



Original investigation

Is Smoking Cessation in Young Adults Associated With Tobacco Retailer Availability in Their Activity Space?

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Abstract

Introduction: The presence of tobacco retailers in residential neighborhoods has been inversely associated with residents' likelihood of quitting smoking. Few studies have yet explored whether this association holds when accounting for tobacco retailers found in the multiple environments where people conduct their daily activities, that is, their activity space.

Methods: We analyzed cross-sectional data from 921 young adults (18- to 25-years old) participating in the Interdisciplinary Study of Inequalities in Smoking (Montreal, Canada). Respondents self-reported sociodemographic, smoking, and activity location data. Log-binomial regression was used to estimate prevalence ratios (PRs) for the association between smoking cessation and (1) the number of tobacco retailers (counts), and (2) the distance to the closest retailer (proximity) in participants' residential neighborhood and activity space.

Results: Smoking cessation was positively associated with low and intermediate tertile levels of tobacco retailer counts in both the residential neighborhood and activity space, and with the furthest distance level in the activity space [PR (95% CI) = 1.21 (1.02 to 1.43)].

Conclusions: Individuals encounter resources in the course of their regular daily activities that may hamper smoking cessation. This study highlights the relevance of considering the tobacco retail environment of both individuals' residential neighborhood and activity space to understand its association with smoking cessation.

Implications: This article contributes to the literature on the association between the tobacco retail environment and smoking cessation in young adults by moving beyond the residential neighborhood to also assess individuals' access to tobacco retailers in the multiple areas where they regularly spend time, that is, their activity space. Findings suggest that lower numbers of tobacco retailers in both the residential neighborhood and activity space, and further distance to tobacco retailers in the activity space are associated with increased smoking cessation.

Introduction

Smoking is a leading risk factor for cardiovascular disease and several cancers, as well as being the number one cause of preventable mortality worldwide.¹ Young adults (18- to 25-years old) consistently register the highest cigarette smoking prevalence among all age groups.^{2,3} As an important transition period during which health behaviors may become established, reinforced, or discontinued,⁴ young adulthood represents a critical window of opportunity for smoking cessation.

Almost 10 years ago tobacco outlet density was dubbed the “new frontier” to tobacco control.⁵ Tobacco retailers may enable or hinder smoking uptake, continuation, and cessation via several mechanisms.^{6,7} They provide opportunities to purchase cigarettes and decrease the time and resources required to obtain them. A high number of tobacco retailers in a given area may be indicative of a more price-competitive market and the normalization of tobacco use among neighborhood residents and visitors.⁷ The mere sight of tobacco retailers can even trigger impulse purchases^{8,9} and smoking-related thoughts that elicit physical and emotional urges to smoke.^{9,10} Smokers have previously reported they would smoke less or try to quit if they did not have a tobacco retailer within walking distance from their home.¹¹ Convenience with which one can access tobacco products thus appears to play an important role in shaping smoking practices.

A number of studies have found that a high density of, and close distance to, tobacco retailers in residential and school neighborhoods were associated with several smoking practices in youth and young adults, including smoking initiation, intensity, and cessation.⁶ Most studies of cessation have however been conducted in adults. Although in this population a high tobacco retailer density in the residential neighborhood has been found to be associated with a lower probability of smoking cessation in some studies^{12–14} but not others,^{15–17} with similar inverse^{13,15,17,18} and null associations^{14,16,19} being reported for retailer proximity, more evidence is needed to support intervening in the tobacco retail environment. One limitation of the current evidence base is that most studies have explored tobacco retailer availability in discrete, residential neighborhoods,⁶ failing to account for individuals’ cumulative experience of the multiple settings where they study, work, or otherwise spend time in the course of their daily activities, that is, their “activity space.”²⁰ In a previous study we found that both high numbers of, and close distance to, tobacco retailers in young adults’ activity space were related to being a smoker.²¹ In this article, we examine whether fewer tobacco retailers and further distance from them in the activity space are associated with an increased likelihood of smoking cessation. For comparison purposes, we also report the associations between smoking cessation and residential tobacco retailer availability and proximity.

