An evaluation of tobacco control strategies on smoking-related outcomes in Canada during the time of the Federal Tobacco Control Strategy

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Abstract

Background:

Various tobacco control laws and strategies have been implemented in Canada since the 1980s. Excise tobacco taxes are a common form of tobacco control, and tax levels in Canada have been gradually increasing since the 1980s. More recently, the Federal Tobacco Control Strategy (FTCS) was launched in 2001 as a planned 10-year initiative by Health Canada (HC), in partnership with Public Health Agency of Canada (PHAC) and other agencies. Two key components of the FTCS were the enforcement of the Tobacco Act and the promotion of smoke-free laws. The Tobacco Act is a set of Canadian laws passed in 1997 that includes tobacco control measures such as restrictions on the manufacture and sale, access, and promotion of tobacco products.

We can summarize the FTCS goals as the following: (i) prevention of smoking among youths, (ii) cessation and reduction of consumption among smokers, and (iii) protection of non-smokers from environmental tobacco smoke. Although both smoking prevalence and smoking frequency have declined during the time of the FTCS, the contributions of the various tobacco control strategies in effect in achieving FTCS goals are unclear.

Moreover, there exists a socioeconomic gap in smoking among the adult population, and it is also unclear what impact tobacco control strategies operating during the time of the FTCS have had on this gap. If agencies such as Health Canada and the Public Health Agency of Canada are motivated to not only lower overall smoking levels, but to reduce the socioeconomic gap in smoking, then tobacco control strategies must have the greatest effect on the least educated where smoking rates remain highest in Canada.

Objectives:

The three studies of my PhD dissertation are motivated by the set of FTCS goals and the socioeconomic inequality in smoking. The first one evaluated the effectiveness of cigarette taxes as a tool for the prevention of smoking and the development of a habit among youths. The second study assessed the effectiveness of cigarette taxes in facilitating smoking cessation, and reducing smoking frequency among adults. The third study evaluated the protective effect of smoke-free legislation, but assessed smoking prevalence and frequency on the adult Canadian population. The second and third studies also included an evaluation of the potential differential effects by education.

Results:

For our analyses, we used the Canadian Tobacco Usage Monitoring Survey 2002-2012 database and exploited the variation in excise cigarette tax levels and implementation of smoke-free legislation among the provinces. We used regression models with province and year fixed effects, individual-level covariates, and provincial-level covariates.

For Research Objective 1, changes in excise cigarette taxes yielded negligible contributions to the reduction in smoking behaviour among youths. For an increase of $1.00 in excise cigarette taxes per package of 20, the marginal effect was 0.2 (95% CI: -1.8, 2.2) percentage points for smoking prevalence, and 0.3 (95% CI: -1.2, 1.8) cigarettes for smoking frequency (past-week).

We obtained similar results for the average effect of taxes on smoking behaviour among adults for Research Objective 2. For an increase of $1.00 in excise cigarette taxes per package of 20, the marginal effect was -0.1 (95% CI: -1.7, 1.5) percentage points for smoking prevalence,

and -0.1 (95% CI: -1.9, 1.7) cigarettes (per week) for smoking frequency. We continued to derive null results when assessing the impact of excise cigarette taxes by education for both smoking outcomes.

Likewise, for Research Objective 3, provincial smoke-free legislation (PSFL) had little impact on smoking behaviour among adults. The marginal average effect for smoking prevalence was 0.1 (95% CI: -1.3, 1.4) percentage points. The marginal average effect for smoking frequency was -0.6 (95% CI: -2.2, 1.0) cigarettes. Again, we derived null results when assessing the impact of PSFL by education for both smoking outcomes.

Conclusions:

Although both excise tobacco taxes and smoke-free legislation have the potential to reduce tobacco consumption, their effectiveness appears sensitive to the current anti-tobacco control environment. During the time of the FTCS, there was a much higher level of tobacco control compared to the time prior to its launch and higher compared to other countries. Excise cigarette taxes have been gradually increasing since the 1980s, and so, tax levels were already quite high by the launch of the FTCS. Moreover, taxes and smoke-free legislation had to work in conjunction with other forms of tobacco control such as the Tobacco Act, point-of-sale restrictions, and the enforcement of graphic warning labels on cigarette packages.

From 2002-2012, both smoking prevalence and mean smoking frequency have been in steady decline in Canada. These declines, however, are present even in provinces with stable or decreasing cigarette tax levels and for provinces which implement smoke-free legislation at a later time, suggesting that other factors common to all provinces such as growing anti-smoking sentiment have had a greater influence over tobacco use.

Résume

Contexte:

Diverses lois et stratégies de lutte contre le tabagisme ont été mises en place au Canada depuis les années 1980. Les taxes d'accises sont une forme commune de lutte contre le tabac, et les niveaux d'imposition au Canada ont augmenté progressivement depuis les années 1980. Plus récemment en 2001, la Stratégie fédérale de lutte contre le tabagisme (SFLT) a été lancée comme une initiative prévue sur 10 ans par Santé Canada, en partenariat avec l'Agence de la santé publique du Canada et d'autres organismes. Deux éléments clés de la SFLT étaient l'application de la Loi sur le tabac et la promotion de lois antitabac. La Loi sur le tabac est un ensemble de lois canadiennes adoptées en 1997 qui comprend des mesures de contrôle du tabac telles que des restrictions sur la production, la vente, l'accès et la promotion des produits du tabac.

Nous pouvons résumer les objectifs de la SFLT comme suit: (1) la prévention du tabagisme chez les jeunes, (2) la cessation et la réduction de la consommation chez les fumeurs, et (3) la protection des non-fumeurs contre la fumée de tabac environnementale. Bien que la prévalence du tabagisme et la fréquence de consommation ait diminué pendant le temps de la SFLT, les contributions des différentes stratégies de contrôle du tabac dans la réalisation des objectifs de la SFLT ne sont pas claires.

En outre, il existe un écart socio-économique chez la population de fumeurs adultes, et on ne connaît pas l'impact que les stratégies de lutte antitabac, mise en place pendant le temps de la SFLT, ont eu sur cette écart. Si les organismes comme Santé Canada et l'Agence de la santé publique du Canada sont motivés à réduire les niveaux de tabagisme et réduire l'écart socio-économique en matière du tabagisme, les stratégies de lutte antitabac doivent avoir un plus grand impact sur les moins instruits, où les taux de tabagisme sont le plus élevé au Canada.

Les Objectifs:

Les trois études de ma thèse de doctorat sont motivées par l'ensemble des objectifs de la SFLT et par les inégalités socio-économiques en matière du tabagisme. La première étude a évalué l'efficacité des taxes sur les cigarettes comme outil pour la prévention du tabagisme, ainsi que comme outil pour la prévention du développement d'habitudes tabagiques chez les jeunes. La deuxième étude a évalué l'efficacité des taxes sur les cigarettes pour faciliter le sevrage tabagique et réduire la fréquence du tabagisme chez les adultes. La troisième étude a évalué l'effet protecteur de la législation antitabac sur la prévalence du tabagisme et la fréquence de la consommation du tabac sur la population adulte canadienne. Les deuxième et troisième études comprenaient également une évaluation de l'impact potentiel sur les écarts du tabagisme par niveau d'éducation

Résultats:

Pour nos analyses nous avons utilisé la base de donnes de L'Enquête de surveillance de l'usage du tabac au Canada (ESUTC), pour les années 2002 à 2012. Nous avons aussi exploité la variation des niveaux de la taxe d'accise sur les cigarettes pendant cette période et la mise en œuvre de la législation antitabac par les provinces. Nous avons utilisé des modèles de régression avec des effets fixes pour chaque province, des variables de niveau individuel et des variables de niveau provincial.

Pour la recherche de l'objectif de la première étude, les changements dans les taxes d'accise sur les cigarettes ont donné des contributions négligeables à la réduction de l'usage du tabac chez les jeunes. Avec une augmentation de 1,00 $ en taxes d'accise sur un paquet de 20 cigarettes, l'effet marginal était de 0,2 (IC 95%: -1,8, 2,2) points de pourcentage pour la

prévalence du tabagisme, et de 0,3 (IC 95%: -1,2, 1,8) cigarettes fumées dans la dernière semaine.

Nous avons obtenu des résultats similaires pour l'effet moyen des impôts sur le tabagisme chez les adultes pour l'objectif de la deuxième étude. Avec une augmentation de 1,00 $ en taxes d'accise sur un paquet de 20 cigarettes, l'effet marginal était de -0,1 (IC 95%: -1,7 1,5) points de pourcentage pour la prévalence du tabagisme, et de -0,1 (IC à 95%: -1.9, 1.7) cigarettes fumées, pour la fréquence de consommation. Nous avons aussi tiré des résultats nuls lors de l'évaluation de l'impact des taxes d'accise sur les cigarettes en rapport avec chaque niveau d'éducation, et ce pour l'effet sur la prévalence du tabagisme et la fréquence de consommation du tabac.

De même pour l'objectif de la troisième étude, la législation antitabac provinciale a eu peu d'impact sur le tabagisme chez les adultes. L'estimation de l'effet moyen marginal de la prévalence du tabagisme était de 0,1 (IC 95% : -1.3, 1,4) points de pourcentage. L'effet moyen marginal pour la consommation du tabac était de -0,6 (IC 95%: -2,2, 1,0) cigarettes. Encore une fois, nous avons tiré des résultats nuls lors de l'évaluation de l'impact de la législation antitabac provinciale en rapport avec chaque niveau d'éducation, et ce pour l'effet sur la prévalence du tabagisme et la fréquence de consommation du tabac.

Conclusions:

Bien que les taxes d'accises sur le tabac, ainsi que la législation antitabac ont le potentiel de réduire le tabagisme, leur efficacité semble être contingent au niveau du contrôle anti-tabac actuel. Pendant le temps de la SFLT, il y avait un niveau de contrôle du tabac beaucoup plus élevé par rapport à la période antérieure à son lancement et un niveau de contrôle plus élevé par rapport à d'autres pays. Les taxes d'accises sur les cigarettes ont augmenté progressivement depuis les années 1980. Donc les niveaux d'imposition étaient déjà assez élevés au moment du lancement de la SFLT. De plus, les taxes d'accises et les lois antitabac ont été mise en œuvre pendants que d'autres formes de contrôle du tabac ont été déjà en place, comme la Loi sur le tabac, les restrictions aux points de vente et l'application des étiquettes d'avertissement sur les paquets de cigarettes.

De 2002 à 2012, la prévalence du tabagisme et la moyenne de la fréquence de la consumation du tabac ont été en baisse constante au Canada. Ces baisses, cependant, sont présents même dans les provinces où les niveaux d'imposition des cigarettes sont stable ou en baisse, ainsi que pour les provinces qui ont mise en place de la législation antitabac plus tard que d'autres. Cela suggéré que d'autres facteurs communs dans toutes les provinces, telle que un sentiment anti-tabac florissant, ont eu une plus grande influence sur la consommation du tabac.

Contribution of Authors

Manuscript 1: **The contribution of excise cigarette taxes on the decline in youth smoking in Canada during the time of the Federal Tobacco Control Strategy (2002-2012)**

Authors: Phongsack Manivong (PhD candidate), Dr. Sam Harper, Dr. Erin Strumpf

Manuscript 2: **Heterogeneous effects of excise cigarette taxes on smoking-related outcomes by education among adults in Canada during the time of the Federal Tobacco Control Strategy (2002-2012)**

Authors: Phongsack Manivong (PhD candidate), Dr. Sam Harper, Dr. Erin Strumpf

Manuscript 3: **The contribution of provincial smoke-free legislation on the decline in smoking and the impact on the smoking inequality among adults in Canada during the time of the Federal Tobacco Control Strategy (2002-2012)**

Authors: Phongsack Manivong (PhD candidate), Dr. Sam Harper, Dr. Erin Strumpf

These three manuscripts represent the doctoral research that I initiated and executed with the guidance of my co-supervisors, Dr. Sam Harper and Dr. Erin Strumpf. I conceptualized the research objectives, design, methodological approach and analytical approach for the first study. I also collaborated on the methodological approach and analytical approach for the second and third studies. I developed the thesis protocol. I was responsible for data acquisition, data management and data analysis of all three studies. I wrote the first draft of all three manuscripts.

The research objectives, initial methodological approach and analytical approach in the second and third studies were conceptualized in the Canadian Institutes for Health Research operating grant TO3-120314 rewarded to Dr. Harper and Dr. Strumpf.

Dr. Sam Harper is an Associate Professor in the Department of Epidemiology & Biostatistics at McGill University. As my thesis supervisor, Dr. Harper helped develop research objectives in manuscripts 2 and 3, provided methodological and analytical guidance, and critically reviewed my thesis protocol and all three manuscripts.

Dr. Erin Strumpf holds a joint appointment in the Departments of Epidemiology, Biostatistics, and Occupational Health and Economics at McGill University. As a co-supervisor, Dr. Strumpf provided methodological and analytical guidance, and critically reviewed all three manuscripts.

Statement of Originality

The studies of my PhD thesis contribute to the literature on the effects of tobacco control strategies on smoking-related outcomes in Canada in several ways. The primary contribution is the assessment of recent changes of cigarette tax levels and implementations of provincial smoke-free laws during the time of the Federal Tobacco Control Strategy (2002-2012). For the case of cigarette taxes, having two separate studies will provide a clearer distinction between the effects of youth and adult populations. Moreover, my studies involving the adult population will provide a methodologically rigorous evaluation of heterogeneous effects of tobacco control strategies by education, and in particular, their potential impact on the socioeconomic gap in smoking.

While my co-supervisors provided guidance in the conception, methodological and analytical approach, and feedback on manuscripts, I declare that the execution of studies and the drafting of their respective manuscripts presented in this thesis represent my original work.

Statement of Financial Support

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List of Acronyms

Acronym	Definition
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CCHS	Canadian Community Health Survey
CI	Confidence Interval
CPI	Consumer Price Index
CTUMS	Canadian Tobacco Use Monitoring Survey
DD	Difference-in-differences
ETS	Environmental Tobacco Smoke
FTCS	Federal Tobacco Control Strategy
GWL	Graphic Warning Label
HC	Health Canada
IARC	International Agency for Research on Cancer
PHAC	Public Health Agency of Canada
PSFL	Provincial Smoke-free Legislation
SEP	Socioeconomic Position
SHS	Second-hand Smoke
TCS	Tobacco Control Strategy
TPM	Two-part Model

Chapter 1: Thesis Prologue

1.1 Introduction

Various tobacco control laws and strategies have been implemented in Canada since the 1980s. At the federal level, these laws started with the Tobacco Products Control Act of 1989, and the Tobacco Sales To Young Persons Act of 1994, which were later replaced by the Tobacco Act in 1997 (Reid & Hammond, 2013). The Tobacco Act is a set of Canadian laws with four purposes: (i) protect the health of Canadians; (ii) prevent the promotion of tobacco use among youths; (iii) restrict accessibility of tobacco products for youths; and (iv) increase public awareness of the health risks of using tobacco products (Minister of Justice, 1997). It aims to achieve these objectives by restricting the manufacture and sale, access, and promotion (advertisement) of tobacco products, and mandating the use of health warning messages and graphic warning labels (GWLs) on tobacco products that provide information on the health risks associated with tobacco use. In 2001, Canada became the first country to require that GWLs cover at least 50% of both front and back of cigarette packages (Canadian Cancer Society, 2012).

The Federal Tobacco Control Strategy (FTCS) was a planned 10-year initiative implemented in 2001 to reduce tobacco consumption in Canada (Health Canada & Public Health Agency Of Canada, 2012). The initiative was launched by a consortium led by Health Canada (HC), in partnership with Public Health Agency of Canada (PHAC) and other agencies such as the Royal Canadian Mounted Police, and Canada Border Services Agency. For the entire 10-year plan, the FTCS had a total budget of approximately $925 million for its tobacco control initiative that included mass media campaigns, research & surveillance, and the monitoring of contraband. Two critical components to its tobacco control initiative were the enforcement of the Tobacco Act, and the increased promotion of smoke-free environments, particularly via legislation.

In the first phase (ending in 2006), the FTCS had four quantifiable goals: (i) reduce smoking prevalence from 25% in 1999 to 20%; (ii) reduce the number of cigarettes sold by 30%; (iii) increase retailer compliance regarding youth access to sales from 69% to 80%; and (iv) reduce the number of people exposed to environmental tobacco smoke (or second-hand smoke) in enclosed public spaces. In the second phase (starting in 2007), the FTCS had four new quantifiable goals: (i) reduce overall smoking prevalence from 19% (2006) to 12% by 2011; (ii) reduce the prevalence of smoking among youths from 15% to 9%; (iii) increase the number of adults (including young adults) who quit smoking by 1.5 million; and (iv) reduce the prevalence of Canadians exposed to daily second-hand smoke from 28% to 20%.

Figure 1-1 and **Figure 1-2** show self-reported smoking prevalence (current smoker) and smoking frequency (past-week) trends for those aged 15 and over, based on the Canadian Tobacco Use Monitoring Survey (CTUMS) 1999-2012 database (N=63,418 for those 15-18, and N=155,371 for those 19 and over). We can see that smoking prevalence and frequency have decreased for both youths and adults. FTCS appeared to have accomplished its first two goals of Phase 1, but fell short in the first and third goals of Phase 2.

In a self-evaluation of FTCS goals, HC and PHAC identified individual and environmental factors in predicting smoking prevalence and frequency (Health Canada & Public Health Agency Of Canada, 2012). The most important predictors were education attainment, tobacco taxes, bans on retail display and legal smoking age. Their conclusions, however, were based on econometric models that did not include indicators for province or time, and thus, did not account for the variation in smoking rates across the provinces of Canada and the general declining smoking trend common among provinces. These types of models provide only associational measures of effect, and do not allow for a causal interpretation.

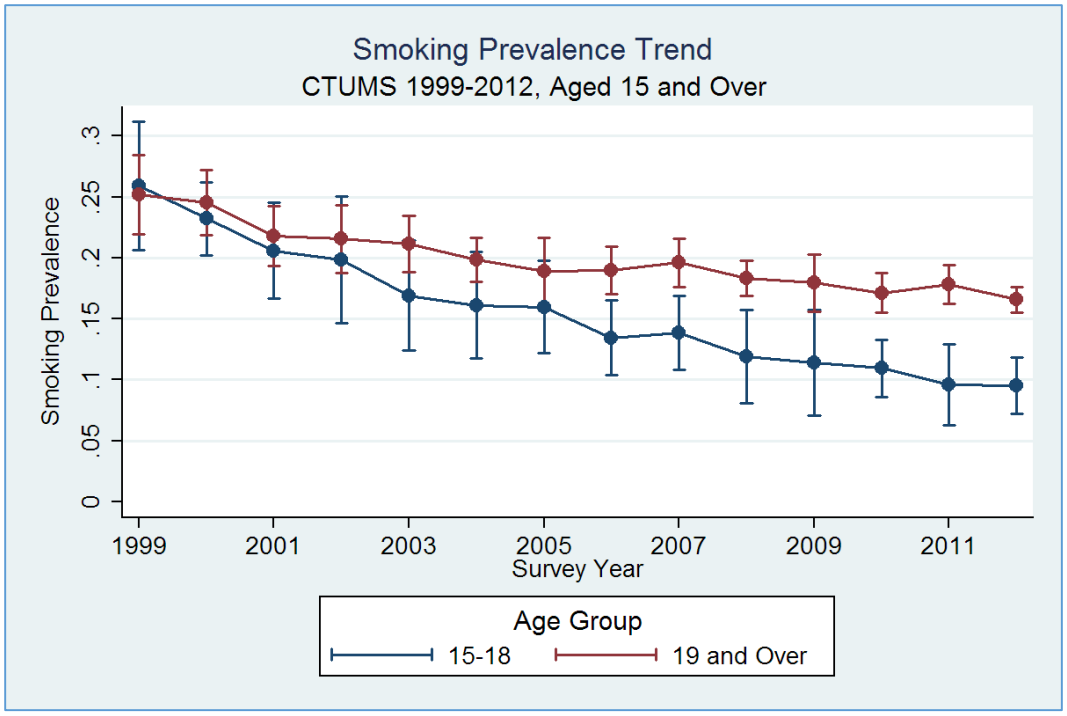

Figure 1-1 Marginal estimates and 95% CIs of smoking prevalence from logistic models with year fixed effects

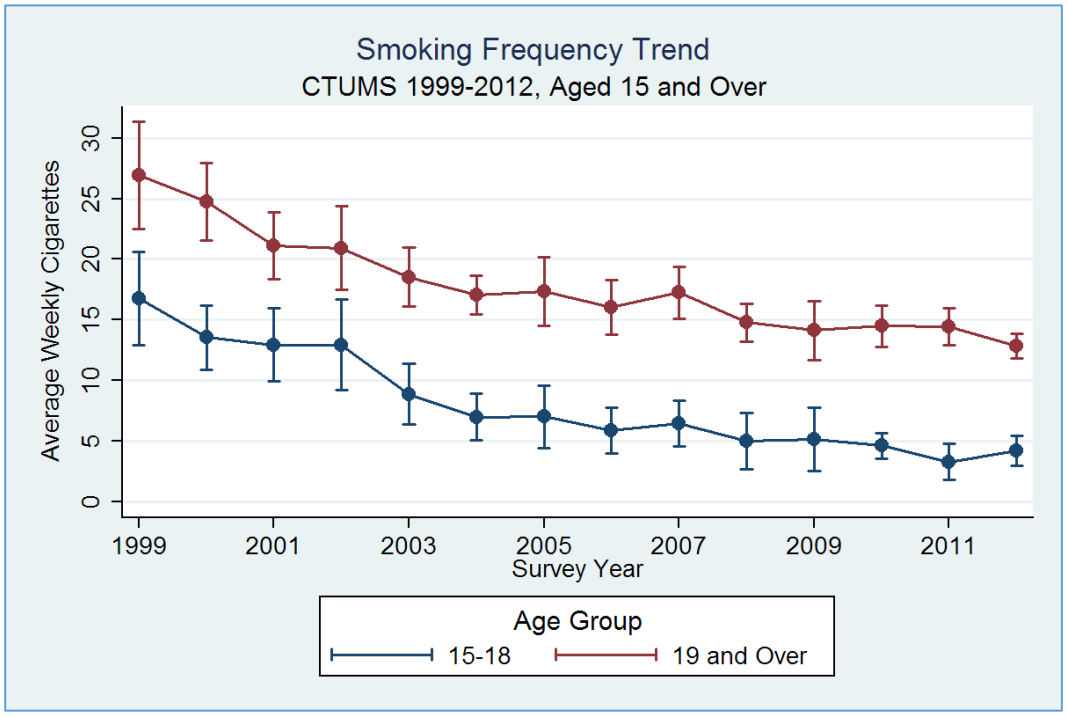

Figure 1-2. Marginal estimates and 95% CIs of smoking frequency from weighted two-part (logistic-Poisson) model with year fixed effects.

Furthermore, it is unclear from the analyses by HC and PHAC how much key components of the FTCS, in particular, smoke-free legislation and graphic warning labels contributed to the success of FTCS goals. Another common tobacco control strategy that HC and PHAC actually cite as being an important predictor for smoking is excise tobacco taxes. (An excise tax is one that is imposed on specific goods.)

Moreover, looking only at the average effect can obscure potential differential effects, in particular, by socioeconomic position (SEP). Although overall tobacco consumption in Canada has decreased during the time of the FTCS, observed inequalities in smoking between groups of low and high SEP have persisted since at least 1999. See **Figure 1-3** and **Figure 1-4** for estimates of smoking prevalence and frequency by education, respectively.

Two perspectives are often provided regarding the need to reduce social inequalities in health. From an altruistic perspective, there is a social or ethical obligation to reduce an inequality when there is a feasible intervention. The second perspective is more pragmatic; an inequality in a health outcome leads to an excess burden on the healthcare system.

Evaluating the impact of social policies on the socioeconomic inequalities in health can highlight social structures that prevent or limit access to health improving resources. It can also reveal paths to reducing excess burdens on the healthcare system (Rehm et al., 2006). Specifically, evaluating the potential differential impact of tobacco control strategies on the socioeconomic inequality in smoking can have implications for the need for new strategies or modifications to existing ones (such as targeting specific socioeconomic groups). Strategies with a greater effect on those of lower SEP will help reduce the inequality, while strategies with a weaker effect on those of lower SEP will exacerbate the inequality (Lorenc et al., 2012).

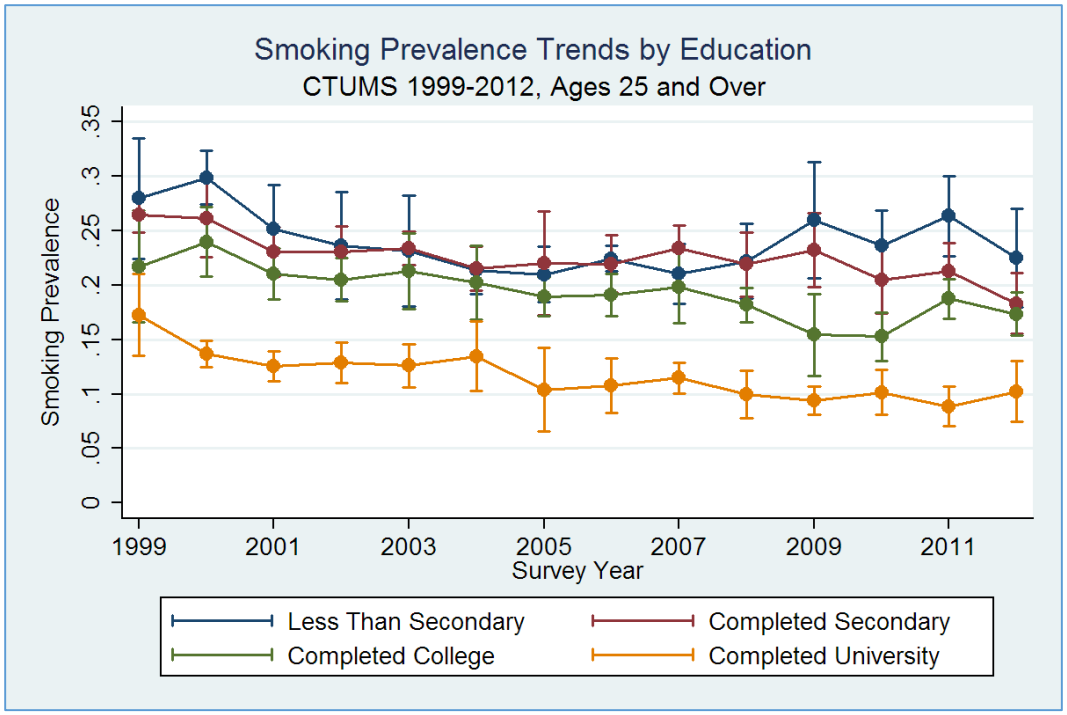

Figure 1-3. Marginal effect estimates and 95% CIs of smoking prevalence by education from a logistic model with year, education, and their cross-product terms as covariates.

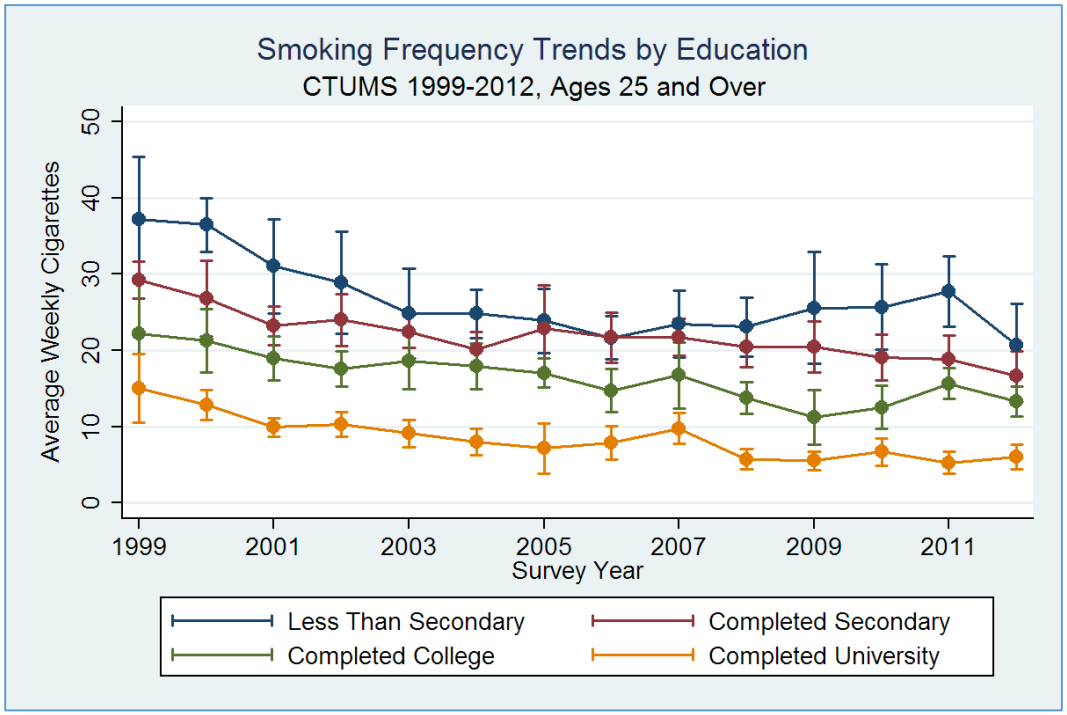

Figure 1-4. Marginal effect estimates and 95% CIs of smoking frequency based on a logistic-Poisson two-part model with year, education, and their cross-product terms as covariates.

In a Cochrane review on the assessment of heath equity in systematic reviews of interventions, the authors conclude that "there is a need for methodological research to identify factors associated with differences in absolute and relative effects to improve our understanding of the rationale for exploring subgroup effects" (Welch et al., 2010). In another systematic review consisting of thirty systematic reviews on public health interventions, the authors conclude that "evidence on the differential impacts of interventions by socioeconomic position is largely absent" (Bambra et al., 2010). Thus, not only are we interested in evaluating the average effect of tobacco control strategies, we are also interested in their potential impact on the socioeconomic inequality in smoking (Main et al., 2008).

Evaluating the impact of these tobacco control strategies on smoking-related outcomes (prevalence and frequency) with methodological rigour, however, requires an appropriate comparison or control group. In Canada, excise tobacco taxes are implemented at the federal and provincial levels (Reid & Hammond, 2013; Treff & Ort, 2008-2012; Treff & Perry, 2002-2007). Smoke-free legislation is mandated primarily at the municipal and provincial levels (Non-Smokers's Rights Association, 2012a, 2012b). Thus, to evaluate the impact of excise cigarette taxes on smoking in Canada, we can exploit the variation in cigarette tax levels over time within provinces. Likewise, to evaluate the impact of smoke-free legislation on smoking, we can utilize differences in their timing of implementation across Canadian provinces.

The general consensus for tobacco taxes is that they do have the potential to impact tobacco consumption. A working group of experts across various disciplines assembled together for the International Agency for Research on Cancer (IARC) to summarize the body of literature on tobacco control policies and their effectiveness (Chaloupka et al., 2011). They deemed that there was sufficient evidence for the following conclusions regarding the effectiveness of

tobacco taxes on smoking habits. (1) Tobacco taxes reduce the prevalence and uptake of tobacco use among youths. (2) Tobacco taxes reduce smoking prevalence among adults. (3) Tobacco taxes lower the consumption of tobacco products among continuing users. (4) Tobacco taxes can have a greater effect on youths than on adults.

Thus, from the above conclusions, it is important to provide a clear distinction between the effects taxes on youths and adults. Additionally, the effects of taxes have different implications. For youths, the effect of taxes is the impact on initiation and habit development; while for adults, the effect is the impact on cessation and reduction. Based on participants aged 15 and over who reported to have ever tried smoking in the 1999-2012 CTUMS database (N=163,193), about 82.3% reported to have had their first cigarette by age 18. About 95.2% reported to have had their first cigarette before age 25. Additionally, from years 2004-2012 (when data on daily smokers are available), about 91.8% reported to have smoked daily before age 25 (N=63,353).

An important stipulation in the effective use of excise taxes in reducing tobacco consumption is that increases in taxes also increase cigarette prices, occur frequently and outpace general price inflation (Chaloupka, 2013). By the twenty-first century, however, taxation levels for tobacco products were already high in Canada, and more importantly, higher than levels in previous studies. To provide some context, from years 1981 to 1999, the average (nominal) national cigarette tax level increased from about $5.00 to $25.00 per carton of 200 cigarettes (Gruber et al., 2003). During that time, the average (real) price of cigarettes (in year 1999 dollars) was US $1.86 and US $2.33 per pack in the United States and Canada, respectively (Gruber et al., 2003). By 2002, inflation-adjusted tobacco taxes accounted for approximately 62% (Nova Scotia and Ontario) to 71% of average cigarette price (Alberta).

Another critical component in the use of excise tobacco taxes is that consumers do not engage in price-reducing strategies. One way to reduce price is tax avoidance, which is the legal purchase of lower-taxed or non-taxed goods such as duty free shopping. Conversely, tax evasion is an illegal circumvention of paying taxes such as purchases of smuggled or counterfeit goods. Thus, we are interested in the intention-to-treat effect of tobacco control policies, or in other words, the effect given the possibility of smokers engaging in tax avoidance and evasion.

Regarding smoke-free legislation, the principle objective is to protect non-smokers from exposure to environmental tobacco smoke (ETS), also known as passive or second-hand smoking (SHS). An unintended consequence of smoking bans at work and public places, however, may be displaced and compensatory smoking, namely increased smoking before and after work, during breaks, or at home (Bell et al., 2009). Hence, questions remain about the effect of smoke-free legislation on individual smoking behaviour in Canada, in particular by SEP.

We initially considered exploiting the variation of smoke-free laws, specifically ones relating to comprehensive workplace and public place smoking restriction across municipalities. Using the Canadian Community Health Survey (CCHS) where sub-province data are available, we first identified municipalities with a population of approximately 150,000 or greater as of 2001. Municipal smoke-free bylaws, however, were all predicated by provincial smoke-free laws except for Ottawa which had implemented a workplace bylaw in 2001, 5 years prior to Ontario implementing both public and workplace smoke-free legislation (Non-Smokers's Rights Association, 2012a). Because we are interested in assessing the effects of smoke-free laws after the launch of the Federal Tobacco Control Strategy (2002-2012) and the smoke-free law in Ottawa was implemented prior to our time period of interest, our evaluation was exclusively on provincial smoke-free laws.

GWLs, on the other hand, operate at the federal level, and evaluating their impact on smoking in Canada would require one or more countries as a control group. One study on the effects of GWLs in Canada found a negative, but statistically non-significant effect of health warnings of tobacco packaging on smoking prevalence and frequency (Gospodinov & Irvine, 2004). The authors postulate that declines in smoking were largely attributable to increases in price and an overall downward temporal trend rather than GWLs. A limitation to this study, however, is that it did not include a comparison group. Additionally, the authors used only two years of survey data, one before (2000) the implementation of GWLs and one after (2001). Thus, their study may have been underpowered, and lacked adequate follow-up time.

A more recent study, however, evaluated the use of GWLs in Canada with the United States as a control group (Huang et al., 2014). With a series of difference-in-differences (DD) models using 9 years of data before and 9 years after the implementation of GWLs, the authors showed that GWLs reduced smoking prevalence by 2.8–4.7 percentage points, or a relative reduction of 12.1%–19.6%. This study incorporated a proper comparison group and used a DD framework that accounted for temporal trends and accounted for changes in cigarette tax levels. It also included many years of data that allowed for adequate follow up and power. Because this recent study has already shown a deterring effect of GWLs on smoking, and initiating a new study would require access to individual and country level data for Canada and at least one other country, my PhD thesis focused primarily on tobacco taxes and smoke-free laws.

1.2 Research Objectives

From a public health perspective, we can summarize the FTCS goals to reduce tobacco consumption in Canada, as the following: (i) prevention, (ii) cessation and reduction, and (iii) protection. The three studies of my PhD dissertation were motivated by these goals, and addressed them, accordingly. The first one evaluated the effectiveness of cigarette taxes as a tool for the prevention of smoking and the development of a habit among youths. The second study assessed the effectiveness of cigarette taxes in facilitating smoking cessation (or in other words, in decreasing smoking prevalence), and reducing smoking frequency among adults. The third study evaluated the protective effect of smoke-free legislation, but assessed for outcomes smoking prevalence and frequency on the adult Canadian population. The second and third studies also included an evaluation of the potential impact on the socioeconomic inequality in smoking.

1.3 Organization of Thesis

This doctoral thesis consists of six chapters. The first is the introduction to the research motivation, and research objectives. Chapter 2 describes the analytical framework and methodology used in our studies, most notably the difference-in-differences framework, as well as the assumptions related to its use. Chapters 3, 4, and 5 are manuscripts of the first, second, and third studies, respectively, where each contains their own introduction, literature review, data description, methodology and analysis section, results, and discussion. The final chapter summarizes our research findings and implications for future tobacco control strategies in Canada.

Chapter 2: Analytical Framework

2.1 Methodology Description

The difference-in-differences (DD) framework provided the analytical foundation for all three studies. In simplest terms, a DD is a contrast of the difference of an outcome between two distinct groups at one time period with the difference of the same outcome at another time period. Equivalently, a DD is also the comparison of a change of an outcome for a treated (or exposed) group within some time period to the change of the same outcome for an untreated (or unexposed) within the same time period. It is a common analytical tool in policy analysis, epidemiology, and economics with the use of a quasi-experimental design (or pseudo-random treatment allocation).

