian	11.28 (0.14)	10.98, 11.67	13.08 (0.12)	12.83, 13.36	14.54 (0.31)	13.65, 15.38
MELAA	1.19 (0.03)	1.14, 1.27	1.40 (0.02)	1.35, 1.44	1.48 (0.03)	1.40, 1.56
Other	1.35 (0.00)	1.34, 1.36	1.25 (0.00)	1.24, 1.26	1.24 (0.01)	1.21, 1.27
Smoking Status						
Regular Smoker	12.02 (0.04)	11.95, 12.14	14.31 (0.04)	14.21, 14.40	16.22 (0.12)	15.96, 16.50
ExSmoker	23.11 (0.05)	23.00, 23.26	22.93 (0.04)	22.81, 23.03	23.09 (0.12)	22.81, 23.39
Never Regularly Smoked	64.86 (0.07)	64.67, 65.03	62.76 (0.07)	62.61, 62.95	60.69 (0.21)	60.28, 61.17
Workforce Status						
Employed	67.12 (0.06)	66.98, 67.33	64.69 (0.06)	64.51, 64.81	63.03 (0.19)	62.67, 63.41
Unemployed	3.32 (0.01)	3.28, 3.35	4.05 (0.01)	4.02, 4.08	4.35 (0.04)	4.28, 4.46
Not in the labour force	29.56 (0.06)	29.37, 29.68	31.25 (0.06)	31.15, 31.43	32.62 (0.17)	32.25, 33.01
Personal Income						
Loss or Zero	7.25 (0.04)	7.17, 7.37	7.09 (0.03)	7.00, 7.14	6.76 (0.05)	6.64, 6.91
\$1–\$15,000	16.27 (0.05)	16.16, 16.38	17.44 (0.04)	17.38, 17.54	18.42 (0.09)	18.12, 18.64
\$15,001–\$50,000	42.66 (0.07)	42.50, 42.83	45.02 (0.07)	44.86, 45.16	47.50 (0.19)	47.03, 47.92
\$50,001–\$70,000	14.90 (0.02)	14.85, 14.97	14.46 (0.02)	14.39, 14.50	13.57 (0.07)	13.42, 13.75
\$70,001–\$150,000	15.72 (0.09)	15.56, 15.91	13.53 (0.07)	13.39, 13.66	11.65 (0.12)	11.41, 11.91
\$150,000+	3.52 (0.03)	3.46, 3.57	2.66 (0.02)	2.61, 2.72	2.11 (0.07)	1.93, 2.25

initial paper found that implementing a 450 m distance restriction between tobacco retailers would result in an average reduction in availability of 58%, increase the median distance to the closest retailer to 718 m, and reduce clustering of retailers in highly deprived areas by 6% (Marsh et al., 2022a). Our current study further explored this policy's impact by focusing specifically on neighbourhoods. We found that as the proximity limit increases from the status quo to 450 m, the proportion of neighbourhoods with 0 tobacco retailers increased by 6%, resulting in 35% of neighbourhoods not having a tobacco retailer present. In addition, the number of neighbourhoods with 3+ retailers decreased by 25%, so that only 8% of neighbourhoods have 3+ retailers.

This reduction in density of tobacco retailers in neighbourhoods can influence smoking behaviours through a number of pathways. Opportunities to purchase tobacco and the normalisation of smoking in

neighbourhoods are diminished (Barnett et al., 2016), and chances of impulse tobacco purchases while making a quit attempt are reduced (Valiente et al., 2021). In a dark market like NZ, with heavy restrictions on marketing tobacco products, simply seeing a tobacco retail outlet is often a sufficient cue to prompt impulse tobacco purchases (Burton et al., 2015). A reduction in density of tobacco retailers near youths' homes would have positive implications for smoking behaviours among youth (Marsh et al., 2020). In jurisdictions where POS promotions are still allowed, a reduction in density would have further impacts on reducing normalisation (Robertson et al., 2014, Robertson et al., 2016). Clustering of tobacco retailers in neighbourhoods may foster a competitive market and lead to price cutting to attract customers (Eng et al., 2020). However, we have found in the NZ context that price discounting is not a strategy that is generally employed (Marsh et al.,

Table 5
Distribution of Characteristics by Number-of-Retailer Groups in the 450 m proximity Limit.