Methods

Sample

Baseline data from the Interdisciplinary Study of Inequalities in Smoking (2011–2012) were analyzed. A total of 6020 young adults were randomly selected from all eligible individuals living in each of the 35 Centre Locaux de Services Communautaires (CLSC) on the island of Montreal, Canada. CLSCs are the main health services catchment areas in the province of Québec and served as sampling units to ensure geographic representativity across the study territory. Of the

total individuals, 2093 were recruited and completed a questionnaire online, on paper, or over the phone. Study procedures are described in more detail elsewhere.²² Ethics approval was obtained from the Research Ethics Committee of the Université de Montréal’s Faculty of Medicine, and participants gave written or verbal informed consent prior to questionnaire completion.

Measures

Dependent Variable

Participants who reported having smoked at least an entire cigarette in their lifetime ($n = 947$) were considered for inclusion in the present analyses.²³ Participants were categorized as current or former smokers based on the following question: “Currently, do you smoke cigarettes: (1) every day; (2) sometimes; or (3) never?” Those who responded “every day” or “sometimes” were considered “current smokers.” Those who responded “never” were considered “former smokers.” This question has been shown to have high sensitivity when compared to urinary cotinine levels.²⁴ For ease of discussion, we use the term “cessation” to refer to former smoking with the understanding that although the term is frequently used in this manner in the literature,^{12,25} smoking cessation is a dynamic process that usually involves multiple quit attempts. Nevertheless, smoking discontinuation is an important milestone in the overall process toward long-term cessation.²⁶

Independent Variables

Defining Participants’ Residential Neighborhood and Activity Space
Respondents provided their residential address along with details (name, address, street, intersection/landmark, city) of the location(s) where they regularly conducted predefined activities—study, work, grocery shopping, sports or physical activities, leisure activities, and two other unspecified activities—in a specially designed questionnaire. In independent samples, the activity space questionnaire had high test–retest reliability with 86.5% overall agreement between locations reported at 2-week intervals, and high convergent validity defined as the spatial congruence, in terms of distance and convex hull size and overlap, between questionnaire-reported activity locations and those identified from 7-day continuous global positioning system tracks and a prompted recall survey.²⁷ Residential and activity locations were geocoded at the highest precision level possible (90% at complete address level) using the Google Maps API. Each participant’s activity space was defined as the combination of his unique residential and outside-of-home activity locations. For example, the activity space of a participant who reported working from home, shopping for groceries at one location, and practicing sports at another location comprised three locations (home, grocery shopping, and sports locations). Residential and activity locations were used as anchors from which to compute two tobacco retailer availability measures, counts and distance, as described next.

Tobacco Retailer Availability

The street addresses of stores that commonly sell tobacco in Québec, Canada (convenience stores, supermarkets, tobacconist shops, and gas stations) were extracted from the 2011 DMTI Enhanced Points of Interest file, a commercial dataset of businesses across Canada. For each listed business, the Enhanced Points of Interest file provides the name, geographic coordinates, and between one and six Standard Industrial Classification codes based on the economic activities declared.²⁸ Duplicate entries and those geocoded at the city level were

discarded. Convenience stores and supermarkets, which were the predominant sources of cigarette purchases in the sample (data not shown), showed moderate-to-high sensitivity and positive predictive value in a field validation of the 2010 version of DMTI Enhanced Points of Interest.²⁹ For each residential and outside-of-home activity location, we computed the following: (1) the number of tobacco retailers within a 500-m buffer around a location (counts) and (2) the distance between a location and the closest tobacco retailer. Both measures were based on pedestrian road networks. For each participant, the residential tobacco retailer measures were (1) the number of retailers within 500 m from home, and (2) the distance from home to the closest tobacco retailer. Tobacco retailer availability measures in each participant's activity space were defined as: (1) the mean number of retailers across activity space locations; and (2) the mean distance to the closest retailer across activity space locations.^{21,30} To allow comparison with previous work, both measures were categorized into approximate tertile groupings using the following cut points: less than 2 retailers (low), 2–5 retailers (intermediate), and 6 retailers or more (high) for tobacco retailer counts in the residential neighborhood; less than 4 retailers (low), 4–7.9 retailers (intermediate), and 8 retailers or more (high) for mean tobacco retailer counts in the activity space; and more than 350 m (furthest), 150–350 m (intermediate distance), and less than 150 m (closest) for distance measures in the residential neighborhood and activity space.²¹

