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Smoke-Free School Policy and Exposure to Secondhand Smoke: A Quasi-Experimental Analysis

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Abstract

Introduction: Tobacco control prevention efforts are important to protect people from exposure to dangerous tobacco smoke, support cessation, and reduce tobacco-use initiation. While smoke-free laws have been a widespread tobacco control strategy, little work has been done to examine the impact of smoke-free school policies. The objective of this study is to evaluate the impact of provincial smoke-free school ground policies on youth-reported exposure to secondhand smoke (SHS) on school property.

Methods: This study used a nationally representative sample of 20 388 youth aged 15–18 from the 2005–2012 Canadian Tobacco Use Monitoring Survey. A quasi-experimental design was used to evaluate the impact of smoke-free school policies on SHS exposure.

Results: Approximately over half (52%) of respondents reported SHS exposure on a school property in the past month. Smoke-free school policy had a statistically significant effect on SHS exposure. Specifically, the adoption of smoke-free school reduced the probability of SHS exposure by about 8 percentage points. Respondents who were smokers were more likely to report being exposed to SHS than nonsmokers. Likewise, those living in urban areas had higher probability of being exposed to SHS than those living in rural parts of Canada.

Conclusions: Reported exposure to tobacco smoke did decrease after the introduction of smoke-free ground policies; however, almost half of high-school aged youth report exposure in the last month. Across Canada, provincial health authorities as well as school administers may need to assess the implementation of these smoke-free policies and improve enforcement strategies to further reduce exposure to dangerous SHS.

Introduction

Tobacco continues to be the leading cause of preventable death and disease in Canada.[1] It is estimated that tobacco use is related to more than 85% of lung cancer cases in Canada, the leading cause of cancer death.[2] Further, exposure to secondhand smoke (SHS), also called tobacco smoke pollution, is responsible for 800 deaths in Canadian nonsmokers from lung cancer and heart disease every year.[3]

In 2012, 16.1% of Canadians (4.6 million people) were current smokers with the highest prevalence rate among young adults aged 25–34 and 20–24, at 21.8% and 20.3%, respectively.[4] Health Canada estimates that every 5 minutes, a teenager starts smoking.[5]

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Data from the 2012 wave of the Canada-wide Youth Smoking Survey[6] revealed that youth are continuing to initiate tobacco use. The 2012 Youth Smoking Survey identified that one in four (24.3%) youth aged 15–19 reported ever having smoked a whole cigarette, and approximately 11% were current smokers, with age-specific rates ranging from 4.5% for 15-year-olds to 16.7% for 19-year-olds.[4] The mean age at which ever-smokers age 25 and over smoked their first cigarette was 16.4 years old; most youth are in secondary school (high school, grade 10 or 11) at this time suggesting the relevance of prevention efforts during high school. To address youth exposure to tobacco, there is a need for comprehensive prevention efforts including implementing a range of policy efforts.[7]

Smoke-free laws have been a widespread tobacco control strategy used in Canada to ensure people are protected from exposure to SHS. Protection from tobacco smoke is a public health priority because SHS is a class-A carcinogen.[8,9] In Canada, since 2009, most indoor workplaces and public places have been made smoke-free from provincial or territorial laws.[10] One of the first environments made smoke-free in Canada was primary, senior public, and secondary school campuses. The province of Ontario, for example, made schools 100% smoke-free since the Smoke-free Ontario Act[11] in June 1994, 12 years before other enclosed workplaces and public places were made smoke-free by the Smoke-free Ontario Act (2006). Smoke-free laws have the obvious benefit of protecting nonsmokers from dangerous SHS. There is no risk-free level of exposure, with evidence suggesting that concentrations of SHS in outdoor environments can be elevated—even approaching levels measured in indoor environments,[12] although concentrations tend to return to background levels quickly after cigarettes are extinguished.[13] In Canada, municipalities and provinces have increasingly passed policies and laws that regulate or ban smoking in public spaces, in particular environments where children or youth frequent including recreational fields, playgrounds, beaches, and parks.[4] The rationale for these emerging policies is not only to protect people from exposure to SHS, but also to socially denormalize tobacco use and support cessation.[14] Smoke-free laws have also been shown to help prevent people from initiating tobacco use, and to support current smokers to quit and stay quit.[15] Evidence from Canada has linked the social exposure of people seeing smoking in public spaces, or smelling smoke to challenges remaining abstinent from smoking. Survey respondents reported that these exposures can provide sensory cues for relapse among people who recently quit smoking, and make it difficult for smokers who are trying to quit.[16]