For our first two research objectives on the effects of cigarette taxes, the treated group comprised of provinces that increased tobacco taxes at a certain time, and the control group were the provinces that did not increase tobacco taxes during the same time period. For our third research objective, the treated or exposed group were the provinces that implemented smoke-free laws, and the control group consisted of provinces that did not have a smoke-free law in effect. (Because all provinces changed the levels of excise cigarette taxes or implemented smoke-free laws during our study period, their timing was the pseudo-randomized component.) Linking data on excise cigarette taxes and smoke-free laws to repeated cross-sections of CTUMS permitted the use of the DD framework.

Figure 2-1 shows the simplest case of the DD framework in tabular form. In this case, the treatment is dichotomous and there are only two periods (before and after). Here, $Y_k(i)$ denotes the mean of a smoking outcome for period k = 1 or 2 (before and after, respectively), i = 0 for the untreated group, and i = 1 for the treated group.

	Untreated Provinces	Treated Provinces
Before TCS	$Y_1(0)$	$Y_1(1)$
After TCS	$Y_2(0)$	$Y_2(1)$
Difference or Change	$Y_2(0) - Y_1(0)$	$Y_2(1) - Y_1(1)$
Difference-in-Differences	$[Y_2(1) - Y_1(1)] - [Y_2(0) - Y_1(0)]$	

Figure 2-1. Tabular form of simplest case of the DD framework where Y is a smoking outcome

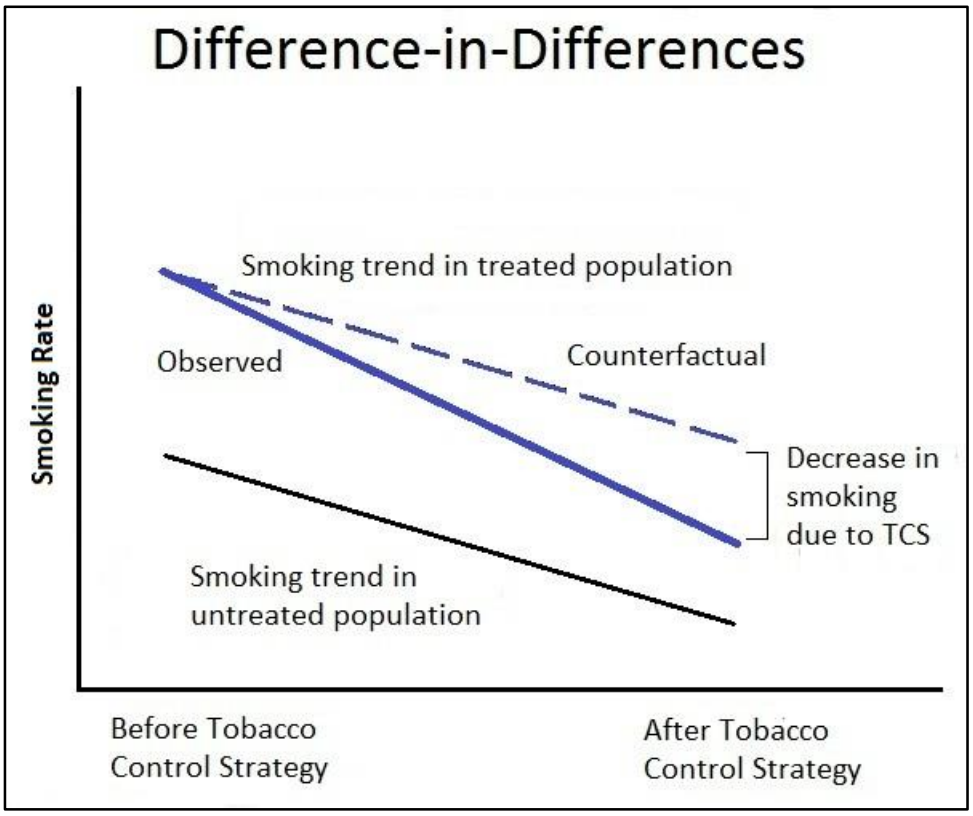

Figure 2-2. Graphical form of the simplest case of the DD framework

Similarly, **Figure 2-2** shows the simplest case of the DD framework in graphical form. The DD compares the change (or rather the *decrease*) in smoking prevalence (or mean smoking frequency) for a population with a TCS in effect over some time period to the change in the same smoking outcome for a population without a TCS in effect over the same time period. Thus, the difference between these two changes is the effect attributable to the implementation of the TCS. In other words, if observed changes in smoking behaviour are similar for both groups, then their difference would be null, and the TCS would have had no effect, and the change would be attributable primarily to temporal trends (or in general, factors common to both groups).

To denote the simplest statistical model for a DD, let Y be a smoking-related outcome, let T indicate a TCS the group to implement (1) or not implement (0), and let A indicate the time (0 for before TCS and 1 for after TCS), in the following,

$$E(Y) = \beta_0 + \beta_1 T + \beta_2 A + \beta_3 TA \quad (1)$$

where TA represents the group with a TCS in effect in the second time period. The coefficient β_1 measures any initial differences between the two groups. The coefficient β_2 is the expected change experienced by the group without a TCS in effect.

The main coefficient of interest is β_3. It is the difference in the change of smoking between the groups that had a TCS in effect compared to one that did not. Under the assumption that the implementation of a TCS reduces smoking prevalence and frequency, β_1 should be negative for both outcomes. If it is a value close to 0 (or in other words, a null value), however, then this indicates that there is no change in smoking behaviour beyond what is expected due to common temporal changes. If using a linear model (as described above), β_1 would have an additive interpretation. For an outcome that is binary such as smoking prevalence, the expected change in the prevalence of smoking due to the implementation of a TCS would be $\beta_1 \times 100\%$ percentage points. Similarly, for the outcome smoking frequency, β_1 is the estimated change in the mean number of cigarettes smoked (past-week) due to the implementation of a TCS.

We described our models on the additive scale for the purpose of simplicity and ease of interpretation. Smoking prevalence, however, was modelled using logistic regression. Assessing smoking frequency, on the other hand, required a two-part model where a binary component is modeled in the first stage and a frequency component in the second stage (Cragg, 1971). A single quantity variable is used to model both parts.

Let Q denote the mean weekly cigarette consumption of an individual, then the mean of Q becomes,

$$\begin{aligned} E(Q \mid \mathbf{X}, \mathbf{Z}) &= P(\text{Nonsmoker})E(Q|\text{Nonsmoker}) + P(\text{Smoker})E(Q|\text{Smoker}) \\ &= P(Q=0 \mid \mathbf{X}, \mathbf{Z})E(Q=0 \mid \mathbf{X}, \mathbf{Z}) + P(Q>0 \mid \mathbf{X}, \mathbf{Z})E(Q>0 \mid \mathbf{X}, \mathbf{Z}) \\ &= P(Q>0 \mid \mathbf{X}, \mathbf{Z})E(Q>0 \mid \mathbf{X}, \mathbf{Z}) \end{aligned} \quad (2)$$

where $P(Q>0 \mid \mathbf{X}, \mathbf{Z})$ is the conditional probability of being a smoker, and $E(Q>0 \mid \mathbf{X}, \mathbf{Z})$ is the conditional mean for cigarette quantity. We used logistic regression to model the binary component in the first stage where a value of 0 indicates a non-smoker, and values of 1 or greater indicate a smoker. We used Poisson regression for the frequency part, namely smoking quantity for those with values of 1 or greater.

For both smoking outcomes, we report tax elasticity and marginal effect estimates derived from their respective models. A marginal estimate is the predicted (or counterfactual) estimate of an outcome when setting the exposure of interest to a specific value (and using observed values for all other covariates). Likewise, a marginal contrast is the difference of predicted estimates when setting the exposure to two different values, while holding values of all other covariates constant.

2.2 Assumptions

One important assumption for using the DD framework to estimate causal effects is that counterfactual time trends are similar between treated and untreated populations. Baseline values may be different between populations, but changes over time should be the same if no tobacco control strategy was implemented. This assumption cannot be verified directly, but one common solution is to investigate pre-study trends for both groups. Since a TCS was implemented for most provinces during our study period, we tested if pre-FTCS trends were generally the same across provinces.

For smoking prevalence trends, we used a survey-weighted logistic regression model for years 1999-2002. Likewise, for mean smoking frequency trends, we used a survey-weighted two-part (logistic-Poisson) regression model for years 1999-2002. We included dummies for province and year, and province-year interaction terms in both models. We then used a Wald test of joint significance on the set of marginal contrasts of these cross product terms.

The Wald test for pre-2003 youth smoking prevalence trends yielded a χ^2 value of 25.7 with 27 degrees of freedom (DF), and a p-value of 0.5348. Similarly, the Wald test for pre-FTSC adult smoking prevalence trends yielded a χ^2 value of 32.6 with 27 DF, and a p-value of 0.2115. The Wald test for pre-2003 youth smoking frequency trends yielded a χ^2 value of 37.5 with 27 DF, and a p-value of 0.0857. Similarly, the Wald test for pre-2003 adult smoking frequency trends yielded a χ^2 value of 34.2 with 27 DF, and a p-value of 0.1597. Thus, for both smoking outcomes and for both youth and adult populations, trends prior to 2003 were not significantly different across the provinces of Canada, and this supports the use of a DD framework.

Another important assumption of the DD technique is that participants are exchangeable for each level of exposure within each group. A potential problem then is the presence of individual-level confounders. These are factors whose distributions could have changed

coincidentally with the timing of implementations or changes of a TCS and that also affect smoking behaviour. Because CTUMS contains representative samples of the Canadian population at any given year, surveys are likely to be exchangeable.

Provincial-level confounders are factors that are different between treated and untreated provinces, coincide with the timing of implementations or changes of a TCS, and also affect smoking behaviour. Additionally, differential effects by SEP of a TCS could be confounded if there are unmeasured factors associated with the timing of implementations or changes which affect smoking, and differ by socioeconomic group.

To help account for both levels of confounding, however, we included in potentially important individual-level and provincial-level covariates in our analytical models. We provide details of expanded statistical models that include all covariates to account for both levels of confounding, and heterogeneous effects (for studies on adults) in subsequent subsections.

Chapter 3: Manuscript 1

The contribution of excise cigarette taxes on the decline in youth smoking in Canada during the time of the Federal Tobacco Control Strategy (2002-2012)

Authors: Phongsack Manivong, Sam Harper, Erin Strumpf

Abstract

This study is an evaluation of the causal effect of cigarette taxes on smoking prevalence and frequency among youths in Canada, aged 15-18, after the launch in 2001 of the Federal Tobacco Control Strategy (FTCS) which was an initiative primarily focusing on the enforcement of the Tobacco Act and promotion of smoke-free legislation. Based on the Canadian Tobacco Usage Monitoring Survey 2002-2012 database and regression models with province and year fixed effects, and individual-level and provincial-level covariates, changes in excise cigarette taxes yielded negligible contributions to the reduction in smoking behaviour. For an increase of $1.00 in excise cigarette taxes per package of 20, the marginal effect was 0.2 (95% CI: -1.8, 2.2) percentage points for smoking prevalence, and 0.3 (95% CI: -1.2, 1.8) cigarettes for smoking frequency (past-week).

Although increases in excise tobacco taxes have the potential to reduce tobacco consumption, their effectiveness is sensitive to several factors including previous tax levels and the current anti-tobacco control environment. Excise cigarette taxes have been gradually increasing since the 1980s, and so, tax levels were already quite high by the launch of the FTCS. Moreover, tobacco taxes had to work in conjunction with other forms of tobacco control during the time of the FTCS, such as the Tobacco Act which regulates the manufacture and sale of tobacco, the enforcement of graphic warning labels on cigarette packages, and the implementation of smoke-free legislation.

Furthermore, a crucial component in the effective implementation of tobacco taxation in reducing tobacco consumption is that tax increases must be frequent and substantially large enough to counteract general price and income inflation. From 2002-2012, we can see that both smoking prevalence and mean smoking frequency have been in steady decline among youths in Canada. This decline, however, is present even in provinces with stable or decreasing cigarette tax levels suggesting that other factors common to all provinces such as growing anti-smoking sentiment have had a greater influence over tobacco use.

Keywords: quasi-experimental, difference-in-differences, health policy evaluation, tobacco taxes, cigarette taxes, provincial taxes, tobacco control strategy, tobacco control policy, smoking, prevention, deterrent, Canada, youths

3.1 Introduction

Since the start of the twenty-first century, tobacco consumption has slowly declined among youths in Canada. **Figure 3-1** shows decreases of 10.9 (95% CI: 9.0, 12.9) and11.2 (95% CI: 9.2, 13.1) percentage points in the prevalence of current smokers and past-week smokers, respectively, among youths aged 15-18 based on the Canadian Tobacco Use Monitoring Survey (CTUMS) 2002-2012 database. Similarly, **Figure 3-2** shows an average decrease of 9.2 (95% CI: 7.4, 11.0) cigarettes in weekly consumption among youths. (See **Appendix Table 1** for sample sizes of each year, and **Appendix Table 2** for estimates.) During this time, various forms of tobacco control were implemented at both the federal and provincial level. For example, the Federal Tobacco Control Strategy (FTCS) was a planned 10-year initiative launched in 2001 by a consortium led by Health Canada (HC) and Public Health Agency Of Canada (PHAC) to reduce tobacco consumption (HC & PHAC, 2012). Two key components were the promotion of smoke-free laws and the enforcement of the Tobacco Act which includes restrictions on the manufacture and sale, access, and promotion of tobacco products (Minister of Justice, 1997).

In a self-evaluation of FTCS goals, HC and PHAC identified individual and environmental factors that predict smoking prevalence and frequency (HC & PHAC, 2012). The most important predictors were education attainment, tobacco taxes, bans on retail display and legal smoking age. Their conclusions, however, were based on econometric models that did not include indicators for province or time, and thus, did not account for the variation in smoking rates across the provinces of Canada and the general declining smoking trend common among provinces. These types of models provide only associational measures of effect, and do not allow for a causal interpretation. Therefore, questions remain about the extent to which policy reforms like the FTCS are responsible for declines in youth smoking rates.

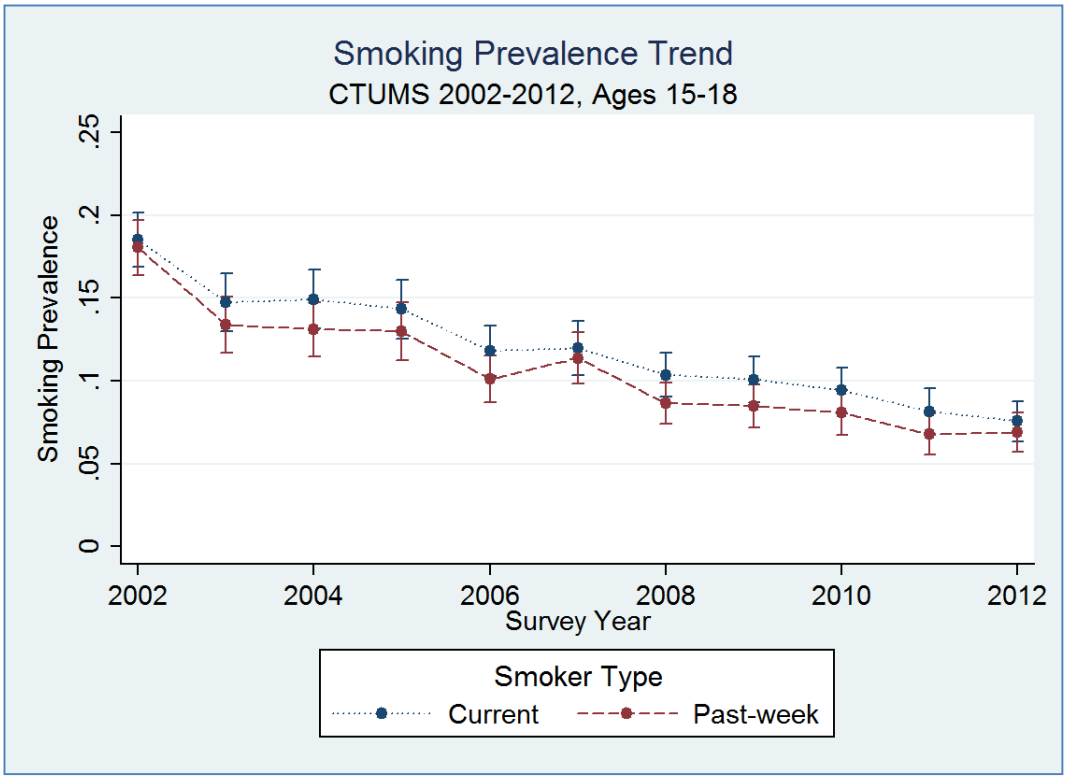

Figure 3-1. Marginal estimates and 95% CIs of smoking prevalence from logistic models with year fixed effects only.

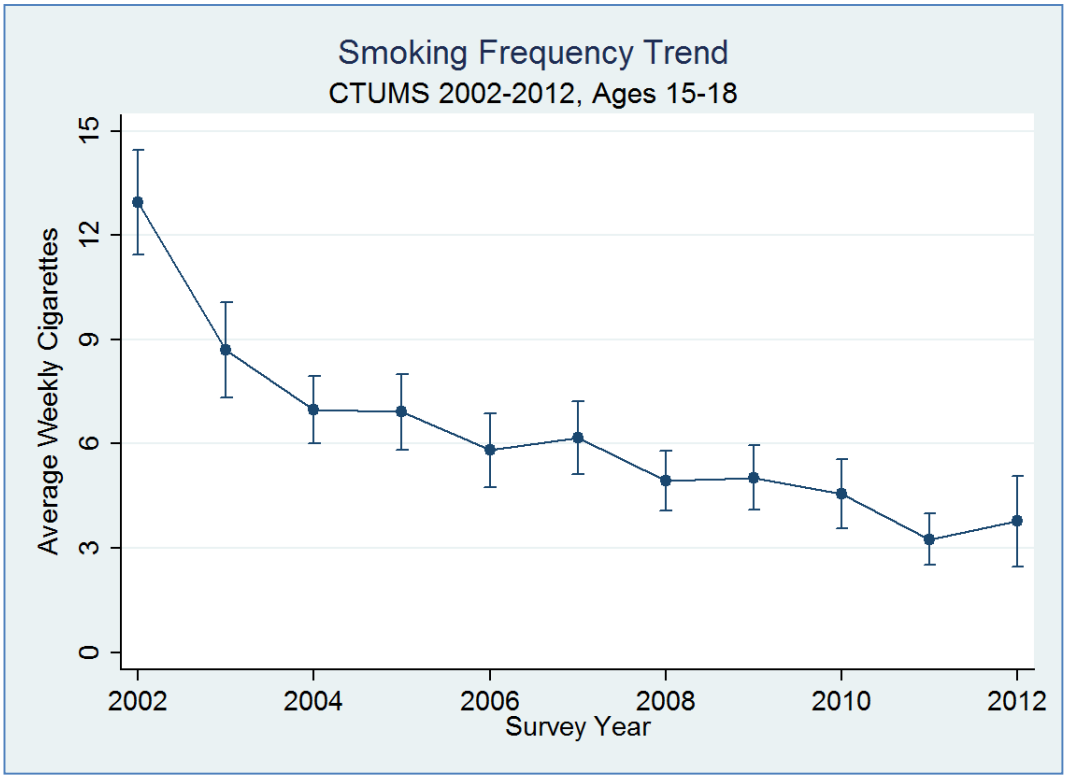

Figure 3-2. Marginal estimates and 95% CIs of smoking frequency from weighted two-part (logistic-Poisson) model with year fixed effects only.

Another common tobacco control strategy that HC and PHAC cite as being an important predictor for smoking is excise tobacco taxes. A working group of experts across various disciplines assembled together for The International Agency for Research on Cancer (IARC) to summarize the body of literature on tobacco control policies and their effectiveness (Chaloupka et al., 2011). The working group deemed that there was sufficient evidence for the following conclusions regarding the effectiveness of tobacco taxes on youth smoking habits. (1) Tobacco taxes reduce the prevalence of tobacco use among youth. (2) Tobacco taxes reduce the development of regular tobacco use.

A stipulation for the effective use of taxation as a tobacco control strategy, however, is that tax increases must be frequent and substantially large enough to counteract general price and income inflation (Chaloupka, 2013). In Canada, tobacco taxes are implemented at both the federal and provincial levels. In February 1994, there was a change in the law that allowed a *reduction* in tobacco taxes at the federal and provincial levels due to concerns about increases in smuggled and contraband tobacco products (Gruber et al., 2003). Evaluations on the effect of tobacco tax cuts suggested an inverse relationship with youth review (Auld, 2005; Sen & Wirjanto, 2010; Waller et al., 2003). In more recent years, however, nominal tobacco taxes have only increased and primarily at the provincial level (Canadian Tax Foundation, n.d.; Reid & Hammond, 2013). Given the variation in tobacco tax levels and tax increases across the provinces of Canada and the existence other forms of tobacco control during the time of the FTCS, it is unclear how much increases in cigarette taxes during the time of the FTCS have contributed to the decline in youth smoking. Thus, an important question of interest with respect to Canada then becomes, how much have recent increases in cigarette taxes during the time of the FTCS contributed to the decline in youth smoking?

Though much research has been done on the effects of taxes and prices on youth smoking (Bader et al., 2011; Thomas et al., 2008; Wilson et al., 2012), previous studies can only partially answer our question of interest. Moreover, one review focused on the effect of tobacco price on smoking onset observed methodological limitations in most studies (Godefroy Emmanuel Guindon, 2013). Thus, the objective of our paper is to evaluate the impact of recent increases in cigarette taxes on smoking behaviour among youths aged 15-18 in Canada, particularly with more methodological rigor. More specifically, we are interested in assessing the impact of cigarette taxes on the prevention and deterrence of youth smoking. (1) How much have recent increases in cigarette taxes influenced the prevalence of youth smoking? (2) Additionally, have changes in cigarette taxes contributed to reducing the development of habitual smoking by reducing smoking frequency (quantity)?

3.2 Background

Numerous studies have evaluated the effects of cigarette price (or taxes) on tobacco consumption for youths. One systematic review on the impact of cigarette taxes and prices on high-risk populations captured 67 studies on youths (Bader et al., 2011). The authors noted that although there was variation in elasticity estimates among included studies, most studies showed increases in price were associated with decreases in smoking prevalence or cigarette quantity. There was less agreement, however, in findings regarding increases in price and smoking initiation. Another systematic review on the impact of tobacco control on smoking initiation, cessation, and prevalence, included 15 studies evaluating their effects on youths (Wilson et al., 2012). The authors reported elasticity estimates ranging from −1.41 to −0.10 for smoking prevalence and −0.65 to −0.09 for smoking initiation. In a systematic review on population tobacco control policies and their effects on social inequalities in smoking, 16 studies focused on the effects of taxes and prices on youth smoking (Thomas et al., 2008). Again, the authors noted a negative association between taxes or price and youth smoking.

The most commonly reported measure of effect among studies captured in these systematic reviews is price or tax elasticity, which is the percentage change in smoking given a percentage change in price or taxes. Elasticity estimates, however, are sensitive to the study population, time frame, price/tax range, and specifications of price and demand (Nghiem, 2013). Thus, there are several limitations in inferring the effect of tax or price changes on smoking from these studies to a Canadian setting during the time of FTCS.

The first limitation is the use of different study populations, in particular different country settings where tobacco tax levels and other policies can vary from country to country. Among the aforementioned systematic reviews, most studies were conducted in the United States or

European countries. Only six Canadian studies were captured in all (Auld, 2005; Boudarbat & Malhotra, 2006; Ferrence et al., 1991; Gruber et al., 2003; Sen & Wirjanto, 2010; Waller et al., 2003). Therefore, the effect of tax or price changes on smoking for other countries may not apply to Canada. To provide some context, in the 1980s and 1990s, the average price of cigarettes (in year 1999 dollars) was US $1.86 and US $2.33 per pack in the United States and Canada, respectively (Gruber et al., 2003).

Moreover, the general tobacco control environment can also vary between countries. For instance, Canada has other forms of tobacco control including smoke-free laws, the Tobacco Act, and graphic warning labels (GWLs). In 2001, Canada became the first country to require that GWLs cover at least 50% of both front and back of cigarette packages (Canadian Cancer Society, 2012). Conversely, in the United States, advocates for the tobacco industry claim that GWLs are violations of their constitutional rights and have thus far prevented the implementation of GWLs. A recent study evaluated the use of GWLs in Canada with the United States as a control group (Huang et al., 2014). With a series of difference-in-differences models using 9 years of data before and 9 years after the implementation of GWLs, the authors showed that GWLs reduced smoking prevalence by 2.8–4.7 percentage points.

Another limitation is the timeframe. All these seven Canadian studies evaluated the effects of changes in cigarette taxes or price in the 1980s and 1990s. As previously mentioned, the federal government allowed reductions in excise tobacco taxes in 1994, and a key interest then was evaluating the effect of these reductions on youth smoking. More importantly however, is that tobacco tax levels were much lower during that time compared to the time of FTCS. From 1981 to 1999, the average national cigarette tax level increased from about $5.00 to $25.00 per carton of 200 cigarettes (Gruber et al., 2003). Moreover, excise tobacco taxes were also the

primary form of tobacco control in Canada with broader provincial smoke-free laws and health warnings on cigarette packages being implemented after 2000 (Non-Smokers's Rights Association, 2012b; Reid & Hammond, 2013). So, although these Canadian studies contributed to the literature on the effects of changes in cigarette taxes and prices on youth smoking for those decades, they cannot shed light on the impact of additional increases in excise cigarette taxes during the time of the FTCS.

A second limitation is the age distribution, particularly the inclusion of both youths and adults within the same study. An important point is that youths and adults respond differently to cigarette taxes. In order for youths to be sensitive to price, they must be able to purchase cigarettes and at least contemplate purchasing cigarettes (Emery et al., 2001). The most common source for cigarettes, however, were other youths (Emery et al., 1999; Forster et al., 2003). This would indicate that most youths were not purchasers of cigarettes, and those who do purchase cigarettes themselves, do so illegally. Note that the legal age for tobacco purchase in Canada is 18 (Reid & Hammond, 2013). Thus, it is unclear how direct of an effect taxes have on youths.

Another point is that the effect of tobacco control on youths and adults have different implications (Chaloupka et al., 2011). For youths, the effect of taxes is the impact on smoking initiation and habit development; while for adults, the effect is the impact on smoking cessation and reduction. The study by Gruber et al. (2003) included all those aged 15 and over, and thus, do not allow for a clear differentiation of the effects of tobacco taxes on youths and adults. Our study focused on youths aged 15-18.

Moreover, these Canadian studies above used *average* annual provincial prices or taxes for a carton of 200 cigarettes or the Canadian Consumer Price Index for tobacco products as the exposure (policy) variable. One disadvantage of this approach to measure price or tax levels is

that changes often occur within the year, and this could cause a bias towards the null as the same price or tax level is assigned to a population before and after a tax increase. Secondly, average cigarette price includes retail mark ups and retail sales taxes. Hence, their conclusions cannot necessarily be inferred as causal effects of tobacco taxation *per se*. We based the policy variable in our study on the cumulative amount of cigarette taxes for a package of 20 cigarettes at the time of interview (DeCicca et al., 2008; DeCicca & McLeod, 2008).

A recent Canadian study evaluating the effects of cigarette taxation on tobacco consumption was published in 2011 (Azagba & Sharaf, 2011). That study used the National Population Health Survey (NPHS), consisting of six biannual longitudinal survey waves from 1998-2008. Although this study focused on Canada and used excise cigarette taxes as the policy variable, it does not fully address our research questions. One limitation is that the included age range (12-24) does not allow for a clear interpretation for the effect of taxes on youth smoking. The most important limitation, however, is their omission of a specification of demand commonly found in the literature, specifically, smoking intensity or frequency. To address our second research objective and for comparability with other publications on the effects of taxes on smoking frequency, however, we included analyses with cigarette quantity as an outcome.

In summary, studies captured in aforementioned systematic reviews, including Canadian ones cannot fully address the impact of recent increase in excise cigarette taxes on youth smoking in Canada during the time of FTCS. Our study will contribute to the literature on the effects of cigarette price on youth smoking in several ways. The primary contribution is the assessment of the effects of recent cigarette tax changes (2002-2012) in Canada when tax levels are already high and where excise taxes must work in conjunction with other forms of tobacco control. By 2002, tobacco taxes (adjusted for the inflation using Canadian Price Index of a basket

of general goods) accounted for approximately 62% (Nova Scotia and Ontario) to 71% (Alberta) of average cigarette price. The second contribution is a clearer distinction of the effects of cigarette tax changes on the youth population. The third is the use of a more precise policy variable compared to the commonly used average annual price, namely cigarette tax levels linked to the time of interview. The final contribution is the inclusion of cigarette quantity as an outcome for comparability with other publications on the effects of price (or taxes) on smoking frequency.

3.3 Data and Measures

Individual-level Covariates

Our analyses required linking data from different sources together. The Canadian Tobacco Use Monitoring Survey (CTUMS) provided data on individual-level demographic variables. CTUMS also contained the year and month of the interview, which allowed for a more precise assignment of cigarette tax levels and the identification of provincial smoke-free laws in effect.

CTUMS was launched in 1999 in order to continuously monitor smoking trends, particularly among the most at-risk group, namely those aged 15-24 (Statistics Canada, 1999). It is a population-weighted, multi-stage, cross-sectional survey conducted semi-annually by telephone using random digit dialling collecting data at the household and individual level. Multiple individuals may be selected from the same household. The target population of CTUMS are residents of Canada aged 15 and older, excluding residents of the Yukon, Northwest Territories and Nunavut, and full-time residents of institutions.

CTUMS data for years from 2002-2012 were used in primary set of analyses to correspond approximately to the timing of the FTCS. Each survey contained approximately 20,000 individuals, with over-sampling of youths (about 46% for those aged 15-24 compared to 16% in the population). The cumulative sample size for the eleven years of data was about 229,000. The target population of our study were youths aged 15 to 18 (about 21.5% of the entire CTUMS database, compared to only 6.5% in the population). After the age exclusion, the potential sample size for our study was 49,172 participants. For information on sample size by year, see **Appendix Table 1**.

Individual-level data of interest included education, age (years), sex, language (spoken at home), and household size. We used binary dummies for age, with 15 as the reference. The variable for sex consisted of two options: *male* and *female* (reference). Language spoken at home was a categorical variable with the following options: *English* (reference), *French*, *English & French*, and *Other*. Household size was a categorical variable with *1* (reference), *2*, *3*, *4* and *5 or more* as options.

Education was a derived variable consisting of four distinct categories: *High school not completed & not current student* (reference), *High school not completed but current student*, *High school graduate & not current student*, and *High school graduate & current student*. We based high school graduation status on self-reported highest level of education attainment. In survey years prior to 2004, we based current student status on the question asked to all participants regarding "main activity in previous year" where student was a possible answer. In survey years 2004 and after, we based current student status on the question regarding "currently in high school, college or university" asked among those under 25.

Outcome Variables

The Canadian Tobacco Use Monitoring Survey provided data on youth smoking behaviour. We considered two smoking-related outcomes: smoker status and smoking frequency. We defined both outcomes based on the cigarette quantity smoked variable. Survey participants were asked if they smoked within the past 30 days and, if so, how many cigarettes they smoked within the previous 7-day period. (The term "past-week" will be used going forward.) Past-week cigarette quantity was set to 0 if the participant did not report smoking within the past 30 days.

We set past-week smoker status to 1 if the number of cigarettes reported was 1 or greater, and 0 if the participant did not smoke within the past week. We used self-identified current smoker status as a sensitivity analysis for past-week smoker status. **Table 3-1** shows the agreement between the two smoking status outcomes. The majority of their differences is attributable to missing data using the past-week definition (N=896). Among those with non-missing data, there was approximately 98.3% agreement. Within the disagreements of non-missing data (N=844), approximately 80% (N=675) consisted of self-described current smokers (consisting of daily and occasional smokers) who did not smoke within the past week, and the other 20% (N=169) consisted of self-identified non-current smokers who did smoke within the past week which presumably consists of experimenters or those in the process of quitting.

Using the number of cigarettes smoked in the past-week definition consistently produced prevalence estimates that were slightly lower than those using the self-identified current smoker definition. Recall **Figure 3-1** showing past-week smoker and current smoker trends from 2002-2012. See **Appendix Table 2** for corresponding yearly estimates of past-week smoker and current smoker prevalence. See **Appendix Table 3** for past-week smoking prevalence estimates by year and province.

Among smokers, the maximum reported value for smoking frequency was 440 cigarettes within the past week which is equal to 22 packs of 20 cigarettes. The value of the 95 percentile was 175 cigarettes which is almost 9 packs. The mean, however, was 58.5 (95% CI: 56.3, 60.7) cigarettes which is almost 3 packs. See **Figure 3-3** for a histogram of past-week cigarette consumption (among smokers). See **Appendix Table 4** for past-week smoking frequency estimates by year and province. See **Appendix Figure 1** and **Appendix Figure 2** for histograms of past-week cigarette consumption by year and by province, respectively.

Table 3-1. Comparison of Smoker Status Outcomes

Smoker Status		Current Smoker		
		No	**Yes**	**Total**
Past-week Smoker	**No**	41,981	675	42,656
	Yes	169	5,451	5,620
	Missing	20	876	896
	Total	42,170	7,002	49,172

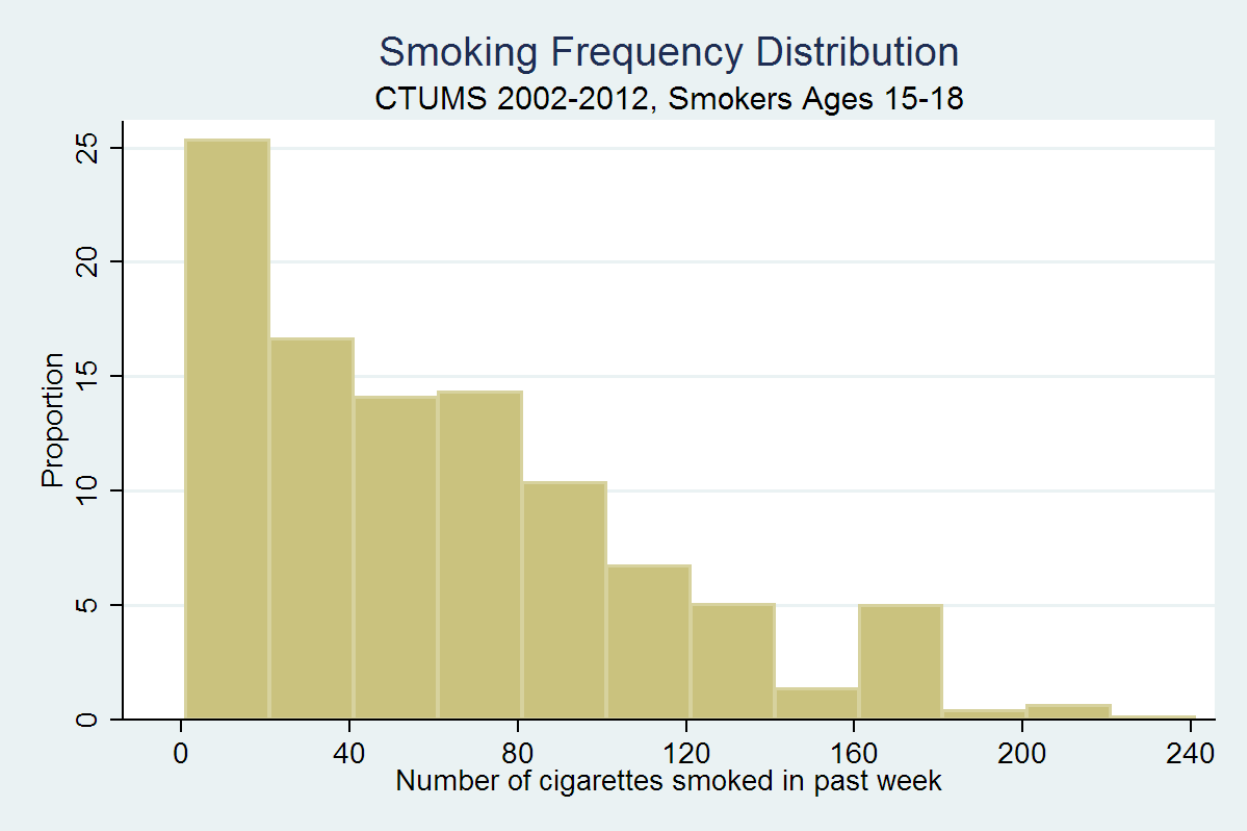

Figure 3-3. Histogram of past-week cigarette quantity. Each bar represents a pack of 20 cigarettes.

Provincial-level Tobacco Taxes

The main source of data on excise cigarette tax levels and their corresponding effective dates were extracted from the Finances of The Nation 2002-2012 reports provided by the Canadian Tax Foundation (Treff & Ort, 2008-2012; Treff & Perry, 2002-2007).[1] The report *Tobacco Use in Canada: Patterns and Trends,* provided by the Propel Centre for Population Health Impact (an affiliate of the University of Waterloo) was used to assess agreement of data on cigarette taxes (Reid & Hammond, 2013). It provided data on excise cigarette tax *increases* and corresponding effective dates starting in December 2003. There was no observed discrepancy between the two sources. For both sources, cigarette taxes were reported for a carton of 200 cigarettes, but we calculated amounts for a typical package of 20 cigarettes (DeCicca et al., 2008; DeCicca & McLeod, 2008).

Although both federal and provincial levels of government imposed excise cigarette taxes, from 2002 to 2012 virtually all tax changes were at the provincial level. Additionally, during this time there were only nominal increases to excise cigarette taxes. (See **Appendix Table 10** for details on the changes and timing of federal and provincial excise tax levels.)