Covariates

Participants' age, sex, and educational attainment were considered potential confounders due to their theoretical and empirical association with the outcome and exposures. Time since smoking onset was adjusted for because it may relate to nicotine dependence and smoking cessation.²⁶ For nonstudents, educational attainment was defined as participants' highest educational level completed, whereas for students (65.1% of respondents), it was defined as the highest level attained between that completed and that enrolled in at the time of survey.^{21,31,32} In an ancillary article, this measure of expected educational attainment by students was a better proxy of future achievement than completed education.³³ Educational attainment was categorized as high school or less (≤ 11 years of schooling), CEGEP or trade school (12–13 years; [CEGEPs, or Collèges d'enseignement général et professionnel, are postsecondary institutions found only in Québec, Canada]), and university (≥ 14 years). Time since smoking onset was defined as the number of years separating participants' age at the time of survey and age when they smoked their first entire cigarette. Occupation categorized as "not in education nor in training," "in education," or "in employment only," and area-level deprivation operationalized as quartiles of the Pampalon relative material deprivation index combining 2006 census data on education, employment status, and income extracted at the dissemination area scale, the smallest administrative unit at which census data are available,³⁴ were also examined as potential confounders. They were excluded from the final models because they were not empirical confounders in the analytical sample.

Analyses

Former and current smokers were compared on sociodemographics and tobacco retailer measures using descriptive analyses and chi-square or *t* tests. Log-binomial regression models with robust standard errors were fitted contrasting former and current smokers. Log-binomial models allow for the valid estimation of prevalence ratios (PRs) and 95% confidence intervals (CIs) in situations where

a binary outcome is highly prevalent (typically $>10\%$).³⁵ We tested whether former smoking was clustered by CLSC area given the sampling design and found the intraclass coefficient to be small and non-significant, thus single-level models were preferred. The tertile level of tobacco retailer availability corresponding to the highest counts or closest distance served as the reference category. Three models were consecutively built for each exposure measure separately for the activity space (models A–C) and the residential neighborhood (models D–F): bivariate models A and D including former smoking and tobacco retailer counts or distance; models B and E further adjusting for the individual-level covariates age, sex, and educational attainment; and models C and F additionally including time since smoking onset. The Akaike information criterion was used as an indicator of model fit, with lower values indicating better fit. We also assessed the statistical interaction between the main exposures of interest, tobacco retailer availability measures in the activity space, and sex and educational attainment, because it has been suggested that different groups may have different daily mobility patterns³⁶ and may interact differently with the tobacco retail environment.^{12–15} Interactions were not statistically significant for sex (*p* for interaction = .605 for mean counts and *p* = .874 for mean distance) nor for educational attainment (*p* for interaction = .614 for mean counts and *p* = .748 for mean distance), thus main effects models are presented. Finally we performed sensitivity analyses assessing whether results were robust across alternative exposure measures in the activity space (maximum retailer counts, ie, the highest number of tobacco retailers found within any one of the 500-m buffers comprising a participant's activity space, and minimum distance to the closest retailer, ie, the shortest distance separating a tobacco retailer to any one activity location comprising a participant's activity space) and spatial delineations of the activity space and residential neighborhood (retailer counts within 800-m buffers). All analyses were performed with Stata SE, v.12.1.

Results

Out of 947 participants, 921 had complete data on outcome, exposure, and adjustment variables, and were included in the present analyses (Table 1). Former smokers comprised 49.3% of the sample. Respondents were on average 21.7 years old (SD = 2.3) and 54.9% were female. University students and graduates accounted for 39.1% of the sample, whereas 22.3% of respondents had attained at most the high school level. Compared to current smokers, a higher proportion of former smokers were in the highest educational category, conducted activities in less deprived areas, and lived in neighborhoods with fewer tobacco retailers. Former and current smokers were similar in terms of age, sex, occupation, time since smoking onset, tobacco retailer counts in the activity space, proximity in both the activity space and residential neighborhood, and residential deprivation (Table 1). Included and excluded participants were not found to differ significantly according to variables considered in this article (data not shown).

