

Comprehensive tobacco control policies and the smoking behaviour of Canadian adults

Thomas Stephens, Linda L Pederson, John J Koval, Jennifer Macnab

Abstract

Objective—To examine the associations of cigarette prices, restrictions on public smoking, and health education with the odds of adult smoking and amount smoked daily.

Design—Multi-level analysis of adult (age 25+) smoking patterns in Canada's National Population Health Survey, after adding administrative data on prices, bylaws, and health education according to the survey respondent's place of residence.

Setting/subjects—Population based sample of Canadians age 25+ in households (n = 14 355).

Outcome measures—Smoking status, amount consumed daily.

Analysis—Logistic regression for smoking status, multiple regression for amount smoked, with controls for age, education, marital status; separate analyses for men and women.

Results—Cigarette prices were positively associated with the odds of being a non-smoker and negatively with amount smoked, for adults of both sexes. Per capita health education expenditures were positively associated with the odds of being a non-smoker and negatively with amount smoked—for men but not women. The restrictiveness of municipal bylaws limiting public smoking was positively associated with the odds of being a non-smoker and negatively with amount smoked—for women but not men. These results are independent of age, education, and marital status.

Conclusions—To be effective, tobacco control must comprise a mix of strategies as men and women respond differently to health education and restrictions on public smoking; taxation, reflected in higher cigarette prices, is the only one of these measures related to smoking for both sexes. This model permits calculations of the level of increase in each measure that is required to reduce the prevalence of smoking by a specified amount.

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Keywords: bylaws; education; policy; taxes

Comprehensive policies to curb cigarette smoking generally employ some mix of taxation, education, and legislation/regulation in order to encourage prevention of smoking, cessation, and protection from environmental tobacco smoke for non-smokers.¹⁻⁴ While the value of specific policies, particularly taxation,

has long been understood,^{1-3 5-7} the relative and independent contribution of these common policy measures to tobacco control is not well delineated, particularly for adults. Moreover, the policy effects on different population subgroups are generally unknown. This paucity of information arises from both substantive and methodological issues.

Conclusive analysis of tobacco control policies is complicated by the fact that the policy measures exist at a variety of aggregate levels (federal, state/province, municipal, work-site etc), while other factors known to be associated with smoking—notably age, sex, education, and other smokers in the household^{1-3 8-10}—are individual level variables. Since data on both individual characteristics and the policy context are not normally available from the same source, analyses of the impact of price or regulation, for example, typically use an ecological or econometric approach.¹¹⁻¹³ Unfortunately, this approach cannot readily account for individual differences. This has led to calls for the development of designs and analytical approaches to overcome this critical limitation.^{14 15}

Firstly, smoking policy studies that involve comparisons among jurisdictions have typically examined only one or two policies at a time. Taxation (or, more accurately, price) has been the most frequently studied policy, either on its own^{6 7 14 16 17} or in combination with clean air bylaws.^{11 12 18-20} On its own, taxation in the form of price increases appears to have more of an impact on young smokers than on established ones, and may affect both amount smoked and prevalence.^{6 7 20-23}

Secondly, complex policies have often been reduced to a single numerical score in these studies. Most commonly, clean air bylaws are defined as simply present or absent across a range of settings.^{11 12 18-20} Of those studies examining multiple policies, only one has identified distinct locales for restricted smoking,²⁴ and none has included other regulatory measures such as enforcement or signage requirements.

Finally, most of these policy studies focus on a single outcome variable, typically smoking status,^{11 18 25} amount smoked¹⁹ or per capita sales.^{14 17 25} Relatively few have examined both smoking status and amount smoked.^{13 16 20 21}

Few studies have examined two or more policies simultaneously while controlling for individual characteristics, and these have their own limitations. Chaloupka and colleagues^{20 21} have studied the association of price, clean air ordinances (bylaws), and purchasing restrictions on smoking by high school and college

Ontario Tobacco
Research Unit/Thomas
Stephens & Associates,
Manotick, Ontario,
Canada
T Stephens

CDC/NCCDPDHP,
Office on Smoking and
Health, Atlanta,
Georgia, USA
L L Pederson

Department of
Epidemiology and
Biostatistics,
University of Western
Ontario, London,
Ontario, Canada
J J Koval
J Macnab

Correspondence to:
Dr Thomas Stephens,
Ontario Tobacco Research
Unit/Thomas Stephens &
Associates, 1118 John Street,
Box 837, Manotick, Ontario
Canada K4M 1A7
tstephens@cyberus.ca

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Table 1 Policy variables used in this analysis (unweighted values)