To account for inflation (or in other words, to express changes to cigarette taxes relative to price changes for all goods), nominal tax changes were standardized to year 2000 dollars by the Canadian Consumer Price Index (CPI) of general goods (Chaloupka, 2013). Data on the CPI of general goods were extracted from Canadian Socioeconomic Information Management system (CANSIM), Statistic Canada's online database (Statistics Canada, 2012, 2014). Our method to adjust cigarette tax levels by the CPI followed that of the Azagba & Sharaf (2011) study. See

[1] A correction was made based on inconsistencies in the Finances of the Nation reports. In the 2003 report, the total of the federal and provincial cigarette taxes for Nova Scotia do not sum correctly. Based on data in the 2004 report, we assumed an addition error in the 2003 report. The authors, however, accept responsibility for any error in this paper.

Appendix A-3 for an explanation of our process to adjust cigarette tax levels by the CPI, including CPI values of general goods by year and province.

Table 3-2 provides means of nominal cigarette tax levels by year and province. **Table 3-3** shows means of annual CPI-adjusted cigarette tax levels by province. (Although there have been no tax cuts, adjusted tax levels can show a decrease after adjustment by the CPI.) **Figure 3-4** shows cumulative nominal and CPI-adjusted cigarette tax levels by province and year. (**Appendix Table 11** contains CPI values of general goods by year and province and **Appendix Table 12** compares different methods of CPI-adjustment). Note that the absolute range in nominal tax levels was approximately $3.00 - $7.00, while the range for CPI-adjusted cigarette tax levels was $3.00-$5.00 and that most year-to-year increases were less than $1.00. It is also important to note that provinces like Nova Scotia and Prince Edward Island experienced gradual increases in CPI-adjusted cigarette tax levels. Quebec on the other hand, had minimal increases in nominal cigarette tax levels, and so, experienced slight decreases in CPI-adjusted cigarette tax levels for most years during the time of the FTCS.

We performed two additional assessments to validate the viability of tobacco taxes as a policy (exposure) variable. The first one determined that there was adequate exogenous variation of cigarette tax levels beyond what exists among and within provinces over time. The second one confirmed the appropriateness of using average cigarette price (when interested in assessing their impact on smoking-related outcomes) to infer that changes are driven by cigarette taxes. See **Appendix A-4** for details on these assessments.

Table 3-2. Means of Nominal (Sum of Federal & Provincial) Cigarette Taxes for a Pack of 20

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland &	3.79	4.29	4.59	4.79	4.99	5.24	5.30	5.30	5.30	5.50	5.50
Prince Edward Island	3.37	3.87	4.57	5.08	5.08	5.13	5.19	5.69	6.19	6.19	6.78
Nova Scotia	3.19	3.69	4.19	4.69	4.69	4.75	5.00	5.00	6.00	6.00	6.00
New Brunswick	3.54	3.94	3.94	3.94	3.94	3.99	4.05	4.05	4.05	4.05	5.10
Quebec	3.40	3.40	3.40	3.65	3.65	3.70	3.76	3.76	3.76	3.82	3.88
Ontario	2.71	3.31	3.31	3.93	3.93	4.11	4.17	4.17	4.17	4.17	4.17
Manitoba	3.99	4.49	4.69	5.09	5.09	5.14	5.20	5.20	5.40	5.80	6.20
Saskatchewan	3.31	4.79	4.79	5.09	5.09	5.24	5.36	5.36	5.36	5.90	5.90
Alberta	2.99	4.79	4.79	4.79	4.79	4.84	5.40	5.40	5.70	5.70	5.70
British Columbia	4.59	4.59	5.17	5.17	5.17	5.22	5.28	5.28	5.40	5.40	5.40

Table 3-3. Means of CPI-Adjusted Federal & Provincial Cigarette Taxes for a Pack of 20 (In Year 2000 Dollars)

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland &	4.03	4.24	4.36	4.43	4.56	4.54	4.46	4.45	4.49	4.37	4.29
Prince Edward Island	3.60	4.04	4.49	4.45	4.38	4.33	4.53	4.94	4.96	5.12	5.17
Nova Scotia	3.39	3.75	4.17	4.14	4.09	4.18	4.14	4.59	4.86	4.69	4.61
New Brunswick	3.36	3.63	3.57	3.49	3.46	3.42	3.39	3.39	3.32	3.77	3.98
Quebec	3.24	3.16	3.29	3.26	3.23	3.20	3.17	3.16	3.11	3.07	3.06
Ontario	2.93	3.06	3.29	3.50	3.56	3.53	3.49	3.49	3.41	3.31	3.26
Manitoba	4.16	4.34	4.57	4.56	4.50	4.44	4.38	4.50	4.75	4.88	5.19
Saskatchewan	4.27	4.42	4.53	4.50	4.46	4.49	4.40	4.37	4.65	4.60	4.53
Alberta	4.22	4.37	4.30	4.21	4.10	4.27	4.30	4.47	4.47	4.36	4.30
British Columbia	4.39	4.46	4.74	4.65	4.59	4.54	4.48	4.58	4.51	4.40	4.35

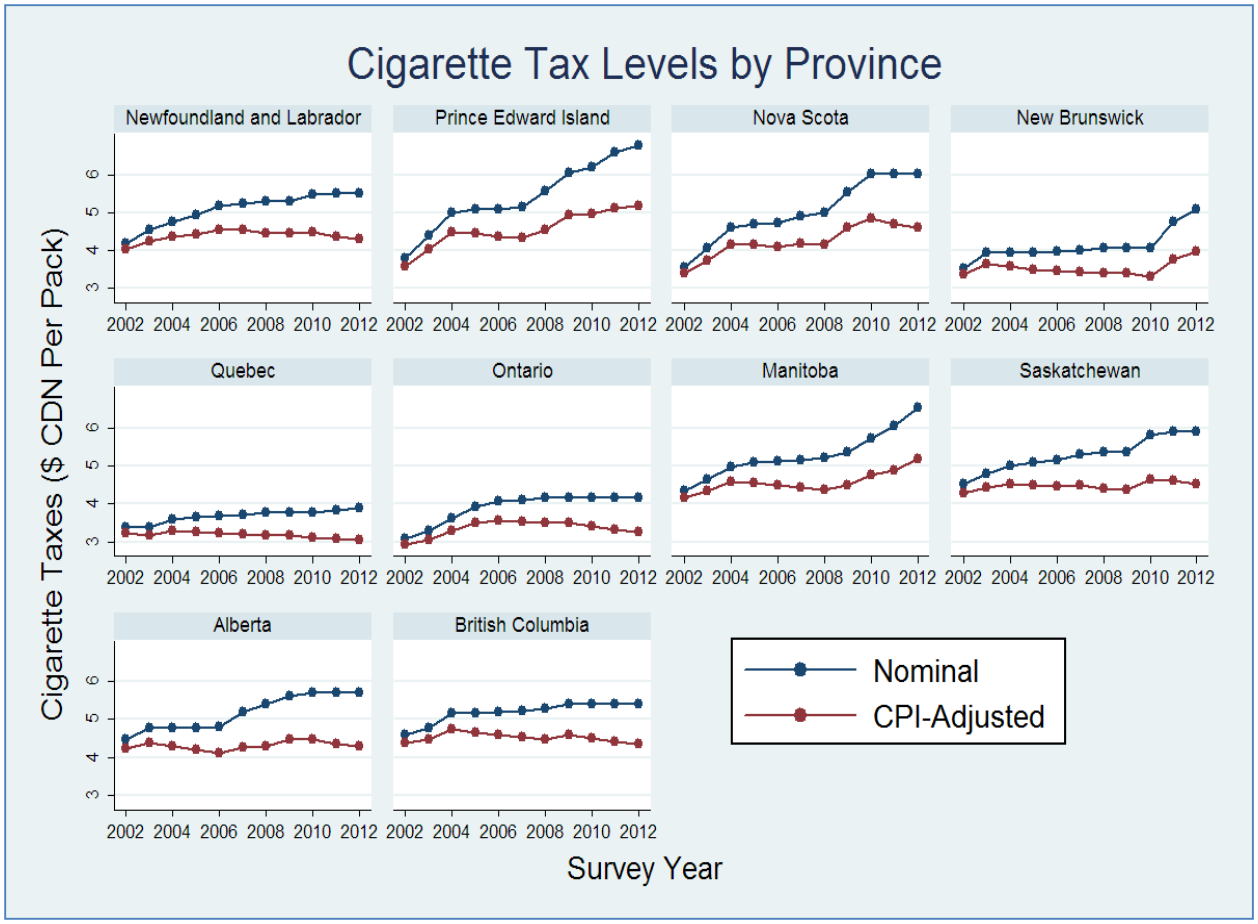

Figure 3-4. Means of cigarette tax levels, based on Finances of the Nation 2002-2012 reports and CTUMS 2002-2012, ages 15 and over

Other Provincial Data

We considered four potential provincial-level confounders in our study. These are factors that affect smoking and whose implementation or changes may have coincided with changes in cigarette tax levels during the time of the FTCS. We included two other tobacco control strategies where their implementation varied by province, namely smoke-free laws and retail tobacco display bans. The main source of provincial smoke-free laws was the report, *Provincial and Territorial Smoke-Free Legislation Summary* (Non-Smokers's Rights Association, 2012b). Data on tobacco retail display bans were extracted from a Canadian Centre for Health Economics working paper (Irvine & Nguyen, 2014). For retail tobacco display bans, we created a binary variable to indicate a ban in effect in each province at time of interview. Similarly, for provincial smoke-free laws, we created a binary variable to indicate a law in effect in each province at time of interview based on the date of first implementation. (See **Appendix Table 14** and **Appendix Table 15** for the timing of provincial smoke-free legislation and provincial retail tobacco display ban, respectively.)

To account for the potential effect of unemployment, we included rates based on those aged 15-19 (Azagba & Sharaf, 2011; DeCicca & McLeod, 2008). (Rates for the age range of 15-18 were not available.) Data on the Labour Force Survey estimates of unemployment rates were extracted from the CANSIM (Statistics Canada, 2012, 2014). Additionally, retail sales tax rates (at time of interview) were another potential provincial-level confounder. Depending on the province and year, we either summed the provincial sales tax (PST) rate and goods & services tax (GST) rate, or the harmonized sales tax (HST) rate (Canada Revenue Agency, n.d.; Canadian Tax Foundation, n.d.). See **Appendix Table 16** for means of annual retail sales tax rates and **Appendix Table 17** for annual unemployment rates.

3.4 Methods and Analyses

Statistical Model

Linking data on excise cigarette taxes to repeated cross-sections of CTUMS permitted the use of the difference-in-differences (DD) analytical framework where timing of tax increases was the pseudo-randomized component in our study. Let Y_{ips} be a smoking-related outcome for individual *i*, in province (*P*) *p*, survey year (*S*) *s*, and let be T_{ps} be the corresponding cumulative amount of excise cigarette taxes. The expectation (or mean) of Y_{ips} then becomes,

$$E(Y_{ips}) = \beta_0 + \beta_1 T_{ps} + \sum_{\forall p} \beta_p P_p + \sum_{\forall s} \beta_s S_s + \sum_{\forall c} \beta_c X_{c_{ips}} + \sum_{\forall k} \beta_k Z_{k_{ps}} \quad (1)$$

where $\boldsymbol{\beta_p}$ and $\boldsymbol{\beta_s}$ are coefficients denoting province and year fixed effects, respectively. Both province and year are modeled with a series of binary dummies. Fixed effects for province account for all time-invariant provincial level differences in the smoking-related outcomes. Fixed effects for year account for shared trends in smoking over time that may be driven by shared factors or policies such as federal level tobacco control strategies like graphic warning labels. The term $\boldsymbol{X_c}$ denotes a potentially important individual-level covariate such as age, gender, education-student status, language spoken at home, and household size, and $\boldsymbol{\beta_c}$ is the corresponding coefficient of association. Similarly, the term $\mathbf{Z_k}$ denotes a potentially important time-varying provincial-level characteristic as described in the previous section, and $\boldsymbol{\beta_k}$ is the corresponding coefficient of association. Retail sales tax rates were not correlated to CPI-adjusted tax levels. Hence, we did not include retail sales tax rates in our regression models.

The main coefficient of interest is β_1. More specifically, the effect of a cigarette tax increase would be the difference in the change of smoking behaviour between provinces that raised taxes relative to provinces that did not raise taxes. Under the assumption that increasing cigarette taxes reduces smoking, β_1 should be a negative value for both smoking outcomes.

We estimated the effect of taxes on the additive scale (marginal effects) for the purpose of simplicity and ease of interpretation. We modeled smoking prevalence, however, using logistic regression. Assessing smoking frequency, on the other hand, required a two-part model where a binary component for smoking is modeled in the first stage and a frequency component in the second stage (Cragg, 1971). A single quantity variable is used to model both parts. We used logistic regression to model the binary component where a value of 0 indicates a non-smoker, and values of 1 or greater indicate smoking prevalence. We used Poisson regression for the frequency part, namely smoking quantity for those with values of 1 or greater.

To assess the contribution of changes in cigarette tax levels on smoking on the additive scale, we computed marginal effect estimates for an increase of $1.00 (per package) for both smoking outcomes which are predicted counterfactual outcomes based on observed values for all other covariates. To compare with other studies, we calculated tax elasticity estimates (a relative effect measure). We, however, will discuss our results primarily on the additive scale.

Analytical Plan

Data extraction and data management were performed using SAS 9.3 and Stata/MP 12.1. All statistical analyses were performed using Stata/MP 12.1. All estimates reported in our paper were derived using survey weights (Korn, 1999). Standard errors (SEs) and 95% confidence intervals (CIs) were computed using bootstrap sampling (Efron & Tibshirani, 1986). Unless stated otherwise, we used the set of 200 bootstrap weights provided by CTUMS, as recommended by Statistics Canada for use of their survey data (Statistics Canada, 2011). (Note that each bootstrap weight itself was an average based on 20 samples). See Appendix A-7 for details on Stata code used for data analyses.

Our analytical structure followed that of DeCicca & McLeod (2008). In addition to a *crude* model, we assessed the effect of cigarette taxes on each smoking outcome (prevalence and frequency) using three regression models. *Model 1* included fixed effects for province and survey year. *Model 2* included individual-level covariates as previously specified. *Model 3* expanded upon *Model 2* by adding provincial-level covariates.

To check for the robustness of our results, we performed seven different types of sensitivity analyses based on the *Model 3*. The first set of sensitivity analyses considered the potential for non-linear effects of tax changes by assessing incremental dollar increases that span the range of our study ($3.00-$5.00). The second involved the use of the Probit model, more commonly found in the literature on tobacco taxation and price on smoking. Thirdly, for the smoking prevalence outcome, we substituted past-week smoker status with current smoker status as described in Section 3. The fourth sensitivity analysis pertained only to the smoking frequency outcome. Here, we used a negative-binomial distribution instead of a Poisson distribution to relax the mean-variance equality assumption. For the fifth set of sensitivity analyses, we estimated robust standard errors with and without clustering by province (assuming non-independence and independence of participants within the same province) in order to compare with the bootstrap sampling method. For the sixth sensitivity, we excluded one province at a time to assess if tax changes for a particular province were influencing our estimates. Similarly, for the last sensitivity, we incrementally included a year of data to determine if tax changes for a particular year had a significant impact on smoking.

3.5 Results

Table 3-4 shows the weighted proportions (or mean for the case of past-week cigarette quantity among smokers) of key demographic characteristics of the 2002-2012 CTUMS sample, ages 15-18. Estimates from the *Full Sample* column include individuals with missing data. Estimates from the *Complete Case* column are based only on individuals with complete data. Note, however, that estimates are similar between both columns. About 97.5% of participants had complete information for covariates considered in this study. The majority of the missing data (N=1,258) were attributable to the outcome past-week smoker, education, and language spoken at home. Since the overall percentage of individuals with missing data was small, we based subsequent analyses for youth smoking on individuals with complete data.

The average prevalence for past-week smoker was about 10.7%, and among smokers, mean weekly consumption was 58.5 cigarettes. Although CTUMS contains an approximately equal proportion of participants from each province, Ontario (39.3%), Quebec (22.1%), British Columbia (13.1%), and Alberta (11.1%) make up the majority of the population. Not surprisingly, among the education-status groups, those who were not high school graduates, but still current students accounted for a majority of the sample at 68.5%. Those who were high school graduates, but still current students were the second largest group at 18.8%. Age was fairly evenly distributed in our sample with each year from 15-18 accounting from 24.0% to 25.6%. English was the most common language spoken at home, accounting for 70.7% of the sample, while French had the second highest representation 19.5%. A four-person household was the most common household size, representing about 39.1% of the sample, while a household of five or more people had the second highest representation at 33.9%.

Table 3-4. CTUMS Survey-weighted Sample Characteristics, 15-18

Characteristic	Full Sample		Complete Case	
	Estimate	**SE**	**Estimate**	**SE**
Sample Size	49,172		47,914	
Past-week Smoker	10.8	0.2	10.7	0.2
Missing (Number)	896			
Past-week Cigarette Quantity (Smokers)	58.6	1.1346	58.5	1.1379
Province				
Newfoundland and Labrador	1.5	0.0	1.5	0.0
Prince Edward Island	0.5	0.0	0.5	0.0
Nova Scotia	2.9	0.0	2.9	0.0
New Brunswick	2.2	0.0	2.2	0.0
Quebec	22.1	0.1	22.1	0.2
Ontario	39.2	0.2	39.3	0.2
Manitoba	4.0	0.0	3.9	0.0
Saskatchewan	3.5	0.0	3.5	0.0
Alberta	11.1	0.1	11.1	0.1
British Columbia	13.1	0.1	13.1	0.1
Survey Year				
2002	8.8	0.2	8.8	0.2
2003	8.8	0.1	8.7	0.1
2004	8.9	0.1	8.9	0.1
2005	8.9	0.1	8.9	0.1
2006	9.2	0.1	9.2	0.1
2007	9.2	0.1	9.1	0.1
2008	9.4	0.1	9.4	0.1
2009	9.4	0.1	9.5	0.1
2010	9.3	0.1	9.3	0.1
2011	9.1	0.1	9.2	0.1
2012	9.1	0.1	9.0	0.1
Education-Student Status				
No H.S. & not current student	5.6	0.2	5.4	0.2
No H.S. & current student	68.3	0.4	68.5	0.4
H.S. grad & not current student	7.3	0.2	7.3	0.2
H.S. grad & current student	18.7	0.3	18.8	0.3
Missing (Number)	338			
Male	51.4	0.2	51.2	0.2
Age (Years)				
15	24.8	0.3	25.0	0.4
16	25.3	0.4	25.4	0.4
17	25.7	0.3	25.6	0.3
18	24.2	0.3	24.0	0.3
Language (Spoken at Home)				
English	70.8	0.3	70.7	0.3
French	19.4	0.2	19.5	0.2
English and French	0.6	0.1	0.6	0.1
Other	9.2	0.2	9.2	0.2
Missing (Number)	328			
Household Size				
1	0.6	0.1	0.6	0.1
2	6.1	0.2	5.8	0.2
3	20.7	0.3	20.6	0.3
4	39.0	0.4	39.1	0.4
5 or more	33.7	0.4	33.9	0.4
Missing (Number)	3			

Weighted proportions (or mean for the case of past-week cigarette quantity among smokers) and standard errors.

Table 3-5. Effect of CPI-adjusted Cigarette Taxes on Smoking Prevalence, Ages 15-18

Model	Marginal Effect			Elasticity		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-0.7%	-1.5%	0.0%	-0.26	-0.51	-0.01
1: Province and Year Fixed Effects	0.0%	-2.1%	2.0%	-0.02	-0.74	0.71
2: Model 1 + Individual Covariates	0.1%	-1.8%	2.1%	0.04	-0.70	0.79
3: Model 2 + Provincial Covariates	0.2%	-1.8%	2.2%	0.08	-0.67	0.84

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on smoking prevalence on the additive scale. Elasticity estimates indicate the percentage change in smoking prevalence given a 1% change in taxes.

Table 3-6. Effect of CPI-adjusted Cigarette Taxes on Smoking Frequency

Model	Marginal Effect			Elasticity		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-0.6	-1.1	-0.1	-0.35	-0.65	-0.04
1: Province and Year Fixed Effects	-0.1	-1.6	1.5	-0.04	-1.01	0.93
2: Model 1 + Individual Covariates	0.1	-1.3	1.6	0.10	-0.91	1.11
3: Model 2 + Provincial Covariates	0.3	-1.2	1.8	0.18	-0.86	1.22

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on mean weekly cigarette consumption on the additive scale. Elasticity estimates indicate the percentage change in mean weekly cigarette consumption given a 1% change in taxes.

Although the direction of effect estimates for *Model* 2 and *Model* 3 were different from estimates for *Model 1*, they remained statistically non-significant (at the 95% confidence level) suggesting that including individual and provincial level covariates did not have much influence on the effect of cigarette taxes on smoking prevalence. Based on *Model 3*, the marginal effect for an increase of $1.00 per package on smoking prevalence was 0.2 (95% CI: -1.8, 2.2) percentage points. As increases in cigarette taxes were actually smaller than $1.00 for many provinces, expected changes in smoking prevalence would remain negligible for smaller increases. Thus, in regards to our first objective, we found little evidence that changes in excise taxes contributed to the decline in smoking prevalence among youths in Canada during the time of the Federal Tobacco Control Strategy. See **Appendix Table 19** for marginal effect estimates of all covariates included in *Models 1-3* for smoking prevalence.

Table 3-6 provides estimates for the marginal effect and elasticity of CPI-adjusted cigarette taxes on smoking frequency. Again, there was a negative association between cigarette tax levels and smoking frequency in the crude model. To answer the second objective of our study using a DD framework, however, changes in taxes during the time of the FTCS did not make a significant contribution on reducing smoking frequency among youths in Canada. Similar to our results for smoking prevalence, including individual and provincial level covariates did not have much influence on the effect of cigarette taxes on smoking frequency. Based on *Model 3*, the marginal effect for an increase of $1.00 per package on mean smoking frequency was 0.3 (95% CI: -1.2, 1.8) cigarettes. See **Appendix Table 20** for marginal effect estimates of all covariates included in *Models 1-3* for smoking frequency.

We based all sensitivity analyses on *Model 3* (which had the lowest AIC and BIC values), for both smoking outcomes. **Table 3-7** and **Table 3-8** contain sensitivity analyses for the marginal effect of CPI-adjusted cigarette taxes on smoking prevalence and smoking frequency, respectively. Although some estimates may have changed signs, they remained statistically non-significant, and thus, were robust to all sensitivity specifications.

Table 3-7: Sensitivity Analyses for the Marginal Effect of CPI-adjusted Cigarette Taxes on Smoking Prevalence

Sensitivity Type	Estimate	95% C.I.	
Preferred Model (Model 3)	0.2%	-1.8%	2.2%
Changes in Tax Levels			
$3-$4	0.2%	-1.7%	2.2%
$4-$5	0.2%	-1.8%	2.3%
Model Specification			
Probit Model	0.3%	-1.7%	2.3%
Current-Smoker	0.6%	-1.5%	2.7%
Weighted with no clustering	0.2%	-1.8%	2.2%
Weighted with clustering	0.2%	-1.7%	2.1%
Province Exclusion			
Newfoundland	0.2%	-1.8%	2.2%
Prince Edward Island	0.2%	-1.8%	2.2%
Nova Scotia	-0.1%	-2.3%	2.2%
New Brunswick	0.2%	-1.8%	2.2%
Quebec	-0.5%	-2.3%	1.2%
Ontario	1.7%	0.0%	3.5%
Manitoba	0.2%	-1.9%	2.3%
Saskatchewan	0.1%	-2.0%	2.1%
Alberta	0.4%	-2.1%	3.0%
British Columbia	0.3%	-1.8%	2.4%
Included Years			
2002 - 2004	1.7%	-2.3%	5.7%
2002 - 2005	-0.1%	-4.0%	3.8%
2002 - 2006	-0.3%	-4.1%	3.5%
2002 - 2007	-0.3%	-3.7%	3.2%
2002 - 2008	0.2%	-2.9%	3.3%
2002 - 2009	-0.3%	-3.3%	2.6%
2002 - 2010	-0.3%	-3.0%	2.4%
2002 - 2011	0.2%	-2.2%	2.6%

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on smoking prevalence on the additive scale.

Table 3-8. Sensitivity Analyses for the Marginal Effect of CPI-adjusted Cigarette Taxes on Smoking Frequency

Sensitivity Type	Estimate	95% C.I.	
Preferred Model (Model 3)	0.3	-1.2	1.8
Changes in Tax Levels			
$3-$4	0.3	-1.2	1.7
$4-$5	0.3	-1.3	1.9
Model Specification			
Probit-Poisson TPM	0.3	-1.2	1.8
Logit-Negative Binomial TPM	0.3	-1.3	1.9
Weighted with no clustering	0.3	-1.5	2.0
Weighted with clustering	0.3	-1.4	1.9
Province Exclusion			
Newfoundland	0.2	-1.3	1.7
Prince Edward Island	0.2	-1.3	1.8
Nova Scotia	0.0	-1.7	1.8
New Brunswick	0.2	-1.3	1.7
Quebec	-0.3	-1.6	1.0
Ontario	0.9	-0.5	2.3
Manitoba	0.2	-1.4	1.7
Saskatchewan	0.1	-1.5	1.6
Alberta	0.8	-1.0	2.6
British Columbia	0.5	-1.1	2.2
Included Years			
2002 - 2004	2.1	-1.6	5.7
2002 - 2005	1.0	-2.0	4.0
2002 - 2006	0.0	-2.6	2.7
2002 - 2007	0.5	-1.9	3.0
2002 - 2008	0.4	-1.9	2.7
2002 - 2009	0.3	-1.9	2.5
2002 - 2010	-0.1	-2.1	1.9
2002 - 2011	0.1	-1.6	1.9

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on mean weekly cigarette consumption on the additive scale.

3.6 Discussion

In this section, we will cover some potential limitations of our study. We will first address potential methodological concerns. We will then broadly discuss general concerns about cigarette taxation in Canada.

Firstly, using self-reported tobacco consumption for our outcome measure may be a concern because of the problem of social desirability, specifically the misreporting of smoking behaviour. In order for this to cause a bias, the rate of misreporting has to change with respect to time and be differential across provinces. One might be concerned, then, that increases in cigarette taxes can either directly cause the under-reporting of smoking or can lead to the use of contraband tobacco products where those engaged in such activity are less likely to report their smoking habits. If increases in cigarette taxes do actually decrease smoking, then the under-reporting of smoking would exaggerate this effect (or in other words, bias our estimates away from the null). We, however, obtained null results for the effect of cigarette taxes on both smoking outcomes, so social desirability is most likely not a problem in our study.

Moreover, because the interest of this paper is the effect of tobacco taxes on individual smoking behaviour (as opposed to legal sales), our estimates based on self-reported tobacco use should not be biased due to the problem of smuggling. Based on aggregate data of legal sales of cigarettes from NCTHP, Gruber et al. (2003) estimated a cigarette price elasticity of −0.72 (se=0.10), and −0.47 (se=0.09) before and after accounting for smuggling, respectively. Based on self-reported household cigarette expenditure data from FAMEX, their price elasticity estimates were −0.45 (se=0.11), and −0.45 (se=0.16) before and after accounting for smuggling, respectively. These elasticity estimates for self-reported cigarette consumption are near identical, and thus, suggest that the bias appears small when using this type of outcome.

Regarding our estimated null effects, this may be a result of a combination of several factors. Firstly, province fixed effects and common temporal changes accounted for much of the variation and declining trends in youth smoking. We calculated survey-weighted smoking prevalence by year and province and then computed R-squared values from linear regression models to infer the variation of smoking explained by each component. For smoker status as the outcome and province as the only set of fixed effects, the adjusted R-squared was 0.348. Similarly, for year fixed effects, the adjusted R-squared was 0.410. Together, province and year fixed effects accounted for 83.7% of the variation in smoking prevalence. The inclusion of mean CPI-adjusted cigarette tax levels (by year and province), however, only increased the variation explained to 83.8%. We derived similar results for smoking frequency.

Thus, our null results intuitively makes sense as overall smoking levels have decreased even within provinces with fairly stable cigarette tax levels. Recall **Table 3-3** for means of CPI-adjusted cigarette tax levels, and see **Appendix Table 3** and **Appendix Table 4** for trends on smoking prevalence and frequency by province, respectively. Prince Edward Island (P.E.I.) increased cigarette taxes by the largest amount during the time of the FTCS, nominally by $3.00 per pack, and after adjustment of the CPI, by about $1.58 per pack. From 2002 to 2012, P.E.I. experienced a decrease in smoking prevalence of about 13.4 percentage points and a decrease in mean smoking frequency of about 11.5 cigarettes. To give some perspective, Quebec had mostly flat or decreasing levels of excise cigarette tax levels during the same timeframe, yet still experienced a decrease in smoking prevalence of about 17.5 percentage points and a decrease in mean smoking frequency of about 15.1 cigarettes. Consequently, any future study on tobacco control would also need to consider the variation in smoking among the provinces and the common secular downward smoking trend.

This leads us to an important potential caveat in the use of taxation as a tobacco control strategy, namely that taxes must be frequent and increase substantially large enough to counteract general price and income inflation (Chaloupka, 2013). This is not the case in certain provinces in Canada, however. From 2002 to 2012, each instance of a cigarette tax increase was often less than $1.00 per package of 20 cigarettes. (Recall **Appendix Table 10** for increases in cigarette taxes.) When factoring in inflation, these increases are even smaller. In 2012, the *cumulative* increase in CPI-adjusted cigarette taxes was at least $1.00 for only three provinces, Prince Edward Island, Nova Scotia, and Manitoba. Recall **Table 3-3** for means of CPI-adjusted cigarette tax levels by year and province. Additionally, the level of tobacco control are different between Canada and other countries, and have increased over time within Canada. Thus, excise tobacco taxes may not have as strong of an effect compared to countries or older periods with lower tobacco tax levels, or generally weaker tobacco control.

3.7 Conclusion

Our findings suggest that changes in cigarette tax levels had very little impact on youth smoking during the period of FTCS (2002-2012). Our study is not suggesting that increases in excise cigarette taxes (or price) do not have the *potential* to reduce smoking behaviour, nor is it necessarily an endorsement for greater increases in cigarette taxes. It does, however, provide an evaluation of the impact of recent taxation increases on youth smoking in Canada. During 2002-2012 timeframe, we can see that both smoking prevalence and smoking frequency have been in steady decline among youths. This decline, however, is present even in provinces with stable cigarette tax levels suggesting that other factors common to all provinces have had a greater influence over tobacco use. Thus, continuing to implement changes in excise tobacco taxes at their current pace and magnitude would be ineffective in further reductions in smoking.

Chapter 4: Manuscript 2

Heterogeneous effects of excise cigarette taxes on smoking-related outcomes by education among adults in Canada during the time of the Federal Tobacco Control Strategy (2002-2012)

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Abstract

This study is an evaluation of the causal effect of cigarette taxes on smoking prevalence and frequency among adults in Canada, aged 25 and over, after the launch in 2001 of the Federal Tobacco Control Strategy (FTCS). Excise taxes are a common form of tobacco control, and although tax levels dipped in the mid-1990s, levels have been gradually increasing since the 1980s. Smoking on the other hand has been in steady decline during that time, but the pace of decline has slowed in recent years. Moreover, there is a persistent negative association between smoking and socioeconomic position, in particular by education. Thus, given the stagnation in the rate of decline in smoking and persistent social inequalities in smoking, a potential concern is that recent changes in tobacco taxes may not be sufficient in reducing the inequality in smoking.

Based on the 2002-2012 Canadian Tobacco Use Monitoring Survey database and regression models with province and year fixed effects, and individual-level and provincial-level covariates, changes in excise cigarette taxes yielded negligible contributions to the reduction in smoking behaviour. For an increase of $1.00 in excise cigarette taxes per package of 20 cigarettes, the marginal effect was -0.1 (95% CI: -1.7, 1.5) percentage points for smoking prevalence, and -0.1 (95% CI: -1.9, 1.7) cigarettes for smoking frequency. We continued to derive null results when assessing the impact of excise cigarette taxes by education for both smoking outcomes.

Although increases in excise tobacco taxes have the potential to reduce tobacco consumption, their effectiveness is sensitive to several factors including previous tax levels and the current anti-tobacco control environment. Excise cigarette taxes have been gradually increasing since the 1980s, and so, tax levels were already quite high by the launch of the FTCS. Moreover, tobacco taxes had to work in conjunction with other forms of tobacco control during the time of the FTCS, such as the Tobacco Act, and smoke-free legislation.

Furthermore, a crucial component in the effective implementation of tobacco taxation in reducing tobacco consumption is that tax increases must be frequent and substantially large enough to counteract general price and income inflation. From 2002-2012, we can see that both smoking prevalence and mean smoking frequency have been in steady decline among youths in Canada. This decline, however, is present even in provinces with stable or decreasing cigarette tax levels suggesting that other factors common to all provinces such as growing anti-smoking sentiment have had a greater influence over tobacco use.

On the other hand, we found some evidence to suggest that instead of facilitating smoking cessation or reducing smoking frequency, an increase in taxes resulted in an increase in the purchasing of discounted cigarettes. For a $1.00 increase in taxes per pack, the proportion of smokers purchasing discounted cigarettes increased by about 14.3 (95% CI: 7.0, 21.6) percentage points. We found little evidence to suggest heterogeneous effects by education, however.

Keywords: quasi-experimental, difference-in-differences, health policy evaluation, differential effects, heterogeneous effects, effect-measure modification, tobacco taxes, cigarette taxes, tobacco control strategy, tobacco control policy, smoking, cessation, reduction, Canada, adults

4.1 Introduction

Various policies and strategies aimed at reducing tobacco consumption have been implemented in Canada since the 1980s (Reid & Hammond, 2013). For example, the Federal Tobacco Control Strategy (FTCS) was a planned 10-year initiative implemented in 2001 to reduce tobacco consumption in Canada (Health Canada & Public Health Agency Of Canada, 2012). The initiative was launched by a consortium led by Health Canada (HC), in partnership with Public Health Agency of Canada (PHAC) and other agencies such as the Royal Canadian Mounted Police (RCMP), and Canada Border Services Agency (CBSA). Two primary objectives were to reduce the prevalence of smoking, and to reduce the quantity of cigarette purchases. Two key components of the FTCS were the enforcement of the Tobacco Act and the promotion of smoke-free laws. The Tobacco Act is a set of Canadian laws passed in 1997 that include restrictions on the manufacture and sale, access, and promotion (advertisement) of tobacco products (Minister of Justice, 1997).

In a self-evaluation of FTCS goals, Health Canada and PHAC identified a number of individual and environmental factors that predict smoking prevalence and frequency (Health Canada & Public Health Agency Of Canada, 2012). The most important predictors were education attainment, tobacco taxes, bans on retail display and legal smoking age. Their conclusions, however, were based on econometric models that did not include the effects of province or time, and thus, did not account for the variation in smoking rates across the provinces of Canada and the general declining smoking trend common among provinces. These types of models provide only associational measures of effect, and do not allow for a causal interpretation. Therefore, questions remain about the extent to which policy reforms like the FTCS are responsible for declines in smoking rates among adults.

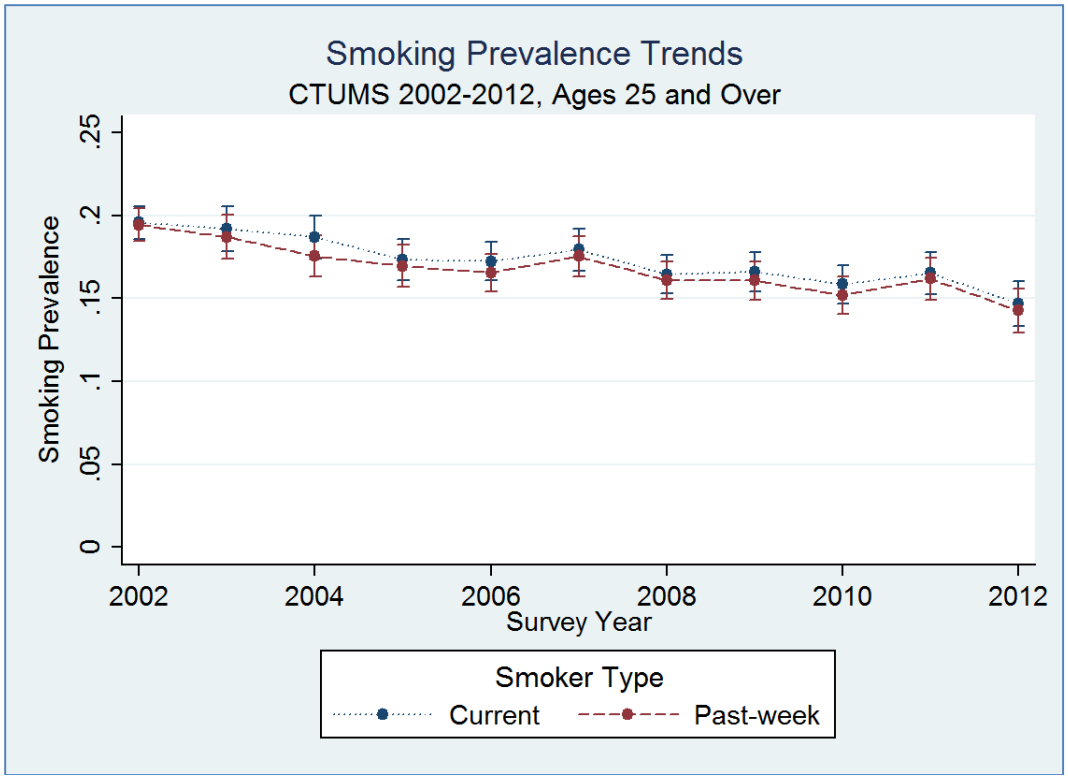

Figure 4-1. Marginal effect estimates and 95% CIs derived from logistic models with year fixed effects.