There is an established association between the frequency that youth witness smoking in public spaces, and the belief that smoking is socially acceptable. Children and adolescents are likely to copy the behaviors they see.[17] If a location in a neighborhood is known to have smokers, and those smokers are highly visible, more student tobacco-users report smoking there as well.[17] Stronger restrictions on smoking in public places have a protective effect on smoking uptake among teenagers.[18,19] Smoke-free spaces decrease the visibility of smoking, and the social acceptability of smoking.[17]

Although many colleges and universities in Canada restrict outdoor smoking, very few campuses have implemented 100% smoke-free grounds. Internationally, smoke-free spaces in particular smoke-free school grounds, are common in jurisdictions like Australia[20] and New Zealand.[21] However, little work has been done to understand or evaluate the impact of smoke-free school ground policies. Considering the changes in youth initiation, the need to protect people from exposure to SHS, and the desire to denormalize smoking and support people trying to quit and stay quit, outdoor smoke-free school policies are an uncontentious and logical contribution to any tobacco control efforts.

The present study examined the effect of smoke-free school policy on self-reported exposure to SHS using data from the Canadian Tobacco Monitoring Survey. In addition, we examined whether the effect of smoke-free school policy on SHS exposure varies by gender given that prior research has shown gender differences in disease burden attributable to SHS exposure.[22–24] Given that smoke-free school policy was adopted at different times across Canada, an opportunity to conduct a natural experiment presented itself.

Methods

Design

To evaluate the effect of smoke-free school policy on exposures to SHS a quasi-experimental design (ie, natural experiment) was conducted using a repeated cross-sectional population survey known as the Canadian Tobacco Use Monitoring Survey (CTUMS). The survey is nationally representative of Canadians aged 15+ years and conducted by Statistics Canada.[25] CTUMS primarily collects information about the attitudes and behaviors of adults with respect to tobacco use, as well as corresponding sociodemographic variables. The survey excludes those living in institutions, and Canadians living in the northern Territories (Yukon, Nunavut and Northwest Territories). CTUMS is based on a two-phase stratified random sampling framework. In the first phase, households are sampled from telephone numbers using a random digit dialing methodology. Individuals are selected in the second stage based on household composition, with an equal representation of respondents in each of 10 Canadian provinces. CTUMS commenced in 1999 and was conducted annually. In the present study, we used annual CTUMS cycles from 2005 to 2012 given that our outcome variable was not available in previous iterations. We excluded three provinces (Ontario, Nova Scotia, and New Brunswick) in this study since smoke-free school policy was implemented in these provinces before 2005. We restricted our analysis to students aged 15–18 given that the policy variable of interest (provincial smoke-free school policy) is not applicable to college and university students. Ethics review was not required given that this research relied exclusively on anonymous secondary survey data.

Variables

Exposure to Second-Hand Smoke on a School Property

The outcome variable was derived from self-reported response to questions on location-specific exposure to SHS in the past month. In particular, a dichotomous variable indicating SHS exposure in the past month was created from the question: "The next questions are about exposure to SHS in places other than your own home. SHS is what smokers exhale and the smoke from a burning cigarette. In the past month, excluding your own smoking were you exposed to SHS on a school property?" (Note from 2005–2008 the wording was slightly more specific, "were you exposed to SHS at your school?"). Self-reported SHS exposure has been shown to be associated with biomarkers of nicotine.[26]

Independent Variables

Smoke-free grounds policy variable, our main independent variable of interest, was derived by using the dates of implementation of province-wide school smoking ban (Table 1), respondents' province of residence and date of interview. A number of sociodemographic

Table 1. Smoke-Free School Policy Timeline in Canada

Province	Enforcement date
Ontario	November 1994
Nova Scotia	January 2003
New Brunswick	October 2004
Quebec	May 2006
British Columbia	March 2008
Prince Edward Island	September 2009
Saskatchewan	August 2010
Newfoundland & Labrador	Not yet
Manitoba	Not yet
Alberta	Not yet

Source: Based on Non-Smokers' Right Association and authors compilation. Analytic sample excluded three provinces (Ontario, Nova Scotia, and New Brunswick) in this study since smoke-free school policy was implemented in these provinces before 2005.

variables were included in the analysis: sex (male = 1, female = 0); smoking status (current smoker = 1, nonsmoker = 0); community where the respondent lives (urban = 1, rural = 0); trend and province of residence (Prince Edward Island, Newfoundland & Labrador, Manitoba, Saskatchewan, Alberta, British Columbia, and Quebec as the reference category). The analysis also adjusted for the possibility of seasonal effect by using month of interview (March/April, May/June, July/August, September/October, November/December, and February as the reference category).