Characteristic	450 m					
	SA2 with 0 Retailers		SA2 1 or 2 Retailers		SA2 3 or more Retailers	
	mean (sd)	min, max	mean (sd)	min,max	mean (sd)	min,max
SA2						
Number	756.59 (6.08)	743, 771	1225.30 (9.09)	1205, 1247	163.11 (5.33)	151, 178
% of 2145 SA2	35.27 (0.28)	34.64, 35.94	57.12 (0.42)	56.18, 58.14	7.60 (0.25)	7.04, 8.30
Distance to closest Retailer						
Median (metres)	N/A	N/A	796.12 (8.74)	775.15, 818.65	598.74 (10.96)	572.27, 627.84
	<i>mean % (sd)</i>	<i>min, max</i>	<i>mean % (sd)</i>	<i>min, max</i>	<i>mean % (sd)</i>	<i>min, max</i>
Urban Rural						
Large/Major Urban	48.57 (0.43)	47.53, 49.67	59.77 (0.34)	58.84, 60.55	52.82 (1.51)	48.77, 55.55
Small/Medium Urban	16.27 (0.29)	15.65, 16.91	19.70 (0.29)	19.16, 20.47	27.89 (1.41)	24.69, 31.48
Rural	34.37 (0.29)	33.64, 35.13	20.53 (0.17)	20.05, 20.86	18.68 (0.69)	17.34, 20.26
Other	0.79 (0.01)	0.78, 0.81	0.00 (0.00)	0.00, 0.00	0.61 (0.02)	0.56, 0.66
Deprivation						
Low	44.48 (0.44)	43.54, 45.71	24.06 (0.27)	23.36, 24.57	8.04 (0.90)	5.99, 10.06
Medium	35.69 (0.51)	34.28, 37.04	42.48 (0.39)	41.47, 43.50	40.96 (1.43)	37.29, 44.91
High	19.83 (0.48)	18.73, 21.32	33.46 (0.35)	32.59, 34.64	51.00 (1.46)	47.17, 54.12
Age						
Under 15 Years	19.18 (0.06)	19.02, 19.31	19.29 (0.05)	19.18, 19.41	17.50 (0.19)	16.95, 17.93
15–29 Years	19.22 (0.12)	18.98, 19.54	20.23 (0.09)	20.00, 20.41	20.52 (0.33)	19.72, 21.25
30–64 Years	46.28 (0.06)	46.10, 46.44	44.79 (0.04)	44.70, 44.92	44.85 (0.20)	44.26, 45.29
65 Years +	15.32 (0.06)	15.19, 15.46	15.68 (0.06)	15.56, 15.84	17.13 (0.28)	16.51, 17.84
Sex						
Male	50.13 (0.03)	50.04, 50.23	49.71 (0.03)	49.64, 49.79	50.80 (0.18)	50.39, 51.30
Female	49.87 (0.03)	49.77, 49.96	50.29 (0.03)	50.21, 50.36	49.20 (0.18)	48.70, 49.61
Ethnicity						
European	76.41 (0.19)	75.95, 76.86	72.14 (0.17)	71.77, 72.58	69.17 (0.70)	66.75, 70.71
Māori	15.28 (0.11)	15.01, 15.51	17.81 (0.09)	17.57, 18.04	20.70 (0.40)	19.85, 21.78
Pasifika	4.98 (0.10)	4.74, 5.21	7.28 (0.08)	7.04, 7.45	7.38 (0.37)	6.48, 8.29
Asian	11.97 (0.14)	11.60, 12.31	13.01 (0.12)	12.73, 13.30	13.48 (0.51)	12.41, 14.73
MELAA	1.28 (0.04)	1.22, 1.35	1.37 (0.02)	1.32, 1.42	1.38 (0.05)	1.25, 1.56
Other	1.34 (0.00)	1.32, 1.35	1.25 (0.00)	1.24, 1.26	1.26 (0.02)	1.21, 1.31
Smoking Status						
Regular Smoker	12.13 (0.05)	11.99, 12.25	14.45 (0.04)	14.35, 14.56	16.76 (0.17)	16.32, 17.24
ExSmoker	22.89 (0.05)	22.76, 23.06	23.00 (0.05)	22.88, 23.11	23.62 (0.19)	23.20, 24.11
Never Regularly Smoked	64.98 (0.09)	64.74, 65.21	62.54 (0.07)	62.37, 62.72	59.62 (0.29)	58.86, 60.19
Workforce Status						
Employed	66.88 (0.08)	66.71, 67.06	64.59 (0.06)	64.43, 64.73	62.89 (0.29)	62.24, 63.57
Unemployed	3.42 (0.02)	3.37, 3.50	4.05 (0.02)	4.01, 4.08	4.37 (0.06)	4.19, 4.52
Not in the labour force	29.70 (0.07)	29.49, 29.88	31.36 (0.06)	31.24, 31.54	32.74 (0.28)	32.08, 33.37
Personal Income						
Loss or Zero	7.28 (0.05)	7.19, 7.38	7.04 (0.04)	6.96, 7.12	6.68 (0.13)	6.38, 6.99
\$1-\$15,000	16.53 (0.07)	16.33, 16.71	17.42 (0.05)	17.30, 17.58	18.47 (0.17)	18.04, 18.97
\$15,001-\$50,000	42.70 (0.09)	42.50, 42.89	45.22 (0.07)	45.06, 45.38	48.32 (0.31)	47.67, 49.07
\$50,001-\$70,000	14.82 (0.03)	14.75, 14.91	14.41 (0.03)	14.33, 14.47	13.53 (0.12)	13.23, 13.80
\$70,001-\$150,000	15.50 (0.09)	15.29, 15.68	13.47 (0.06)	13.33, 13.58	11.07 (0.18)	10.62, 11.59
\$150,000+	3.46 (0.03)	3.37, 3.55	2.63 (0.02)	2.56, 2.68	1.93 (0.09)	1.68, 2.22