Variable (units or possible range)	Mean	Standard deviation	Minimum	Maximum
Price, 200 cigarettes (\$C)	\$30.28	\$9.75	\$21.28	\$50.62
Public education expenditure/capita (\$C)	\$0.36	\$0.54	\$0.01	\$1.87
Clean-air bylaw restrictions (0–24)	5.3	4.7	0	16
Provisions for enforcing bylaws (0–2)	0.6	0.6	0	2
Bylaw signage requirements (0–2)	0.2	0.5	0	2

students. Stephens and associates examined the association of both price and clean air regulation on smoking in a national population,¹⁸ but smoking status was the only outcome variable and only a rough indicator was used for the regulations. Townsend and colleagues¹³ attempted to examine the association of prices and health education, but “health publicity” as an indicator of health education was not clearly defined and lacked appropriate quantification.

This study is therefore intended to answer the following questions about tobacco control: (1) What are the separate and joint associations of cigarette prices, restrictions on smoking in public places, and health education with (a) the likelihood of adult smoking, and (b) the amount smoked by adults?

(2) Are there subpopulations in which these policies have more apparent effect than in others? In particular, are the associations between policy and smoking the same for men and women?

Methods

OUTCOME MEASURES AND CONTROL VARIABLES

The outcome measures for adults were (a) smoking status (current smoker/non-smoker), and (b) amount smoked by daily smokers. “Current” smoker refers to both daily and non-daily smokers.

The individual level variables that were controlled for in the sex specific analyses were: age, education completed, and marital status.

Both outcome and control variables were taken from the cross sectional data of the public use data file of the National Population Health Survey (NPHS), conducted by Statistics Canada in 1994–95 on a nationally representative household based sample of 17 626 Canadians age 12 years and older.²⁶ (The NPHS is Canada’s equivalent of the US Health Interview Survey.) Data in this study were for 14 355 persons age 25 years and older. Using a standard set of questions on smoking (and other health behaviours and issues), interviewers completed in-home computer assisted data collection in June, August, and November 1994, and March 1995. Data of interest to this study were collected from one individual per household age 12 years or older, who was selected at random (although we analysed data for adults only in this case). Proxy data (from a third party) were accepted only in the case of illness or incapacity on the part of the selected interviewee; this amounted to only 4% of cases.

MEASURES OF TOBACCO CONTROL POLICIES

The independent variables in this study are:

- the price of cigarettes and recent price changes
- public tobacco control/health education expenditures
- municipal bylaws limiting smoking in public places
- provisions for enforcement of the bylaws
- requirements for posting signs about smoking bans.

These variables were taken from three distinct data sources, described below, and added to the NPHS data file according to respondent’s place of residence. All are from sources overlapping the 12 month data collection period of the NPHS. Table 1 summarises these variables.

Price of cigarettes

The retail price of cigarettes (and other commodities) in 26 major Canadian cities is monitored regularly by Statistics Canada. For current price, we used the value for July 1994 for a carton of 200 cigarettes.²⁷ The retail price reflects the dealers’ cost, profit, and federal and provincial taxes. We used municipality specific values for all the major cities in Canada and provincial averages for other locations within the same province (within-province variation is much smaller than inter-province variation in price). It should be noted that the federal government and five provincial governments reduced their excise taxes on cigarettes in February 1994, just before the period under study. These tax cuts effectively reduced cigarette prices by 50% for about two thirds of the Canadian population. After the initial reduction in February, prices were stable for the balance of the survey data collection period.

Public tobacco control expenditures

In Canada, the provinces play a major role in the delivery of tobacco control programmes, primarily in the form of health education and bylaw enforcement. In order to quantify this role, which varies substantially from province to province and over time, we used dollar figures for expenditures during the fiscal year April 1994 through March 1995 collected from each of the 10 provincial health departments.²⁸ Population estimates from the 1991 Census of Canada were used to calculate per capita expenditures.

Municipal bylaws

A federal government survey provided a detailed description of restrictions on public smoking in place in 1995.²⁹ We rated 367 bylaws for restrictiveness, as follows: with codes similar to those in a Centers for Disease Control and Prevention (CDC) study of state laws,³⁰ we scored bylaw strength 0–2 for each of 12 locations within the municipality (0 = no limits on smoking; 1 = designated smoking areas required or allowed; 2 = 100% smoke-free); restrictiveness was the sum of location specific scores. The 30 municipalities that did not respond to the survey were scored as zero in restrictiveness; the vast majority of these were small communities, which are less

likely to have any restrictions on public smoking.³¹

Municipal signage requirements

Signs may heighten a bylaw's effectiveness by increasing its visibility. Our scoring scheme gave points for measures that raise the likelihood of self enforcement, which is relied upon in a wide variety of settings.³² Scores are based on municipality specific descriptions of signage regulations and were scored 0–2, by awarding one point for requiring both symbols and words on signs and one point for requiring a sign at the entrance of public buildings with restrictions. The average score was low, as 297 municipalities out of 367 had no provision for signage. This variable was treated as binary (signs required/not required) in the analyses.