Statistical Analysis

To examine the effect of the province-level smoke-free school policy on exposure to SHS, we used the difference-in-difference approach.[27,28] The difference-in-difference method estimates changes in exposure to SHS for individuals in provinces with smoke-free school policy over time relative to individuals in provinces without smoke-free school policy. Specifically, a difference-in-difference model of the following form is estimated:

$$Y_{ipt} = \alpha + \beta_1 (Smoke_{free} school)_{pt} + \beta_2 X_{ipt} + \tau_t + \tau_t^2 + S_{it} + \varphi_p + \varepsilon_{ipt}$$

where Y_{ipt} represents outcome variable (exposure to SHS) for individual i in provine p at survey time t. The variable $Smoke_{free} school$ is a dummy variable that equaled one if the individual is in a province and a time period when the policy is implemented and zero otherwise. We estimated linear probability model for the ease of interpretation, however, results were similar using a probit regression model. The main coefficient, β_1 represents the average change in the probability of exposure to SHS due to smoke-free school policy. The analysis also controlled for individual sociodemographic characteristics, vector X_{ipt}, including gender, smoking status and place of residence (city or rural). τ_t and τ_t^2 represent linear and quadratic trends, respectively. S_{it} captures seasonal effects (month of interview). φ_p represents time-invariant province fixed effects. Three different model specifications were estimated: the baseline specification (Model 1) adjusted for gender, smoking status, place of residence and province fixed effects; Model 2 adjusted for season in addition to Model 1 variables; and Model 3 added linear and quadratic trend to the analysis. To examine a potential heterogeneous effect of smoke-free school policy, separate analysis was conducted for males and females. In order for variance estimates to account for the complex survey design, the Fay-modified balanced repeated replication approach was used in the analysis.[29] Analysis was carried out using Stata version 13.1.

Results

The average sample characteristics are reported in Table 2. In total, over 50% of respondents reported SHS exposure on a school property (or their school property) in the past month. The prevalence of SHS exposure for each year is shown in Figure 1. There has been gradual decline in SHS exposure, with a decrease from 58.5% in 2005 to 45% in 2012.

Table 3 reports the average impact of smoke-free school on exposure to SHS from a linear probability model estimating three model specifications (Models 1–3). In all model specifications, smoke-free school policy had a statistically significant effect on SHS exposure. In particular, the adoption of smoke-free school reduced the probability of SHS exposure by about 8.4 percentage points (Model 1). In terms of the average pre-policy SHS exposure (58.5% in 2005), the 8.4 percentage-point decrease means a 14% decrease in the probability of SHS exposure. As expected, results showed that smokers were

Table 2. Average Sample Characteristics 2005–2012 (n = 20 388)

	Frequency	Unweighted (%)	Weighted (%)
SHS exposure	10 035	49.2	51.9
Non-SHS exposure	10 353	50.8	48.1
Gender			
Male	10 200	50.0	50.2
Female	10 188	50.0	49.8
Smoking status			
Smoker	2165	10.6	10.9
Nonsmoker	18 223	89.4	89.1
Community of residence			
Urban	14 483	71.0	80.0
Rural	5905	29.0	20.0
Province of residence			
Newfoundland & Labrador	2967	14.6	2.7
Prince Edward Island	2953	14.5	0.9
Manitoba	3004	14.7	7.0
Saskatchewan	2927	14.3	6.1
Alberta	2846	14.0	19.0
British Columbia	2521	12.4	23.0
Quebec	3170	15.5	41.3

SHS = secondhand smoke. Analytic sample excluded three provinces (Ontario, Nova Scotia, and New Brunswick).

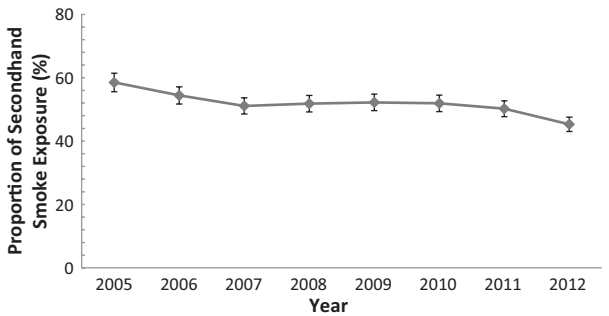

Figure 1. Prevalence of secondhand smoke exposure in the Canadian Tobacco Use Monitoring Survey 2005–2012.

