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Obesity, smoking, and cigarette taxes: Evidence from the Canadian Community Health Surveys

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ABSTRACT

Objectives: Recent studies suggest an ambiguous relationship between obesity and cigarette taxes. We employ Canadian data to evaluate the effects of cigarette taxes on smoking and obesity.

Methods: We use a simple reduced form approach and exploit the significant cross-province differences that exist between Eastern and Western Canada to estimate the effects of higher cigarette taxes using aggregate health region and individual level data from the 2003 and 2005 waves of the Canadian Community Health Surveys (CCHS).

Results: OLS estimates based on health regions data suggest that a 10% increase in cigarette taxes is significantly correlated with a 4–5% increase in the percentage of obese population. We also find cigarette tax elasticities of between -0.2 and -0.4 with respect to the percentage of smokers. Estimates from individual level data are similar.

Conclusions: In tandem, these results offer support to the possibility that health benefits from higher cigarette taxes and lower smoking, might be partially offset by a corresponding increase in obesity levels.

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1. Introduction

Much research suggests that smoking is correlated with weight loss. In this respect, recent studies by economists suggest conflicting views on the possible effects of cigarette taxes with respect to obesity. Using individual level data from the Behavioral Risk Factor Surveillance Surveys (BRFSS) between 1984 and 1999, Chou et al. [1] offer evidence that within-state price increases resulted in a significant increase in the proportion of obese population. In contrast, Gruber and Frakes [2] also employ individual level data from the 1984 to 2002 waves of the BRFSS, but find that higher cigarette taxes are significantly correlated with a lower average body mass index (BMI). Baum [3] suggests that the difference in results obtained between these stud-

ies is not because of the use of cigarette taxes as opposed prices, but possibly due to how state specific linear time trends are incorporated.

Employing similar BRFSS data from 2000 to 2005, DeCicca [4] finds that higher cigarette taxes increased the proportion of obese female and older male smokers and also reduced the fraction of clinically underweight female smokers. Using the 1981–2002 waves of the National Longitudinal Survey of Youth (NLSY79), Baum [3] similarly finds that cigarette costs significantly increase BMI and the probability of being obese and overweight. In summary, recent research offers support to the idea that benefits of higher cigarette taxes (from reduced smoking) may be muted or even offset by negative spillovers through an increase in the percentage of overweight and obese populace.

We attempt to contribute to the literature by employing Canadian data. The use of Canadian data is attractive for several reasons. First, while Canadian obesity rates are lower than corresponding U.S. trends, Canada also experi-

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enced a significant rise in obesity rates during the 1980s and the 1990s – the same time period in which obesity in the U.S. increased dramatically. Specifically, from 1978/1979 to 2004, the percentage of Canadian adults who were obese rose from 14% to 23%.¹ Second, we are able to exploit the significant variation in cigarette taxes between provinces. Finally, our exercise has important implications for Canadian policy given the dearth of contemporary research on: (1) smoking and obesity; and (2) the effects of cigarette taxes on adult smoking in that country.

Our contribution to the literature is premised on the use of data from the 2003 and 2005 waves of the Canadian Community Health Surveys (CCHS). We use these data to estimate the effects of provincial cigarette taxes on the percentage of obese population and daily smokers in 112 health regions in Canada in 2003 and 2005, which allows us to exploit cross-province and time-series variation. The sensitivity of these findings is evaluated by using individual level data (156,737 observations) from the public use files of these surveys. Specifically, we use the individual level data to estimate the effects of cigarette taxes on the likelihood of obesity and daily smoking. The data also allow us to evaluate whether daily smokers are less likely to be obese, controlling for all else.

2. Smoking and obesity

There has been a recent spate of research that have investigated the effects of a variety of economic factors – such as technological change, maternal labor supply, and social interactions – on obesity in the United States and Canada. These include Philipson and Posner [5], Lakdawalla and Philipson [24], Cutler et al. [21], Auld and Powell [6], and Chia [7].