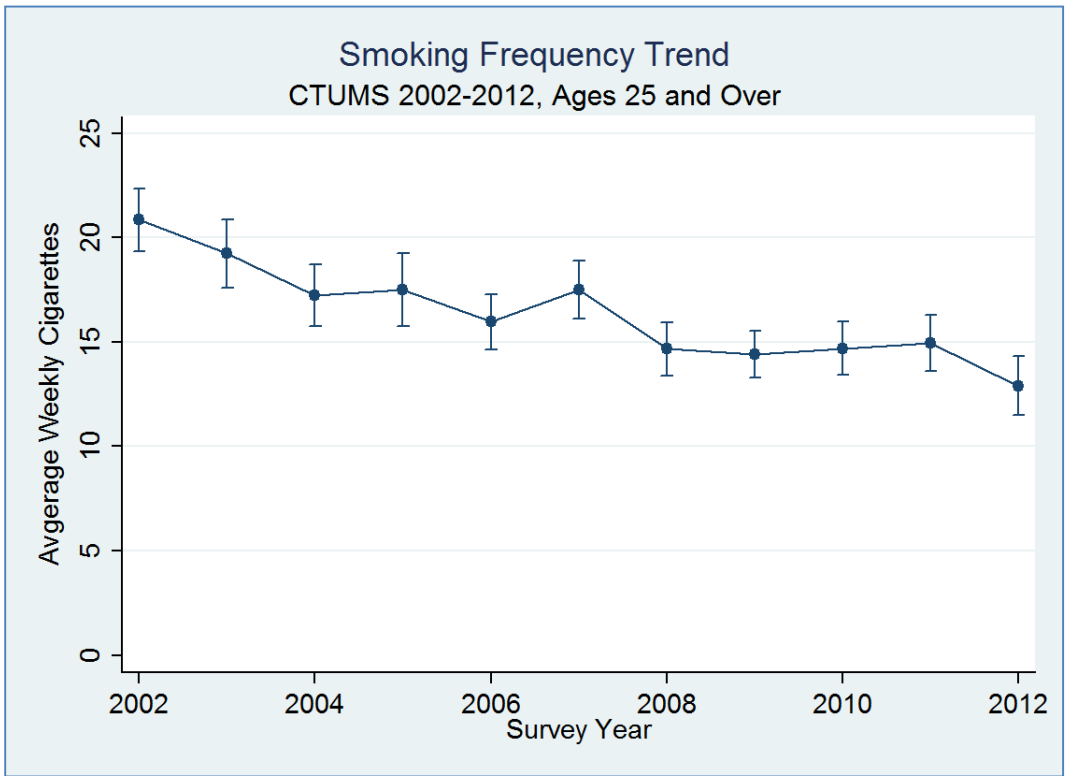

Figure 4-2. Marginal effect estimates and 95% CIs derived from a logistic-Poisson two-part model with year fixed effects.

Another common tobacco control strategy is excise tobacco taxes. (An excise tax is one that is imposed on a specific good.) A stipulation in the effective use of excise taxes in reducing tobacco consumption is that increases in taxes are frequent and outpace general inflation (Chaloupka, 2013). By the start of the twenty-first century, however, taxation levels for tobacco products were already high in Canada, and more importantly, higher than levels in previous studies. Another stipulation for the effective use of tobacco taxes is that consumers do not engage in price-reducing strategies such as tax evasion or tax avoidance (Chaloupka et al., 2011). Tax avoidance is the legal purchase of lower-taxed or non-taxed goods such as duty free shopping. Conversely, tax evasion is an illegal circumvention of paying taxes such as purchases of smuggled goods. Given already high tax levels during the time of the FTCS, the implementation of various tobacco control strategies over this time period and the potential occurrence of tax avoidance or evasion, it is unclear what effect recent changes in tobacco taxation had on smoking among adults in Canada. An interest then would be an assessment of the impact of additional increases in excise cigarette taxes on smoking among adults.

Figure 4-1 and **Figure 4-2** show self-reported smoking prevalence (current and past-week) and smoking frequency trends for adults aged 25 and over, based on the Canadian Tobacco Use Monitoring Survey (CTUMS) 2002-2012 database. (See **Appendix Table 1** for sample sizes of each year, and **Appendix Table 5** for estimates.) Smoking prevalence decreased by 4.9 (95% CI: 3.3, 6.5) and 5.2 (95% CI: 3.6, 6.7) percentage points for current smoker and past-week smoker, respectively. Mean smoking frequency decreased by 8.0 (95% CI: 6.0, 9.9) cigarettes. Although, both smoking prevalence and frequency have declined after the launch of the FTCS, it is unclear how changes in excise cigarette taxes have contributed to these declines in smoking among adults in Canada.

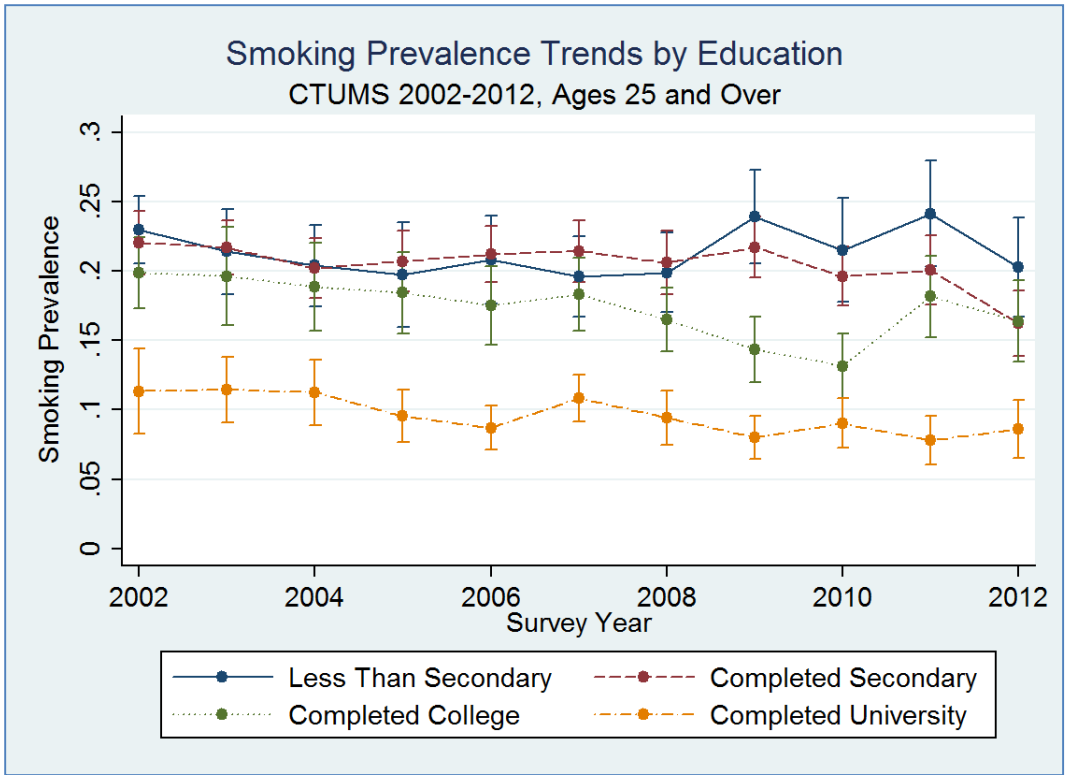

Figure 4-3. Marginal effect estimates and 95% CIs of smoking prevalence by education from a logistic model with year, education, and their cross-product terms as covariates.

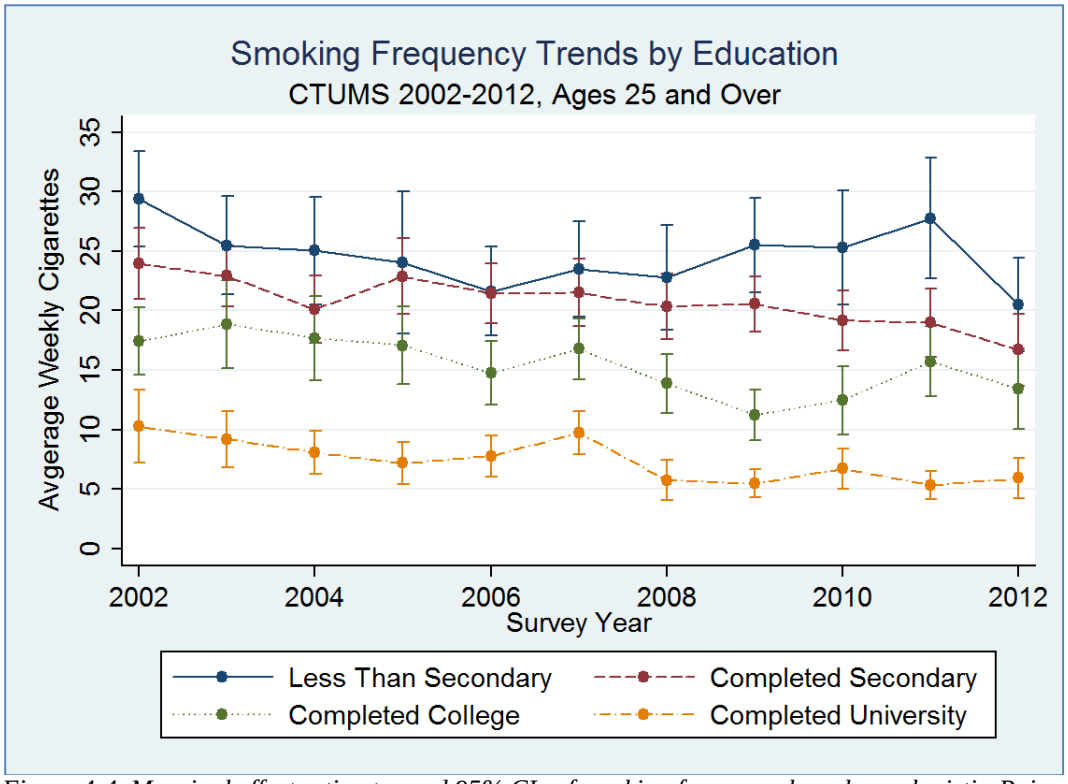

Figure 4-4. Marginal effect estimates and 95% CIs of smoking frequency based on a logistic-Poisson two-part model with year, education, and their cross-product terms as covariates.

In our evaluation of cigarette taxes on youth smoking in Canada from 2002-2012, we found that changes in cigarette taxes did not have a significant impact on either smoking initiation or frequency (Manivong, Harper, & Strumpf, 2015). Youths and adults, however, may respond differently to cigarette taxes (Chaloupka et al., 2011). Moreover, looking only at the average effect can obscure potential heterogeneity by socioeconomic position (SEP). Unfortunately in our study on youths, we did not have a proper measure of SEP for youths and only assessed the average effect of cigarette taxes on smoking.

Figure 4-3 and **Figure 4-4** show self-reported past-week smoking prevalence and smoking frequency trends by education for those aged 25 and over based on 2002-2012 CTUMS data. Rates of both smoking outcomes have generally decreased for all education groups during the time of the FTCS. Smoking rates, however, have increased slightly in later years for the least educated group. Thus, although overall tobacco consumption has decreased, observed inequalities in smoking between groups of low and high education have remained since the start of the FTCS.

Table 4-1. Changes in Smoking Prevalence and the Educational Gap in Canada, Ages 25 and Over

Education Group	2002-2012 Change			2002 Smoking Gap			2012 Smoking Gap		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Less than Secondary	-2.7%	-6.9%	1.5%	11.6%	7.3%	15.9%	11.7%	7.5%	15.8%
Completed Secondary	-5.8%	-9.0%	-2.6%	10.7%	6.2%	15.2%	7.6%	4.5%	10.7%
Completed College	-3.5%	-7.4%	0.4%	8.5%	4.3%	12.8%	7.8%	4.4%	11.1%
Completed University	-2.7%	-6.5%	1.0%	*Reference*			*Reference*		

Table 4-2. Changes in Smoking Frequency and the Educational Gap in Canada, Ages 25 and Over

Education Group	2002-2012 Change			2002 Smoking Gap			2012 Smoking Gap		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Less than Secondary	-8.9	-14.6	-3.2	19.2	13.3	25.0	14.6	10.3	18.9
Completed Secondary	-7.3	-11.5	-3.1	13.7	8.6	18.8	10.8	7.5	14.1
Completed College	-4.0	-8.1	0.1	7.2	2.6	11.8	7.5	3.7	11.3
Completed University	-4.3	-7.9	-0.8	*Reference*			*Reference*		

Table 4-1 and **Table 4-2** show changes in (past-week) smoking prevalence and frequency from 2002 and 2012 by education, respectively, for those aged 25 and over. (See **Appendix Table 6** and **Appendix Table 7** for yearly estimates of smoking prevalence and frequency by education, respectively.) Changes (decreases) in smoking prevalence were -2.7 (95% CI: -6.9, 1.5), -5.8 (95% CI: -9.0, -2.6), -3.5 (95% CI: -7.4, 0.4) and -2.7 (95% CI: -6.5, 1.0) percentage points for the *Less than Secondary*, *Completed Secondary*, *Completed College*, and *Completed University* groups, respectively. Because decreases in smoking prevalence varied by education, the smoking gap (or absolute difference) with respect to the *Completed University* group remained virtually the same for the *Less than Secondary* group, but decreased for the other two groups. For mean smoking frequency, changes (decreases) were -8.9 (95% CI: -14.6, -3.2), -7.3 (95% CI: -11.5, -3.1), -4.0 (95% CI: -8.1, 0.1), and -4.3 (95% CI: -7.9, -0.8) for the least to most educated groups, respectively. The smoking gap decreased for the *Less than Secondary* and *Completed Secondary* groups, but increased slightly for the *Completed College* group compared to the *Completed University* group. (Although not reported, the smoking prevalence ratio and mean smoking frequency ratio also increased for all education groups.)

It is important to note, however, that we cannot infer that these changes are a result of excise tobacco taxes or any other form of tobacco control. Hence, given the observed differential decreases in smoking, another important objective would be an evaluation of the impact of tobacco taxes on the socioeconomic inequality in smoking (Main et al., 2008). Though much research has been done on the effects of taxes and prices on smoking among adults, previous studies can only partially answer our research questions. Furthermore, although there is on-going surveillance of smoking by subgroups such as province, age and gender by Health Canada, even fewer studies have evaluated heterogeneous effects of cigarette taxes or prices on smoking.

If agencies such as Health Canada and PHAC are motivated to not only reduce smoking rates, but to also reduce inequalities in smoking, then this might suggest that tobacco control strategies need to focus on those with lower education or lower socioeconomic position (SEP), or more generally, on social groups with higher smoking rates. Strategies with a greater effect on lower SEP groups will help reduce the inequality, while ones with a weaker effect on lower SEP groups will exacerbate the inequality (Lorenc et al., 2012). In a systematic review on socioeconomic position and smoking, the authors highlighted findings of higher rates of smoking among the most disadvantaged, yet lower success rates of quitting (Hiscock et al., 2012). The authors suggested reasons such as lower social support and higher addiction.

Thus, the objective of this paper is twofold. The first is to estimate the average effect of tobacco taxes on adult smoking behaviour in Canada. Specifically, we want to know if recent (2002-2012) increases in cigarette taxes have decreased the prevalence and quantity of smoking among adults. The second is to explore potential differential effects by education and, more importantly, how these differential effects have potentially impacted the socioeconomic gap in smoking. In both cases, we are interested in the intention-to-treat effect of tobacco taxes, or in other words, the effect given the potential for consumers to engage in avoidance or evasion of tobacco taxes. Additionally, because a key interest in our study is the heterogeneous effects by education, we focused on the adult population aged 25 and over.

4.2 Background

Numerous studies have evaluated the effects of cigarette price (or taxes) on tobacco consumption among adults. One systematic review on the impact of tobacco control on smoking initiation, cessation, and prevalence included 22 studies evaluating the effect of taxes on adults (Wilson et al., 2012). The authors reported elasticity estimates ranging from −0.45 to 0.10 for smoking prevalence and 0.375 to 1.17 for smoking cessation. Another systematic review on the impact of cigarette taxes and prices on high-risk populations captured twenty-two studies focusing on socioeconomic position (Bader et al., 2011). Twelve studies reported a greater effect of taxes on smoking among the more disadvantaged group, while another five studies reported non-differential effects by socioeconomic position. In a systematic review of tobacco control policies and their effects on social inequalities in smoking, thirteen studies focused on the effects of price and five studies evaluated multiple tobacco control interventions among adults (Thomas et al., 2008). The authors noted tobacco price provided the most consistent evidence for a beneficial effect on disadvantaged groups. They, however, also acknowledged conflicting evidence where some studies show no differential effect or the converse effect.

The most commonly reported measure of effect among studies captured in these systematic reviews is price or tax elasticity, which is the percentage change in smoking, given a percentage change in price or taxes. Elasticity estimates, however, are sensitive to the study population, time frame, price/tax range, and specifications of price and demand (Nghiem, 2013). Thus, there are several limitations in inferring the effect of tax or price changes on smoking from these studies to a Canadian setting during the time of FTCS.

The main limitation is the use of different study populations, in particular different country settings. The general anti-smoking sentiment and tobacco control environment, particularly tobacco tax levels can vary from country to country. Among the aforementioned

systematic reviews, most studies were conducted in the United States or European countries. Therefore, the effect of tax or price changes on smoking for other countries may not apply to Canada. To provide some context, in the 1980s and 1990s, the average price of cigarettes (in year 1999 dollars) was US $1.86 and US $2.33 per pack in the United States and Canada, respectively (Gruber et al., 2003).

Moreover, Canada has other forms of tobacco control including smoke-free laws, the Tobacco Act, and graphic warning labels (GWLs). In 2001, Canada became the first country to require that GWLs cover at least 50% of both front and back of cigarette packages (Canadian Cancer Society, 2012). Conversely, in the United States, advocates for the tobacco industry claim that GWLs are violations of their constitutional rights and have thus far prevented the implementation of GWLs. A recent study evaluated the use of GWLs in Canada with the United States as a control group (Huang et al., 2014). With a series of difference-in-differences models using 9 years of data before and 9 years after the implementation of GWLs, the authors showed that GWLs reduced smoking prevalence by 2.8–4.7 percentage points.

Returning to the aforementioned systematic reviews, among included studies, only four were based in Canada (Azagba & Sharaf, 2011; Gospodinov & Irvine, 2009; Gruber et al., 2003; Stephens et al., 2001). In the Stephens et al. (2001) study, the authors were interested in the separate and joint associations of five different types of tobacco control policies on the likelihood of smoking. They used the 1994/1995 cross-section from Canada's National Population Health Survey for adults aged 25 and over and reported the effect of increase in cigarette price on smoking by sex. For a $1.00 increase, the estimated odds of being a *non-smoker* was 1.02 (95% CI: 1.00, 1.03) for men, and 1.01 (95% CI: 1.00, 1.02) for women.

Gruber et al. (2003) used aggregate data (1981-1999) on legal sales of cigarettes per

capita per person-year provided by the National Clearinghouse on Tobacco and Health Program (NCTHP) and self-reported household cigarette expenditure data (1982-1998) from the Canadian Survey of Family Expenditure (FAMEX). The study included participants aged 12-24. Their price elasticity estimates ranging from -0.45 to -0.47 indicating that a 10% increase in cigarette price would lead to a relative decrease in household cigarette consumption by 4.5% to 4.7%.

In the Gospodinov & Irvine (2009) study, the authors evaluated the effect of the price of a carton of 200 cigarettes on self-reported smoking prevalence and frequency as outcomes, but only for years 2000 to 2005. Their population of interest, based on CTUMS data, was adults aged 20 or older. Their marginal estimate for the effect of price on the probability of smoking was −0.0008 (se= 0.0006). In other words, a $10.00 increase in a carton of 200 cigarettes (or equivalently, an increase of $1.00 per pack) was associated with an average reduction of smoking of 0.8 percentage points.

Azagba & Sharaf (2011) evaluated the effect of excise taxes per carton of 200 cigarettes on smoking prevalence using the National Population Health Survey (NPHS) consisting of 6 biannual longitudinal waves from 1998-2008. Their tax elasticity for the whole population (aged 12-65) was −0.227 (SE = 0.062) indicating that a 10% increase in taxes would yield a *relative* decrease in smoking prevalence of 2.3%.

These Canadian studies, though, too have their limitations in addressing our research objectives. One limitation is the timeframe, particularly for years prior to the FTCS. Among the Canadian studies, two evaluated the impact of changes to price on smoking in the 1980s and 1990s (Gruber et al., 2003; Stephens et al., 2001). Although these studies help shed light on the effect of price (and excise tax) changes prior to the FTCS, levels during that time period were considerably lower than current levels. From 1981 to 1999, the average national cigarette tax

level increased from about $5.00 to $25.00 per carton of 200 cigarettes (Gruber et al., 2003). Moreover, excise tobacco taxes were also the primary form of tobacco control in Canada with broader provincial smoke-free laws and health warnings on cigarette packages being implemented after 2000 (Non-Smokers's Rights Association, 2012b; Reid & Hammond, 2013). The other two studies only partially covered the years of interest of our objective.

A second limitation is the age distribution, particularly the inclusion of both youths and adults within the same study (Azagba & Sharaf, 2011; Gruber et al., 2003). Not only can youths and adults respond differently to cigarette taxes, their effects also have different implications (Chaloupka et al., 2011). For youths, the effect of cigarette taxation is the impact on smoking initiation and development of a habit. For adults, however, the effect is the impact on smoking cessation and reduction. Thus, the inclusion of both youths and adults does not allow for a clear interpretation of the effects of cigarette taxes for either adults or children. Our study included only adults aged 25 and over.

Another limitation among three of the Canadian studies above is the use of average annual provincial prices of a carton of 200 cigarettes as the policy (exposure) variable (Gospodinov & Irvine, 2009; Gruber et al., 2003; Stephens et al., 2001). One disadvantage of this approach is that changes in taxes often occur within the year, and this could cause a bias towards the null as the same price level is assigned to a population before and after changes in tax levels. Secondly, average cigarette price includes retail mark ups and retail sales taxes. Hence, their conclusions cannot necessarily be inferred as causal effects of tobacco taxation *per se*. Gruber et al. (2003), however, did use cigarette taxes as an instrumental variable for price.

A fourth limitation is that only two studies included an evaluation of cigarette price on some measure of smoking intensity or frequency (Gospodinov & Irvine, 2009; Gruber et al.,

2003). Azagba & Sharaf state that although data on the number of cigarettes smoked were available in the NPHS database, they believed that quantity smoked was not an appropriate measure of intensity. The authors recommend using cotinine intake level, though no such measure was available in their database. For comparability with other publications, however, we included analyses with cigarette quantity as an outcome.

Although three of the Canadian studies provided some type of evaluation on the heterogeneous effects of taxes/price on smoking by socioeconomic position (SEP), another limitation is that each one only partially addresses our second research objective. Gruber et al. (2003) provided price elasticity estimates by income quartiles for household smoking expenditure, but did not provide an evaluation for smoking prevalence. Estimates ranged from −0.99 (SE=0.247) to −0.36 (SE=0.199) for the lowest to highest income quartiles, respectively. So a 3.7% to 9.9% reduction in smoking expenditure was expected per 10% increase in price.

Azagba & Sharaf (2011) provided an assessment of the effect of cigarette taxes on smoking prevalence by education, but did not provide one for a measure of smoking frequency. For those with less than secondary education, the average partial effect (APE) and corresponding tax elasticity were -0.0038 (SE=0.0100) and -0.5549 (SE=0.1484), respectively. For those with post-secondary education, the APE and corresponding tax elasticity were -0.0003 (SE=0.0007) and -0.0422 (SE=0.1079), respectively.

Gospodinov & Irvine (2009) provided an evaluation of the effect of price on smoking frequency by education, but not for smoking prevalence. Their marginal estimates for the effect of price on the number of cigarettes smoked (in the previous week) varied slightly from -0.131 (95% CI: −0.544, 0.291) for the *Less than High School* group, −0.145 (95% CI: −0.406, 0.119) for the *Completed Secondary* group, and -0.105 (95% CI: −0.497, 0.268) for the *Completed*

College group. Their estimated price elasticity estimates were the following: -0.229 (95% CI: −0.950, 0.510), −0.333 (95% CI: −0.930, 0.273), and -0.300 (95% CI: −1.407, 0.779) for these same groups, respectively. The authors reported no evidence of differences by education.

Another important caveat in for Gospodinov & Irvine (2009) study, however, was the omission of the *Completed University* group in their main analysis. The smoking trends in their Table 4 (and in our **Figure 4-3** and **Figure 4-4**) show that the *Completed University* group has as a strikingly lower rate than those of the other three education groups in terms of both smoking prevalence and frequency. Thus, with the exclusion of this group, we cannot infer the potential impact of recent cigarette taxes on the socioeconomic inequality in smoking between the least and most educated where the gap is the largest.

In summary, studies captured in aforementioned systematic reviews, including Canadian ones can only partially address our research objective. Our study will contribute to the literature on the effects of excise cigarette taxes on adult smoking behaviour in several ways. The first is the assessment of the effects of recent cigarette tax changes in Canada when tax levels are already high and where excise taxes must work in conjunction with other forms of tobacco control. The second is a clearer distinction of the effect of cigarette tax changes on adult smoking behaviour based on the use of a strictly adult sample. The third is the use of a policy variable that is more precise than average price, namely the cumulative amount of cigarette taxes at time of interview (based on the precise date of adoption). The fourth is the inclusion of cigarette quantity as an outcome for comparability with other publications on the effects of price (or taxes) on smoking frequency. The final contribution is the evaluation of heterogeneous effects by education on the socioeconomic inequality for both smoking prevalence and smoking frequency.

4.3 Data and Measures

Individual-level Covariates

Our analyses required linking data from different sources together. The Canadian Tobacco Use Monitoring Survey (CTUMS) provided data on individual-level demographic variables. CTUMS also contained the year and month of the interview, which allowed for the precise assignment of cigarette tax levels and the identification of other provincial tobacco control in effect.

CTUMS was launched in 1999 in order to continuously monitor smoking trends, particularly among the most at-risk group, namely those aged 15-24 (Statistics Canada, 1999). It is a population-weighted, multi-stage, cross-sectional survey conducted semi-annually by telephone using random digit dialling collecting data at the household and individual level. Multiple individuals may be selected from the same household. The target population of CTUMS are residents of Canada aged 15 and older, excluding residents of the Yukon, Northwest Territories and Nunavut, and full-time residents of institutions.

CTUMS data for years from 2002-2012 were used in the primary set of analyses to correspond approximately to the timing of the FTCS. Each survey contained approximately 20,000 individuals, with over-sampling of youths (about 46% for those aged 15-24 compared to 16% in the population). Because a key interest of our paper was to explore the potential impact of cigarette taxes by education, the accurate measurement of highest level of education attainment was of utmost importance. Based on CTUMS data where current student status was available for those aged 25 and over (survey years 2002 and 2003), only 2.3% (95% CI: 2.2%, 2.4%) were students. Thus, we included only those aged 25 and over. After the age exclusion, the sample size was 122,943. (For information on sample size, see **Appendix Table 1**.)

Individual-level covariates of interest included education, age (years), sex, marital status, language (spoken at home), and household size. Age contained the following groups: *25-34* (reference), *35-44*, *45-54*, *55-64* and *65 & Over.* The variable for sex consisted of two options: *male* and *female* (reference). Marital status contained three options: *Common-law/Married* (reference), *Widow/Divorced/Separated*, and *Single*. Language was a categorical variable with the following options: *English* (reference), *French*, *English & French*, and *Other*. Household size was a categorical variable with *1* (reference), *2*, *3*, *4* and *5 or more* as options.

Our measure for SEP was highest level of education attainment which consisted of four categories: *Less than Secondary, Completed Secondary, Completed College,* and *Completed University* (reference). Data on income were only available in earlier years, and hence, we could not use income as measure of SEP. Though income data is not available, it is unlikely to be a confounder as personal income is generally a consequence of education (Card, 1999). Moreover, we are not estimating the effect of education on smoking; we are looking at whether the causal effect of taxes varies by education.

Outcome Variables

The Canadian Tobacco Use Monitoring Survey provided data on adult smoking behaviour. We considered two smoking-related outcomes: smoker status and smoking frequency. We defined both smoking outcomes based on the cigarette quantity smoked variable. Survey participants were asked if they smoked within the past 30 days, and if so, how many cigarettes they smoked within the previous 7-day period. (The term "past-week" will be used going forward.) Past-week cigarette quantity was set to 0 if the participant did not report smoking within the past 30 days.

Table 4-3. Comparison of Smoker Status Outcomes

Smoker Status		Current Smoker		
		No	**Yes**	**Total**
Past-week Smoker	**No**	99,112	717	99,829
	Yes	239	21,197	21,436
	Missing	16	1,662	1,678
	Total	99,367	23,576	122,943

We set past-week smoker status to 1 if the number of cigarettes reported was 1 or greater, and 0 if the participant did not smoke within the past week. We used self-identified current smoker status as a sensitivity analysis for past-week smoker status. **Table 4-3 s**hows the agreement between the two smoking status outcomes. The majority of their differences is attributable to missing data using the past-week definition (N=1,678). Among those with non-missing data, there was approximately 99% agreement. Within the disagreements of non-missing data (N=956), approximately 75% (N=717) consisted of self-described current smokers (consisting of daily and occasional smokers) who did not smoke within the past week, and the other 25% (N=239) consisted of self-identified non-current smokers who did smoke within the past week which presumably consists of experimenters or those in the process of quitting.

Using the number of cigarettes smoked in the past-week definition consistently produced prevalence estimates that were slightly lower than those using the self-identified current smoker definition. Recall **Figure 4-1** showing past-week smoker and current smoker trends from 2002-2012. See **Appendix Table 5** for corresponding yearly estimates of past-week smoker and current smoker prevalence. The maximum difference in prevalence between these two smoking prevalence outcomes was 1.1% in 2004. See **Appendix Table 6** for yearly estimates of past-week smoking prevalence by education. See **Appendix Table 8** for past-week smoking prevalence estimates by year and province.

Among smokers, the maximum reported value for smoking frequency was 630 cigarettes within the past week which is equal to 31.5 packs of 20 cigarettes. The value of the 95 percentile was 189 cigarettes which is almost 9.5 packs. The mean, however, was 97.3 (95% CI: 95.7, 98.9) cigarettes which is almost 5 packs. See **Figure 4-5** for a histogram of past-week cigarette consumption (among smokers). See **Appendix Table 5** for yearly estimates of past-week smoking frequency. See **Appendix Table 7** for yearly estimates of smoking frequency by education**.** See **Appendix Table 9** for past-week smoking frequency estimates by year and province. See **Appendix Figure 5** and **Appendix Figure 6** for histograms of past-week cigarette consumption by year and by province, respectively.

Unfortunately, for our studies on the adult population, we cannot model smoking cessation specifically as an outcome. CTUMS does probe self-reported former smokers about the timing of their quitting smoking. The available options, however, do not allow us to determine the appropriate excise cigarette tax levels at the time of a participant's smoking cessation. More importantly, we hypothesize that changes in smoking prevalence among adults are primarily driven by cessation. Based on participants aged 15 and over who reported to have ever tried smoking in the 1999-2012 CTUMS database (N=163,193), about 96.1% reported to have had their first cigarette by age 25. Additionally, between years 2004-2012 (when data on daily smokers are available), about 91.8% of daily smokers reported to being one by age 25 (N=63,353).

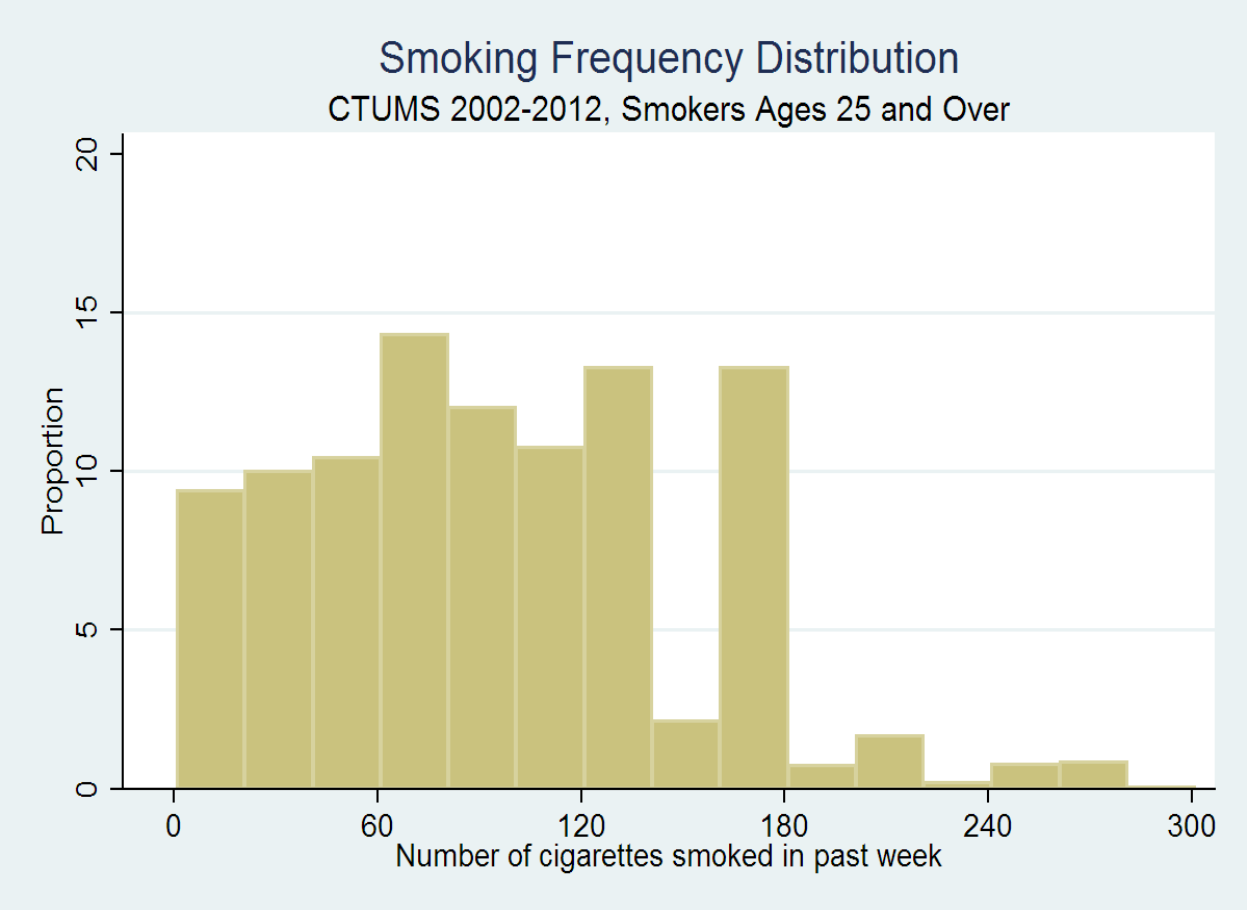

Figure 4-5. Histogram of past-week cigarette quantity. Each bar represents a pack of 20 cigarettes.

Provincial-level Tobacco Taxes

The main source of data on excise cigarette tax levels and their corresponding effective dates were extracted from the Finances of The Nation 2002-2012 reports provided by the Canadian Tax Foundation (Treff & Ort, 2008-2012; Treff & Perry, 2002-2007).[2] The report *Tobacco Use in Canada: Patterns and Trends,* provided by the Propel Centre for Population Health Impact (an affiliate of the University of Waterloo) was used to assess agreement of data on cigarette taxes (Reid & Hammond, 2013). It provided data on excise cigarette tax *increases* and corresponding effective dates starting in December 2003. There was no observed discrepancy between the two sources. For both sources, cigarette taxes were reported for a carton of 200 cigarettes, but we calculated amounts for a typical package of 20 cigarettes (DeCicca et al., 2008; DeCicca & McLeod, 2008).

Although both federal and provincial levels of government imposed cigarette excise taxes, from 2002 to 2012 virtually all tax changes were at the provincial level. Additionally, in that time, there were only nominal increases to excise cigarette taxes. **Table 4-4** provides means of nominal cigarette tax levels by year and province. (See **Appendix Table 10** for details on the timing of cigarette tax increases and corresponding levels of federal and provincial excise taxes.)

To account for inflation (or in other words, to express changes to cigarette taxes relative to price changes for all goods), nominal tax changes were standardized to year 2000 dollars by the Canadian Consumer Price Index (CPI) of general goods (Chaloupka, 2013). Data on the CPI of general goods were extracted from Canadian Socioeconomic Information Management system (CANSIM), Statistic Canada's online database (Statistics Canada, 2012). Our method to adjust

[2] A correction was made based on inconsistencies in the Finances of the Nation reports. In the 2003 report, the total of the federal and provincial cigarette taxes for Nova Scotia do not sum correctly. Based on data in the 2004 report, we assumed an addition error in the 2003 report. The authors, however, accept responsibility for any error in this paper.

cigarette tax levels by the CPI followed that of the Azagba & Sharaf (2011) study. See **Appendix A-3** for an explanation of our process to adjust cigarette tax levels by the CPI, including CPI values of general goods by year and province.

Table 4-5 shows mean annual CPI-adjusted cigarette tax levels by province. (Although there have been no tax cuts, tax levels can show a decrease after adjustment by the CPI.) **Figure 4-6** shows cumulative nominal and CPI-adjusted cigarette tax levels by province and year. (**Appendix Table 11** contains CPI values of general goods by year and province and **Appendix Table 12** compares different methods of CPI-adjustment). Note that the absolute range in nominal tax levels was approximately $3.00 - $7.00, while the range for CPI-adjusted cigarette tax levels was $3.00-$5.00 and that most year-to-year increases were less than $1.00. It is also important to note that provinces like Nova Scotia and Prince Edward Island experienced gradual increases in CPI-adjusted cigarette tax levels. Quebec on the other hand, had minimal increases in nominal cigarette tax levels, and so, experienced slight decreases in CPI-adjusted cigarette tax levels for most years during the time of the FTCS.