Enforcement of clean air bylaws

While self regulation of public smoking is important for compliance, it is seldom adequate. Official enforcement is thus fundamental for bylaw effectiveness.^{2 23} In the absence of data on actual enforcement effort, we scored the *provisions* for enforcement contained in each bylaw, again using data specific to each municipality, allocating 0–2 points as follows: one point for having a designated enforcement official, and one point for fines that escalate with repeated offenses. Since 193 of 367 municipalities had no provisions for enforcement and there was little variation among the remainder, we treated this variable as binary in the analyses.

LINKAGE OF DATA SETS

Data on these five tobacco control policies were added to every survey record in the NPHS data file, using detailed geographic codes for the municipal level data (prices and bylaws). Since these were not available on the public use file, the linkage was carried out by Statistics Canada on their master file. Per capita tobacco control expenditures were added to the survey file using the respondent's province of residence.

ANALYSIS

After linking the policy variables to the survey file, 8615 (49%) of the survey cases had no bylaw data—that is, these respondents lived in areas for which the bylaw study provided no data. Because the coverage of the bylaw study had been extensive, we suspected that these cases of missing data were from communities with no bylaws. To confirm this, we contacted a random sample of 40 of these communities,

stratified by size and region, to ascertain their 1995 bylaw status. Thirty two of them (80%) confirmed that they had no clean air bylaws as of mid 1995. Accepting that there would be some misclassification on this variable, we imputed “no restrictions/enforcement/signage” for all survey cases missing bylaw data, thereby increasing the total usable sample for the analyses to 14 355 cases age 25 years and older. Since the survey oversampled residents of small municipalities and rural areas, the cases with imputed data were in fact far fewer than 49% of the weighted sample used in analysis.

Logistic regression was used to model smoking status (current/not) and multiple linear regression to model amount smoked. Age, education (no high school/high school completed/post-secondary), and marital status (married/not married) were controlled in the regressions, which were conducted separately for men and women. As the distribution of expenditures per capita was highly skewed, we used the square root of this value in the regressions. Enforcement provisions and signage were treated as binary variables (some/none), while the scores for price and bylaw restrictiveness were entered into the model as described above. Because of the complex sample design underlying the survey, we calculated exact variances using the bootstrap method.³³ There was no collinearity among the policy variables.

Results

SMOKING STATUS

We found significant associations between *each* of these tobacco control policies and the odds of being a non-smoker—while controlling for individual differences and the other policies. The associations were all in the expected directions but were often different for men and women.

Tobacco taxation (price) was positively related to the odds of being a non-smoker for both sexes—that is, as price increases, the odds of an individual being a non-smoker also increase. This was the only policy to have the same association for both men and women, although it was stronger for men (table 2). The price elasticity for type of smoker for men is thus –0.5 (based on a 30.4% decrease in odds of being a smoker associated with 63% price increase), and for women it is –0.3 (30.4/102).

Tobacco control expenditure per capita was positively related to the odds of being a non-smoker for men, but not for women. In contrast, the restrictiveness (severity and extent) of municipal bylaws limiting public smoking was positively related to the odds of being a non-smoker for women, but not for men. Interestingly, however, requiring prominent signs to inform the public of the non-smoking bylaw and having written provisions for enforcement (designating an enforcement authority, escalating fines for repeat offences) were both significantly related to the odds of being a non-smoker for men, but not for women.

Table 2 Multivariate odds of being a non-smoker associated with various tobacco control policies, Canada, age 25+

	Men			Women		
	Odds ratio	95% CI	p Value	Odds ratio	95% CI	p Value
Price of cigarettes	1.02	1.00 to 1.03	0.01	1.01	1.00 to 1.02	0.05
Public education expenditure	1.36	1.09 to 1.70	0.01	1.13	0.91 to 1.39	NS
Clean air bylaw restrictions	0.99	0.97 to 1.01	NS	1.02	1.00 to 1.04	0.03
Provisions for enforcing bylaw	1.21	1.00 to 1.46	0.05	0.99	0.83 to 1.19	NS
Bylaw signage requirements	1.25	1.01 to 1.55	0.04	0.87	0.70 to 1.08	NS