The focus of this study is on the effects of cigarette taxes. In this respect, DeCicca [4] offers a comprehensive overview of the epidemiology between smoking and obesity. First, several clinical studies find smoking cessation to be associated with weight gain (for example [8–11]). In terms of the magnitude of change, some studies suggest the weight gain to be modest while others imply more severe changes. Specifically, while the U.S. Department of Health and Human Services [12] and Williamson et al. [13] suggest that smoking cessation is associated with a weight gain of 5–10 pounds, evidence from Klesges et al. [14] demonstrates that weight gain could actually be between 10 and 15 pounds.

The relevant question then is: why does smoking result in weight gain? Two potential explanations stem from human physiology. First, a significant amount of research have established that smoking results in a higher metabolic rate for the body (for example [15,16]). This is because smoking results in a higher production of a hormone called 'catecholamine', which causes a faster heart beat, and therefore, more caloric expenditure when the body is at rest. Consequently, 'quitters' tend to burn fewer calories, which would result in weight gain absent any offsetting

activity such as exercise. Second, smoking (because of nicotine) is associated with suppressed appetite.

The third and final explanation for a potential positive correlation between smoking cessation and obesity relies on simple economics. Specifically, a significant amount of research has established that smoking prevalence is especially high among low income households. Significant increases to cigarette taxes (and therefore, prices) would impact the budget constraint of such households, reducing disposable income available for the consumption of other commodities. Therefore, individuals might then substitute towards the consumption of cheaper but less nutritious food (such as fast food) which increases the likelihood of obesity.

3. Methods

3.1. Canadian cigarette taxes

Cigarette taxes in Canada are basically determined by (federal and provincial) excise taxes. Although, we limit ourselves to exploiting 2 years of tax data (2003 and 2005) across provinces, it is relevant to note the historically rich variation in Canadian cigarette taxes. Specifically, there was a steep decline in Canadian taxes in February 1994, which was the result of a tax cut of roughly 50% that was imposed by both federal and eastern provincial governments (Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island) aimed at curbing cross border smuggling of contraband tobacco in the early 1990s.² While several provinces implemented significant changes in excise taxes between January of 2001 and June of 2002, pronounced differences between Western and Eastern provinces persisted in 2003 and 2005.

Specifically, in 2005, Ontario, Quebec, and New Brunswick had the lowest excise taxes at (roughly) \$14, \$17, and \$19 a carton (200 cigarettes). Corresponding taxes in Nova Scotia and Prince Edward Island were slightly higher at (approximately) \$20 and \$23 a carton, respectively. The highest per carton excise taxes in eastern Canada were in Newfoundland at approximately \$33. Corresponding taxes in Western Canada, on average, were much higher at \$27.65, \$28.05, \$24.85, and \$32.85 in Manitoba, Saskatchewan, Alberta, and British Columbia, respectively.

3.2. The Canadian Community Health Surveys (CCHS)

In 1991, the National Task Force on Health Information established by the Federal Government of Canada, pointed out numerous deficiencies with the health information system. As a result, the Canadian Community Health Survey (CCHS) was conceived by the Canadian Institute for Health Information (CIHI), Statistics Canada and Health Canada. As noted in Statistics Canada documentation (<http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3226&lang=en&db=imdb&adm=8&dis=2>): "The CCHS is a cross-

¹ Tjepkema M. Adult obesity. Health reports (Statistics Canada, Catalogue 82-003) 2006;17(3):9–25.

² Please see Gruber et al. [35] for further details.

sectional survey that collects information related to health status, health care utilization and health determinants for the Canadian population. It relies upon a large sample of respondents and is designed to provide reliable estimates at the health region level. The CCHS has the following objectives: (1) Support health surveillance programs by providing health data at the national, provincial and infraprovincial levels; (2) provide a single data source for health research on small populations and rare characteristics; (3) Timely release of information easily accessible to a diverse community of users; and (4) Create a flexible survey instrument that includes a rapid response option to address emerging issues related to the health of the population.” In essence, the objective of the CCHS is to provide cross-sectional estimates of health determinants, health status and health system utilization at a sub-provincial level to both provincial and federal levels of government.