2015).

A further key finding is a large increase in the average distance to the closest tobacco retailer of 510 m for neighbourhoods with 3+ tobacco retailers as the proximity limit increases from 150 m to 450 m. A recent meta-analysis found that reducing the proximity to a tobacco retailer has a positive impact on reducing tobacco use (Lee et al., 2021), and increases odds of successfully quitting (Reitzel et al., 2011; Pulakka et al., 2016; Valiente et al., 2021; Halonen et al., 2014). However, an increase in distance to a tobacco retailer also increases the search and purchase costs associated with buying tobacco. At the 450 m proximity limit there is a 5% difference in the proportion of regular smokers in neighbourhoods with 3+ retailers compared with neighbourhoods containing no retailers. People who continue to smoke in these neighbourhoods would have increased costs associated with purchasing tobacco and may contribute to exacerbating economic SDOH.

A number of studies examining policies for reducing tobacco

availability have found that these policies reduce overall density of tobacco availability, but may inequitably impact different communities (Glasser and Roberts, 2021). For this current study the random removal of retailers within a proximity limit policy will reduce the number and density of tobacco retailers as the proximity limit increases. However, for those 8% of neighbourhoods with a density of 3+ tobacco retailer, inequities are exacerbated by this policy. These neighbourhoods are characterised by an increase in proportion of highly deprived areas, slight increase in proportion of Māori, Pasifika, and Asian ethnicities, increase in proportion of people with an income of \$70,000 or less, slightly more regular smokers, and an overrepresentation of tobacco retailers in rural areas compared with areas with zero tobacco retailers. It is, however, also important to note that as the proximity limit increases, the distribution of tobacco retailers across the three density groups changes, i.e. although the relative proportions suggest increased inequity, the context of decreasing absolute numbers should also be