All participants' activity space included a residential location (100%); 63.5% included a place of study; 55.7% and 6.5% a main or secondary workplace, respectively; 34.6% and 17.4% a main or secondary grocery shopping location; 38.3% a location for practicing sports; 29.6% a place of leisure; and 21.4% and 7.2% a main and secondary place for conducting unspecified activities. The activity space of 7.1% of participants (*n* = 71) only comprised their residential location, either because all of their reported activities

Table 1. Descriptive Statistics for 921 Ever Smokers From the Interdisciplinary Study of Inequalities in Smoking (ISIS) Study (Montreal, Canada, 2011–2012), Complete Sample and by Smoking Status

	Complete sample (<i>n</i> = 921)	Former smokers 49.3% (<i>n</i> = 454)	Current smokers 50.7% (<i>n</i> = 467)	<i>t</i> Test/ χ^2 <i>p</i> value
Individual-level characteristics				
Age (y), mean (SD)	21.7 (2.3)	21.8 (2.3)	21.6 (2.3)	.351
Female, %	54.9	57.9	52.0	.072
Educational attainment, %*				
High school or less	22.3	17.0	27.4	<.001
CEGEP/trade school	38.7	37.9	39.4	
University	39.1	45.2	33.2	
Occupation, % ^a				
Not in education nor employment	8.4	7.3	9.5	.331
In education (and employed or not)	65.0	67.1	63.0	
In employment only	26.5	25.6	27.5	
Time since smoking onset, mean (SD)	5.9 (3.4)	5.7 (3.4)	6.1 (3.4)	.080
Activity space characteristics				
Mean tobacco retailer counts ^b , %				
Less than 4 (low)	28.7	30.0	27.4	.170
4–7.8 (intermediate)	35.7	37.4	34.1	
8 or more (high)	35.6	32.6	38.5	
Mean distance to closest tobacco retailer ^c , %				
More than 350 m (furthest)	23.7	25.6	21.4	.237
150–350 m (intermediate)	44.3	43.6	45.0	
Less than 150 m (closest)	32.0	30.4	33.6	
Mean relative deprivation, %*				
Low	16.5	19.6	13.5	.040
Medium–low	38.4	39.0	37.9	
Medium–high	37.0	33.5	40.5	
High	8.0	7.9	8.1	
Residential neighborhood characteristics				
Tobacco retailer counts ^d , %*				
Less than 2 (low)	29.3	33.0	25.7	.006
2–5 (intermediate)	30.7	31.9	29.6	
6 or more (high)	40.0	35.0	44.8	
Distance to closest tobacco retailer ^e , %				
More than 350 m (furthest)	30.8	33.3	28.5	.289
150–350 m (intermediate)	36.9	35.5	38.3	
Less than 150 m (closest)	32.3	31.3	33.2	
Relative deprivation, %				
Low	19.7	21.6	17.8	.357
Medium to low	27.5	26.9	28.1	
Medium to high	32.5	30.4	34.5	
High	20.4	21.2	19.7	

SD = standard deviation.

^aAmong 912 participants with data on occupation.

^bMedian (interquartile range) for mean tobacco retailer counts in the activity space are 6.0 (6.5) for the complete sample, 5.8 (6.0) for former smokers, and 6.4 (6.8) for current smokers.

^cMedian (interquartile range) for mean distance to closest tobacco retailer in the activity space are 208.9 (211.7) for the complete sample, 226.0 (228.6) for former smokers, and 197.0 (196.0) for current smokers.

^dMedian (interquartile range) for residential tobacco retailer counts are 4.0 (7.0) for the complete sample, 3.5 (8.0) for former smokers, and 5 (8) for current smokers.

^eMedian (interquartile range) for distance between home and closest tobacco retailer are 212.7 (281.7) for the complete sample, 297.6 (228.6) for former smokers, and 204.2 (274.2) for current smokers.

*Difference between former and current smokers at *p* = .05 significance level.

were conducted at home (*n* = 27) or because they did not report conducting any of the specified activities or did not provide enough detail for accurate geocoding (*n* = 44) (data not shown).