We employ individual level as well as aggregate data across different health regions from the Canadian Community Health Surveys (CCHS).³ These data are collected from individual survey responses through personal and telephone interviews. We employ cycles 2.1 (2003) and 3.1 (2005) of these surveys which contain data on responses from roughly 130,000 individuals across 137 health regions.

3.3. Empirical strategy

With respect to data aggregated to the level of health regions, we rely on the following empirical model in order to evaluate the impact of cigarette taxes on obesity and smoking, pooling data from the 2003 and 2005 waves of the CCHS:

$$OBESE_{ijt} \text{ or } SMOK_{ijt} = \beta_0 + \beta_1 TAX_{jt} + \beta_2 UNEMP_{ijt} + Z_{ij} + \Sigma REG_j + u_{ijt} \quad (1)$$

where i represents the health region, j the province, and t the year. u_{ijt} is the error term, which is assumed to be independently and identically distributed. Employing the two waves of the CCHS results in a sample of 223 observations.⁴ We use both levels and log-log models to estimate (1).

$OBESE_{ijt}$ is the percentage of population within a health region that is obese. Obesity is defined according to Health Canada guidelines that are consistent with the definition used by the U.S. Centers for Disease Control and Prevention (CDC) and is based on an individual's body mass index (BMI), which is calculated by dividing weight (in kilograms) by height (in metres) squared. An index value equal to or exceeding 30 implies obesity. $SMOK_{ijt}$ is the other dependent variable we use and is the percentage of daily smokers in a health region.

³ Health regions, in many cases, roughly correspond to census sub divisions. According to the definition available from the Statistics Canada website: 'Health regions are legislated administrative areas defined by provincial ministries of health. These administrative areas represent geographic areas of responsibility for hospital boards or regional health authorities'.

⁴ There is a single missing observation for one of the 112 health regions in 2005.

The key covariate of interest is TAX_{jt} which is the sum of provincial and federal cigarette excise taxes per carton (in real dollars). $UNEMP_{ijt}$ is the annual unemployment rate (obtained from Statistics Canada) and varies over time for each health region. Z_{ij} represents other potential determinants of obesity and smoking, specific to each health region and that are fixed over time. Specifically, we use the following covariates: the percentage of adults with a high school degree; the percentage of adults with a postsecondary degree; the percentage of low income households; average personal income; immigrants as a percentage of total population; visible minorities as a percentage of total population; percentage of families that are lone parent; and finally, the percentage of population living in urban areas. These explanatory variables are constructed from 2001 Census of Canada data, and then matched to the appropriate health region.^{5,6}

We also employ regional fixed effects (ΣREG_j) in order to account for unobserved policy shocks.⁷ While employing province specific fixed effects is certainly desirable, their inclusion removes much of the identifying variation in cigarette taxes, given the limited time-series variation available from our data. However, relying on regional fixed effects is certainly a plausible strategy given the strong region specific variation in anti-smoking policies (such as cigarette taxes) discussed above and observed from the data.

A comparable model is used when the data are from the same surveys, but at the individual level.

$$OBESE_{kjt} \text{ or } SMOK_{kjt} = \beta_0 + \beta_1 TAX_{jt} + \beta_2 MALE_{kjt} + \beta_3 EMP_{kjt} + \Sigma AGE_k + \Sigma REG_j + u_{ijt} \quad (2)$$

where k denotes the individual, j the province of residence, and t the year. u_{kjt} is the error term, which as before, is assumed to be independently and identically distributed. Employing the two waves of individual level data from the CCHS results in a sample of 156,737 observations. $OBESE_{kjt}$ is a dummy variable that is 1 if the individual is obese and 0 otherwise. This variable is constructed from an individual's body mass index (BMI), which turn is calculated by dividing the survey respondent's self reported weight (in kilograms) by height (in metres) squared. Analogously, $SMOK_{kjt}$ is 1 if the individual admits to being a daily smoker and is 0 otherwise. $MALE_{kjt}$ is a 1–0 dummy variable to capture gender differentials while EMP_{kjt} is also a 1–0 binary variable that denotes whether the individual is in the labor force. ΣAGE_k are age specific dummies for individuals aged

⁵ The Canadian Census provides a statistical profile of the Canadian population is conducted every five years. Participation is mandatory. For further details please refer to <http://www12.statcan.ca/census-renewement/2006/ref/dict/overview-apercu/index-eng.cfm>.