We performed two additional assessments to validate the viability of tobacco taxes as a policy (exposure) variable. The first one determined the level of exogenous variation of cigarette tax levels beyond what exists among and within provinces over time. The second one evaluated the appropriateness of using average cigarette price (when interested in assessing their impact on smoking-related outcomes) to infer that changes are driven by cigarette taxes. See **Appendix A-4** for details on these assessments.

Table 4-4. Means of Nominal (Sum of Federal & Provincial) Cigarette Taxes for a Pack of 20

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	3.79	4.29	4.59	4.79	4.99	5.24	5.30	5.30	5.30	5.50	5.50
Prince Edward Island	3.37	3.87	4.57	5.08	5.08	5.13	5.19	5.69	6.19	6.19	6.78
Nova Scotia	3.19	3.69	4.19	4.69	4.69	4.75	5.00	5.00	6.00	6.00	6.00
New Brunswick	3.54	3.94	3.94	3.94	3.94	3.99	4.05	4.05	4.05	4.05	5.10
Quebec	3.40	3.40	3.40	3.65	3.65	3.70	3.76	3.76	3.76	3.82	3.88
Ontario	2.71	3.31	3.31	3.93	3.93	4.11	4.17	4.17	4.17	4.17	4.17
Manitoba	3.99	4.49	4.69	5.09	5.09	5.14	5.20	5.20	5.40	5.80	6.20
Saskatchewan	3.31	4.79	4.79	5.09	5.09	5.24	5.36	5.36	5.36	5.90	5.90
Alberta	2.99	4.79	4.79	4.79	4.79	4.84	5.40	5.40	5.70	5.70	5.70
British Columbia	4.59	4.59	5.17	5.17	5.17	5.22	5.28	5.28	5.40	5.40	5.40

Table 4-5. Means of Sum of CPI-Adjusted Federal & Provincial Cigarette Taxes for a Pack of 20 (In Year 2000 Dollars)

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	4.03	4.24	4.36	4.43	4.56	4.54	4.46	4.45	4.49	4.37	4.29
Prince Edward Island	3.60	4.04	4.49	4.45	4.38	4.33	4.53	4.94	4.96	5.12	5.17
Nova Scotia	3.39	3.75	4.17	4.14	4.09	4.18	4.14	4.59	4.86	4.69	4.61
New Brunswick	3.36	3.63	3.57	3.49	3.46	3.42	3.39	3.39	3.32	3.77	3.98
Quebec	3.24	3.16	3.29	3.26	3.23	3.20	3.17	3.16	3.11	3.07	3.06
Ontario	2.93	3.06	3.29	3.50	3.56	3.53	3.49	3.49	3.41	3.31	3.26
Manitoba	4.16	4.34	4.57	4.56	4.50	4.44	4.38	4.50	4.75	4.88	5.19
Saskatchewan	4.27	4.42	4.53	4.50	4.46	4.49	4.40	4.37	4.65	4.60	4.53
Alberta	4.22	4.37	4.30	4.21	4.10	4.27	4.30	4.47	4.47	4.36	4.30
British Columbia	4.39	4.46	4.74	4.65	4.59	4.54	4.48	4.58	4.51	4.40	4.35

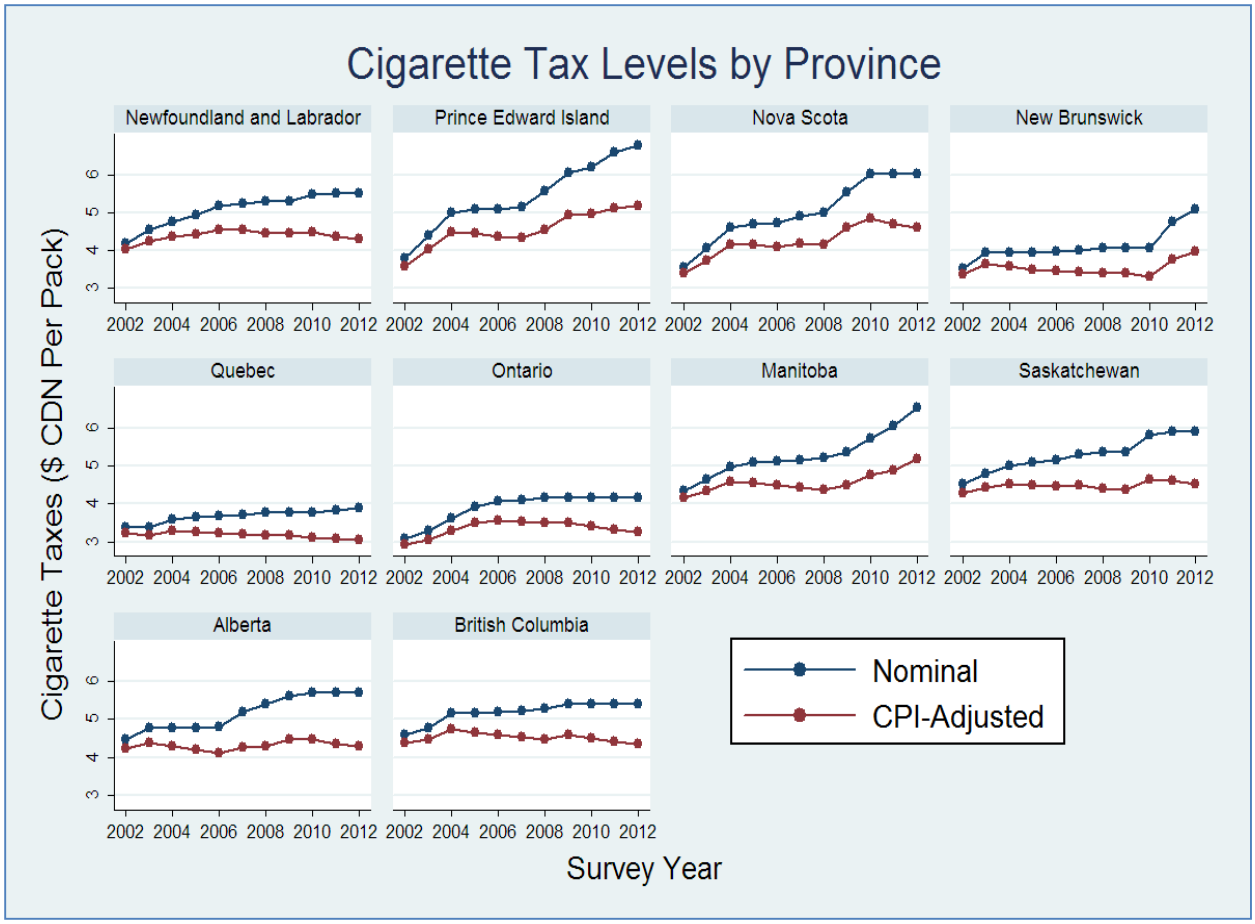

Figure 4-6. Means of cigarette tax levels, based on Finances of the Nation 2002-2012 reports and CTUMS 2002-2012, ages 15 and over

Other Provincial Data

We considered four potential provincial-level confounders in our study. These are factors that affect smoking and whose implementation or changes may have coincided with changes in cigarette tax levels during the time of the FTCS. We included two other tobacco control strategies where their implementation varied by province, namely smoke-free laws and retail tobacco display bans. The main source of provincial smoke-free laws was the report, *Provincial and Territorial Smoke-Free Legislation Summary* (Non-Smokers's Rights Association, 2012b). Data on tobacco retail display bans were extracted from a Canadian Centre for Health Economics working paper (Irvine & Nguyen, 2014). For retail tobacco display bans, we created a binary variable to indicate a ban in effect in each province at time of interview. Similarly, for provincial smoke-free laws, we created a binary variable to indicate a law in effect in each province at time of interview based on the date of first implementation. (See **Appendix Table 14** for the timing of provincial smoke-free legislation and **Appendix Table 15** for the timing of provincial retail tobacco display ban.)

To account for the potential effect of unemployment, we included rates based on those aged 25 and over (Azagba & Sharaf, 2011; DeCicca & McLeod, 2008). Data on the Labour Force Survey estimates of unemployment rates were extracted from CANSIM (Statistics Canada, 2014). Additionally, retail sales tax rates (at time of interview) were another potential provincial-level confounder. Depending on the province and year, we either summed the provincial sales tax (PST) rate and goods & services tax (GST) rate, or the harmonized sales tax (HST) rate (Canada Revenue Agency, n.d.; Canadian Tax Foundation, n.d.). See **Appendix Table 16** for means of annual retail sales tax rates and **Appendix Table 18** for annual unemployment rates.

4.4 Methods and Analyses

Statistical Models

Linking data on excise cigarette taxes to repeated cross-sections of CTUMS permitted the use of the difference-in-differences (DD) analytical framework. It is a common analytical tool in policy analysis, epidemiology, and economics with the use of a quasi-experimental design. For our study, the timing of tax increases was the pseudo-randomized component.

Let Y_{ips} be a smoking-related outcome for individual i, in province (P) p, survey year (S) s, and let be T_{ps} be the corresponding cumulative amount of excise cigarette taxes. The expectation (or mean) of Y_{ips} then becomes,

$$E(Y_{ips}) = \beta_0 + \beta_1 T_{ps} + \sum_{\forall p} \beta_p P_p + \sum_{\forall s} \beta_s S_s + \sum_{\forall c} \beta_c X_{c\,ips} + \sum_{\forall k} \beta_k Z_{k\,ps} \quad (1)$$

where $\boldsymbol{\beta_p}$ and $\boldsymbol{\beta_s}$ are coefficients denoting province and year fixed effects, respectively. Both province and year are modeled with a series of binary dummies. Fixed effects for province account for all time-invariant provincial level differences in the smoking-related outcomes. Fixed effects for each year account for trends in smoking over time that may be driven by shared factors or policies such as social norms or federal level tobacco control strategies like graphic warning labels.

The term $\boldsymbol{X_c}$ denotes individual-level covariates such as age, gender, education-student status, marital status, language spoken at home, and household size, and $\boldsymbol{\beta_c}$ is the corresponding coefficient of association. Similarly, the term $\boldsymbol{Z_k}$ denotes a potentially important time-varying provincial-level characteristic such as unemployment rates, indicators for retail tobacco display bans, and indicators for the implementation of smoke-free laws, and $\boldsymbol{\beta_k}$ is the corresponding coefficient of association.

The main coefficient of interest is β_1, the effect of a $1 per pack increase in cigarette taxes. More specifically, it is the difference in the change of smoking behaviour between provinces that raised taxes relative to provinces that did not raise taxes. Under the assumption that increasing cigarette taxes reduces smoking, β_1 should be a negative value for both smoking outcomes.

The difference-in-differences framework is easily extendable to allow the estimation of heterogeneous effects of tobacco taxes by socioeconomic position (SEP) (eg. Goldin & Homonoff, 2013; Harper et al., 2012). Specifically, when using education groups (G) as the measure of SEP, the expectation of Y_{ips} becomes,

$$E(Y_{ips}) = \beta_0 + \sum_{\forall g} \beta_g G_g T_{ps} + \sum_{\forall g}\sum_{\forall p} \beta_{gp} G_g P_p + \sum_{\forall g}\sum_{\forall s} \beta_{gs} G_g S_s + \sum_{\forall c} \beta_c X_{c_{ips}} + \sum_{\forall k} \beta_k Z_{k_{ps}} \quad (2)$$

where g = 1, 2, 3, and 4 represent the four education groups *Less than High School*, *Completed Secondary, Completed College,* and *Completed University*, respectively.

The set of coefficients denoted by $\boldsymbol{\beta_{gp}}$ is a collection of cross-product (or interaction) terms that account for factors affecting smoking rates in each education group that stay constant over time within provinces. If socioeconomic differences in smoking vary by province, but the differences do not vary over time, then they cannot confound the differential effect of excise tobacco taxes. Similarly, the set of coefficients denoted by $\boldsymbol{\beta_{gs}}$ is a collection of cross-product terms that account for factors affecting smoking rates across all provinces that may be different over time in each education group. If trends in smoking vary by education, but do not differ by province, then they cannot confound the differential effect of excise tobacco taxes. We already see some evidence of a common declining trend in smoking that differs by education in **Appendix Figure 7** and **Appendix Figure 8**, so it seems important to control for these trends.

Because a key objective of our study was to investigate the potential impact of tobacco control strategies on socioeconomic inequalities in smoking, the main regression coefficients of interest are $\boldsymbol{\beta_g}$ for g = 1, 2, 3 or 4 which are the effects of taxes on smoking for each education group. If these coefficients decrease in magnitude with higher education, then this would help to reduce the socioeconomic inequality in smoking. Conversely, an increase in magnitude with higher education would suggest that taxes have weaker effects on lower educated groups, potentially widening the gap in smoking inequality.

We described our statistical models on the additive scale for the purpose of simplicity and ease of interpretation. We modeled smoking prevalence, however, using logistic regression. Assessing smoking frequency, on the other hand, required a two-part model where a binary component is modeled in the first stage and a frequency component in the second stage (Cragg, 1971). A single quantity variable is used to model both parts. We used logistic regression to model the binary component where a value of 0 indicates a non-smoker, and values of 1 or greater indicate smoking prevalence. We used and Poisson regression for the frequency part, namely smoking quantity for those with values of 1 or greater.

For the relative effect, we calculated tax elasticity estimates. To assess the contribution of changes in cigarette tax levels on smoking on the additive scale, we computed marginal effect estimates for an increase of $1.00 (per package of 20 cigarettes) for both smoking outcomes which are predicted counterfactual outcomes holding constant the observed values for all other covariates. Moreover, to evaluate the joint significance of the heterogeneous effects of cigarette taxes by education on smoking on the additive scale, we used a Wald test on the contrasts of their marginal effect estimates. Hence, we will discuss our results primarily on the additive scale.

Analytical Plan

Data extraction and data management were performed using SAS 9.3 and Stata/MP 12.1. All statistical analyses (including figures) were performed using Stata/MP 12.1. All estimates reported in our paper were derived using survey weights (Korn, 1999). Standard errors (SEs) and 95% confidence intervals (CIs) were computed using bootstrap sampling (Efron & Tibshirani, 1986). Unless stated otherwise, we used the set of 200 bootstrap weights provided by CTUMS, as recommended by Statistics Canada for use of their survey data (Statistics Canada, 2011). (Note that each bootstrap weight itself was an average based on 20 samples). See **Appendix A-7** for details on Stata code used for data analyses.

Our analytical structure followed that of DeCicca & McLeod (2008). In addition to a *crude* model, we assessed the impact of cigarette taxes for each effect type (average and heterogeneous) and on both smoking outcomes using three regression models. *Model 1* provided a causal estimate using the simplest case of the DD framework with the inclusion of fixed effects for province and survey year. *Model 2* included individual-level covariates as previously specified. *Model 3* expanded upon *Model 2* by adding provincial-level covariates.

To check for the robustness of our results, we performed eight different types of sensitivity analyses based on *Model 3*. The first set considered the potential for non-linear effects and assessed the effect of an increase of $1.00 at different tax levels within our study. The second involved the use of the Probit model, more commonly found in the literature on tobacco taxation and price on smoking. Thirdly, for smoking prevalence, we substituted past-week smoker status with current smoker status as described in Section 3-2. The fourth sensitivity analysis pertained only to the smoking frequency outcome. Here, we used a negative-binomial distribution instead of a Poisson distribution to relax the mean-variance equality assumption.

Table 4-6. Distribution of Education by Age Range

Education	25+	25-64
Less than Secondary	0.154	0.104
Completed Secondary	0.346	0.348
Completed College	0.207	0.229
Completed University	0.293	0.318
Sample Size	116652	91180

In order to account for older cohorts being generally less educated, the fifth type of sensitivity analysis excluded those in the oldest age category (65 and older). (See **Table 4-6** for the education distribution with and without the age restriction.) For the sixth set of sensitivity analyses, we estimated robust standard errors with and without clustering by province (assuming non-independence and independence of participants within the same province) in order to compare with the bootstrap sampling method. For the seventh sensitivity, we excluded one province at a time to assess if tax changes for a particular province were influencing our estimates. Similarly, for the last sensitivity, we incrementally included a year of data to determine if tax changes for a particular year had a significant impact on smoking.

4.5 Results

Table 4-7 shows the weighted proportions (or means) of key demographic characteristics of our CTUMS sample. The *Full Sample* column provides estimates including individuals with missing data, while the *Complete Case* column provides estimates based on individuals with complete data. Note, however, that estimates are similar between both columns. About 95% of survey participants have complete information for covariates considered in our study. The majority of the missing data (N=6,291) were attributable to the outcome past-week smoker, education, marital status, and language spoken at home. Since the overall percentage of individuals with missing data was small, subsequent analyses were based on individuals with complete data.

The average prevalence for past-week smoker was about 16.7%, and among smokers, mean weekly consumption was 97.3 cigarettes. Although CTUMS contains an approximately equal proportion of survey participants from each province, Ontario (38.5%), Quebec (24.2%), British Columbia (13.5%), and Alberta (10.1%) make up the majority of the Canadian population. Among the education groups, the *Less than Secondary* group was the smallest, representing about 15.4% of the sample. The *Completed Secondary*, *Completed College* and *Completed University* groups accounted for 34.6%, 20.7%, and 29.3% of the sample, respectively. The age groups were fairly evenly distributed, ranging from 16.8% for the *55-64* group to 22.5% for the *45-54* group. For marital status, those who were married or common-law accounted for the majority of the sample at 72.4%. English was the most common language spoken at home, accounting for 67.0% of the sample, while French had the second highest representation 21.7%. A two-person household was the most common household size, representing about 37.8% of the sample. The remaining household size groups ranged from 10.8% for *5 or More* to 19.1% for a four-person household.

Table 4-7. CTUMS Survey-weighted Sample Characteristics, Ages 25 and Over

Characteristic	Full Sample		Complete Case	
	Estimate	**SE**	**Estimate**	**SE**
Sample Size	122,943		116,652	
Past-week Smoker	16.6	0.2	16.7	0.2
Missing (Number)	1,678			
Past-week Cigarette Quantity (Smokers)	97.2	0.8	97.3	0.8
Province				
Newfoundland and Labrador	1.6	0.0	1.6	0.0
Prince Edward Island	0.4	0.0	0.4	0.0
Nova Scotia	2.9	0.0	2.9	0.0
New Brunswick	2.3	0.0	2.4	0.0
Quebec	24.0	0.0	24.2	0.0
Ontario	38.7	0.0	38.5	0.1
Manitoba	3.5	0.0	3.4	0.0
Saskatchewan	2.9	0.0	2.9	0.0
Alberta	10.1	0.0	10.1	0.0
British Columbia	13.6	0.0	13.5	0.0
Survey Year				
2002	8.5	0.0	8.4	0.0
2003	8.6	0.0	8.3	0.0
2004	8.7	0.0	8.7	0.0
2005	8.8	0.0	8.8	0.0
2006	8.9	0.0	8.8	0.0
2007	9.1	0.0	9.1	0.0
2008	9.2	0.0	9.2	0.0
2009	9.4	0.0	9.4	0.0
2010	9.5	0.0	9.6	0.0
2011	9.6	0.0	9.7	0.0
2012	9.7	0.0	9.8	0.0
Education				
Less than secondary	15.6	0.2	15.4	0.2
Completed secondary	34.7	0.2	34.6	0.2
Completed community college	20.6	0.2	20.7	0.2
Completed university	29.1	0.2	29.3	0.2
Missing (Number)	2,599			
Male	49.0	0.0	49.2	0.1
Age Group				
25-34	20.1	0.1	20.4	0.1
35-44	21.9	0.1	22.1	0.1
45-54	22.5	0.2	22.7	0.2
55-64	16.8	0.1	16.8	0.1
65+	18.7	0.0	18.1	0.1
Marital Status				
Common-law/Married	72.4	0.3	72.6	0.3
Widow/Divorced/Separated	13.4	0.2	13.2	0.2
Single	14.2	0.2	14.1	0.2
Missing (Number)	2,421			
Language (Spoken at Home)				
English	67.0	0.2	67.0	0.2
French	21.7	0.1	22.0	0.1
English and French	0.9	0.0	0.9	0.0
Other	10.4	0.2	10.2	0.2
Missing (Number)	1,132			
Household Size				
1	14.5	0.2	13.9	0.2
2	37.8	0.2	37.9	0.2
3	17.9	0.2	18.0	0.2
4	19.1	0.2	19.4	0.2
5 or more	10.8	0.2	10.8	0.2
Missing (Number)	2			

Weighted proportions (or mean for the case of past-week cigarette quantity among smokers) and standard errors.

Table 4-8. Average Effect of CPI-adjusted Cigarette Taxes on Smoking Prevalence

Model	Marginal Effect			Elasticity		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-1.1%	-1.6%	-0.6%	-0.24	-0.35	-0.12
1: Province and Year Fixed Effects	-0.4%	-2.0%	1.2%	-0.09	-0.45	0.27
2: Model 1 + Individual Covariates	-0.3%	-1.9%	1.3%	-0.07	-0.45	0.31
3: Model 2 + Provincial Covariates	-0.1%	-1.7%	1.5%	-0.03	-0.41	0.35

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on smoking prevalence. Elasticity estimates indicate the percentage change in smoking prevalence given a 1% change in taxes.

Table 4-9. Average Effect of CPI-adjusted Cigarette Taxes on Smoking Frequency

Model	Marginal Effect			Elasticity		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-1.9	-2.5	-1.3	-0.44	-0.57	-0.31
1: Province and Year Fixed Effects	-0.3	-2.0	1.5	-0.06	-0.46	0.35
2: Model 1 + Individual Covariates	-0.1	-1.9	1.6	-0.04	-0.46	0.38
3: Model 2 + Provincial Covariates	-0.1	-1.9	1.7	-0.03	-0.47	0.41

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on mean weekly cigarette consumption. Elasticity estimates indicate the percentage change in mean weekly cigarette consumption given a 1% change in taxes.

Marginal effect estimates were similar across *Model 1*, *Model 2*, and *Model 3* when estimating average and heterogeneous effects of cigarette taxes on smoking prevalence and smoking frequency. This suggests that the set of included individual and provincial level covariates did not have much influence on the effect of cigarette taxes on either smoking outcome. Going forward, we will reference only marginal effect estimates based on *Model 3* of each respective smoking outcome and effective type (average or heterogeneous).

Table 4-8 and **Table 4-9** provide estimates for the marginal effect and elasticity of CPI-adjusted cigarette taxes on smoking prevalence and frequency, respectively. The marginal effect for an increase of $1.00 of cigarette taxes per package was -0.1 (95% CI: -1.7, 1.5) percentage points for smoking prevalence and -0.1 (95% CI: -1.9, 1.7) cigarettes per week. Thus, to answer the first objective, changes in cigarette taxes during the time of the FTCS did not have a significant impact on smoking prevalence or smoking frequency among adults in Canada. As tax increases were actually smaller than $1.00 for many provinces, expected changes would remain negligible for both smoking prevalence and frequency. See **Appendix Table 21** and

Appendix Table 22 for marginal effect estimates of all other covariates included in *Models 1-3* for smoking prevalence and frequency, respectively.

Table 4-10 and **Table 4-11** provide estimates for the marginal effect and elasticity of CPI-adjusted cigarette taxes on smoking prevalence by education, respectively. For the *Less than Secondary* group, the marginal effect estimate for an increase of $1.00 on smoking prevalence was 2.1 (95% CI: -1.8, 5.9) percentage points. The marginal effect estimates were 0 (95%: -2.8, 2.9), 0 (95% CI: -3.4, 3.5), and -2.0 (95% CI: -4.9, 1.0) percentage points for the *Completed Secondary*, *Completed College* and *Completed University* groups, respectively. A Wald test of joint significant yielded a χ^2 value of 2.56 with 3 degrees of freedom (DF), and a p-value of 0.4646, suggesting there is insufficient evidence to reject a null hypothesis that the effects are homogenous across levels of education. See **Appendix Table 23** for marginal estimates of all covariates in our heterogeneous effect models for smoking prevalence.

Similarly, **Table 4-12** and **Table 4-13** provide estimates for the marginal effect and elasticity of CPI-adjusted cigarette taxes on smoking frequency, respectively. The marginal effects for an increase of $1.00 per package on smoking frequency were 2.5 (95% CI: -2.8,7.7), -0.4 (95% CI: -3.8, 3.0), -1.4 (95% CI: -5.1, 2.3), and -0.3 (95% CI: -2.9, 2.2) cigarettes per week for the *Less than Secondary*, *Completed Secondary*, *Completed College* and *Completed University* groups, respectively. A Wald test of joint significance yielded a χ^2 value of 1.26 (DF=3), and a p-value of 0.7383, suggesting a lack of evidence for heterogeneous effects. See **Appendix Table 24** for marginal estimates of all covariates in our heterogeneous effect models for smoking frequency.

Thus, regarding the second objective, we see weak evidence of differing effects of excise cigarette taxes by education. All marginal effect estimates by education and the corresponding

Wald test on their contrasts were statistically non-significant for both smoking outcomes. This would imply that from 2002-2012, there were negligible differences in the effect of cigarette taxes on smoking among education groups, and hence, cigarette taxes did not contribute to the reduction of the inequality in either smoking outcome during the time of the FTCS. Furthermore, as previously noted, tax increases were actually smaller than $1.00 for many provinces, and so differences between education groups would be smaller and remain negligible for both smoking prevalence and frequency.

We based all sensitivity analyses on *Model 3*, our preferred model, for both smoking outcomes and effect type. **Table 4-14** and **Table 4-15** show sensitivity analyses for the average effect of cigarette taxes on smoking prevalence and frequency, respectively. Likewise, **Table 4-16** and **Table 4-17** show sensitivity analyses for the heterogeneous effects of cigarette taxes by education on smoking prevalence and frequency, respectively. Although certain sensitivity analyses have effects of the opposite sign from our main results, all estimates remain non-significant. Thus, estimates were robust to all sensitivity specifications.

Table 4-10: Marginal Estimates of the Effects of CPI-adjusted Cigarette Taxes on Smoking Prevalence by Education

Model	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimat**	**95% C.I.**	
Crude	1.4%	0.1%	2.8%	-1.1%	-2.2%	-0.1%	-1.1%	-2.3%	0.1%	-2.7%	-3.6%	-1.7%
1	2.6%	-1.8%	6.9%	-0.2%	-3.1%	2.8%	-0.6%	-4.1%	2.8%	-2.5%	-5.5%	0.5%
2	2.0%	-1.9%	5.9%	0.0%	-2.8%	2.9%	0.0%	-3.4%	3.4%	-2.0%	-5.0%	1.0%
3	2.1%	-1.8%	5.9%	0.0%	-2.8%	2.9%	0.0%	-3.4%	3.5%	-2.0%	-4.9%	1.0%

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on smoking prevalence on the additive scale.

Table 4-11. Elasticity Estimates of CPI-adjusted Cigarette Taxes on Smoking Prevalence by Education

Model	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	0.25	0.01	0.49	-0.21	-0.39	-0.02	-0.24	-0.48	0.01	-1.05	-1.39	-0.70
1	0.44	-0.30	1.19	-0.03	-0.57	0.50	-0.14	-0.89	0.61	-0.97	-2.14	0.20
2	0.38	-0.35	1.11	0.00	-0.55	0.55	-0.01	-0.77	0.76	-0.81	-2.01	0.38
3	0.39	-0.35	1.12	0.01	-0.55	0.57	0.01	-0.77	0.78	-0.80	-1.98	0.38

Elasticity estimates indicate the percentage change in smoking prevalence given a 1% change in taxes.

Table 4-12. Marginal Estimates of the Effects of CPI-adjusted Cigarette Taxes on Smoking Frequency by Education

Model	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-0.9	-2.8	1.0	-2.6	-3.9	-1.4	-1.8	-3.1	-0.6	-1.9	-2.8	-1.0
1	3.0	-2.6	8.6	-0.4	-3.9	3.1	-2.0	-5.7	1.7	-0.8	-3.4	1.8
2	2.7	-2.6	7.9	-0.2	-3.5	3.1	-1.2	-4.8	2.4	-0.3	-2.9	2.3
3	2.5	-2.8	7.7	-0.4	-3.8	3.0	-1.4	-5.1	2.3	-0.3	-2.9	2.2

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on mean weekly cigarette consumption on the additive scale.

Table 4-13. Elasticity Estimates of CPI-adjusted Cigarette Taxes on Smoking Frequency by Education

Model	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-0.13	-0.41	0.14	-0.47	-0.69	-0.25	-0.45	-0.74	-0.16	-0.98	-1.38	-0.57
1	0.45	-0.39	1.29	-0.07	-0.69	0.56	-0.50	-1.40	0.41	-0.42	-1.76	0.92
2	0.40	-0.39	1.19	-0.03	-0.65	0.59	-0.30	-1.22	0.62	-0.17	-1.56	1.21
3	0.37	-0.42	1.16	-0.07	-0.70	0.57	-0.33	-1.28	0.61	-0.20	-1.57	1.17

Elasticity estimates indicate the percentage change in mean weekly cigarette consumption given a 1% change in taxes.

Table 4-14. Sensitivity Analyses for the Marginal Effect of CPI-adjusted Cigarette Taxes on Smoking Prevalence

Sensitivity Type	Estimate	95% C.I.	
Preferred Model (Model 3)	-0.1%	-1.7%	1.5%
Changes in Tax Levels			
$3-$4	-0.1%	-1.7%	1.5%
$4-$5	-0.1%	-1.7%	1.4%
Model Specification			
Probit Model	-0.1%	-1.7%	1.5%
Current-Smoker	-0.1%	-1.7%	1.5%
Ages 25 - 64	-0.2%	-2.1%	1.7%
Weighted with no Clustering	-0.1%	-1.8%	1.5%
Weighted with Clustering	-0.1%	-1.4%	1.1%
Province Excluded			
Newfoundland & Labrador	-0.2%	-1.8%	1.4%
Prince Edward Island	-0.1%	-1.8%	1.5%
Nova Scotia	-0.2%	-2.1%	1.7%
New Brunswick	-0.2%	-1.8%	1.5%
Quebec	-0.8%	-2.3%	0.8%
Ontario	0.4%	-0.9%	1.7%
Manitoba	-0.1%	-1.8%	1.6%
Saskatchewan	-0.2%	-1.8%	1.5%
Alberta	0.3%	-1.5%	2.2%
British Columbia	-0.2%	-1.9%	1.5%
Years Included			
2002 - 2003	0.0%	-3.0%	3.0%
2002 - 2004	0.2%	-2.9%	3.3%
2002 - 2005	-0.3%	-3.0%	2.4%
2002 - 2006	-0.5%	-3.0%	2.0%
2002 - 2007	-0.4%	-2.8%	2.0%
2002 - 2008	-0.3%	-2.6%	2.0%
2002 - 2009	-0.2%	-2.4%	2.0%
2002 - 2010	0.3%	-1.7%	2.2%
2002 - 2011	0.0%	-1.8%	1.7%

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on smoking prevalence on the additive scale.

Table 4-15. Sensitivity Analyses for the Marginal Effect of CPI-adjusted Cigarette Taxes on Smoking Frequency

Sensitivity Type	Estimate	95% C.I.	
Preferred Model (Model 3)	-0.1	-1.9	1.7
Changes in Tax Levels			
$3-$4	-0.1	-1.9	1.7
$4-$5	-0.1	-1.9	1.7
Model Specification			
Probit-Poisson TPM	-0.1	-1.9	1.7
Logit-Negative Binomial TPM	0.0	-1.9	1.8
Ages 25 - 64	-0.2	-2.3	1.9
Weighted with no clustering	-0.1	-2.2	1.9
Weighted with clustering	-0.1	-1.6	1.3
Province Excluded			
Newfoundland & Labrador	-0.2	-2.0	1.6
Prince Edward Island	-0.2	-2.0	1.7
Nova Scotia	-0.3	-2.4	1.8
New Brunswick	-0.1	-2.0	1.8
Quebec	-0.9	-2.7	1.0
Ontario	0.3	-1.3	1.8
Manitoba	-0.1	-2.1	1.8
Saskatchewan	-0.2	-2.1	1.6
Alberta	0.6	-1.4	2.7
British Columbia	-0.1	-2.1	1.9
Years Included			
2002 - 2003	-0.7	-4.6	3.2
2002 - 2004	0.5	-3.4	4.4
2002 - 2005	-0.2	-3.6	3.2
2002 - 2006	-0.7	-3.7	2.3
2002 - 2007	-0.5	-3.4	2.3
2002 - 2008	-0.4	-3.0	2.3
2002 - 2009	-0.2	-2.7	2.2
2002 - 2010	0.3	-1.9	2.5
2002 - 2011	0.0	-2.0	2.0

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on mean weekly cigarette consumption on the additive scale.

Table 4-16. Sensitivity Analyses for the Marginal Effect of CPI-adjusted Cigarette Taxes on Smoking Prevalence by Education

Sensitivity Type	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Preferred Model (Model 3)	2.1%	-1.8%	5.9%	0.0%	-2.8%	2.9%	0.0%	-3.4%	3.5%	-2.0%	-4.9%	1.0%
Changes in Tax Levels												
$3-$4	2.0%	-1.8%	5.8%	0.0%	-2.8%	2.9%	0.0%	-3.4%	3.5%	-2.0%	-5.2%	1.1%
$4-$5	2.2%	-2.1%	6.5%	0.0%	-2.8%	2.9%	0.0%	-3.4%	3.5%	-1.7%	-3.8%	0.4%
Model Specification												
Probit Model	2.0%	-1.9%	6.0%	0.0%	-2.9%	2.8%	0.1%	-3.4%	3.5%	-1.7%	-4.6%	1.2%
Current-Smoker	2.1%	-1.8%	5.9%	0.0%	-2.8%	2.9%	0.0%	-3.4%	3.5%	-2.0%	-4.9%	1.0%
Ages 25 - 64	5.5%	-0.5%	11.5%	-0.2%	-3.6%	3.2%	-0.2%	-3.9%	3.6%	-2.5%	-5.7%	0.8%
Weighted with no Clustering	2.1%	-1.8%	5.9%	0.0%	-2.9%	3.0%	0.0%	-3.7%	3.7%	-2.0%	-4.8%	0.8%
Weighted with Clustering	2.1%	-1.7%	5.8%	0.0%	-1.2%	1.3%	0.0%	-1.3%	1.3%	-2.0%	-3.9%	0.0%
Province Excluded												
Newfoundland & Labrador	2.0%	-2.0%	6.0%	0.0%	-3.0%	3.0%	0.0%	-4.0%	4.0%	-2.0%	-5.0%	1.0%
Prince Edward Island	2.0%	-2.0%	6.0%	0.0%	-3.0%	3.0%	0.0%	-4.0%	4.0%	-2.0%	-5.0%	1.0%
Nova Scotia	3.0%	-2.0%	7.0%	0.0%	-3.0%	3.0%	0.0%	-4.0%	4.0%	-2.0%	-6.0%	1.0%
New Brunswick	2.0%	-2.0%	6.0%	0.0%	-3.0%	3.0%	0.0%	-3.0%	4.0%	-2.0%	-5.0%	1.0%
Quebec	-1.0%	-5.0%	3.0%	0.0%	-3.0%	3.0%	-1.0%	-4.0%	3.0%	-2.0%	-5.0%	1.0%
Ontario	2.0%	-1.0%	6.0%	0.0%	-3.0%	2.0%	1.0%	-2.0%	4.0%	0.0%	-3.0%	2.0%
Manitoba	2.0%	-2.0%	7.0%	0.0%	-3.0%	3.0%	0.0%	-4.0%	4.0%	-2.0%	-5.0%	1.0%
Saskatchewan	2.0%	-2.0%	6.0%	0.0%	-3.0%	3.0%	0.0%	-4.0%	3.0%	-2.0%	-5.0%	1.0%
Alberta	2.0%	-2.0%	6.0%	1.0%	-3.0%	4.0%	0.0%	-4.0%	4.0%	-1.0%	-5.0%	2.0%
British Columbia	3.0%	-1.0%	7.0%	0.0%	-3.0%	3.0%	0.0%	-3.0%	4.0%	-3.0%	-6.0%	1.0%
Years Included												
2002 - 2003	0.0%	-6.2%	6.2%	0.5%	-6.0%	7.1%	3.8%	-5.1%	12.6%	-2.0%	-7.2%	3.3%
2002 - 2004	1.3%	-4.8%	7.4%	0.6%	-4.5%	5.8%	1.3%	-6.6%	9.2%	-1.5%	-7.2%	4.2%
2002 - 2005	4.5%	-1.9%	10.9%	-0.7%	-5.4%	4.1%	2.6%	-4.5%	9.7%	-4.5%	-9.3%	0.3%
2002 - 2006	5.0%	-1.1%	11.1%	-1.2%	-5.4%	3.1%	3.4%	-3.2%	10.1%	-5.1%	-9.3%	-0.9%
2002 - 2007	4.4%	-1.3%	10.0%	-0.6%	-4.6%	3.5%	1.3%	-4.9%	7.4%	-4.0%	-8.3%	0.3%
2002 - 2008	4.4%	-1.1%	9.9%	-0.4%	-4.4%	3.6%	0.4%	-5.3%	6.1%	-3.2%	-7.4%	1.0%
2002 - 2009	2.1%	-3.1%	7.3%	0.6%	-3.2%	4.3%	0.0%	-5.0%	5.0%	-2.6%	-6.6%	1.3%
2002 - 2010	2.3%	-2.3%	6.9%	0.7%	-2.7%	4.2%	0.6%	-3.8%	5.0%	-1.8%	-5.2%	1.7%
2002 - 2011	1.9%	-2.3%	6.1%	0.0%	-3.1%	3.1%	0.5%	-3.4%	4.5%	-1.8%	-5.1%	1.4%

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on smoking prevalence on the additive scale.