Table 3. Effect of Smoke-Free School Policy on SHS Exposure

	Model 1	Model 2	Model 3
Smoke-free school policy	−0.084* (0.015)	−0.075* (0.015)	−0.065* (0.018)
Gender			
Male	−0.025* (0.010)	−0.026* (0.010)	−0.026* (0.010)
Female	Ref	Ref	Ref
Smoking status			
Smoker	0.217* (0.015)	0.216* (0.015)	0.215* (0.015)
Nonsmoker	Ref	Ref	Ref
Community of residence			
Urban	0.066* (0.014)	0.064* (0.013)	0.064* (0.013)
Rural	Ref	Ref	Ref
Province of residence			
Newfoundland & Labrador	−0.133* (0.019)	−0.127* (0.019)	−0.119* (0.020)
Prince Edward Island	−0.174* (0.015)	−0.171* (0.015)	−0.167* (0.015)
Manitoba	−0.143* (0.019)	−0.139* (0.019)	−0.130* (0.021)
Saskatchewan	−0.151* (0.017)	−0.147* (0.017)	−0.141* (0.018)
Alberta	−0.196* (0.018)	−0.191* (0.018)	−0.182* (0.019)
British Columbia	−0.135* (0.015)	−0.135* (0.015)	−0.132* (0.015)
Quebec	Ref	Ref	Ref
Season			
March/April		0.023 (0.021)	0.020 (0.021)
May/June		0.004 (0.021)	0.000 (0.021)
July/August		−0.164* (0.021)	−0.168* (0.021)
September/October		−0.017 (0.022)	−0.021 (0.022)
November/December		0.026 (0.021)	0.022 (0.021)
February		Ref	Ref
Trend			
Linear			0.010 (0.011)
Quadratic			−0.002 (0.001)
Observations	20 388	20 388	20 388

SHS = secondhand smoke. Standard errors in parentheses using balanced repeated replications. Population weighted.
*$P < .05$.

more likely to be exposed to SHS than nonsmokers. Likewise, those living in urban areas had higher probability of being exposed to SHS.

In Tables 4 and 5 we examined the heterogeneous effects of smoke-free school policy on SHS exposure for males and females. Results were consistent across all model specifications indicating statically significant effect of smoke-free school policy on SHS exposure (with the exception of Model 3 for males). We found 7 and 10 percentage points reductions in the probability of SHS exposure for males and females, respectively. Relative to the average pre-policy SHS exposure rates for males (57%) and females (60%), the policy reduced the probability of SHS exposure by about 12% for males and 17% for females. Though not reported, estimation results from a probit regression returned similar results.

Discussion

These findings highlight the important role smoke-free policy can play in reducing exposure to SHS; however, a large proportion of high school aged youth continue to report exposure to SHS on school property. Decreased rates of exposure could, in part, be explained by reduced smoking prevalence, however youth smoking rates have remained fairly constant for the last several years.[4] Higher rates of reported exposure by youth who smoke suggest that smoking on school grounds is done socially—with smokers being exposed to SHS from other smokers. Higher reported rates of exposure in urban settings could be explained, in part, by physical differences in school properties; urban schools may have smaller properties increasing the likelihood that youth are exposed. We also found gender differences in the effect of smoke-free school policy on SHS exposure, with a larger reduction in SHS exposure for females. Consistent with prior studies showing that women are disproportionally affected by exposure to SHS,[22–24] our finding provide evidence of the potential benefit of smoke-free school policy, especially for females.

This study has several limitations including the issue that the wording around exposure to SHS on school properties changed slightly; however, the change broadened possible positive responses. From 2005–2008 the question asked respondents about exposure to SHS at their school, and in 2009–2012 the question included reported exposure at any school. Youth are most likely to be spending time at their school, but the change in wording results in a more general reporting of smoke-free ground policy compliance. The survey—CTUMS—is not a school-based survey which would be preferable for this subject area. Youth may be reporting exposure to SHS that technically is taking place on property near or beside their school—but is not officially part of school property. SHS exposure decline at school property could be attributable to other potential confounding variables or policies not accounted for in the present study.