⁶ A relevant concern is whether this model is comparable to those used by previous studies. This specification is in fact, quite comprehensive in comparison to other papers on smoking that have used aggregate level data. For example, Gruber et al. [35] use province-year Canadian data from 1981 to 1999, and apart from cigarette taxes, just employ per capita income, unemployment rates, and province and year fixed effects.

⁷ We construct regional fixed effects for: the Atlantic provinces, Ontario, Quebec, and Manitoba and Saskatchewan. The use of province fixed effects, is of course, not possible because of the province specific variation in cigarette taxes.

20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, and 60 and older (the reference category being 15–19-year olds). ΣREG_j are similarly defined regional dummies relative to those employed with respect to the health region data. Unlike the health region data, we cannot match census level covariates to the survey data as the public use files do not allow us to identify the health region the individual respondent is located in.

Our use of aggregate health region as well as individual level data is deliberate. Most studies have relied on surveys, and thus, it is important to use similar data in order to compare our findings with estimates from other research. However, Moulton [17] points out that evaluating the efficacy of aggregate national (or sub-national) policies with individual survey level data may lead to confounded inference through artificially small standard errors. That is the motivation of employing data aggregated at the health region. It is also important to note that coefficient estimates of cigarette taxes with respect to aggregate and individual data are not comparable. Estimates with respect to aggregate data yield the efficacy of tax policy at the population level, while results from survey data denote the effects of taxes on the likelihood of obesity. However, there should still be consistency between the two, as it would be difficult to accept that higher cigarette taxes can result in more obesity among the populace, if we are unable to obtain a statistically significant association at the individual level.

4. Results

4.1. Estimates from health regions

Table 1 contains summary statistics for all these variables. Table 2 contains OLS baseline estimates of the impact of cigarette taxes with respect to the percentage of obese population (across health regions) using simple log-log and levels specifications. As noted above, the data are from the 2003 and 2005 waves of the Canadian Community Health Surveys (CCHS). Columns 1 and 2 consist of estimates from levels models, while columns 3 and 4 contain results from log-log specifications. Columns 1 and 3 are based on models that only employ cigarette taxes, unemployment rates, and regional fixed effects. In contrast, columns 2 and 4 also use other controls. Standard errors of all coefficient estimates are clustered by health region.

Empirical estimates are similar across levels and log-log models. Specifically, coefficient estimates of cigarette taxes are positive and statistically significant (at either the 1% or 5% levels) across all columns. Results from columns 1 and 3 suggest tax elasticities between 0.4 and 0.5. The range of elasticities remains robust with the addition of other covariates. In terms of other explanatory variables, estimates from the log-log model reveal that health region specific population, the percentage of high school graduates, and the percentage of visible minorities are significantly correlated with a drop in the percentage of obese population. On the other hand, higher average personal income and more immigrants are significantly correlated with an increase in the proportion of obese individuals.

Table 3 contains OLS estimates of the effects of cigarette taxes on the percentage of daily smokers, with standard

errors clustered by health regions. Columns 1(4) and 2(5) contain estimates from levels (log-log) specifications with column 2(5) also consisting of more controls. Instead of current taxes, columns 3 and 6 contain estimates of 2-year lagged cigarette taxes (with other covariates).

As was the case with obesity elasticities, cigarette tax elasticities are remarkably similar across specifications. Both columns 1 and 3 suggest that a 10% increase in cigarette taxes are significantly correlated, on average, with a 4% decline in the percentage of smokers within and across health regions. Coefficient estimates of cigarette taxes are slightly lower in absolute value in columns 2 and 4, but the implied elasticities are still comparable at -0.2 . Finally, we note that columns 3 and 6 suggest that (roughly) a 10% increase in lagged cigarette taxes is significantly correlated with a 1% decline in the percentage of daily smokers. These results offer support to the belief that taxes impact smoking over a period of time, which then affects the probability of weight gain.