CI, confidence interval; NS, not significant

Table 3 Amount smoked daily associated with various tobacco control policies, Canada, daily smokers age 25+, 1996-97

	Men			Women		
	Estimate (No. cigs)	95% CI	p Value	Estimate (No. cigs)	95% CI	p Value
Tax cut in Feb 1994	12.4	0.8 to 24.0	0.01	9.3	-0.7 to 19.3	0.05
Current price of cigarettes	0.1	-0.9 to 0.3	NS	0.1	-0.1 to 0.3	NS
Interaction: current price × tax cut in February 1994	-0.3	-0.6 to -0.0	0.02	-0.2	-0.5 to 0.0	0.07
Public education expenditure	-2.7	-4.6 to -0.8	< 0.001	-0.9	-0.1 to 0.3	NS
Clean air bylaw restrictions	-0.1	-0.2 to 0.1	NS	-0.1	-0.3 to 0.1	0.05
Provisions for enforcing bylaw	-0.3	-1.6 to 1.0	NS	0.7	-0.8 to 2.2	NS
Bylaw signage requirements	0.0	-1.9 to 2.0	NS	0.6	-1.4 to 2.5	NS

AMOUNT SMOKED DAILY

The associations between these policies and the amount smoked by daily smokers (table 3) were similar to those just described for smoking status. The substantial tax cut in February 1994, affecting about two thirds of the population, was significantly related to the amount smoked by both men and women—that is, the larger the drop, the more the amount smoked, from 9.3 to 12.4 cigarettes more for women and men, respectively.

While there was no *direct* association between the current price of cigarettes and amount smoked, there was an interaction of the tax cut and current price of cigarettes. In the five provinces that experienced a recent tobacco tax cut (but still retained some variation in price), there was a negative association between price and amount smoked by male daily smokers. There was a similar tendency for women.

In a fashion similar to the association with smoking status, health education expenditures were significantly inversely related to the amount smoked by men, but not women, while the restrictiveness of bylaws was significantly inversely related to the amount smoked by women, but not men. Neither bylaw sign requirements nor enforcement provisions were related to the amount smoked daily by men or women smokers.

Discussion

This study set out to assess the associations of cigarette prices, restrictions on smoking in public places, and health education on (a) the likelihood of adult smoking, and (b) amount smoked daily. Our findings demonstrate significant independent associations for each of these policy measures, after controlling for sex, age, education level, and marital status. Moreover, these policy interventions tend to have an association with smoking status that is similar to its association with amount smoked. However, these associations are sometimes different for men and women. They may be summarised as follows:

- as the price of cigarettes increases, the odds of being a smoker decline; this is true for both men and women, but more so for men
- in the Canadian provinces that reduced tobacco taxes in 1994, the amount smoked by men and women smokers is much greater than in the provinces that maintained taxes; further, within the tax cut provinces, there is

a negative association between current price and amount smoked

- as tobacco control expenditures increase, the odds of not smoking increase for men, but not women, and the average amount smoked by men, but not women, declines
- with increasing restrictions on smoking in public places, the odds of being a non-smoker increase for women but not men, while the amount smoked daily declines
- where there are the provisions for bylaw enforcement, the odds of being a non-smoker also increase for men, but not women; there is no association with amount smoked for either sex
- similarly, as the visibility of a no-smoking bylaw increases through prominent signage, the odds of being a non-smoker increase for men, but not women; there is no association with amount smoked for either sex.

These associations are consistent with previous studies showing the positive contribution of tobacco taxes and clean-air bylaws to tobacco control^{3 6 7 11 12 16-18 20 21} and the greater price sensitivity of men than women.³ Although there is much less literature on the sex specific effects of smoking restrictions, our finding that women's smoking is more strongly associated than men's with the existence of clean air laws is consistent with results from the Massachusetts Tobacco Survey³ but inconsistent with an earlier study by Chaloupka.³⁴ The sex specific effects of clean air restrictions and public education both need further study.

The contributions made by this study are: (a) demonstrating the independent and comparative effects of these three major tobacco-control policies, and (b) quantifying the contribution of public health education and demonstrating its sex specific effects, while (c) controlling for individual differences that are usually overlooked in comparing tobacco control in different jurisdictions.

There are two fundamental implications of these findings for tobacco control:

- (1) since price (or taxation) is the only policy associated with the smoking behaviour of both men and women, after controlling for age, education, and marital status, it should be an integral part of any serious, comprehensive tobacco control policy
- (2) since health education and clean air bylaws are associated with the smoking behaviour of adults differently according to sex, both should be part of comprehensive tobacco control policy in order to reach the entire population.