Recent studies suggest that youth are using other forms of tobacco including smokeless products, and that experimentation is taking place primarily during the time youth are high school-aged.[30] The introduction of other nicotine delivery products like e-cigarettes also raises important policy issues for school campuses. A recent study identified that 16% of young adults reported trying e-cigarettes, with evidence of use among nonsmokers.[31] Although

Table 4. Effect of Smoke-Free School Policy on SHS Exposure for Males

	Model 1	Model 2	Model 3
Smoke-free school policy	−0.067* (0.021)	−0.059* (0.020)	−0.041 (0.025)
Smoking status			
Smoker	0.215* (0.023)	0.216* (0.023)	0.215* (0.023)
Nonsmoker	Ref	Ref	Ref
Community of residence			
Urban	0.058* (0.018)	0.057* (0.018)	0.057* (0.018)
Rural	Ref	Ref	Ref
Province of residence			
Newfoundland & Labrador	−0.155* (0.025)	−0.149* (0.025)	−0.135* (0.028)
Prince Edward Island	−0.174* (0.020)	−0.173* (0.020)	−0.165* (0.021)
Manitoba	−0.142* (0.026)	−0.140* (0.026)	−0.125* (0.029)
Saskatchewan	−0.157* (0.023)	−0.153* (0.023)	−0.144* (0.024)
Alberta	−0.206* (0.025)	−0.202* (0.025)	−0.186* (0.027)
British Columbia	−0.131* (0.021)	−0.131* (0.021)	−0.127* (0.022)
Quebec	Ref	Ref	Ref
Season			
March/April		0.023 (0.031)	0.018 (0.031)
May/June		0.023 (0.030)	0.016 (0.030)
July/August		−0.135* (0.030)	−0.142* (0.031)
September/October		−0.033 (0.030)	−0.040 (0.030)
November/December		0.029 (0.031)	0.022 (0.031)
February		Ref	Ref
Trend			
Linear			0.012 (0.015)
Quadratic			−0.002 (0.002)
Observations	10 200	10 200	10 200

SHS = secondhand smoke. Standard errors in parentheses using balanced repeated replications. Population weighted.
*$P < .05$.

Table 5. Effect of Smoke-Free School Policy on SHS Exposure for Females

	Model 1	Model 2	Model 3
Smoke-free school policy	−0.102* (0.021)	−0.091* (0.021)	−0.088* (0.025)
Smoking status			
Smoker	0.220* (0.021)	0.216* (0.020)	0.215* (0.020)
Nonsmoker	Ref	Ref	Ref
Community of residence			
Urban	0.078* (0.018)	0.076* (0.018)	0.075* (0.018)
Rural	Ref	Ref	Ref
Province of residence			
Newfoundland & Labrador	−0.111* (0.026)	−0.105* (0.026)	−0.103* (0.028)
Prince Edward Island	−0.174* (0.021)	−0.171* (0.021)	−0.170* (0.021)
Manitoba	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Saskatchewan	−0.144* (0.027)	−0.138* (0.027)	−0.136* (0.028)
Alberta	−0.145* (0.024)	−0.140* (0.024)	−0.139* (0.025)
British Columbia	−0.186* (0.026)	−0.180* (0.026)	−0.178* (0.027)
Quebec	Ref	Ref	Ref
Season			
March/April		0.024 (0.030)	0.022 (0.030)
May/June		−0.014 (0.031)	−0.016 (0.031)
July/August		−0.190* (0.031)	−0.191* (0.031)
September/October		0.001 (0.031)	−0.000 (0.031)
November/December		0.025 (0.031)	0.023 (0.032)
February		Ref	Ref
Trend			
Linear			0.009 (0.015)
Quadratic			−0.001 (0.002)
Observations	10 188	10 188	10 188

SHS = secondhand smoke. Standard errors in parentheses using balanced repeated replications. Population weighted.
*$P < .05$.

e-cigarettes in Canada currently cannot legally contain nicotine, advocates and public health officials have raised concerns that these products might undercut the tobacco denormalization efforts of the past and be a gateway to combustible tobacco products.[32]

Globally, support for smoke-free public places is increasing, particularly for environments frequented by young people.[19] Across Canada, provincial health authorities as well as school administers need to assess the implementation of these smoke-free policies and improve enforcement strategies to further reduce exposure to dangerous SHS. Policy makers may also take this opportunity to consider expanding policies to include all forms of tobacco/nicotine, and devices like e-cigarettes.

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Declaration of Interests

None declared.

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