Table 2 shows prevalence ratios and 95% confidence intervals for the association between former smoking and tobacco retailer counts in the activity space (models A–C) and in the residential neighborhood (models D–F). In fully adjusted models, smoking cessation was

associated with exposure to low and intermediate tobacco retailer counts, compared to higher counts, in both the activity space (model C) and residential neighborhood (model F). Estimates were slightly higher for intermediate counts in the activity space [PR (95% CIs) = 1.28 (1.09 to 1.50)] than in the residential neighborhood [PR (95% CI) = 1.20 (1.02 to 1.41)] although confidence intervals overlapped. Former smoking increased slightly with age and was higher

Table 2. Prevalence Ratios (PR) and 95% Confidence Intervals (CI) for the Association Between Number of Tobacco Retailers in the Activity Space and Residential Neighborhood and Smoking Cessation

	Activity space			Residential neighborhood		
	Model A PR (95% CI)	Model B PR (95% CI)	Model C PR (95% CI)	Model D PR (95% CI)	Model E PR (95% CI)	Model F PR (95% CI)
Tobacco retailer counts ^a						
Low counts	1.14 (0.97 to 1.35)	1.27 (1.08 to 1.50)	1.28 (1.08 to 1.51)	1.29 (1.10 to 1.51)	1.28 (1.10 to 1.50)	1.28 (1.10 to 1.50)
Intermediate	1.15 (0.98 to 1.34)	1.26 (1.08 to 1.48)	1.28 (1.09 to 1.50)	1.19 (1.01 to 1.40)	1.22 (1.04 to 1.43)	1.20 (1.02 to 1.41)
High counts	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Individual-level characteristics						
Age (y)		1.00 (0.97 to 1.03)	1.03 (1.00 to 1.07)		1.01 (0.97 to 1.04)	1.03 (1.00 to 1.07)
Sex						
Female		1.12 (0.98 to 1.28)	1.14 (1.00 to 1.29)		1.11 (0.97 to 1.27)	1.12 (0.99 to 1.28)
Male		Ref.	Ref.		Ref.	Ref.
Educational attainment						
University		1.60 (1.30 to 1.96)	1.53 (1.25 to 1.87)		1.49 (1.21 to 1.82)	1.43 (1.17 to 1.75)
CEGEP/trade school		1.27 (1.03 to 1.56)	1.25 (1.02 to 1.54)		1.27 (1.03 to 1.56)	1.25 (1.02 to 1.54)
High school or less		Ref.	Ref.		Ref.	Ref.
Years since smoking onset			0.97 (0.94 to 0.99)			0.97 (0.95 to 1.00)
AIC	1.388751	1.365265	1.36032	1.381595	1.365243	1.361862

AIC = Akaike information criterion, CEGEP = Collèges d'enseignement général et professionnel.

Bold results are statistically significant at the 0.05 level.

^aExact cutpoints are 0–3.75 (low), 4–7.8 (intermediate), and 8–30.7 (high) for mean tobacco retailer counts in the activity space, and 0–1 (low), 2–5 (intermediate), and 6–45 (high) for tobacco retailer counts in the residential neighborhood.

in university and CEGEP or trade school students and graduates compared to the least educated category. The Akaike information criteria suggested better model fit for the fully adjusted activity space model than the residential model.

Table 3 presents results for the association between distance to the closest tobacco retailer in the activity space and residential neighborhood, and smoking cessation. Former smoking was higher among those conducting activities in places located further from tobacco retailers (on average more than 350 m away) compared to less than 150 m away, after adjusting for age, sex, educational attainment, and time since smoking onset (model C) [PR (95% CI) = 1.21(1.02 to 1.43)]. Residential proximity to tobacco retailers was not significantly associated with smoking cessation. There was an educational gradient in former smoking, with increasing smoking cessation prevalence as educational attainment increased. Model fit was better for activity space than residential models.

Sensitivity Analyses

In sensitivity analyses, findings relative to the maximum number of tobacco retailers in the activity space were similar to those presented here, although slightly lower for the intermediate tertile level [PR (95% CI) = 1.20 (1.01 to 1.41) in the fully adjusted model]. When analyzing minimum distance to the closest tobacco retailer in the activity space, we found the association for the closest distance level (>100 m) to be slightly stronger than that for mean distance [PR (95% CI) = 1.28 (1.10 to 1.50)]. Estimates for the association between smoking cessation and tobacco retailer counts within 800 m buffers were slightly lower than those presented here for both activity space and residential measures, and they were only statistically significant for low counts, with PRs (95% CI) = 1.23 (1.05 to 1.46) for mean activity space counts and 1.21 (1.04 to 1.41) for residential neighborhood counts.