4.2. Estimates from individual level data

We test the sensitivity of our findings by employing individual level survey data from the same waves of the CCHS. Table 4 contains OLS (column 1) and logit (column 2) estimates of the effects of cigarette taxes on individual level obesity. Both columns contain estimates of cigarette taxes, controlling for regional fixed effects and other individual level explanatory variables (dummies for gender, employment, and age). Standard errors of OLS and logit coefficient estimates are clustered by province, in order to account for unobserved correlations across individuals within the same province. Logit coefficient estimates are in terms of marginal effects. Coefficient estimates of age dummies are not reported for the sake of brevity, but are available on request.

OLS and logit estimates are strikingly similar across columns. Coefficient estimates of cigarette taxes are positive and statistically significant (at the 5% level) with implied elasticities close to 0.49, suggesting that a 10% increase in cigarette taxes is significantly associated with a 4.9% rise in the probability of being obese, controlling for all else. Although not directly comparable, these estimates correspond with findings from the aggregate data. Being a male is significantly associated (at the 1% level) with roughly a 0.02 increase in the probability of obesity. On the other hand, employment is significantly (at the 1% level) with a 0.04 reduction in the probability of obesity, controlling for all else.

Table 4 also contains OLS (column 3) and logit (column 4) estimates of the effects of cigarette taxes on the probability of being a daily smoker. As before, logit coefficient estimates are in marginal effects and the standard errors of OLS and logit estimates are clustered by province. In both columns, coefficient estimates of cigarette taxes are negative and statistically significant at the 5% level. The implied elasticities are -0.49 , and are similar in spirit to results in Table 3.

Columns 5 and 6 contain some final sensitivity analyses. The individual level data allow us to test the underlying hypothesis of our research. In other words, whether

Table 1
Descriptive statistics.

Variable (source)	Mean	Standard deviation	Min	Max
<i>Health Region Data (223 Observations)</i>				
Percent of daily smokers (CCHS)	18.812	3.806	7.3	35.4
Percent of obese population (CCHS)	18.427	4.356	7.6	32.8
Cigarette taxes (per 200 cigarettes) – Federal Ministry of Canada	21.749	7.162	14.05	32.85
Unemployment rate (COC)	7.743	4.892	2.8	60.2
Population (COC)	183,033.1	251,012.8	8143	1,872,377
Percent of high school graduates (COC)	81.719	16.331	54.7	98.6
Percent of postsecondary graduates (COC)	51.84	11.204	32.3	93.3
Incidence of low income (%) (COC)	11.834	4.046	5.3	39.1
Average personal income (COC)	27,454.3	6005.422	17,917	89,667
Percent of immigrants (COC)	10.30987	10.624	0.5	54
Percent of lone parent families (COC)	14.999	4.434	8.5	63
Percent of visible minorities (COC)	5.786	10.1111	0.2	59
Percent of urban population (COC)	64.094	22.08	7.4	100
<i>Individual Level Data – 2003 and 2005 CCHS (156,737 observations)</i>				
Obesity	0.185	0.388	0	1
Daily smoker	0.23	0.44	0	1
Male	0.48	0.49	0	1
Employed	0.85	0.35	0	1
Age 15–19 dummy	0.059	0.236	0	1
Age 20–24 dummy	0.085	0.28	0	1
Age 25–29 dummy	0.104	0.305	0	1
Age 30–34 dummy	0.119	0.324	0	1
Age 35–39 dummy	0.124	0.33	0	1
Age 40–44 dummy	0.131	0.34	0	1
Age 45–49 dummy	0.117	0.322	0	1
Age 50–54 dummy	0.1297	0.34	0	1
Age 55–59 dummy	0.1302756	0.34	0	1

CCHS = Canadian Community Health Surveys, COC = Census of Canada.