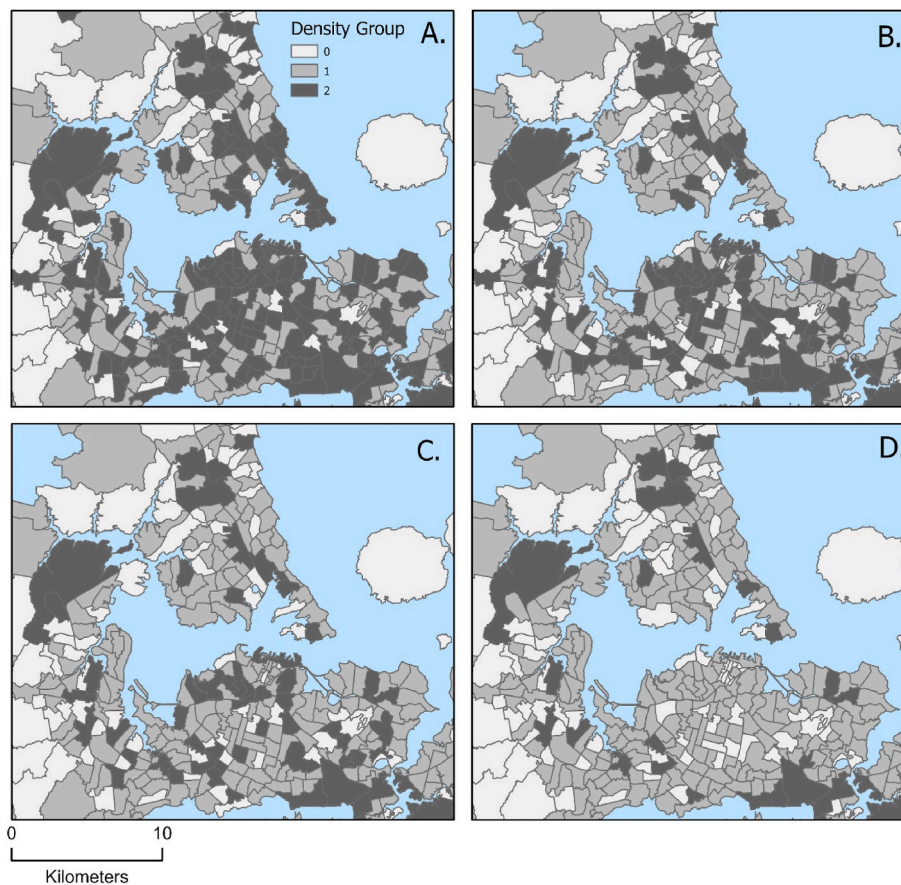


Fig. 1. Tobacco retailer distributions in the three density groups for A.) status quo, B.) 150 m, C.) 300 m, and D.) 450 m distance restrictions.

considered.

Our study is an example of how a one size fits all approach in a "mature" tobacco control setting such as NZ, may produce unintended consequences that perpetuate or even exacerbate inequities. Our findings suggest more targeted interventions, including differential proximity limits based on existing retailer densities, may be more effective at eliminating inequities in these contexts. For example, smaller proximity limits may be necessary for areas that have 3+ tobacco retailers, whereas in areas with low density, larger proximity limit distances may be sufficient.

Proposals open for consultation on the smoked tobacco regulatory regime are based on availability in urban and rural areas (Ministry of Health, 2023). This population based policy will reduce tobacco retailers, but, based on our models, will not specifically address the inequitable distribution of tobacco retailers in neighbourhoods. Implementing a proximity limit policy in addition to the measures outlined in the Act would facilitate a reduction in tobacco retailers, but as shown, inequities would remain in neighbourhoods with 3+ retailers. Other amendments to the Act will help reduce smoking initiation and increase quitting in those neighbourhoods where tobacco retailers remain. The Smokefree Generation included in the amended Act (Smokefree Environments And Regulated Products Amendment Act, 2023) will sustain reductions in smoking prevalence by protecting young people from tobacco (Berrick, 2013). The amended Act also limits nicotine levels in smoked tobacco products (Smokefree Environments And Regulated Products Amendment Act, 2023), which has been shown to have equal effectiveness for Māori and non-Māori (Walker et al., 2012), will further protect wider populations. However, further targeted policies are needed such as culturally appropriate and meaningful cessation interventions and programmes (Walker et al., 2021; McCormack et al., 2022) in order to increase cessation rates in neighbourhoods with high

tobacco retailer density.

4.1. Strengths and limitations

One of the strengths of this study is that it provides local information for NZ, and being a national study, all areas of the country have been included. However, these findings may only apply to NZ, since the distance between retailers varies widely across countries and regions (Chaiton et al., 2013).

A further strength of this study is that we have been able to examine the impact of a proximity limit policy at the neighbourhood level (SA2), in comparison to the meshblock level (SA1) in our first study (Marsh et al., 2022a). SA2 is a more valid approximation of a neighbourhood definition than SA1 as it is intended to model communities that interact and allowed us to examine a number of variables that make up a neighbourhood that cannot be provided at SA1 due to concerns of anonymity of data (Stats NZ, 2017).

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 underrepresent the actual distances between retailers and associated costs. A further limitation of this research is that the random tobacco retailer removal process 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 a distance restricted policy. The real-world policy implementation, however, could logically involve a more targeted strategy. These simulations also assume that the policy would apply to existing retailers, and that no new retailers would enter the market.

Using SA2 as a proxy for neighbourhoods and excluding those with fewer than 12 people could be considered limitations. However, the construction of the SA2 takes into account communities of interest and so is not entirely composed of disassociated spatial data. The removal of SA2s with nil or nominal populations also means that the results are more likely to be meaningful and related to areas with people in communities.

5. Conclusion

This research expands on our previous study by indicating that a tobacco retailer proximity limit policy would reduce the number of retailers in each density group, with 35% of neighbourhoods not having a tobacco retailer present at a 450 m limit. However, with differing measures available at the neighbourhood level our study was also able to discern potential neighbourhood inequities. This has important implications for policy and shows that a more directed policy targeting these inequities is needed to address these remaining inequities.

Funding

This research was supported by a grant from the Cancer Society of New Zealand.

Ethical consent

The University of Otago Human Ethics Committee approved this project (D17/249).

Declaration of competing interest

Although we do not consider it a competing interest, for the sake of full transparency we note that authors have undertaken work for health sector agencies.

Data availability

Data will be made available on request.

Acknowledgements:

We thank Melanie Tomintz for providing the census data for this study. We gratefully acknowledge Mei-Ling Blank, University of Otago, for her comments on drafts of this manuscript.

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