Table 4-17. Sensitivity Analyses for the Marginal Effect of CPI-adjusted Cigarette Taxes on Smoking Frequency by Education

Sensitivity Type	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Preferred Model (Model 3)	2.5	-2.8	7.7	-0.4	-3.8	3.0	-1.4	-5.1	2.3	-0.3	-2.9	2.2
Changes in Tax Levels												
$3-$4	2.4	-2.7	7.6	-0.4	-3.8	3.0	-1.4	-5.2	2.4	-0.3	-2.9	2.3
$4-$5	2.6	-3.4	8.6	-0.4	-3.7	2.9	-1.3	-4.5	1.9	-0.4	-2.8	2.1
Model Specification												
Probit-Poisson TPM	2.4	-2.9	7.7	-0.5	-3.9	2.9	-1.3	-5.1	2.4	-0.1	-2.6	2.5
Logit-Negative Binomial TPM	2.4	-2.8	7.7	-0.1	-3.5	3.3	-1.5	-5.2	2.2	-0.3	-2.9	2.3
Ages 25 - 64	6.3	-2.4	15.0	-0.6	-4.6	3.5	-1.8	-5.8	2.2	-0.6	-3.4	2.2
Weighted with no Clustering	2.5	-2.9	8.0	-0.4	-4.2	3.3	-1.5	-5.7	2.7	-0.3	-3.0	2.3
Weighted with Clustering	2.5	-2.1	7.2	-0.4	-2.5	1.7	-1.5	-3.1	0.1	-0.3	-2.1	1.4
Province Excluded												
Newfoundland & Labrador	2.3	-3.1	7.6	-0.5	-3.9	3.0	-1.5	-5.2	2.3	-0.3	-2.9	2.3
Prince Edward Island	2.5	-2.9	7.9	-0.4	-3.9	3.1	-1.4	-5.2	2.4	-0.4	-3.0	2.2
Nova Scotia	2.9	-3.4	9.1	-0.3	-4.3	3.6	-2.0	-6.3	2.3	-0.6	-3.6	2.3
New Brunswick	2.5	-2.9	8.0	-0.6	-4.1	3.0	-1.0	-4.9	2.9	-0.3	-3.0	2.3
Quebec	-0.6	-6.2	5.1	-1.2	-4.6	2.1	-1.4	-5.1	2.3	-0.6	-3.1	1.8
Ontario	3.4	-1.7	8.4	-1.1	-4.3	2.2	-0.9	-4.3	2.6	0.4	-1.6	2.5
Manitoba	2.5	-3.1	8.2	-0.4	-4.0	3.3	-1.1	-5.2	2.9	-0.5	-3.2	2.2
Saskatchewan	2.6	-2.8	8.1	-0.5	-4.1	3.0	-1.7	-5.5	2.2	-0.3	-3.0	2.4
Alberta	2.2	-3.8	8.2	1.2	-2.8	5.3	-1.1	-5.2	3.0	0.5	-2.6	3.5
British Columbia	3.5	-2.0	9.0	-0.8	-4.5	3.0	-1.1	-5.0	2.8	-0.5	-3.3	2.3
Years Included												
2002 - 2003	1.9	-7.5	11.4	-1.7	-8.6	5.3	1.5	-7.7	10.6	-1.8	-6.9	3.3
2002 - 2004	1.6	-7.3	10.5	0.3	-6.1	6.6	0.6	-7.8	9.0	0.6	-4.9	6.1
2002 - 2005	5.6	-3.2	14.4	-0.8	-7.0	5.4	1.5	-5.5	8.5	-2.9	-7.4	1.7
2002 - 2006	5.9	-2.4	14.2	-1.2	-6.5	4.1	0.6	-6.1	7.4	-3.6	-7.8	0.6
2002 - 2007	3.4	-4.5	11.3	-0.6	-5.6	4.5	-0.2	-6.4	6.0	-2.1	-6.3	2.2
2002 - 2008	4.1	-3.6	11.8	-0.5	-5.5	4.5	-1.1	-6.9	4.7	-1.3	-5.3	2.6
2002 - 2009	2.4	-4.6	9.3	0.1	-4.6	4.7	-0.9	-6.1	4.3	-1.1	-4.7	2.5
2002 - 2010	2.2	-4.1	8.5	0.6	-3.6	4.8	-0.6	-5.3	4.1	-0.2	-3.4	2.9
2002 - 2011	2.0	-3.8	7.8	-0.3	-4.1	3.5	-1.0	-5.2	3.2	-0.2	-3.0	2.6

Marginal estimates indicate the effect of a $1.00 increase for a pack of 20 cigarettes on mean weekly cigarette consumption on the additive scale.

4.6 Discussion

In this section we will cover some potential issues and limitations of our study. We will first address potential methodological concerns. Then we will broadly discuss general concerns about cigarette taxation strategies in Canada.

Firstly, using self-reported tobacco consumption for our outcome measure may be a concern because of the problem of social desirability, specifically the misreporting of smoking behaviour. In order for this to cause a bias, the rate of misreporting has to change with respect to time, or in other words, at different cigarette tax levels, and be differential across provinces. One might be concerned, then, that increases in cigarette taxes can either directly cause the under-reporting of smoking or can lead to the use of contraband tobacco products where those engaged in such activity are less likely to report their smoking habits. If increases in cigarette taxes do actually decrease smoking rates, then the under-reporting of smoking would exaggerate this effect (or in other words, bias our estimates away from the null). However, we obtained null results for the effect of cigarette taxes on both smoking outcomes, so social desirability is most likely not a limitation in our study.

Furthermore, when looking at heterogeneous effects of cigarette taxes, in order to generate bias the misreporting also has to be differential by education. If increases in taxes lead those with lower education to under-report their smoking behaviour, then this would exaggerate the effect of taxes for them and artificially decrease the smoking gap between those with low and high education. Conversely, if those with higher education tend to under-report their smoking behaviour, then this would exaggerate the effect of taxes for them and widen the smoking gap. As in the case of average effects, however, we obtained null results for the effect of cigarette taxes by education and the corresponding test of their contrasts for both smoking outcomes.

Moreover, because the interest of this paper is the effect of tobacco taxes on individual smoking behaviour (as opposed to legal sales), our estimates based on self-reported tobacco use should not be biased due to the problem of smuggling. Based on aggregate data of legal sales of cigarettes from NCTHP, Gruber et al. (2003) estimated a cigarette price elasticity of −0.72 (se=0.10), and −0.47 (se=0.09) before and after accounting for smuggling, respectively. Based on self-reported household cigarette expenditure data from FAMEX, their price elasticity estimates were −0.45 (se=0.11), and −0.45 (se=0.16) before and after accounting for smuggling, respectively. These elasticity estimates for self-reported cigarette consumption are near identical, and thus, suggest that the bias appears small when using this type of outcome.

Returning to our null results for the effect of excise cigarette taxes, they are likely attributable to a combination of several factors. Firstly, province fixed effects and common temporal changes accounted for much of the variation and declining trends in adult smoking. We calculated survey-weighted smoking prevalence by year and province and then computed R-squared values to infer the variation of smoking explained by each component. In a linear regression model with smoking prevalence as the outcome and province as the only set of fixed effects, the adjusted R-squared was 0.462. Similarly, for year fixed effects, the adjusted R-squared was 0.198. Thus, province accounted for more of the variation in smoking prevalence. Together, province and year fixed effects accounted for 73.0 % of the variation in smoking prevalence. The inclusion of mean CPI-adjusted cigarette tax levels (by year and province), however, only increased the variation explained to 73.4%. We derived similar results for smoking frequency.

This intuitively makes sense as overall smoking levels have decreased even within provinces with fairly stable cigarette tax levels. Prince Edward Island (P.E.I.) increased cigarette taxes by the largest amount during the time of the FTCS, nominally by $3.00 per pack, and after adjustment by the CPI, by about $1.58 per pack. From 2002 to 2012, P.E.I. experienced a decrease in smoking prevalence of about 7.2 percentage points and a decrease in mean smoking frequency of about 8.3 cigarettes. To give some perspective, however, Quebec had mostly flat or decreasing levels of excise cigarette tax levels during the same timeframe, yet still experienced a decrease in smoking prevalence of about 8.6 percentage points and a decrease in mean smoking frequency of about 13.4 cigarettes.

This leads us to an important caveat in the use of taxation as a tobacco control strategy, namely that taxes must be frequent and increase substantially large enough to counteract general price and income inflation (Chaloupka, 2013). This is not the case in certain provinces in Canada, however. From 2002 to 2012, each instance of a cigarette tax increase was often less than $1.00 per package of 20 cigarettes. (Recall **Appendix Table 10** for increases in cigarette taxes and their corresponding effective dates.) When factoring in inflation, these increases are even smaller. In 2012, the *cumulative* increase in CPI-adjusted cigarette taxes was at least $1.00 for only three provinces, Prince Edward Island, Nova Scotia, and Manitoba. Recall **Table 4-5** for means of CPI-adjusted cigarette tax levels by year and province. Additionally, anti-smoking sentiment and the level of tobacco control are different between Canada and other countries, and have increased over time within Canada. Thus, excise tobacco taxes may not have as strong of an effect compared to countries or older periods with lower tobacco tax levels, or generally weaker tobacco control.

Recall that another important stipulation for the effective use of excise taxes as a form of tobacco control is that smokers do not engage in price-reducing strategies such as tax evasion or tax avoidance. Based on data from International Tobacco Control Policy Evaluation Project, self-reported purchases of tobacco from "low or untaxed sources" have risen from about 3% to about 12% between 2002 and 2011 (Guindon et al., 2014). Additionally, in the evaluation of the FTCS, HC and PHAC showed that contraband tobacco seizures from the RCMP and CBSA have steadily increased since 2001 (Health Canada & Public Health Agency Of Canada, 2012). Increases in the seizure of contraband goods can indicate an increase in the effectiveness of surveillance and control of the Canadian border, but they can also indicate a rise in consumer engagement of price-reducing strategies. We see some evidence of this using CTUMS data.

Within our entire 2002-2012 CTUMS sample, there were 21,228 participants who identified as being current smokers. For years 2004-2011, CTUMS asked those who identified as being current smokers if they purchased discounted cigarettes. After excluding years where this data was unavailable (N=5,945) and those who refused to answer (N=699), the sample contained 14,584 smokers. Using the same covariates in *Model 3* as described in Section 4-2, we modeled the relationship between CPI-adjusted cigarette taxes and purchase of discounted cigarettes using logistic regression. For a $1.00 increase in taxes per pack, the proportion of smokers purchasing discounted cigarettes increased by about 14.3 (95% CI: 7.0, 21.6) percentage points. (Using covariates in *Model 1* and *Model 2* yielded similar marginal effect estimates.) Thus, instead of increasing smoking cessation or reducing smoking frequency, an increase in taxes resulted in an increase in the purchasing of discounted cigarettes. A Wald test of joint significance of marginal effect estimates by education, however, yielded a χ^2 value of 1.23 (DF=3), and a p-value of 0.7463, suggesting a lack of evidence for heterogeneous effects.

In general, we obtained weak evidence of heterogeneous effects of taxes by education on smoking, in particular, positive marginal effect estimates for the *Less than Secondary* education group for both smoking outcomes. As previously mentioned, tobacco price and tax levels provided the most consistent evidence for a beneficial effect on disadvantaged groups, but there is also conflicting evidence of no differential effect or the converse effect (Bader et al., 2011; Thomas et al., 2008). It is important to note that these positive estimates do not necessarily mean that increases in cigarette taxes have caused an increase in smoking rates. On the contrary, both smoking prevalence and frequency have been generally on the decline for all education groups. A more accurate interpretation of these positive estimates would be that among the *Less than Secondary* education group, smoking rates decreased at a slower rate for provinces that increased taxes compared to ones that did not increase taxes, potentially exacerbating the smoking gap.

This may be attributable to differing levels of smokers engaging in price-reducing strategies by education as seen in **Figure 4-7**. Estimates for the proportion purchasing discounted cigarettes were 33.5% (95% CI: 30.4%, 36.6%), 34.0% (95% CI: 32.1%, 35.9%), 31.5% (95% CI: 29.0%, 34.1%), and 24.8% (95% CI: 21.9%, 27.6%) for the *Less than Secondary, Completed Secondary*, *Completed College* and *Completed University* groups, respectively. Hence, purchasing of discounted cigarettes was inversely related to level of education. Moreover, a Wald test of joint significance on the set of these proportions between the *Completed University* group and the other three education groups yielded a χ^2 value of 30.0 (DF=3), and a p-value < 0.0001. Thus, if smokers with less education are more likely to purchase discounted cigarettes, and if an increase in cigarette taxes leads to an increase in the purchase of discounted cigarettes, then this could lead to a slower decline in smoking prevalence and frequency, and explain the positive estimates for these smoking outcomes for the *Less than Secondary* group.

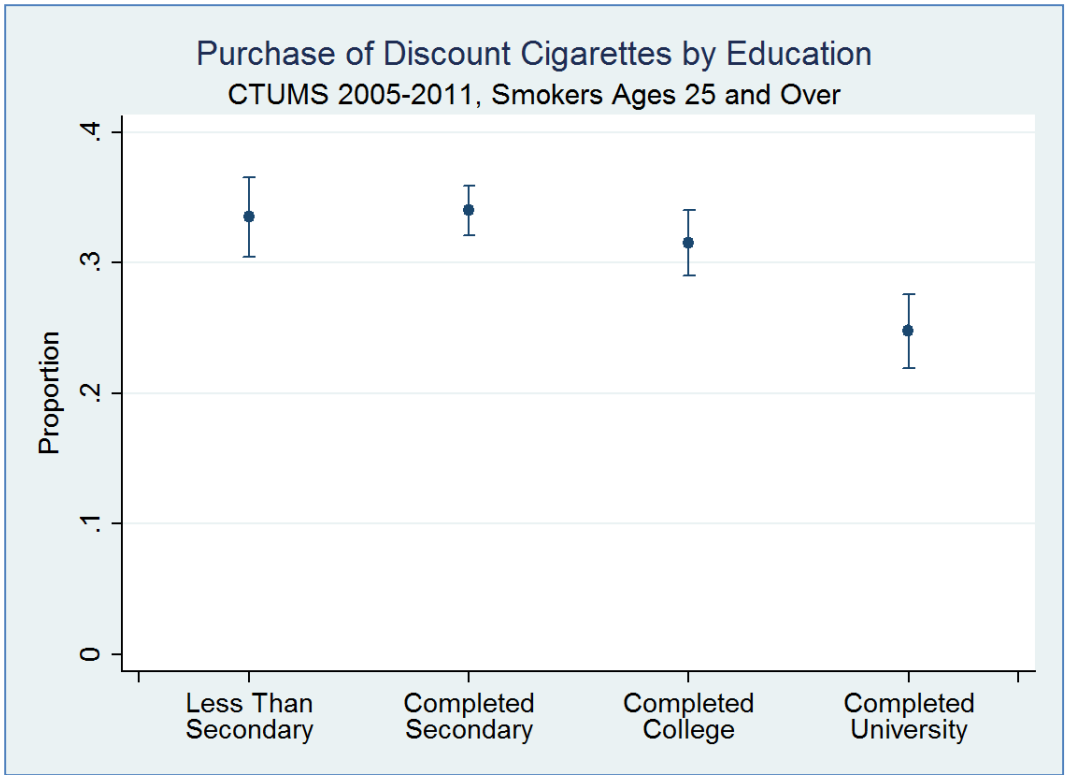

Figure 4-7. Marginal estimates for the proportion of smokers purchasing discount cigarettes by education.

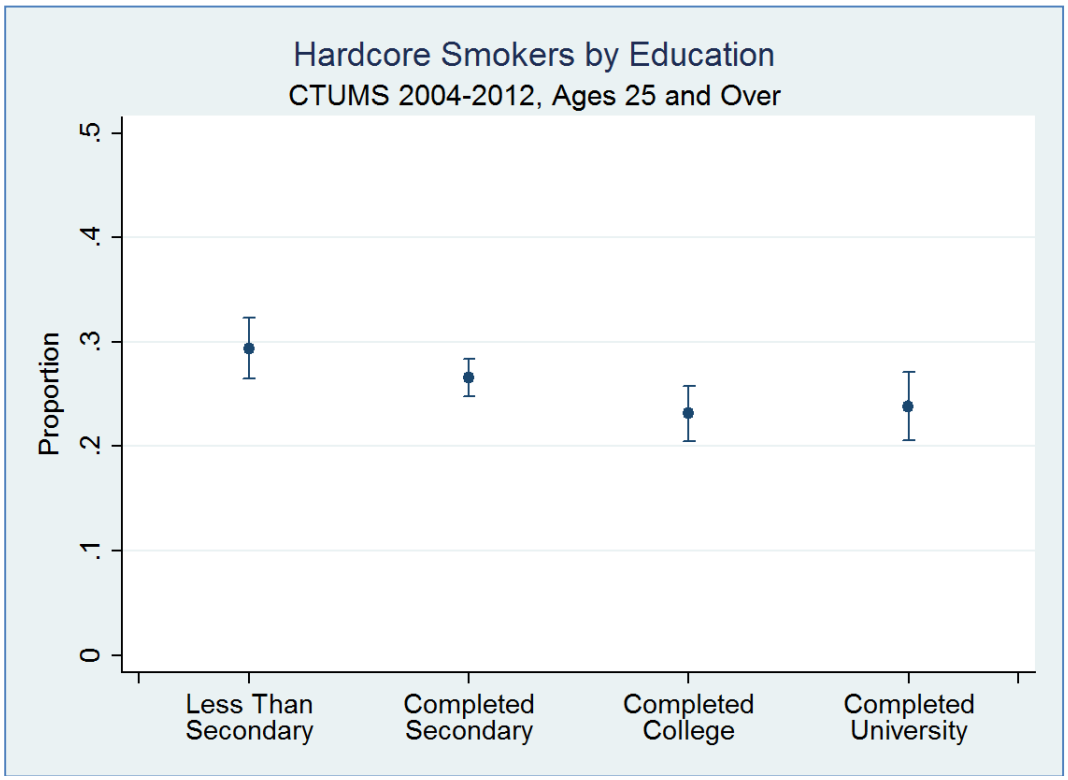

Figure 4-8. Marginal estimates for the proportion of "hardcore" smokers within past-week smokers by education

One plausible reason for the variation in engagement in price-reducing strategies is the occurrence of a "hardening" effect and the increasing prevalence of "hardcore" or persistent smokers. In other words, as smoking prevalence declined in Canada, more addicted smokers who are unable or unwilling to quit make up an increasingly larger proportion of smokers (Costa et al., 2010; Warner & Burns, 2003). Moreover, the presence of hardcore smokers can vary by education. Warner & Burns (2003) postulate that it may be more difficult for smokers of lower SEP to quit due to less personal support and fewer social resources to facilitate cessation.

Costa et al. (2010) summarized definitions of "hardcore" smokers from six papers and applied them to the Ontario Tobacco Survey data (2005–2008; N=4,130). We applied the components of a hardcore smoker where applicable to our CTUMS sample (of past-week smokers) in order to assess the presence of a hardening effect by education group. Our definition of a hardcore smoker was someone who did not have a prior quit attempt within the past year, had no intention to quit within the next 6 months, and was a long-term smoker.

Figure 4-8 shows the proportion of hardcore smokers within past-week smokers by education after adjusting for individual-level covariates (N=15,279). See **Appendix A-8** for greater detail on the procedure to derive these estimates and estimates for the individual components for the hardcore smoker definition. We can see that the proportion of hardcore smokers appears inversely associated with education. However, a Wald test of joint significance on the set of these proportions between the *Completed University* group and the other three education groups yielded a χ^2 value of 4.6 (DF=3), and a p-value of 0.2055. This would suggest that differences in these proportions were negligible among education groups. Moreover, it is important to reiterate that observed positive estimates for the effect of taxes on smoking for the *Less than Secondary* group were not statistically significant at the 95% level of confidence.

4.7 Conclusion

We find that recent increases in excise cigarette taxes appear to have contributed little to the decline in tobacco consumption. During the period of Federal Tobacco Control Strategy (2002-2012), we can see that both smoking prevalence and mean smoking frequency have been in steady decline even in provinces with stable cigarette taxation levels (or even slightly decreasing levels such as Quebec) implicating that other factors common to all provinces such as growing anti-smoking sentiment have had a greater influence over tobacco use among the adults in Canada. Moreover, there was weak evidence to support the potential of differential effects of recent changes cigarette taxes by education on smoking.

Thus, changes in cigarette taxes during the time of the Federal Tobacco Control Strategy neither helped to reduce nor widened the educational gap in smoking among adults in Canada. On the other hand, we do see evidence of increases in taxes leading to increases in the purchase of discounted cigarettes. If agencies such as Health Canada and the Public Health Agency of Canada are motivated to not only lower overall smoking levels, but to reduce the socioeconomic gap in smoking, then alternative strategies must be devised, particularly those that target socioeconomic groups where smoking rates still remain significantly high in Canada.

Chapter 5: Manuscript 3

The contribution of provincial smoke-free legislation on the decline in smoking and the impact on the smoking inequality among adults in Canada during the time of the Federal Tobacco Control Strategy (2002-2012)

Authors: Phongsack Manivong, Sam Harper, Erin Strumpf

Abstract

This study is an evaluation of the causal effect of provincial smoke-free legislation on smoking prevalence and frequency among adults in Canada, aged 25 and over, after the launch in 2001 of the Federal Tobacco Control Strategy (FTCS). The FTCS was an initiative primarily focusing on the enforcement of the Tobacco Act and promotion of smoke-free legislation.

Smoking has been in steady decline since the turn of the twenty-first century, but the pace of decline has slowed in recent years. Moreover, there is a persistent negative association between smoking and socioeconomic position, in particular by education. Thus, given the stagnation in the rate of decline in smoking and persistent social inequalities in smoking, a potential concern is that recent tobacco control strategies including smoke-free legislation may not be sufficient in reducing the inequality in smoking.

Based on the Canadian Tobacco Usage Monitoring Survey 2002-2012 database and regression models with province and year fixed effects, and individual-level and provincial-level covariates, provincial smoke-free legislation (PSFL) had little impact on smoking behaviour among adults. The marginal average effect for smoking prevalence was 0.1 (95% CI: -1.3, 1.4) percentage points. The marginal average effect for smoking frequency was -0.6 (95% CI: -2.2, 1.0) cigarettes. Moreover, we derived null results when assessing the impact of PSFL by education for both smoking outcomes.

Although smoke-free legislation has the potential to reduce tobacco consumption, its effectiveness is sensitive to the current anti-tobacco control environment. During the time of the FTCS, there was a much higher level of tobacco control compared to the time prior to its launch and higher compared to other countries. Furthermore, smoke-free legislation had to work in conjunction with other forms of tobacco control such as the Tobacco Act, and graphic warning labels on cigarette packages.

From 2002-2012, both smoking prevalence and mean smoking frequency have been in steady decline in Canada. These declines, however, are present even for provinces which implemented smoke-free legislation at a later time suggesting that other factors common to all provinces have had a greater influence over tobacco use. Moreover, there was weak evidence to support the potential of differential effects of recent changes cigarette taxes by education on smoking. Thus, the implementation of provincial smoke-free legislation neither helped to reduce nor widened the educational gap in smoking among adults in Canada. If agencies such as Health Canada and the Public Health Agency of Canada are motivated to not only lower overall smoking levels, but to reduce the socioeconomic gap in smoking, then alternative strategies must be devised, particularly those that target the least educated where smoking rates still remain significantly high in Canada.

Keywords: quasi-experimental, difference-in-differences, health policy evaluation, differential effects, heterogeneous effects, effect-measure modification, tobacco control strategy, tobacco control policy, smoke-free legislation, smoking, cessation, reduction, Canada, adults

5.1 Introduction

Various forms of policies and strategies aimed at reducing tobacco consumption have been implemented in Canada since the 1980s (Reid & Hammond, 2013). For example, the Federal Tobacco Control Strategy (FTCS) was a planned 10-year initiative implemented in 2001 to reduce tobacco consumption in Canada (Health Canada & Public Health Agency Of Canada, 2012). The initiative was launched by a consortium led by Health Canada (HC), in partnership with Public Health Agency of Canada (PHAC) and other agencies such as the Royal Canadian Mounted Police (RCMP), and Canada Border Services Agency (CBSA). Primary objectives included the reduction of the prevalence of smokers and quantity of cigarette purchase, and the reduction of exposure to second-hand smoke. Two key components of the FTCS were the enforcement of the Tobacco Act and the promotion of smoke-free laws. The Tobacco Act is a set of Canadian laws passed in 1997 that include restrictions on the manufacture and sale, access, and promotion (advertisement) of tobacco products (Minister of Justice, 1997).

In a self-evaluation of FTCS goals, Health Canada and PHAC identified a number of individual and environmental factors that predict smoking prevalence and frequency (Health Canada & Public Health Agency Of Canada, 2012). The most important predictors were education attainment, tobacco taxes, bans on retail display and legal smoking age. Their conclusions, however, were based on econometric models that did not include the effects of province or time, and thus, did not account for the variation in smoking rates across the provinces of Canada and the general declining smoking trend common among provinces. These types of models provide only associational measures of effect, and do not allow for a causal interpretation. Therefore, questions remain about the extent to which policy reforms like the FTCS are responsible for declines in smoking rates among adults.

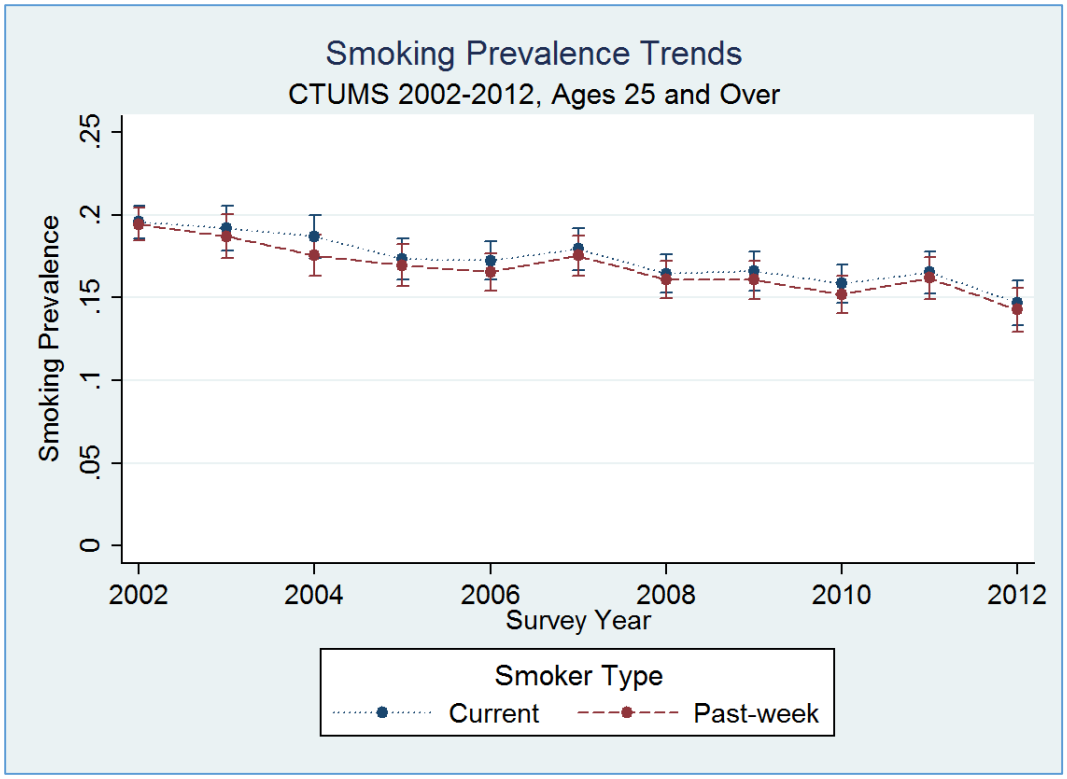

Figure 5-1. Marginal effect estimates and 95% CIs derived from logistic models with year fixed effects.

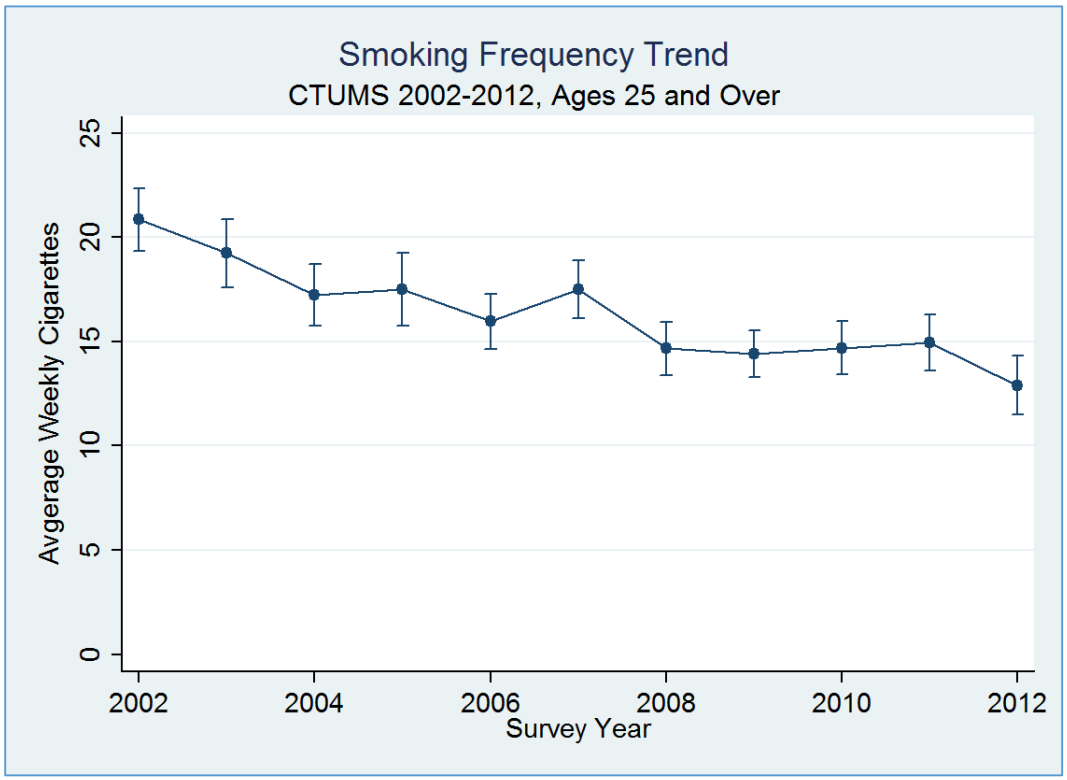

Figure 5-2. Marginal effect estimates and 95% CIs derived from a logistic-Poisson two-part model with year fixed effects.

Figure 5-1 and **Figure 5-2** show self-reported smoking prevalence (current and past-week) and smoking frequency trends for adults aged 25 and over, based on the Canadian Tobacco Use Monitoring Survey (CTUMS) 2002-2012 database. (See **Appendix Table 1** for sample sizes of each year, and **Appendix Table 5** for estimates.) Smoking prevalence decreased by 4.9 (95% CI: 3.3, 6.5) and 5.2 (95% CI: 3.6, 6.7) percentage points for current smoker and past-week smoker, respectively. Mean smoking frequency decreased by 8.0 (95% CI: 6.0, 9.9) cigarettes. Although, both smoking prevalence and frequency have declined after the launch of the FTCS, it is unclear how the elements of the FTCS or taxes or any other policy reform have contributed to these declines in smoking among adults in Canada.

The principle objective of smoking bans is to protect non-smokers from exposure to environmental tobacco smoke (ETS), also known as passive or second-hand smoking (SHS). Smoking restrictions, however, make tobacco consumption less socially desirable while limiting opportunities to smoke. Thus, it is conceivable that smoking bans can also potentially reduce smoking prevalence and consumption among smokers (International Agency for Research on Cancer, 2009). On the other hand, an unintended consequence of smoking bans at work and public places, may be displaced and compensatory smoking, namely increased smoking before and after work or at home (Bell et al., 2009).

A recent evaluation of public place smoking laws in Canada from 2000-2008, found that these laws did not have a significant impact on smoking prevalence or frequency (Carpenter, et al., 2011). This study focused primarily on the effects of smoke-free legislation on environment tobacco exposure, and only assessed the average effect on individual smoking behaviour. Assessing only average effects, however, can obscure potential differential impacts by socioeconomic position (SEP) such as income or education.

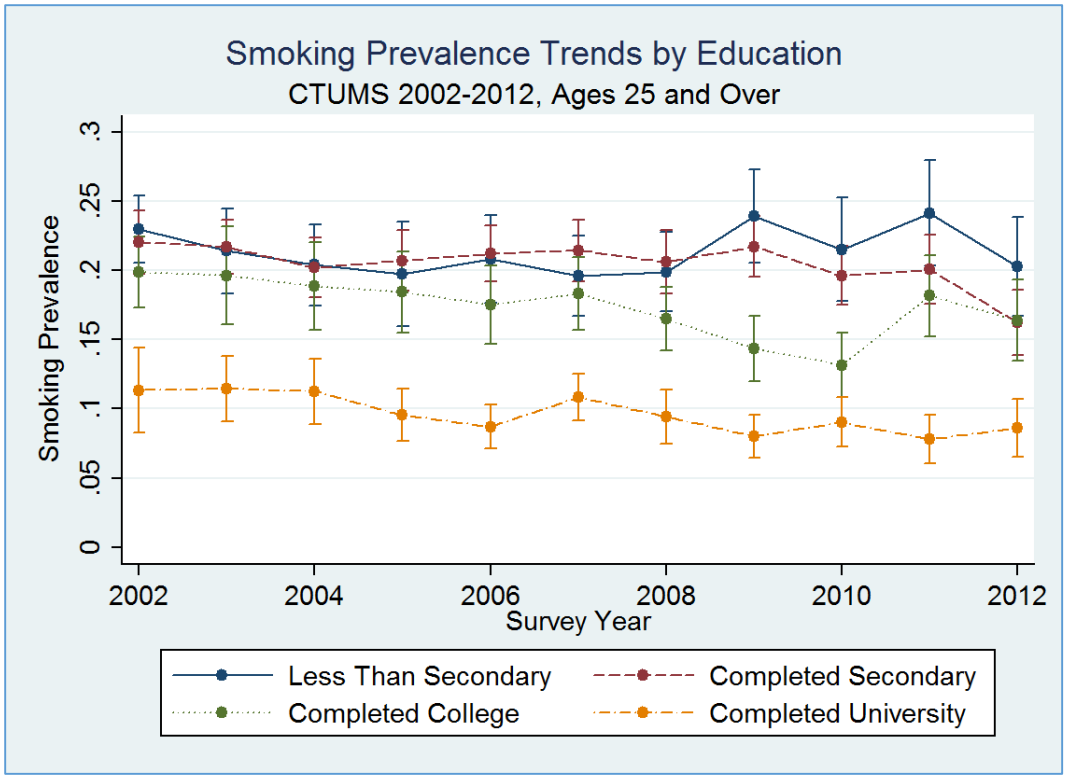

Figure 5-3. Marginal effect estimates and 95% CIs of smoking prevalence by education from a logistic model with year, education, and their cross-product terms as covariates.

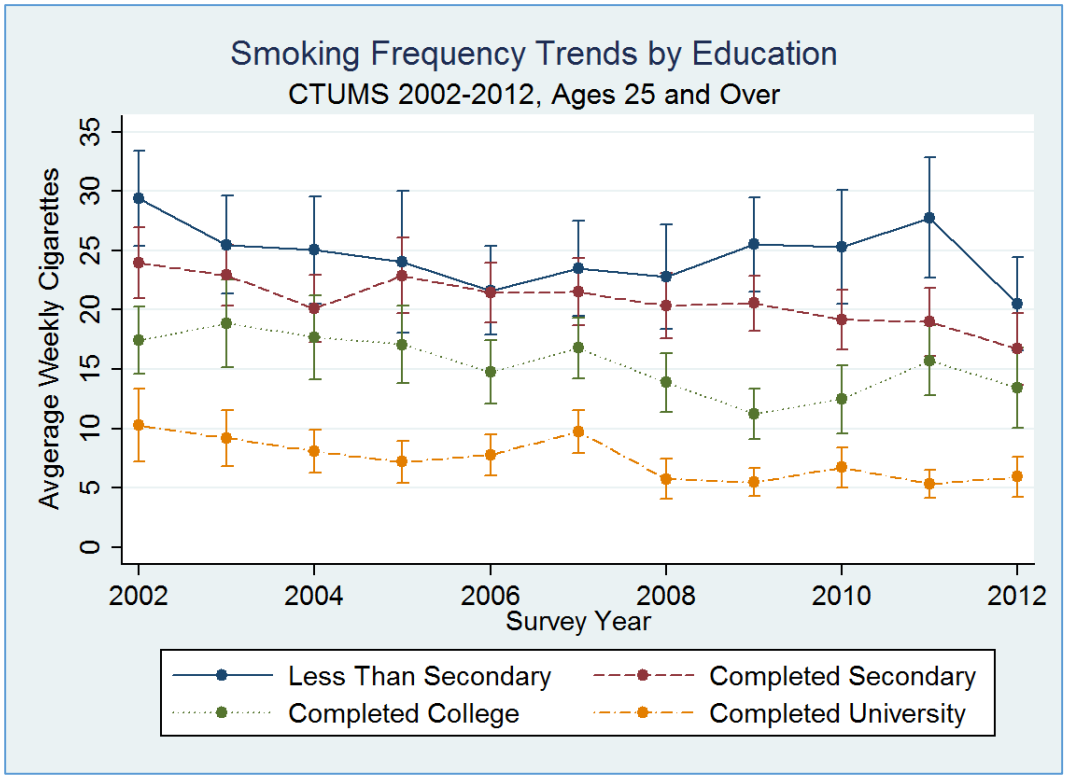

Figure 5-4. Marginal effect estimates and 95% CIs of smoking frequency based on a logistic-Poisson two-part model with year, education, and their cross-product terms as covariates.