Table 2
Obesity and cigarette taxes – pooled estimates employing health region data from the 2003 and 2005 Canadian Community Health Surveys (CCHS).

	Levels (1)	Levels (2)	Log-Log (3)	Log-Log (4)
Cigarette tax	0.358 [0.097]***	0.319 [0.114]***	0.470 [0.157]***	0.397 [0.158]**
Tax elasticity	0.539	0.480		
Unemployment rate	–0.048 [0.067]	–0.020 [0.130]	–0.007 [0.051]	0.087 [0.062]
Population		0.00007 [0.00002]***		–0.101 [0.013]***
Percent of high school graduates		–0.037 [0.063]		–0.551 [0.296]*
Percent of postsecondary graduates		–0.033 [0.093]		0.017 [0.243]
Incidence of low income (%)		0.115 [0.178]		0.084 [0.093]
Average personal income		0.000 [0.000]		0.376 [0.210]*
Percent of immigrant population		0.102 [0.104]		0.145 [0.044]***
Percent of lone parent families		–0.058 [0.137]		–0.117 [0.109]
Percent of visible minorities		–0.063 [0.103]		–0.086 [0.036]**
Percent of urban population		–0.034 [0.020]*		–0.043 [0.057]
Regional fixed effects	Yes	Yes	Yes	Yes
Adjusted R ²	0.247	0.323	0.227	0.394
Number of observations	223	223	223	223

Notes: The regressions have been run employing aggregate health region data. Standard errors are in square brackets beneath coefficient estimates and are clustered by health region.

* Statistical significance at the 10% level.

** Statistical significance at the 5% level.

*** Statistical significance at the 1% level.

Table 3

Smoking and cigarette taxes – pooled estimates employing health region data from the 2003 and 2005 Canadian Community Health Surveys (CCHS).

	Levels (1)	Levels (2)	Levels (3)	Log-Log (4)	Log-Log (5)	Log-Log (6)
Cigarette tax	-0.401 [0.087]***	-0.193 [0.020]***		-0.660 [0.138]***	-0.400 [0.114]***	
Tax elasticity	-0.464	-0.223				
Two-year lagged cigarette tax			-0.064 [0.020]***			-0.129 [0.037]**
Tax elasticity			-0.111			
Unemployment rate	0.152 [0.061]**	0.094 [0.071]	-0.033 [0.071]	0.126 [0.045]***	0.051 [0.045]	-0.041 [0.038]
Population		0.000 [0.000]	0.000 [0.000]		0.011 [0.010]	0.011 [0.010]
High school		-0.092 [0.041]**	-0.060 [0.039]		-0.552 [0.215]**	-0.362 [0.207]*
Postsecondary		-0.170 [0.060]**	-0.205 [0.058]***		-0.303 [0.176]*	-0.446 [0.170]***
Economic families – incidence of low income		0.288 [0.116]**	0.287 [0.115]**		-0.053 [0.067]	-0.070 [0.067]
Average personal income		0.000 [0.000]***	0.000 [0.000]***		0.405 [0.152]***	0.391 [0.152]**
Immigrant population		-0.254 [0.068]***	-0.274 [0.066]***		0.024 [0.032]	0.018 [0.031]
Lone parent		0.199 [0.089]**	0.251 [0.085]***		0.312 [0.079]***	0.403 [0.074]***
Visible minorities		0.009 [0.067]	0.021 [0.066]		-0.134 [0.026]**	-0.128 [0.026]**
Urban population		-0.004 [0.013]	-0.007 [0.013]		0.096 [0.041]**	0.080 [0.041]*
Regional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R ²	0.150	0.590	0.600	0.169	0.556	0.556
Number of observations	223	223	223	223	223	223

Notes: The regressions have been run employing aggregate health region data. Standard errors are in square brackets beneath coefficient estimates and are clustered by health region.