Discussion

Main Findings

In this study, we assessed the association between smoking cessation and the number of, and distance to, tobacco retailers in young adults' activity space and residential neighborhood. We found that living and conducting activities in areas characterized, on average, by low and intermediate tobacco retailer counts, compared to areas where tobacco retailers were more available, increased the probability of being a former smoker. Mean distance to the closest tobacco retailer in the activity space was associated with smoking cessation, but only for the furthest distance category (>350 m), whereas residential distance was not.

Comparison With Other Studies

To the best of our knowledge, our study is one of the first to consider individuals' potential exposure to tobacco retailers in their multiple daily activity locations, in addition to their residential neighborhood, to study smoking cessation.⁸ High tobacco retailer density^{12-14,37} and proximity^{13,15,17,18} in residential neighborhoods have previously been reported to be inversely associated with smoking cessation, mainly among adults. Our study takes this evidence further and addresses a previous limitation¹⁸ by recognizing that residential neighborhoods are not the sole areas where exposure to resources conducive to smoking may be important.²¹ A previous small global positioning system-based study which showed that daily exposure to tobacco

retailers increased the risk of relapse among would-be quitters, even when their temptation to smoke was low,⁸ supports the results presented here, although its findings could be affected by selective daily mobility bias.³⁸ This bias may occur if an individual's reasons for visiting a certain activity location were associated with both the exposure of interest (tobacco retailers) and with the outcome (smoking). The risk of this bias would be high if one attempted, for example, to correlate visits to tobacco retailers with cigarette purchasing. In that case, it would be difficult to untangle whether exposure to tobacco retailers was incidental and had spurred the willingness to purchase cigarettes, or if a tobacco retailer was intentionally visited to purchase cigarettes. By focusing on regular activity locations unrelated to smoking practices, our study is less at risk of this selective daily mobility bias.

Potential Mechanisms of Action

Our findings lend support to the hypothesis that exposure to tobacco retailers may make it more difficult for smokers to successfully abstain from smoking.^{8,13,39} Although tobacco retailer availability and accessibility as studied here are only two aspects of the tobacco retail environment, which also involves such dimensions as promotional displays and cigarette prices, they may influence smoking cessation by facilitating the purchase of tobacco products, creating a more competitive market and thus reducing prices, and normalizing smoking behaviors in an area.⁷ Living and conducting activities near a large number of retailers may increase exposure to tobacco advertising,⁴⁰ although bans on point-of-sale tobacco marketing and pack displays are increasingly widespread, as it has been in Canadian provinces and territories, including Québec, since the mid-2000s.⁴¹ Tobacco retailers may also have a more subtle effect on smoking. Studies have suggested that individuals may have an autonomic response to the sight of tobacco retailers, which triggers the thought and physical urge to smoke.⁸⁻¹⁰ In their qualitative study of smokers and attempting quitters, Burton et al.⁹ reported that even in the absence of point-of-sale marketing and cigarette displays, the mere sight of a tobacco retailer stimulated smokers to buy cigarettes or to smoke. In our study, tobacco retailer counts were slightly more strongly associated with smoking cessation than retailer proximity, which may suggest that cumulative encounters with tobacco-selling outlets throughout daily activities may trigger recurrent thoughts about smoking, making it more difficult for smokers to quit. In our study, residential distance to a tobacco retailer was not associated with smoking cessation, but distance in the activity space was, a finding similar to that reported in an ancillary article on smoking status in the same sample.²¹ This lends support to the convenience mechanism hypothesized to link tobacco retailer proximity to smoking behaviors, whereby how close one gets to a tobacco retailer in the course of their daily activities may be more of a relevant trigger for purchasing cigarettes "on the go" than the sheer number of retailers available. The potential impact of proximity should thus not be underestimated because ultimately, a smoker trying to quit only needs one tobacco retailer to purchase cigarettes from to prevent him or her from quitting.¹⁷

Educational Inequalities

We found differences in smoking cessation by educational attainment, whereby university students and graduates more likely to be former smokers compared to the least educated participants, followed by CEGEP or trade school students and graduates (Tables 1

Table 3. Prevalence Ratios (PR) and 95% Confidence Intervals (CI) for the Association Between Distance to Tobacco Retailer in the Activity Space and Residential Neighborhood and Smoking Cessation