Figure 5-3 and **Figure 5-4** show self-reported past-week smoking prevalence and frequency trends by education for those aged 25 and over based on 2002-2012 CTUMS data. Rates of both smoking outcomes have generally decreased for all groups during the time of the FTCS. Rates, however, have increased slightly in later years for the least educated group. Thus, although overall tobacco consumption has decreased, observed inequalities in smoking between groups of low and high education have remained since the start of the FTCS.

Table 5-1 and **Table 5-2** show changes in (past-week) smoking prevalence and frequency from 2002 and 2012 by education, respectively, for those aged 25 and over. (See **Appendix Table 6** and **Appendix Table 7** for yearly estimates of smoking prevalence and frequency by education, respectively.) Changes (decreases) in smoking prevalence were -2.7 (95% CI: -6.9, 1.5), -5.8 (95% CI: -9.0, -2.6), -3.5 (95% CI: -7.4, 0.4) and -2.7 (95% CI: -6.5, 1.0) percentage points for the *Less than Secondary*, *Completed Secondary*, *Completed College*, and *Completed University* groups, respectively. Because decreases in smoking prevalence varied by education, the smoking gap (or absolute difference) with respect to the *Completed University* group remained virtually the same for the *Less than Secondary* group, but decreased for the *Completed Secondary* and *Completed College* groups. For mean smoking frequency, changes (decreases) were -8.9 (95% CI: -14.6, -3.2), -7.3 (95% CI: -11.5, -3.1), -4.0 (95% CI: -8.1, 0.1), and -4.3 (95% CI: -7.9, -0.8) for the least to most educated groups, respectively. The smoking gap decreased for the *Less than Secondary* and *Completed Secondary* groups, but increased slightly for the *Completed College* group compared to the *Completed University* group. (Although not reported, the smoking prevalence ratio and mean smoking frequency ratio also increased for all education groups.)

Table 5-1. Changes in Smoking Prevalence and the Educational Gap in Canada, Ages 25 and Over

Education Group	2002-2012 Change			2002 Smoking Gap			2012 Smoking Gap		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Less than Secondary	-2.7%	-6.9%	1.5%	11.6%	7.3%	15.9%	11.7%	7.5%	15.8%
Completed Secondary	-5.8%	-9.0%	-2.6%	10.7%	6.2%	15.2%	7.6%	4.5%	10.7%
Completed College	-3.5%	-7.4%	0.4%	8.5%	4.3%	12.8%	7.8%	4.4%	11.1%
Completed University	-2.7%	-6.5%	1.0%	*Reference*			*Reference*		

Table 5-2. Changes in Smoking Frequency and the Educational Gap in Canada, Ages 25 and Over

Education Group	2002-2012 Change			2002 Smoking Gap			2012 Smoking Gap		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Less than Secondary	-8.9	-14.6	-3.2	19.2	13.3	25.0	14.6	10.3	18.9
Completed Secondary	-7.3	-11.5	-3.1	13.7	8.6	18.8	10.8	7.5	14.1
Completed College	-4.0	-8.1	0.1	7.2	2.6	11.8	7.5	3.7	11.3
Completed University	-4.3	-7.9	-0.8	*Reference*			*Reference*		

It is important to note, however, that we cannot infer that these changes are a result of excise tobacco taxes or any other form of tobacco control. Hence, given differential decreases in smoking during the time of the FTCS, another important objective would be an evaluation of the impact of smoke-free legislation on the socioeconomic inequality in smoking (Main et al., 2008). Though much research has been done on the effects of smoke-free legislation on smoking among adults, previous studies can only partially answer our research questions of interest.

If agencies such as Health Canada and the Public Health Agency of Canada are motivated to not only reduce both smoking rates and reduce inequalities in smoking, then this might suggest that tobacco control strategies need to focus on those with lower education or lower socioeconomic position (SEP), or more generally, on social groups with higher smoking rates (Harper et al., 2010). Strategies with a greater effect on lower SEP groups will help reduce the inequality, while ones with a weaker effect on lower SEP groups will exacerbate the inequality (Lorenc et al., 2012). Furthermore, although there is on-going surveillance of smoking patterns by subgroups such as province, age and gender by Health Canada, even fewer studies have evaluated heterogeneous effects of smoke-free legislation on individual smoking behaviour by SEP (Thomas et al., 2008).

Thus, the objective of our paper is twofold. The first is to estimate the average effect of comprehensive provincial workplace and public place smoke-free legislation on adult smoking behaviour during the time of the Federal Tobacco Control Strategy in Canada. Specifically, we want to know how much smoke-free legislation has contributed to the decline in the prevalence of smoking and reduction of smoking quantity in the adult population of Canada. The second is then to explore potential differential effects or effect-measure modification by education and more importantly, how these differential effects have impacted the socioeconomic gap in smoking. Additionally, because a key interest in our study is the heterogeneous effects by education, we focused on the adult population aged 25 and over.

5.2 Background

Given that the principal objective of smoke-free legislation is to protect non-smokers from ETS, many studies have assessed the relationship between legislation and ETS or health-related issues associated with ETS. A review of smoke-free legislation proposes that bans reduce the risk of exposure to ETS by improving indoor air quality (Hahn, 2010). Additionally, two systematic reviews concluded that smoke-free legislations significantly reduce the risk of acute myocardial infarction (AMI) (Lin et al., 2013; Meyers et al., 2009).

Regarding the effect of smoking restriction on smoking behaviour, several systematic reviews have evaluated the effect of smoking bans on either smoking prevalence, smoking frequency, or cessation (Bell et al., 2009; Brownson et al., 2002; Chapman et al., 1999; Fichtenberg & Glantz, 2002; Hahn, 2010; Levy & Friend, 2003; Thomas et al., 2008; Wilson et al., 2012). Generally, two types of studies are included in these systematic reviews, ones on specific workplaces and communities, and others on broader smoking restriction legislation.

Overall, studies based on specific worksites showed either decreases in smoking prevalence or increases in cessation due to smoking bans. For example, the Fichtenberg & Glantz (2002) review reported that workplace bans contributed to a reduction in smoking prevalence of 3.8 (95% CI: 2.8, 4.7) percentage points, and a decrease in daily consumption of 3.1 (95% CI: 2.4, 3.8) cigarettes among continuing smokers. There were mixed results in studies evaluating broader smoking restrictions, however. In the Wilson et al. (2012) systematic review, twenty-nine studies evaluated the effects of smoking bans in public places. The review reported that the included longitudinal studies provided little evidence of smoke-free legislation facilitating smoking cessation. On the other hand, studies focusing on smoking prevalence showed moderate evidence of an effect with relative reductions in ranging from -31.9% to -7.4%.

There are several limitations in inferring the effect of smoke-free legislation on individual smoking behaviour from studies in the aforementioned systematic reviews to a Canadian setting during the time of FTCS, however. One limitation is the use of different study populations, in particular different country settings and older time periods. In the Wilson et al. (2012) systematic review, the authors proposed that the size of the impact of smoke-free legislation on smoking is inversely related to the level of prior tobacco legislation environment and anti-smoking sentiment. In Canada, other forms of tobacco control include excise tobacco taxes, anti-smoking media and education campaigns, graphic warning labels (GWLs), and the Tobacco Act.

To provide some context, in the 1980s and 1990s, the average price of cigarettes (in year 1999 dollars) was US $1.86 and US $2.33 per pack in the United States and Canada, respectively (Gruber et al., 2003). In 2001, Canada became the first country to require that GWLs cover at least 50% of both front and back of cigarette packages (Canadian Cancer Society, 2012). Conversely, in the United States, advocates for the tobacco industry claim that GWLs are violations of their constitutional rights and have thus far prevented the implementation of GWLs. A recent study evaluated the use of GWLs in Canada with the United States as a control group (Huang et al., 2014). With a series of difference-in-differences models using 9 years of data before and 9 years of data after the implementation of GWLs, the authors showed that GWLs reduced smoking prevalence by 2.8–4.7 percentage points.

In a 2011 study not captured in any of the above systematic reviews, the authors looked at the effect of smoke-free laws on smoking prevalence of 21 jurisdictions which included four Canadian provinces (New Brunswick, Nova Scotia, Ontario and Quebec) (Bajoga et al., 2011). Their analysis was based on segmented regression models (also known as interrupted time series) using the Canadian Tobacco Use Monitor Survey (CTUMS). The authors did not find a

statistically significant change in trends before and after the introduction of smoke-free legislation in any of these provinces. The authors noted that detecting changes in trends may be difficult for jurisdictions with already strong declining smoking trends prior to an implementation of smoke-free legislation.

Another Canadian study included in the Wilson et al. (2012) systematic review evaluated the effect of the smoking ban in Saskatoon (Lemstra et al., 2004). The main outcomes of interest in that study were the incidence of AMI and smoking prevalence. For smoking prevalence, the authors compared changes in smoking behaviour for Saskatoon (which had implemented a public smoking ban in July 1, 2004) to that of Saskatchewan and Canada using the Canadian Community Health Survey between years 2003 and 2005. During this time, Saskatoon experienced the greatest decrease in smoking prevalence from 24.1% (95% CI: 20.4%, 27.7%) in 2003 to 18.2% (95% CI: 15.7%, 20.9%) in 2005. Although some studies may evaluate more comprehensive smoke-free legislation, another limitation is the lack of applicability or generalizability to the Canadian population.

A second limitation is that many studies lacked a control group, particularly the worksite-specific studies. Without a comparison group, the effect of the smoking ban is confounded with common temporal trends. One Canadian study evaluated the impact of smoking bans of three public workplace buildings (in 1989 and 1990) with no control group, and reported a reduction in ETS, but no change in smoking prevalence (Broder et al., 1993).

The Hopkins et al. (2010) systematic review cited other possible limitations prevalent in their review, though, also prevalent in other systematic reviews. One limitation was the use of a single cross-sectional survey, and thus, providing only associational measures of effect. Two Canadian studies did not meet the quality of execution assessment primarily due to their cross-

sectional design (Stephens et al., 1997; Stephens et al., 2001). One Canadian study included in the Hahn (2010) review compared the odds of being a former smoker (among current and former smokers) of Ontario municipalities with and without smoking bans using the 2001 (Cycle 1.1) Canadian Community Health Survey (Viehbeck & McDonald, 2010).

Two studies were based on the Community Intervention Trial for Smoking Cessation (COMMIT) funded by the National Cancer Institute (Bauer et al., 2005; Glasgow et al., 1997). The COMMIT cohort consisted of smokers from twenty-two North American communities including two Canadian ones and compared changes in smoking behaviour among smokers who were employed at worksites with and without smoking bans. Worksite-specific studies, however, may exaggerate the effect of a smoking ban. One potential reason is differential reporting of smoking where those who are smokers may be less likely to report their true smoking habits if they are employees at worksite with a smoking ban due to social desirability. Another potential reason is selection bias where "those who quit or take a job in a given workplace might self-select" (IARC, 2009). In other words, estimates reflect the displacement of smokers instead of reductions in smoking prevalence.

Another limitation is the lack of evaluations for differential effects by some measure of socioeconomic position (Bell et al., 2009; Hahn, 2010). As previously noted, assessing only average effects can obscure potential different effects. In the Thomas et al. (2008) systematic review on tobacco control policies and their effects on social inequalities in smoking, only five evaluated the effect of smoking restrictions by income or education (Becker et al., 1989; Donchin & Baras, 2004; Heloma & Jaakkola, 2003; Stillman et al., 1990; Tang et al., 2003) The reviewers found insufficient evidence of heterogeneous effects. No study has explored differential effects of smoke-free legislation in Canada.

One Canadian study not captured in previously mentioned reviews evaluated the actual impact of municipal public place smoking laws using two different surveys, the Canadian Tobacco Use Monitoring Survey (CTUMS) and Canadian Community Health Survey (CCHS) in order to incorporate other jurisdictions within Canada (Carpenter et al., 2011). The authors report smoke-free legislation having no effect on either smoking prevalence or frequency (log-quantity). The study, however, only looked at average effects. Moreover, the primary interest of their study was to evaluate the impact of public place smoke-free bylaws on environmental tobacco exposure for various conditions and venues. The objective of our study, on the other hand, is to evaluate the impact of comprehensive workplace and public place smoking restrictions on individual smoking behaviour, and to evaluate potential heterogeneous effects by education.

Thus, previous studies on smoke-free restriction can only partially address our research objective. Our study will provide three main contributions to the literature on smoke-free legislation. The first is a methodologically rigorous evaluation that includes a proper comparison group that is followed up over time. The second is an assessment of comprehensive workplace and public place smoke-free legislation in a Canadian setting. The final is the evaluation of potential heterogeneous effects of smoke-free legislation, particularly on the education inequality in smoking.

5.3 Data and Measures

Individual-level Covariates

Our analyses required linking data from different sources together. The Canadian Tobacco Use Monitoring Survey (CTUMS) provided data on smoking-related outcomes and other individual-level demographic variables. CTUMS also contained the year and month of the interview, which allowed for the precise assignment of provincial smoke-free laws and the identification of other forms of tobacco control in effect.

CTUMS was launched in 1999 in order to continuously monitor smoking trends, particularly among the most at-risk group, namely those aged 15-24 (Statistics Canada, 1999). It is a population-weighted, multi-stage, cross-sectional survey conducted semi-annually by telephone using random digit dialling collecting data at the household and individual level. Multiple individuals may be selected from the same household. The target population of CTUMS are residents of Canada aged 15 and older, excluding residents of the Yukon, Northwest Territories and Nunavut, and full-time residents of institutions.

CTUMS data for years from 2002-2012 were used in the primary set of analyses to correspond approximately to the timing of the FTCS. Each survey contained approximately 20,000 individuals, with over-sampling of youths (about 46% for those aged 15-24 compared to 16% in the population). Because a key interest of our paper was to explore the potential impact of cigarette taxes by education, the accurate measurement of highest level of education attainment was of utmost importance. Based on CTUMS data where current student status was available for those aged 25 and over (survey years 2002 and 2003), only 2.3% (95% CI: 2.2%, 2.4%) were students. Thus, we included only those aged 25 and over. After the age exclusion, the sample size was 122,943. (For information on sample size, see **Appendix Table 1**.)

Individual-level covariates of interest included education, age (years), sex, marital status, language (spoken at home), and household size. Age contained the following groups: *25-34* (reference), *35-44*, *45-54*, *55-64* and *65 & Over.* The variable for sex consisted of two options: *male* and *female* (reference). Marital status contained three options: *Common-law/Married* (reference), *Widow/Divorced/Separated*, and *Single*. Language was a categorical variable with the following options: *English* (reference), *French*, *English & French*, and *Other*. Household size was a categorical variable with *1* (reference), *2*, *3*, *4* and *5 or more* as options.

Our measure for SEP was highest level of education attainment which consisted of four categories: *Less than Secondary, Completed Secondary, Completed College,* and *Completed University* (reference). Data on income were only available in earlier years, and hence, we could not use income as measure of SEP. Though income data is not available, it is unlikely to be a confounder as personal income is generally a consequence of education (Card, 1999). Moreover, we are not estimating the effect of education on smoking; we are looking at whether the causal effect of taxes varies by education.

Outcome Variables

The Canadian Tobacco Use Monitoring Survey provided data on adult smoking behaviour. We considered two smoking-related outcomes: smoker status and smoking frequency. We defined both smoking outcomes based on the cigarette quantity smoked variable. Survey participants were asked if they smoked within the past 30 days, and if so, how many cigarettes they smoked within the previous 7-day period. (The term "past-week" will be used going forward.) Past-week cigarette quantity was set to 0 if the participant did not report smoking within the past 30 days.

Table 5-3. Comparison of Smoker Status Outcomes

Smoker Status		Current Smoker		
		No	**Yes**	**Total**
Past-week Smoker	**No**	99,112	717	99,829
	Yes	239	21,197	21,436
	Missing	16	1,662	1,678
	Total	99,367	23,576	122,943

We set past-week smoker status to 1 if the number of cigarettes reported was 1 or greater, and 0 if the participant did not smoke within the past week. We used self-identified current smoker status as a sensitivity analysis for past-week smoker status. **Table 5-3 s**hows the agreement between the two smoking prevalence outcomes. The majority of their differences is attributable to missing data using the past-week definition (N=1,678). Among those with non-missing data, there was approximately 99% agreement. Within the disagreements of non-missing data (N=956), approximately 75% (N=717) consisted of self-described current smokers (consisting of daily and occasional smokers) who did not smoke within the past week, and the other 25% (N=239) consisted of self-identified non-current smokers who did smoke within the past week which presumably consists of experimenters or those in the process of quitting.

Using the number of cigarettes smoked in the past-week definition consistently produced prevalence estimates that were slightly lower than those using the self-identified current smoker definition. Recall **Figure 5-1** showing past-week smoker and current smoker trends from 2002-2012. See **Appendix Table 5** for corresponding yearly estimates of past-week smoker and current smoker prevalence. The maximum difference in prevalence between these two smoking prevalence outcomes was 1.1% in 2004. See **Appendix Table 6** for yearly estimates of smoking prevalence by education**.** See **Appendix Table 8** for past-week smoking prevalence estimates by year and province.

Among smokers, the maximum reported value for smoking frequency was 630 cigarettes within the past week which is equal to 31.5 packs of 20 cigarettes. The value of the 95 percentile was 189 cigarettes which is almost 9.5 packs. The mean, however, was 97.3 (95% CI: 95.7, 98.9) cigarettes which is almost 5 packs. See **Figure 5-5** for a histogram of past-week cigarette consumption (among smokers). See **Appendix Table 5** for yearly estimates of past-week smoking frequency. See **Appendix Table 7** for yearly estimates of smoking frequency by education**.** See **Appendix Table 9** for past-week smoking frequency estimates by year and province. See **Appendix Figure 5** and **Appendix Figure 6** for histograms of past-week cigarette consumption by year and by province, respectively.

Unfortunately, for our studies on the adult population, we cannot model smoking cessation specifically as an outcome. CTUMS does probe self-reported former smokers about the timing of their quitting smoking. The available options, however, do not allow us to determine the appropriate excise cigarette tax levels at the time of a participant's smoking cessation. More importantly, we hypothesize that changes in smoking prevalence among adults are primarily driven by cessation. Based on participants aged 15 and over who reported to have ever tried smoking in the 1999-2012 CTUMS database (N=163,193), about 96.1% reported to have had their first cigarette by age 25. Additionally, between years 2004-2012 (when data on daily smokers are available), about 91.8% of daily smokers reported to being one by age 25 (N=63,353).

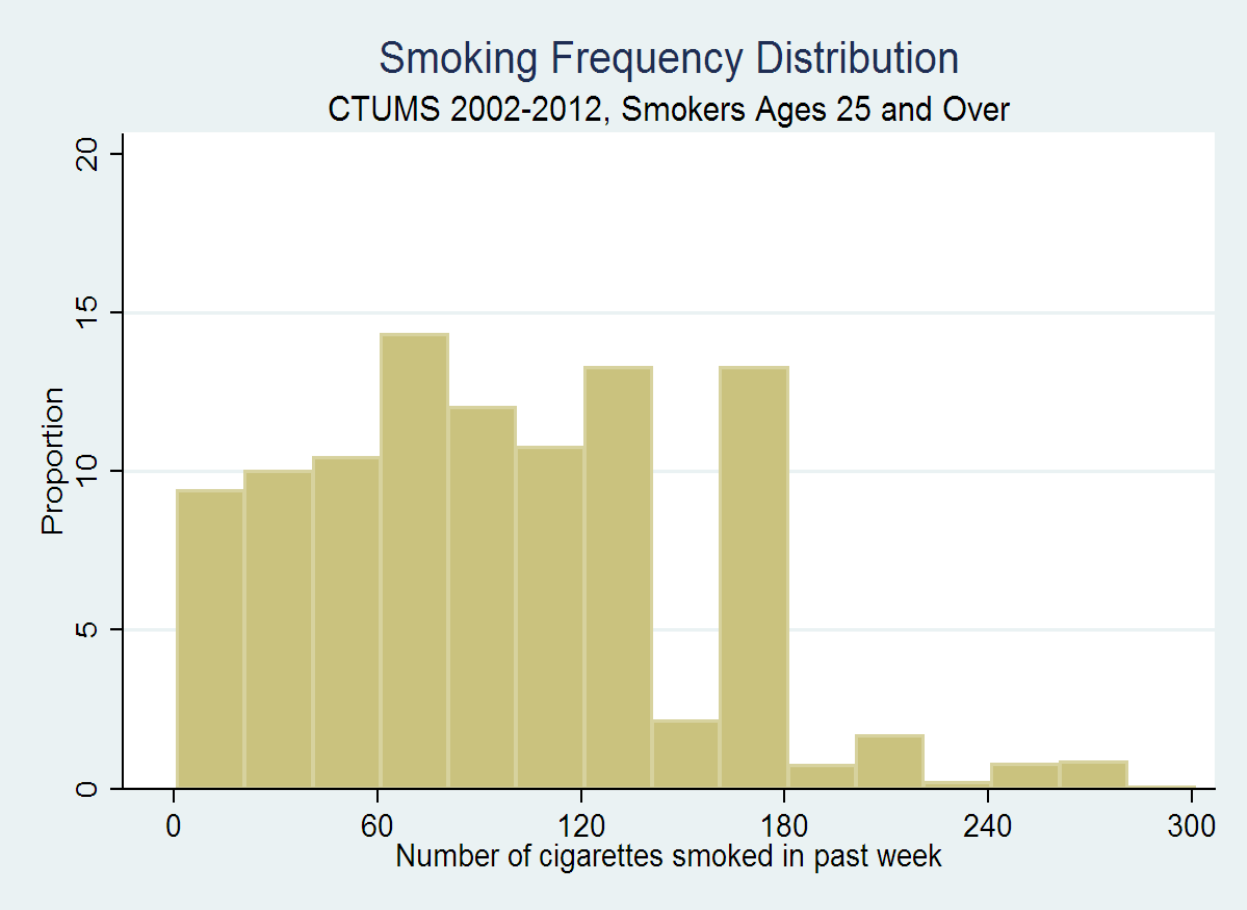

Figure 5-5. Histogram of past-week cigarette quantity. Each bar represents a pack of 20 cigarettes.

Smoke-free Legislation

Our policy (treatment) variable was provincial smoke-free laws, specifically ones relating to comprehensive workplace and public place smoking restriction. We initially considered exploiting the variation of smoke-free bylaws for municipalities with a population of 150,000 or greater as of 2001 using data from the Canadian Community Health Survey (Statistics Canada, 2002). Municipal smoke-free bylaws, however, were all predicated by provincial smoke-free laws except for Ottawa which had implemented a workplace bylaw in 2001, 5 years prior to Ontario implementing both public and workplace smoke-free legislation (Non-Smokers's Rights Association, 2012a). Because we are interested in assessing the effects of smoke-free laws after the launch of the FTCS (2002-2012) and the smoke-free law in Ottawa was implemented prior to our time period of interest, our evaluation was exclusively on provincial smoke-free laws. The main source of provincial smoke-free laws was the report, *Provincial and Territorial Smoke-Free Legislation Summary* (Non-Smokers's Rights Association, 2012b). We created a binary variable to indicate a law in effect based on the date of first implementation.

Table 5-4 and **Figure 5-6** contain the proportion of the sample living in a province with a PSFL in effect at time of survey. See **Appendix Table 13** and **Appendix Table 14** for a list of effective dates on municipal and provincial workplace and public place smoke-free legislation, respectively.

Table 5-4. Proportion of Participants with a Provincial Smoke-free Law in Effect at time of Survey

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	0	0	0	45.8	100	100	100	100	100	100	100
Prince Edward Island	0	0	0	0	0	0	0	27.1	100	100	100
Nova Scotia	0	0	0	0	0	100	100	100	100	100	100
New Brunswick	0	0	17.9	100	100	100	100	100	100	100	100
Quebec	0	0	0	0	63.9	100	100	100	100	100	100
Ontario	0	0	0	0	63.9	100	100	100	100	100	100
Manitoba	0	0	18.4	100	100	100	100	100	100	100	100
Saskatchewan	100	100	100	100	100	100	100	100	100	100	100
Alberta	0	0	0	0	0	0	100	100	100	100	100
British Columbia	0	0	0	0	0	0	82.0	100	100	100	100

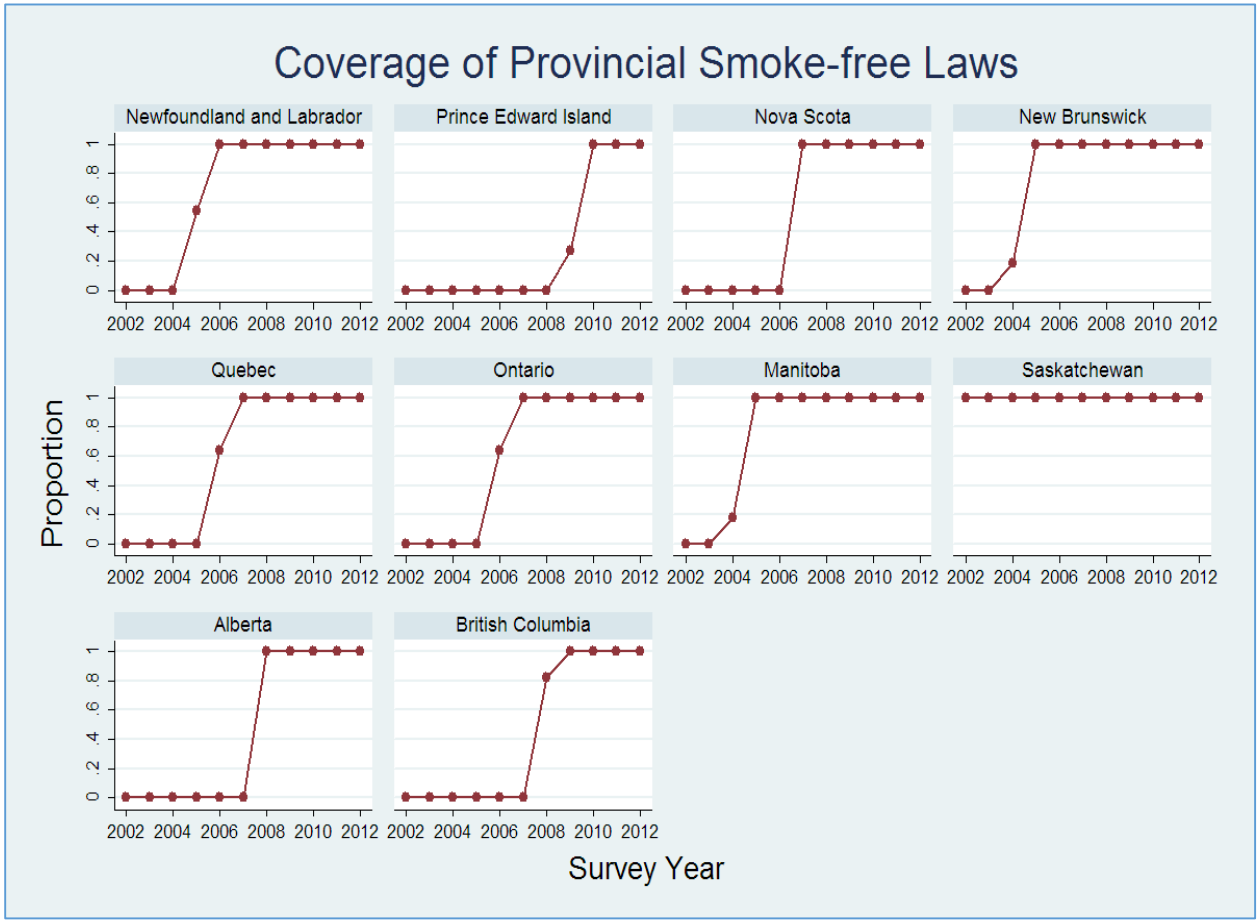

Figure 5-6. Trajectory of proportion of participants with a smoke-free law in effect at time of interview, based on the report Provincial and Territorial Smoke-Free Legislation Summary and CTUMS 2002-2012, ages 25 and over.

Other Provincial Data

We considered four potential provincial-level confounders in our study. These are factors that affect smoking and whose implementation or changes may have coincided with the implementation of provincial smoke-free laws during the time of the FTCS. Two of which were other tobacco control strategies, namely excise cigarette taxes and retail tobacco display ban.

Excise tobacco taxes were another form of tobacco control that varied by province where changes may have coincided with the implementation of smoke-free legislation. The main source of data on excise cigarette tax levels and their corresponding effective dates were extracted from the Finances of The Nation 2002-2012 reports provided by the Canadian Tax Foundation (Treff & Ort, 2008-2012; Treff & Perry, 2002-2007).[3] The report *Tobacco Use in Canada: Patterns and Trends,* provided by the Propel Centre for Population Health Impact (an affiliate of the University of Waterloo) was used to assess agreement of data on cigarette taxes (Reid & Hammond, 2013). It provided data on excise cigarette tax *increases* and corresponding effective dates starting in December 2003. There was no observed discrepancy between the two sources. For both sources, cigarette taxes were reported for a carton of 200 cigarettes, but we calculated amounts for a typical package of 20 cigarettes (DeCicca et al., 2008; DeCicca & McLeod, 2008).

To adjust for inflation (or in other words, to express changes to cigarette taxes relative to price changes for all goods), nominal tax changes were standardized to year 2000 dollars by the Canadian Consumer Price Index (CPI) of general goods (Chaloupka, 2013). Data on the CPI of general goods were extracted from Canadian Socioeconomic Information Management system (CANSIM), Statistic Canada's online database (Statistics Canada, 2012). See **Appendix Table**

[3] A correction was made based on inconsistencies in the Finances of the Nation reports. In the 2003 report, the total of the federal and provincial cigarette taxes for Nova Scotia do not sum correctly. Based on data in the 2004 report, we assumed an addition error in the 2003 report. The authors, however, accept responsibility for any error in this paper.

10 for changes in excise cigarette taxes, and **Appendix Table 11** for CPI values.

Data on tobacco retail display bans were extracted from a Canadian Centre for Health Economics working paper (Irvine & Nguyen, 2014). For retail tobacco display bans, we created a binary variable to indicate a ban in effect in each province at time of interview. See **Appendix Table 15** for the timing of provincial retail tobacco display ban.

To account for the potential effect of unemployment, we included rates based on those aged 25 and over (Azagba & Sharaf, 2011; DeCicca & McLeod, 2008). Data on the Labour Force Survey estimates of unemployment rates were extracted from CANSIM (Statistics Canada, 2014). Additionally, retail sales tax rates (at time of interview) were another potential provincial-level confounder. Retail sales tax rates data were again provided by the Canadian Tax Foundation, as well as the Canada Revenue Agency (CRA, 2013). Depending on the province and year, we either summed the provincial sales tax (PST) rate and goods & services tax (GST) rate, or the harmonized sales tax (HST) rate (Canada Revenue Agency, n.d.; Canadian Tax Foundation, n.d.). See **Appendix Table 16** for means of annual retail sales tax rates and **Appendix Table 18** for annual unemployment rates.

5.4 Methods and Analyses

Statistical Models

Linking data on provincial smoke-free laws (PSFLs) to repeated cross-sections of CTUMS permitted the use of the difference-in-differences (DD) analytical framework in our study. It is a common analytical tool in policy analysis, epidemiology, and economics with the use of a quasi-experimental design. Because all provinces implemented smoke-free laws during our study period, their timing was the pseudo-randomized component.

Let Y_{ips} be a smoking-related outcome for individual i, in province (P) p, survey year (S) s, and let be L_{ps} be an indicator for a PSFL in effect. The expectation (or mean) of Y_{ips} then becomes,

$$E(Y_{ips}) = \beta_0 + \beta_1 L_{ps} + \sum_{\forall p} \beta_p P_p + \sum_{\forall s} \beta_s S_s + \sum_{\forall c} \beta_c X_{c_{ips}} + \sum_{\forall k} \beta_k Z_{k_{ps}} \quad (1)$$

where $\boldsymbol{\beta_p}$ and $\boldsymbol{\beta_s}$ are coefficients denoting province and year fixed effects, respectively. Both province and year are modeled with a series of binary dummies. Fixed effects for province account for all time-invariant provincial level differences in the smoking-related outcomes. Fixed effects for year account for shared trends in smoking over time that may be driven by shared factors or policies such as federal level tobacco control strategies like graphic warning labels.

The term $\boldsymbol{X_c}$ denotes a potentially important individual-level covariate such as age, gender, education-student status, marital status, language spoken at home, and household size, and $\boldsymbol{\beta_c}$ is the corresponding coefficient of association. Similarly, the term $\boldsymbol{Z_k}$ denotes a potentially important time-varying provincial-level characteristic such as unemployment rates, indicators for retail tobacco display bans, and excise cigarette tax levels, and $\boldsymbol{\beta_k}$ is the corresponding coefficient of association. Retail sales tax rates were not correlated to CPI-adjusted tax levels, and so, were not included in our regression models.

The main coefficient of interest is β_1, the effect of implementing a PSFL. More specifically, it is the difference in the change of smoking behaviour between provinces that implemented a PSFL in comparison to provinces that did not implement a PSFL. Under the assumption that a PSFL reduces smoking, β_1 should be a negative value for both smoking outcomes.

The difference-in-differences framework is easily extendable to allow the estimation of heterogeneous effects of PSFL by socioeconomic position (SEP) (eg. Goldin & Homonoff, 2013; Harper et al., 2012). Specifically, when using education groups (G) as the measure of SEP, the expectation of Y_{ips} becomes,

$$E(Y_{ips}) = \beta_0 + \sum_{\forall g} \beta_g G_g L_{ps} + \sum_{\forall g}\sum_{\forall p} \beta_{gp} G_g P_p + \sum_{\forall g}\sum_{\forall s} \beta_{gs} G_g S_s + \sum_{\forall c} \beta_c X_{c_{ips}} + \sum_{\forall k} \beta_k Z_{k_{ps}} \quad (2)$$

where g = 1, 2, 3, and 4 represent the four education groups *Less than High School*, *Completed Secondary, Completed College,* and *Completed University*, respectively.

The set of coefficients denoted by $\boldsymbol{\beta_{gp}}$ is a collection of cross-product (or interaction) terms that account for factors affecting smoking rates in each education group that stay constant over time within provinces. If socioeconomic differences in smoking vary by province, but do not vary over time, then they cannot confound the differential effect of PSFLs. Similarly, the set of coefficients denoted by $\boldsymbol{\beta_{gs}}$ is a collection of cross-product terms that account for factors affecting smoking rates across all provinces that may be different over time in each education group. If trends in smoking vary by education, but do not differ by province, then they cannot confound the differential effect of PSFLs. We already see some evidence of a common declining trend in both smoking prevalence and frequency from **Appendix Figure 7** and **Appendix Figure 8**, so it seems important to control for these trends.

Because a key objective of our study was to investigate the potential impact of tobacco control strategies on socioeconomic inequalities in smoking, the main regression coefficients of interest are $\boldsymbol{\beta_g}$ for g = 1, 2, 3 or 4 which are the effects of PSFLs on smoking for each education group. If these coefficients decrease in magnitude with higher education, then this would help to reduce the socioeconomic inequality in smoking. Conversely, an increase in magnitude with higher education would suggest that PSFLs have weaker effects on lower educated groups, potentially widening the gap in smoking inequality.

We described our statistical models on the additive scale for the purpose of simplicity and ease of interpretation. We modeled smoking prevalence, however, using logistic regression. Assessing smoking frequency, on the other hand, required a two-part model where a binary component is modeled in the first stage and a frequency component in the second stage (Cragg, 1971). A single quantity variable is used to model both parts. We used logistic regression to model the binary component where a value of 0 indicates a non-smoker, and values of 1 or greater indicate smoking prevalence. We used and Poisson regression for the frequency part, namely smoking quantity for those with values of 1 or greater.

Because we are primarily interested in the contribution of PSFLs on smoking on the additive scale, we will not report the direct model coefficients. We instead report marginal effect estimates which are predicted counterfactual outcomes based on observed values for all other covariates. Moreover, to evaluate the joint significance of the heterogeneous effects of PSFLs by education, we used a Wald test on the contrasts of their marginal effect estimates. Hence, we will discuss our results primarily on the additive scale.

Analytical Plan

Data extraction and data management were performed using SAS 9.3 and Stata/MP 12.1. All statistical analyses (including figures) were performed using Stata/MP 12.1. All estimates reported in our paper were derived using survey weights (Korn, 1999). Standard errors (SEs) and 95% confidence intervals (CIs) were computed using bootstrap sampling (Efron & Tibshirani, 1986). Unless stated otherwise, we used the set of 200 bootstrap weights provided by CTUMS, unless stated otherwise, as recommended by Statistics Canada for use of their survey data (Statistics Canada, 2011). (Note that each bootstrap weight itself was an average based on 20 samples). See **Appendix A-7** for details on Stata code used for data analyses.

Our analytical structure followed that of DeCicca & McLeod (2008). In addition to a *crude* model, we assessed the impact of PSFL for each effect type (average and heterogeneous) and on both smoking outcomes (prevalence and frequency) using three regression models. *Model 1* provided a causal estimate using the simplest case of the DD framework with the inclusion of fixed effects for province and survey year. *Model 2* included individual-level covariates as previously specified. *Model 3* expanded upon *Model 2* by adding provincial-level covariates.