- * Statistical significance at the 10% level.
- ** Statistical significance at the 5% level.
- *** Statistical significance at the 1% level.

daily smokers are less likely to be obese, controlling for the effects of other factors. Columns 5 and 6 contain OLS and logit estimates (clustered by province) and the covariates are the same as those employed in previous

columns. Empirical estimates are extremely similar across both columns and imply that daily smokers are less likely to be obese relative to non-smokers – a relationship that is statistically significant at the 1% level.

Table 4

Obesity, smoking and cigarette taxes – pooled estimates employing individual level data from the 2003 and 2005 Canadian Community Health Surveys (CCHS).

	(Dependent variable – obesity) Linear probability (1)	(Dependent variable – obesity) Logit (marginal effects) (2)	(Dependent variable – daily smoker) Linear probability (3)	(Dependent variable – daily smoker) Logit (marginal effects) (4)	(Dependent variable – obesity) Linear probability (5)	(Dependent variable – obesity) Logit (marginal effects) (6)
Smoking					-0.027 [0.006]***	-0.033 [0.004]***
Cigarette tax	0.0023 [0.001]**	0.0027 [0.001]**	-0.027 [0.006]**	-0.0026 [0.001]**		
Tax elasticity	0.499	0.51	-0.48	-0.48		
Male	0.016 [0.002]***	0.016 [0.002]***	0.04 [0.003]***	0.04 [0.003]***	0.017 [0.002]***	0.019 [0.0024]***
Employed	-0.043 [0.006]***	-0.043 [0.006]***	-0.053 [0.006]***	-0.055 [0.006]***	-0.045 [0.0059]***	-0.034 [0.005]***
Age dummies	Yes	Yes	Yes	Yes	Yes	Yes
Regional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted or pseudo-R ²	0.023	0.026	0.013	0.012	0.023	0.026
Number of observations	156,737	156,737	156,737	156,737	156,737	156,737

Notes: The regressions have been run employing individual level data. Standard errors are in square brackets beneath coefficient estimates and are clustered by province.

- * Statistical significance at the 10% level.
- ** Statistical significance at the 5% level.
- *** Statistical significance at the 1% level.

5. Discussion and conclusion

Recent studies offer conflicting evidence on the effects of cigarette taxes on obesity. We attempt a modest contribution by exploiting variation in provincial cigarette taxes in Canada and estimating their relationship with obesity and smoking employing data from the 2003 and 2005 waves of the Canadian Community Health Surveys.

OLS estimates from multivariate regression models imply that a 10% increase in cigarette taxes is significantly correlated with a 4–5% increase in the proportion of obese populace. These results suggest a statistically significant correlation between higher cigarette taxes and a more obese population. Our findings are robust across different models and to the use of a wide array of controls intended at controlling for time-invariant characteristics specific to each health region. Further, we obtain extremely similar results from individual level data. We also note that our elasticities are comparable to Chou et al. [1], who report a cigarette price elasticity of 0.445.

There are legitimate concerns on the validity of our estimates given the limited time-series variation, which basically precludes the use of province fixed effects. Therefore, as a sensitivity analysis, we also employ the data in order to estimate the effects of taxes on the percentage of smokers. Empirical estimates that are consistent with the literature would offer some reassurance on our findings with respect to obesity levels and cigarette taxes.

This is in fact, what we find, as our results reveal a statistically significant relationship between higher cigarette taxes and a decline in the percentage of daily smokers across health regions. The corresponding cigarette tax elasticities are consistent with most studies, yielding some reassurance on the stability of our results. Specifically, the results correspond with the consensus range of -0.4 and -0.6 of smoking participation elasticities suggested by Chaloupka and Warner [18] and are also comparable to a lower range of tax effects offered by recent studies [19,22]. As was the case with estimates with respect to obesity, we obtain extremely similar results using individual level data from the surveys.

In summary, our empirical estimates give some modest evidence on the existence of a statistically significant correlation between cigarette taxes and obesity levels across health regions. Therefore, health gains from higher taxes through reduced smoking may be partially offset through a rise in obesity levels. Future research will employ individual panel longitudinal data (similar to the approach used by Baum [3]) from the National Population Health Surveys in order to evaluate weight changes in smokers in response to amendments in cigarette taxes over time.

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