	Activity space			Residential neighborhood		
	Model A PR (95% CI)	Model B PR (95% CI)	Model C PR (95% CI)	Model D PR (95% CI)	Model E PR (95% CI)	Model F PR (95% CI)
Distance to tobacco retailer						
Furthest distance	1.16 (0.97 to 1.38)	1.19 (1.01 to 1.41)	1.21 (1.02 to 1.43)	1.11 (0.95 to 1.31)	1.13 (0.96 to 1.33)	1.12 (0.96 to 1.32)
Intermediate	1.04 (0.89 to 1.21)	1.03 (0.88 to 1.21)	1.05 (0.90 to 1.23)	0.99 (0.84 to 1.17)	1.02 (0.87 to 1.20)	1.01 (0.86 to 1.18)
Closest distance	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Individual-level characteristics						
Age (y)		1.00 (0.97 to 1.03)	1.03 (0.99 to 1.07)		1.00 (0.97 to 1.03)	1.03 (0.99 to 1.07)
Sex						
Female		1.11 (0.97 to 1.27)	1.13 (0.99 to 1.29)		1.10 (0.97 to 1.26)	1.12 (0.98 to 1.27)
Male		Ref.	Ref.		Ref.	Ref.
Educational attainment						
University		1.51 (1.23 to 1.85)	1.45 (1.18 to 1.77)		1.49 (1.22 to 1.83)	1.43 (1.17 to 1.76)
CEGEP/trade school		1.27 (1.02 to 1.56)	1.25 (1.01 to 1.53)		1.26 (1.02 to 1.55)	1.24 (1.01 to 1.53)
High school or less		Ref.	Ref.		Ref.	Ref.
Years since smoking onset			0.97 (0.95 to 0.99)			0.97 (0.95 to 0.99)
AIC	1.389481	1.372352	1.368143	1.389916	1.374442	1.370526

AIC = Akaike information criterion, CEGEP = Collèges d'enseignement général et professionnel.

Exact tertile cut points are 350–2682.1 m (furthest), 150.1–350 m (intermediate), and 6.3–150 m (closest) for mean distance to closest tobacco retailer in the activity space, and 351.5–4378.2 m (furthest), 150.4–349.0 m (intermediate), and 1.5–148.4 m (closest) for distance between home and closest tobacco retailer.

Bold results are statistically significant at the 0.05 level.

and 2). There were also educational differences in exposure to tobacco retailers in the activity space: the most educated participants encountered more tobacco retailers in their activity space, potentially due to the spatial concentration of tobacco retailers in commercially dense areas where high skill educational and work places tend to be located, but the high school and CEGEP or trade school students and graduates were equally overrepresented in the high proximity category (data not shown). The education–smoking cessation associations were however independent of tobacco retailer measures (Tables 1 and 2).

Although we did not find statistically significant interactions between educational attainment and tobacco retailer measures, the main effects were not significant until education was included in the models (see models B Tables 2 and 3), thus suggesting some effect modification. Subanalyses stratified by education showed the association between tobacco retailer counts and smoking cessation to be stronger in the most educated (data not shown), suggesting that our formal test for interaction may be underpowered.

Strengths and Limitations

An important strength of our study is its large, geographically representative sample of young adults, a population subgroup that is often overlooked in tobacco control research. Young adulthood, as a transition period during which smoking may either be taken up or abandoned, is a critical period for intervention.⁴ Canadian public health organizations have only recently identified young adults as a priority group in their tobacco control initiatives, with Health Canada at last including “marketing awareness and outreach campaigns to get young people talking about quitting smoking” in its 2012–2017 Federal Tobacco Control Strategy.² Although the desire to quit smoking may be widespread among young adult smokers,^{4,42} intention alone poorly predicts cessation, and interventions other than the more individual-centered actions such as information campaigns, counselling, and provision of stop smoking medications⁴³ are required. Substance use ultimately takes place in a context involving personal and social factors as well as environmental cues,⁸ and these must be examined, as we have done here. Another strength of our study is its focus on two dimensions of the tobacco retail environment—availability (counts) and accessibility (distance)—both of which may affect smoking cessation through distinct yet complementary mechanisms. Furthermore, by focusing on regular activities, our measure of activity spaces curtailed the risk of being affected by selective daily mobility bias, which can be problematic in built environment studies.³⁸ In our study, it is unlikely that participants’ activity locations were influenced by their smoking status, that is, that former smokers would deliberately have chosen to conduct activities in lower retailer availability or accessibility areas than current smokers.