Having established the independent odds ratios for being a smoker in the face of these three basic tobacco control measures, it is theoretically possible to specify how smoking prevalence might change in response to a given change in policy. For example, prevalence should drop from 25% to 23% among adult men in Canada if tobacco prices are raised 21%, or by \$C0.60 over the 1994-95 baseline level (table 4). To achieve this same gain among women, however, prices would have to be raised 69%. To reach a prevalence level of

Table 4 Theoretical policy changes required to achieve specified reductions in the prevalence of smoking, by sex, adults age 25+, Canada

	To reduce prevalence from 25% to:			
	23%		20%	
	Men	Women	Men	Women
Target for not smoking (%)	77	77	80	80
Target odds, not smoking (p/1-p)	3.3	3.3	4	4
Base odds, not smoking (p/1-p)	3	3	3	3
% increase in odds required	10	10	33.3	33.3
Change policies as follows:				
Increase price (%)	21	33	69	111
i.e. add \$/pack	\$0.60	\$0.98	\$2.01	\$3.26
Or increase education spending (%)	34.6	?	115.3	?
i.e. add \$/capita	\$0.30		\$1.00	
Or ... upgrade restrictions to bans (%)	?	73	?	244
i.e. number of changed locations		4.3		14.5

? = impact unclear, according to the model.

20% would require price increases of 33% for men and 111% for women.

While such increases over a short period may prove politically impractical, they are not the only effective measure available. A prevalence level of 23% among men should be achieved by increasing health education spending by 35%, while increasing restrictions on public smoking by 73% should have a similar effect on women, according to our model (table 4). Alternatively, some combination of policy enhancements could be enacted, bearing in mind that the effects are different for the two sexes.

This study illustrates the value of multi-level analysis in epidemiology³⁵ and has added to the body of knowledge in assessing the associations of three tobacco control policies with smoking patterns in a general population. However, refinements are needed. These should include a more detailed and precise measure of health education, quantifying type of activity as well as per capita expenditure, and accounting for actual enforcement of clean air bylaws and not just provisions for it. Even more basically, it would be important to minimise the imputation of any policy variables.

In the current study, the proportion of cases for which "no bylaw" had to be imputed may have reduced the apparent association with smoking. To assess this possibility, we repeated the analyses with only those cases that had no missing bylaw data. The result was very little change in the values of the odds ratios or multiple regressions, but fewer of the associations were significant because of the smaller sample size. The fact that the relationships remained relatively constant despite a substantial reduction in the sample size indicates the robustness of the findings. We opted to report data based on the larger sample with the imputed data.

Even without our data problems, however, this approach to analysis must make some assumptions about the policy context in which the individual lives. For example, our analysis assumes the smoker always purchases cigarettes in his or her own province and that the clean air bylaws in the municipality where one works are not substantially different from those where one lives. Few population based surveys or other data sources are likely to have the level of detail required to avoid these assumptions, and even with them, we have

What this paper adds

Comprehensive tobacco control policies usually consist of some mix of taxation, education, and legislation/regulation. The value of specific policies, particularly taxation and clean indoor laws, is well documented, but the *relative* and *independent* contribution of these common policy measures to tobacco control is not well delineated, particularly for adults. Moreover, with the exception of taxation, the policy effects on different population subgroups are also largely unknown.

This study demonstrates the independent and comparative effects of these three major tobacco control policies, and quantifies the contribution of public health education and demonstrates its sex specific effects, while controlling for individual differences that are usually overlooked in comparing tobacco control in different jurisdictions. Since price (taxation), clean air bylaws, and health are differentially associated with the smoking behaviour of adults according to sex, all three should be part of comprehensive tobacco control policy.

found evidence of the potential impact of all three tobacco control measures. Further study is needed to establish whether the sex differences reported here are reliable, and, if so, what the reasons might be.

Replications and extensions of this study should include other populations, especially youth, using more recent data, from jurisdictions where the changes are not confounded by an abrupt change in tobacco taxation, as was the case in Canada in 1994. Sample size will be important, and it would be very desirable to avoid the extent of imputation of bylaw data that characterised this study. Further, the additional power of a longitudinal design to detect change in response to policy would be a welcome improvement over the cross sectional data used in this analysis. Longitudinal data have been used to good effect by Tauras and Chaloupka in studies of youth smoking.³⁶ Nevertheless, this study has clearly shown the importance of taxation, restrictions on public smoking, and health education as three pillars of comprehensive tobacco control policy among adults.

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