Study limitations should also be acknowledged. Ever and former smoking were self-reported, which could have led to response bias and misclassification in the outcome variable. For instance, light or occasional smokers might have identified as former smokers.⁴⁴ However, it is unlikely that this would have depended on tobacco retailer exposures, thus misclassification is likely to be nondifferential. In that case, estimates would be biased toward the null and true associations would be underestimated. We defined “ever smoking” based on having smoked at least an entire cigarette in one’s lifetime, a definition that might encompass both experimenters, that is, individuals who are experimenting with smoking but will not become regular smokers in the long term and established smokers, that is,

individuals who have been smoking for a longer period and are more likely to be nicotine dependent and hence to keep smoking in the future. Experimenting and established smokers may respond differently to the tobacco retail environment,¹⁸ but here again, combining them would bias estimates toward the null. The first entire cigarette smoked is nevertheless an important milestone in the smoking process, and mental and physical addiction has been found to appear rapidly after, before individuals become daily smokers.⁴⁵ We therefore do not expect our findings to have been much different had we distinguished experimenters from established smokers.

A related issue is that having assessed former smoking cross-sectionally, we have no indication of whether cessation would be sustained through time. This could be problematic because Chaiton et al.⁴⁶ (2016) suggested that around 30 quit attempts may be needed for successful smoking cessation. A recent study of adult smokers by these same authors found that high tobacco retailer density in the residential neighborhood was associated with lower odds of making a quit attempt, but not with relapse. Given that young adults are more likely than other age groups to attempt to quit smoking and to succeed when they do,⁴⁷ intervening to limit tobacco retailer availability thus may be a promising avenue to support cessation among young people.

Finally, limitations linked to temporality should be highlighted. First, smoking cessation might have occurred at a time when exposure to tobacco retailers was different than that assessed here. This is especially important in the case of young adults who tend to be more mobile, residentially and otherwise, than other age groups.⁴⁸ We assumed, as has been done in similar articles,^{12,18} that exposure to tobacco retailers was relatively stable over time so that the exposure-to-outcome temporality assumption for causality would not be violated. Although we could not formally test for this, nor could we distinguish between more and less recent quitters, longitudinal studies are needed to assess if changes in activity space exposure to tobacco retailers are associated with changes in smoking behaviors, as has been done in studies focused exclusively on the residential neighborhood.^{15,18} Second, we did not account for tobacco retailers’ hours of operation; therefore exposure measures neglected the “daycourse of places,” which suggests that place characteristics are dynamic over the course of a day.⁴⁹ This is of particular importance if we consider that a key mechanism linking tobacco retailers to smoking cessation is through cigarette purchasing, but it should not undermine the fact that even when retailers are not open to the public, they may still influence smoking behaviors via other mechanisms described earlier.

Conclusion

Many countries have “tobacco endgame” targets, including Canada, which is committed to reducing tobacco use to less than 5% by 2035.⁵⁰ Encouraging smoking cessation will be necessary to attain this objective, and to reduce the future burden of tobacco-related diseases. This study highlighted the relevance of considering both residential and nonresidential places where people spend time to identify contextual factors, such as tobacco retailers, which may influence the likelihood of quitting smoking. Our findings add to the body of evidence suggesting that environmental-level initiatives to reduce the density and proximity of tobacco retailers might be promising for tobacco control, including in young adults. Interventions previously suggested include implementing zoning policies restricting tobacco retailers not only in residential areas, but across entire

cities, instigating minimum allowable distances between tobacco retailers, and limiting the type and opening hours of stores that can sell cigarettes.^{5,51} Tobacco control advocates may want to further contemplate these options.

Funding

MS holds a Banting Postdoctoral Fellowship. YK holds an Applied Public Health Chair in Urban Interventions and Population Health from the Canadian Institutes of Health Research (CIHR). GDD holds a career award from the Canadian Cancer Society (no. 703946). This work was supported by a CIHR Operating Grant (no. DCO150GP).

Declaration of Interests

None declared.

Acknowledgments

The authors acknowledge Yuddy Ramos and Benoît Thierry for extracting area-level variables, Dr. Jennifer O'Loughlin for her feedback on an earlier version of the manuscript, the ISIS research team, study participants, as well as the three anonymous reviewers who provided their feedback.

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