To check for the robustness of our results, we performed seven different types of sensitivity analyses based on *Model 3*. The first sensitivity involved the use of the Probit model, more commonly found in the health economics literature. Secondly, for the smoking prevalence outcome, we substituted past-week smoker status with current smoker status as described in Section 3-2. The third sensitivity analysis pertained only to the smoking frequency outcome. Here, we used a negative-binomial distribution instead of a Poisson distribution to relax the mean-variance equality assumption.

Table 5-5. Distribution of Education by Age Range

Education	25+	25-64
Less than Secondary	0.154	0.104
Completed Secondary	0.346	0.348
Completed College	0.207	0.229
Completed University	0.293	0.318
Sample Size	116652	91180

In order to account for older cohorts being generally less educated, the fourth type of sensitivity analysis excluded those in the oldest age category (65 and older). (See **Table 5-5** for the education distribution with and without the age restriction.) For the fifth set of sensitivity analyses, we estimated robust standard errors with and without clustering by province (assuming non-independence and independence of participants within the same province) in order to compare with the bootstrap sampling method. For the sixth sensitivity, we excluded one province at a time to assess if the implementation of smoke-free legislation for a particular province was influencing our estimates. Similarly, for the last sensitivity, we incrementally included a year of data to determine if the implementation of smoke-free legislation for a particular year had a significant impact on smoking. (We started with a sample that included years 2002-2004 since a PSFL was first implemented only in 2004.)

5.5 Results

Table 5-6 shows the weighted proportions (or mean) of key demographic characteristics of our CTUMS sample. The *Full Sample* column provides estimates based on individuals with missing data, while the *Complete Case* column provides estimates based on individuals with complete data. Note, however, that estimates are similar between both columns. About 95% of survey participants have complete information for covariates considered in our study. The majority of the missing data (N=6,291) were attributable to the outcome past-week smoker, education, marital status, and language spoken at home. Since the overall percentage of individuals with missing data was small, subsequent analyses were based on individuals with complete data.

The average prevalence for past-week smoker was about 16.7%, and among smokers, mean weekly consumption was 97.3 cigarettes. Although CTUMS contains an approximately equal proportion of participants from each province, Ontario (38.5%), Quebec (24.2%), British Columbia (13.5%), and Alberta (10.1%) make up the majority of the population. Among the education groups, the *Less than Secondary* group was the smallest, representing about 15.4% of the sample. The *Completed Secondary*, *Completed College* and *Completed University* groups accounted for 34.6%, 20.7%, and 29.3% of the sample, respectively. The age groups were fairly evenly distributed, ranging from 16.8% for the *55-64* group to 22.5% for the *45-54* group. For marital status, those who were married or common-law accounted for the majority of the sample at 72.4%. English was the most common language spoken at home, accounting for 67.0% of the sample, while French had the second highest representation 21.7%. A two-person household was the most common household size, representing about 37.8% of the sample. The remaining household size groups ranged from 10.8% for *5 or More* to 19.1% for a four-person household.

Table 5-6. CTUMS Survey-weighted Sample Characteristics, Ages 25 and Over

Characteristic	Full Sample		Complete Case	
	Estimate	**SE**	**Estimate**	**SE**
Sample Size	122,943		116,652	
Past-week Smoker	16.6	0.2	16.7	0.2
Missing (Number)	1,678			
Past-week Cigarette Quantity (Smokers)	97.2	0.8	97.3	0.8
Province				
Newfoundland and Labrador	1.6	0.0	1.6	0.0
Prince Edward Island	0.4	0.0	0.4	0.0
Nova Scotia	2.9	0.0	2.9	0.0
New Brunswick	2.3	0.0	2.4	0.0
Quebec	24.0	0.0	24.2	0.0
Ontario	38.7	0.0	38.5	0.1
Manitoba	3.5	0.0	3.4	0.0
Saskatchewan	2.9	0.0	2.9	0.0
Alberta	10.1	0.0	10.1	0.0
British Columbia	13.6	0.0	13.5	0.0
Survey Year				
2002	8.5	0.0	8.4	0.0
2003	8.6	0.0	8.3	0.0
2004	8.7	0.0	8.7	0.0
2005	8.8	0.0	8.8	0.0
2006	8.9	0.0	8.8	0.0
2007	9.1	0.0	9.1	0.0
2008	9.2	0.0	9.2	0.0
2009	9.4	0.0	9.4	0.0
2010	9.5	0.0	9.6	0.0
2011	9.6	0.0	9.7	0.0
2012	9.7	0.0	9.8	0.0
Education				
Less than secondary	15.6	0.2	15.4	0.2
Completed secondary	34.7	0.2	34.6	0.2
Completed community college	20.6	0.2	20.7	0.2
Completed university	29.1	0.2	29.3	0.2
Missing (Number)	2,599			
Male	49.0	0.0	49.2	0.1
Age Group				
25-34	20.1	0.1	20.4	0.1
35-44	21.9	0.1	22.1	0.1
45-54	22.5	0.2	22.7	0.2
55-64	16.8	0.1	16.8	0.1
65+	18.7	0.0	18.1	0.1
Marital Status				
Common-law/Married	72.4	0.3	72.6	0.3
Widow/Divorced/Separated	13.4	0.2	13.2	0.2
Single	14.2	0.2	14.1	0.2
Missing (Number)	2,421			
Language (Spoken at Home)				
English	67.0	0.2	67.0	0.2
French	21.7	0.1	22.0	0.1
English and French	0.9	0.0	0.9	0.0
Other	10.4	0.2	10.2	0.2
Missing (Number)	1,132			
Household Size				
1	14.5	0.2	13.9	0.2
2	37.8	0.2	37.9	0.2
3	17.9	0.2	18.0	0.2
4	19.1	0.2	19.4	0.2
5 or more	10.8	0.2	10.8	0.2
Missing (Number)	2			

Weighted proportions (or mean for the case of past-week cigarette quantity among smokers) and standard errors.

Table 5-7. Marginal Average Effects of Provincial Smoke-free Laws on Smoking

Model	Smoking Prevalence			Smoking Frequency		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-1.6%	-2.3%	-0.9%	-3.0	-3.9	-2.2
1: Province and Year Fixed Effects	0.3%	-1.0%	1.5%	-0.5	-2.0	1.0
2: Model 1 + Individual Covariates	0.1%	-1.1%	1.3%	-0.5	-2.0	1.0
3: Model 2 + Provincial Covariates	0.1%	-1.3%	1.4%	-0.6	-2.2	1.0

Marginal estimates indicate the effect of an implementation of smoke-free legislation on smoking prevalence and mean weekly cigarette consumption on the additive scale.

Table 5-8. Marginal Heterogeneous Effects of Provincial Smoke-free Laws on Smoking Prevalence

Model	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	0.2%	-1.7%	2.1%	-0.9%	-2.3%	0.5%	-1.9%	-3.6%	-0.3%	-1.3%	-2.5%	-0.1%
1	-0.4%	-4.2%	3.3%	-0.9%	-3.3%	1.6%	3.2%	0.2%	6.2%	-0.1%	-2.2%	1.9%
2	-0.6%	-5.0%	3.9%	-0.8%	-3.2%	1.5%	2.8%	0.1%	5.6%	-0.4%	-2.3%	1.5%
3	-0.8%	-5.3%	3.7%	-1.0%	-3.5%	1.5%	2.7%	-0.1%	5.5%	-0.4%	-2.4%	1.5%

Marginal estimates indicate the effect of an implementation of smoke-free legislation on smoking prevalence on the additive scale.

Table 5-9. Marginal Heterogeneous Effects of Provincial Smoke-free Laws on Smoking Frequency

Model	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Crude	-1.7	-4.3	0.9	-2.4	-4.2	-0.7	-3.2	-4.9	-1.5	-1.6	-2.8	-0.5
1	0.2	-4.8	5.2	-1.4	-4.5	1.6	-0.4	-3.7	2.8	0.3	-1.7	2.4
2	0.2	-5.7	6.1	-1.4	-4.4	1.5	-0.4	-3.4	2.6	0.3	-1.6	2.3
3	-0.2	-6.1	5.7	-1.7	-4.8	1.3	-0.6	-3.7	2.5	0.2	-1.8	2.2

Marginal estimates indicate the effect of an implementation of smoke-free legislation on mean weekly cigarette consumption on the additive scale.

Marginal effect estimates were similar across *Model 1*, *Model 2*, and *Model 3* when estimating average and heterogeneous effects of provincial smoke-free legislation (PSFL) on smoking prevalence and smoking frequency. This suggests that the set of included individual and provincial level covariates did not have much influence on the effect of PSFL on either smoking outcome. Going forward, we will reference only marginal effect estimates based on *Model 3* of each respective smoking outcome and effective type (average or heterogeneous).

Table 5-7 provides marginal effect estimates for the average effect of PSFL on past-week smoking prevalence and mean smoking frequency for adults, ages 25 and over. To address our first objective using the DD framework, however, we can see that having a PSFL in effect had a negligible impact on both smoking outcomes. The marginal average effect for smoking prevalence was 0.1 (95% CI: -1.3, 1.4) percentage points. Similarly, the marginal average effect for smoking frequency was -0.6 (95% CI: -2.2, 1.0) cigarettes. See **Appendix Table 25** and **Appendix Table 26** for marginal effects of all covariates included in models for smoking prevalence and smoking frequency, respectively.

Table 5-8 provides marginal estimates for the effect of PSFL on past-week smoking prevalence by education. Marginal effect estimates were -0.8 (95% CI: -5.3, 3.7), -1.0 (95% CI: -3.5, 1.5), 2.7 (95% CI: -0.1, 5.5), and -0.4 (95% CI: -2.4, 1.5) percentage points for the *Less than Secondary*, *Completed Secondary*, *Completed College*, and *Completed College* education groups, respectively. Moreover, a Wald test of joint significant yielded a χ^2 value of 4.77 with 3 degrees of freedom, and a p-value of 0.1897. Thus, there was little evidence to suggest heterogeneous effects of smoke-free legislation by education in Canada. See **Appendix Table 27** for marginal estimates of all covariates included in our heterogeneous effect models for smoking prevalence.

Table 5-9 provides marginal estimates for the effect of PSFL on smoking frequency by education. Marginal effect estimates were -0.2 (95% CI: -6.1, 5.7), -1.7 (95% CI: -4.8, 1.3), -0.6 (95% CI: -3.7, 2.5), and 0.2 (95% CI: -1.8, 2.2) cigarettes for the *Less than Secondary*, *Completed Secondary*, *Completed College*, and *Completed College* education groups, respectively. Again, all estimates were statistically non-significant at the 95% level of confidence. A Wald test of joint significant yielded a χ^2 value of 1.12 with 3 degrees of freedom, and a p-value of 0.7730, and thus, suggesting a lack of evidence for heterogeneous effects. See **Appendix Table 28** for marginal estimates of all covariates included in our heterogeneous effect models for smoking frequency.

Regarding the second objective, we obtained weak evidence of differing effects of PSFL by education. All marginal effect estimates by education were statistically non-significant for both smoking outcomes (at the 95% level of confidence). Moreover, a Wald test of joint significant suggested little evidence for heterogeneous effects of PSFL by education for both smoking outcomes. This would imply that from 2002-2012, there were negligible differences in the effect of PSFL on smoking among education groups. In turn, this would also imply that education groups experienced similar declines in smoking, and thus, PSFL did not contribute to the reduction of the inequality (on the additive scale) in either smoking prevalence or frequency during the time of the FTCS.

We based all sensitivity analyses on *Model 3*, our preferred model, for both smoking outcomes and effect type. **Table 5-10** and **Table 5-11** show sensitivity analyses for the average effect of PSFL on smoking prevalence and frequency, respectively. Although certain sensitivity analyses have effects of the opposite sign from our main results, all estimates remain non-significant, except with the exclusion of Ontario for the smoking frequency. For that sensitivity analysis, the marginal effect estimate was -1.8 (95% CI: -3.6, -0.1). Otherwise, our results were robust to sensitivity specifications.

Likewise, **Table 5-12** and **Table 5-13** show sensitivity analyses for the heterogeneous effects of PSFL by education on smoking prevalence and frequency, respectively. Overall, estimates were robust to all sensitivity specifications across education groups except for the *Completed College* group for the smoking prevalence outcome. Here point estimates were similar to the main result (generally indicating an *increase* in smoking prevalence with the implementation of PSFL) which was not statistically significant, but confidence interval estimates were statistically significant for some sensitivity specifications.

Table 5-10. Sensitivity Analyses for the Marginal Effect of Provincial Smoke-free on Smoking Prevalence

Sensitivity Type	Estimate	95% C.I.	
Preferred Model (Model 3)	0.1%	-1.3%	1.4%
Model Specification			
Probit Model	0.1%	-1.2%	1.4%
Current-Smoker	0.1%	-1.3%	1.4%
Ages 25 - 64	0.3%	-1.3%	1.9%
Weighted with no Clustering	0.1%	-1.4%	1.6%
Weighted with Clustering	0.1%	-1.6%	1.7%
Province Excluded			
Newfoundland & Labrador	0.1%	-1.3%	1.4%
Prince Edward Island	0.1%	-1.3%	1.4%
Nova Scotia	0.1%	-1.2%	1.5%
New Brunswick	0.1%	-1.3%	1.5%
Quebec	0.6%	-0.9%	2.1%
Ontario	-0.9%	-2.3%	0.5%
Manitoba	0.0%	-1.4%	1.4%
Saskatchewan	0.3%	-1.2%	1.8%
Alberta	0.3%	-1.2%	1.7%
British Columbia	0.2%	-1.2%	1.6%
Years Included			
2002 - 2004	2.6%	-2.2%	7.4%
2002 - 2005	1.1%	-1.2%	3.4%
2002 - 2006	0.5%	-1.7%	2.8%
2002 - 2007	0.6%	-1.2%	2.3%
2002 - 2008	0.2%	-1.4%	1.7%
2002 - 2009	0.2%	-1.3%	1.7%
2002 - 2010	0.1%	-1.3%	1.5%
2002 - 2011	0.2%	-1.2%	1.5%

Marginal estimates indicate the effect of an implementation of smoke-free legislation on smoking prevalence on the additive scale.

Table 5-11. Sensitivity Analyses for the Marginal Effect of Provincial Smoke-free on Smoking Frequency

Sensitivity Type	Estimate	95% C.I.	
Preferred Model (Model 3)	-0.6	-2.2	1.0
Model Specification			
Probit-Poisson TPM	-0.6	-2.2	1.0
Logit-Negative Binomial TPM	-0.6	-2.2	1.1
Ages 25 - 64	-0.6	-2.5	1.4
Weighted with no clustering	-0.7	-2.7	1.3
Weighted with clustering	-0.7	-2.6	1.2
Province Excluded			
Newfoundland	-0.7	-2.3	1.0
Prince Edward Island	-0.7	-2.3	1.0
Nova Scotia	-0.6	-2.2	1.0
New Brunswick	-0.7	-2.4	1.0
Quebec	0.1	-1.6	1.9
Ontario	-1.8	-3.6	-0.1
Manitoba	-0.7	-2.4	1.0
Saskatchewan	-0.5	-2.3	1.3
Alberta	0.0	-1.8	1.7
British Columbia	-0.6	-2.4	1.2
Years Included			
2002 - 2004	4.3	-2.1	10.6
2002 - 2005	0.2	-2.5	2.9
2002 - 2006	-0.1	-2.9	2.7
2002 - 2007	-0.3	-2.4	1.9
2002 - 2008	-0.7	-2.6	1.3
2002 - 2009	-0.6	-2.4	1.2
2002 - 2010	-0.6	-2.3	1.1
2002 - 2011	-0.5	-2.2	1.1

Marginal estimates indicate the effect of an implementation of smoke-free legislation on mean weekly cigarette consumption on the additive scale.

Table 5-12. Sensitivity Analyses for the Marginal Effect of Provincial Smoke-free on Smoking Prevalence by Education

Sensitivity Type	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Preferred Model (Model 3)	-0.8%	-5.3%	3.7%	-1.0%	-3.5%	1.5%	2.7%	-0.1%	5.5%	-0.4%	-2.4%	1.5%
Model Specification												
Probit Model	-0.7%	-4.9%	3.6%	-1.1%	-3.6%	1.4%	2.8%	0.0%	5.6%	-0.3%	-2.2%	1.7%
Current-Smoker	-0.8%	-5.3%	3.7%	-1.0%	-3.5%	1.5%	2.7%	-0.1%	5.5%	-0.4%	-2.4%	1.5%
Ages 25 - 64	-0.3%	-6.7%	6.1%	-0.8%	-3.6%	2.0%	3.0%	-0.3%	6.3%	-0.5%	-2.8%	1.8%
Weighted with no Clustering	-0.8%	-5.5%	3.9%	-1.0%	-3.6%	1.6%	2.7%	-0.3%	5.7%	-0.4%	-2.6%	1.7%
Weighted with Clustering	-0.8%	-7.0%	5.4%	-1.0%	-3.0%	1.0%	2.7%	0.1%	5.4%	-0.4%	-2.4%	1.5%
Province Excluded												
Newfoundland & Labrador	-0.9%	-5.6%	3.8%	-1.0%	-3.5%	1.5%	2.8%	-0.1%	5.6%	-0.5%	-2.4%	1.5%
Prince Edward Island	-0.8%	-5.3%	3.8%	-1.1%	-3.6%	1.4%	2.8%	-0.1%	5.6%	-0.5%	-2.4%	1.5%
Nova Scotia	-1.0%	-5.6%	3.6%	-0.9%	-3.4%	1.5%	2.9%	0.1%	5.7%	-0.4%	-2.4%	1.5%
New Brunswick	-0.8%	-5.5%	4.0%	-1.1%	-3.7%	1.5%	2.8%	-0.1%	5.7%	-0.5%	-2.5%	1.5%
Quebec	0.8%	-4.3%	5.9%	-0.1%	-2.7%	2.5%	2.1%	-1.1%	5.4%	0.3%	-1.8%	2.4%
Ontario	-3.5%	-7.8%	0.8%	-1.4%	-4.0%	1.2%	1.8%	-1.1%	4.7%	-1.0%	-3.0%	0.9%
Manitoba	-1.0%	-5.7%	3.8%	-1.2%	-3.9%	1.4%	3.3%	0.4%	6.2%	-0.9%	-3.0%	1.2%
Saskatchewan	-0.1%	-5.2%	5.0%	-0.8%	-3.6%	2.0%	2.9%	-0.2%	6.0%	-0.6%	-2.7%	1.5%
Alberta	-1.1%	-5.9%	3.8%	-0.5%	-3.2%	2.2%	3.2%	0.1%	6.3%	-0.6%	-2.7%	1.6%
British Columbia	1.0%	-3.8%	5.9%	-2.1%	-4.8%	0.7%	2.8%	-0.2%	5.8%	0.4%	-1.9%	2.7%
Years Included												
2002 - 2004	-3.5%	-16.7%	9.7%	8.0%	-0.7%	16.6%	-3.1%	-10.6%	4.5%	3.3%	-6.4%	13.0%
2002 - 2005	0.8%	-6.1%	7.8%	0.4%	-3.5%	4.4%	0.6%	-4.7%	5.8%	3.3%	-1.4%	8.0%
2002 - 2006	4.0%	-3.5%	11.6%	-2.1%	-5.9%	1.7%	5.0%	-0.3%	10.4%	-0.8%	-3.9%	2.3%
2002 - 2007	0.3%	-5.3%	5.9%	-1.0%	-3.9%	2.0%	3.7%	-0.3%	7.7%	0.2%	-2.4%	2.7%
2002 - 2008	-0.4%	-5.5%	4.7%	-0.9%	-3.7%	1.9%	2.5%	-1.0%	6.0%	-0.2%	-2.4%	2.1%
2002 - 2009	-1.0%	-5.7%	3.8%	-1.0%	-3.7%	1.7%	3.0%	-0.2%	6.2%	-0.1%	-2.2%	1.9%
2002 - 2010	-1.2%	-5.8%	3.4%	-0.9%	-3.5%	1.7%	2.8%	-0.1%	5.8%	-0.3%	-2.3%	1.7%
2002 - 2011	-0.8%	-5.4%	3.8%	-1.0%	-3.5%	1.6%	2.9%	0.1%	5.7%	-0.4%	-2.3%	1.6%

Marginal estimates indicate the effect of an implementation of smoke-free legislation on smoking prevalence on the additive scale.

Table 5-13. Sensitivity Analyses for the Marginal Effect of Provincial Smoke-free on Smoking Frequency by Education

Sensitivity Type	Less than Secondary			Completed Secondary			Completed College			Completed University		
	Est.	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**		**Est.**	**95% C.I.**	
Preferred Model (Model 3)	-0.2	-6.1	5.7	-1.7	-4.8	1.3	-0.6	-3.7	2.5	0.2	-1.8	2.2
Model Specification												
Probit-Poisson TPM	-0.1	-5.7	5.5	-1.8	-4.9	1.2	-0.5	-3.6	2.6	0.3	-1.7	2.4
Logit-Negative Binomial TPM	0.3	-5.5	6.1	-1.6	-4.7	1.5	-0.4	-3.4	2.6	0.0	-2.0	2.0
Ages 25 - 64	0.3	-8.1	8.6	-1.7	-5.3	1.9	-0.7	-4.2	2.9	0.3	-2.0	2.6
Weighted with no Clustering	-0.2	-6.5	6.2	-1.8	-5.1	1.5	-0.7	-4.2	2.9	0.2	-2.0	2.4
Weighted with Clustering	-0.2	-8.1	7.7	-1.8	-4.1	0.6	-0.7	-4.4	3.1	0.2	-2.2	2.6
Province Excluded												
Newfoundland & Labrador	-0.3	-6.4	5.9	-1.7	-4.9	1.4	-0.6	-3.7	2.5	0.2	-1.8	2.2
Prince Edward Island	-0.1	-6.1	5.9	-1.8	-4.9	1.3	-0.6	-3.7	2.5	0.2	-1.8	2.2
Nova Scotia	-0.3	-6.4	5.7	-1.6	-4.7	1.5	-0.5	-3.6	2.6	0.2	-1.8	2.2
New Brunswick	-0.2	-6.4	6.0	-1.7	-4.9	1.5	-0.9	-4.1	2.3	0.2	-1.9	2.2
Quebec	-0.3	-6.8	6.2	-0.7	-4.0	2.6	-0.5	-3.8	2.9	1.5	-0.5	3.5
Ontario	-3.1	-8.8	2.7	-2.6	-5.5	0.4	-0.4	-3.6	2.8	-1.5	-3.7	0.7
Manitoba	0.1	-6.3	6.4	-1.9	-5.2	1.4	-0.2	-3.4	2.9	-0.1	-2.2	2.0
Saskatchewan	1.0	-5.7	7.7	-1.7	-5.1	1.8	-1.0	-4.4	2.3	0.3	-1.9	2.4
Alberta	0.1	-6.2	6.4	-0.6	-3.9	2.7	0.2	-3.3	3.6	0.2	-2.2	2.5
British Columbia	3.0	-3.0	9.1	-3.1	-6.7	0.5	-1.0	-4.4	2.5	0.7	-1.6	3.0
Years Included												
2002 - 2004	-5.9	-22.4	10.5	9.3	-2.0	20.5	0.6	-10.1	11.4	3.7	-6.8	14.1
2002 - 2005	0.4	-9.3	10.1	-2.1	-6.4	2.3	0.6	-5.2	6.4	2.2	-2.3	6.7
2002 - 2006	8.5	-2.3	19.2	-2.7	-7.6	2.3	-0.8	-5.4	3.7	0.1	-3.5	3.7
2002 - 2007	1.5	-6.0	8.9	-1.4	-5.3	2.5	-1.2	-5.2	2.7	0.8	-2.1	3.6
2002 - 2008	0.3	-6.4	6.9	-1.3	-4.9	2.2	-1.9	-5.4	1.6	0.5	-2.0	3.0
2002 - 2009	-0.3	-6.6	6.0	-1.6	-5.0	1.8	-1.0	-4.3	2.3	0.5	-1.7	2.7
2002 - 2010	-0.7	-6.8	5.5	-1.5	-4.8	1.8	-0.7	-3.8	2.4	0.3	-1.8	2.4
2002 - 2011	-0.1	-6.3	6.0	-1.7	-4.8	1.4	-0.5	-3.5	2.6	0.3	-1.7	2.4

Marginal estimates indicate the effect of an implementation of smoke-free legislation on mean weekly cigarette consumption on the additive scale.

5.6 Discussion

In this section, we will cover some potential issues and limitations of our study. We will first address potential methodological concerns. Then we will broadly discuss general concerns about provincial smoke-free legislation (PSFL) in Canada.

Firstly, using self-reported tobacco consumption for our outcome measure may be a concern because of the problem of social desirability, specifically the misreporting of smoking behaviour. In order for this to cause a bias, the rate of misreporting has to change with respect to time (before and after implementation of PSFL) and be differential across provinces. One might be concerned, then, that the implementation of PSFL can cause the under-reporting of smoking. If the implementation of PSFL does decrease smoking, then the under-reporting of smoking would exaggerate the decline in smoking (or in other words, bias our estimates away from the null). We, however, obtained null results for both smoking outcomes (prevalence and frequency), so social desirability is most likely not a limitation in our study.

Furthermore, when looking at heterogeneous effects of PSFL, the misreporting also has to be differential by education. If the implementation of PSFL leads to the under-reporting of smoking behaviour among those with lower education, then this would exaggerate the effect of PSFL for them and artificially decrease the smoking gap between those with low and high education. Conversely, if the implementation of PSFL leads to the under-reporting of smoking behaviour among those with higher education, then this would exaggerate the effect of PSFL for them and artificially widen the smoking gap. As in the case of average effects, however, we obtained null results for the effect of PSFL by education and the corresponding test of their contrasts for both smoking prevalence and smoking frequency. This would suggest that the education groups experienced a similar rate in decline for both smoking outcomes.

Regarding our results for the effect of provincial smoke-free legislation, marginal effect estimates for the average effect were statistically non-significant for both smoking outcomes, except for one sensitivity analysis. In our evaluation of the average effect of PSFL on smoking frequency, the marginal effect was statistically significant (at the 95% confidence level) when excluding Ontario. This might suggest that PSFL had a negligible effect in Ontario, and because the province represents about 38.5% of the Canadian population, reduced the overall effect of PSFL. That result, however, was not consistent when assessing the effect of PSFL on smoking frequency by education with the same province exclusion which would indicate that the previous result was most likely a spurious one.

These null results may be due to a common growing anti-smoking environment in Canada as province fixed effects and common temporal changes accounted for much of the variation and declining trends in adult smoking. We calculated survey-weighted smoking prevalence by year and province and then computed R-squared values to infer the variation of smoking explained by each component. In a linear regression model with smoking prevalence as the outcome and province fixed effects, the adjusted R-squared was 0.462. Similarly, for year fixed effects, the adjusted R-squared was 0.198. Together, they accounted for 73.0 % of the variation in smoking prevalence. We derived similar results for smoking frequency.

This intuitively makes sense as overall smoking levels have decreased even within provinces where no PSFL was in effect. Note that Prince Edward Island (P.E.I.) was the last province to implement a PSFL in 2009. From 2002 to 2008, Canada experienced an overall drop of 3.3 percentage points in smoking prevalence and 6.2 cigarettes in mean smoking frequency. To give some perspective, in that same timeframe, P.E.I. experienced a decline of about 4.0 percentage points in smoking prevalence and 6.5 cigarettes in mean smoking frequency.

Consequently, any future study on tobacco control would also need to consider the variation in smoking among the provinces and the common secular downward smoking trend.

Moreover, we see weak evidence of heterogeneous effects of PSFL by education for both smoking outcomes. Marginal effect estimates for heterogeneous effects were statistically non-significant for both smoking outcomes, except for the *Completed College* education group for some sensitivity specifications. Note, however, that point estimates were similar to the main result which were not statistically significant. A concern when doing subgroup analyses and repeating procedures with modified specifications, however, is that a statistically significant result could be an artefact of multiple testing (Benjamini & Yekutieli, 2001).

5.7 Conclusion

Although smoke-free legislation has the potential to reduce environmental tobacco exposure, we find that implementation of provincial smoke-free legislation during the period of FTCS (2002-2012) contributed little to the decline in tobacco consumption. During that timeframe, we observe a steady decline in both smoking prevalence and smoking frequency even in provinces that implemented smoking restrictions much later compared to other provinces. This would suggest that other factors common to all provinces had a greater influence over tobacco use among the adults in Canada. Moreover, there was weak evidence to support the potential of differential effects of provincial smoke-free legislation by education on smoking.

Thus, the implementation of provincial smoke-free legislation during the time of the FTCS did not help to reduce the educational gap in smoking among adults in Canada. If agencies such as Health Canada and the PHAC are motivated to not only lower overall smoking levels, but to reduce the socioeconomic gap in smoking, then alternative strategies must be devised, particularly targeting socioeconomic groups where smoking rates still remain high in Canada.

Chapter 6: Summary and Conclusion

Although both excise tobacco taxes and smoke-free legislation have the potential to reduce tobacco consumption, their effectiveness is sensitive to the current anti-tobacco control environment. During the time of the FTCS, there was a much higher level of tobacco control compared to the time prior to its launch and higher compared to other countries. Excise cigarette taxes have been gradually increasing since the 1980s, and so, tax levels were already quite high by the launch of the FTCS. Moreover, taxes and smoke-free legislation had to work in conjunction with other forms of tobacco control such as the Tobacco Act, and the enforcement of graphic warning labels on cigarette packages.

From 2002-2012, both smoking prevalence and mean smoking frequency have been in steady decline in Canada. These declines, however, are present even in provinces with stable or decreasing cigarette tax levels and for provinces which implement smoke-free legislation at a later time suggesting that other factors common to all provinces such as growing anti-smoking sentiment have had a greater influence over tobacco use.

Moreover, there was little evidence to suggest heterogeneous effects by education where socioeconomic inequalities in smoking have carried over from the twentieth century. If agencies such as Health Canada and the Public Health Agency of Canada are motivated to not only reduce smoking rates, but to reduce inequalities in smoking, then a potential strategy would be target social groups with higher smoking rates. One such focus must include those of lower socioeconomic position where smoking rates remain the high.

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Appendices

A-1 CTUMS Sample Size, Smoking Prevalence and Mean Smoking Frequency

Appendix Table 1: CTUMS Sample Size, 2002-2012

Year	Everyone	Ages 15-18		Ages 25+	
		Full Sample	**Complete**	**Full Sample**	**Complete**
2002	23,341	5,052	4,927	12,098	11,416
2003	21,300	4,527	4,394	11,111	10,296
2004	20,275	4,258	4,153	10,719	10,133
2005	20,840	4,474	4,370	11,040	10,495
2006	21,976	4,783	4,668	11,626	10,961
2007	20,921	4,550	4,429	11,289	10,722
2008	20,541	4,508	4,397	11,060	10,500
2009	20,121	4,428	4,316	10,985	10,461
2010	19,822	4,171	4,065	10,907	10,496
2011	20,703	4,412	4,301	11,311	10,817
2012	19,286	4,009	3,894	10,797	10,355
Total	229,126	49,172	47,914	122,943	116,652

Note: All analyses were performed using the complete case sample, unless stated otherwise.

Appendix Table 2: Smoking Prevalence and Smoking Frequency, Ages 15-18

Year	Current Smoker		Past-week Smoker		Smoking Frequency	
	Proportion	**SE**	**Proportion**	**SE**	**Mean**	**SE**
2002	18.5	0.8	18.0	0.8	12.9	0.8
2003	14.7	0.9	13.4	0.9	8.7	0.7
2004	14.9	0.9	13.1	0.8	7.0	0.5
2005	14.3	0.9	13.0	0.9	6.9	0.6
2006	11.8	0.8	10.1	0.7	5.8	0.5
2007	12.0	0.8	11.4	0.8	6.2	0.5
2008	10.4	0.7	8.7	0.6	4.9	0.4
2009	10.1	0.7	8.5	0.7	5.0	0.5
2010	9.4	0.7	8.1	0.7	4.5	0.5
2011	8.2	0.7	6.8	0.6	3.3	0.4
2012	7.6	0.6	6.9	0.6	3.8	0.7

Note: Mean smoking frequency values are marginal effect estimates derived from a logistic-Poisson, two-part regression model with year fixed effects.

Appendix Table 3: Smoking Prevalence Trends by Province, Ages 15-18

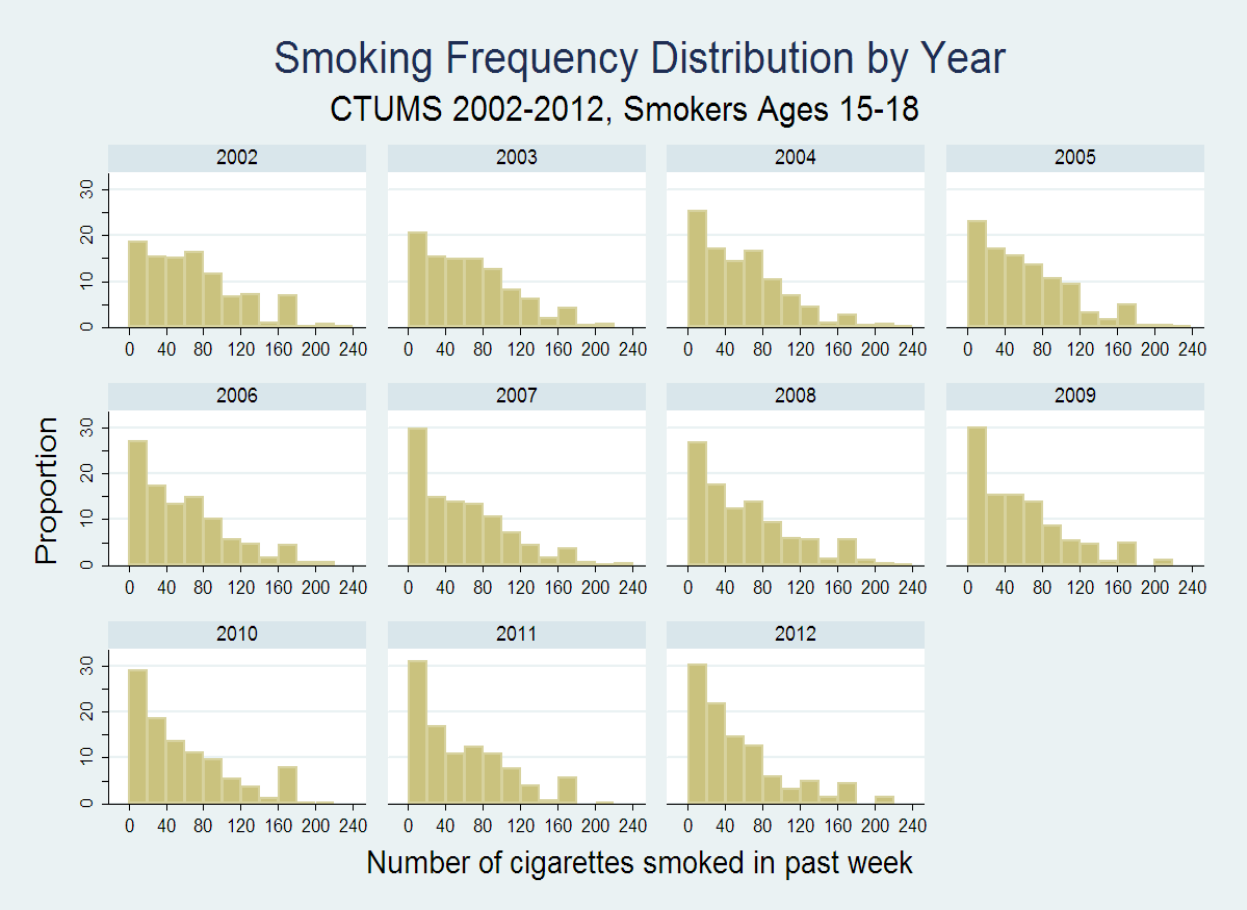
Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	16.8 (2.0)	16.9 (2.1)	17.3 (2.2)	13.6 (2.0)	11.6 (1.7)	12.5 (1.6)	9.7 (1.4)	10.4 (1.6)	10.4 (1.8)	9.8 (1.5)	7.7 (1.5)
Prince Edward Island	15.9 (2.2)	14.3 (1.9)	10.5 (1.5)	10.3 (1.6)	10.6 (1.8)	8.2 (1.3)	8.7 (1.3)	8.3 (1.6)	7.6 (1.5)	8.0 (1.4)	2.8 (0.9)
Nova Scotia	15.5 (1.7)	14.3 (2.0)	12.4 (1.6)	8.9 (1.5)	10.1 (1.5)	8.3 (1.4)	8.4 (1.4)	9.8 (1.4)	9.2 (1.6)	7.5 (1.6)	7.1 (1.4)
New Brunswick	12.2 (1.4)	16.1 (2.3)	15.7 (2.3)	13.1 (2.4)	12.0 (2.0)	10.4 (1.6)	10.7 (1.6)	11.2 (2.0)	7.8 (1.4)	10.0 (2.2)	8.7 (2.2)
Quebec	27.4 (2.7)	19.5 (2.7)	17.6 (2.0)	19.9 (2.1)	14.5 (1.9)	14.9 (1.9)	12.4 (1.6)	13.9 (1.7)	9.2 (1.5)	10.1 (1.7)	9.9 (1.6)
Ontario	14.7 (1.3)	9.9 (1.5)	10.2 (1.7)	9.6 (1.8)	7.3 (1.2)	9.6 (1.6)	4.5 (0.9)	4.7 (1.1)	6.9 (1.3)	5.3 (1.1)	4.7 (1.1)
Manitoba	22.3 (2.2)	14.9 (2.1)	14.8 (2.0)	14.8 (2.0)	12.2 (1.6)	12.5 (1.6)	13.6 (2.0)	10.9 (1.7)	11.7 (1.8)	8.2 (1.4)	8.1 (1.5)
Saskatchewan	25.1 (2.6)	23.1 (2.4)	21.0 (2.3)	19.8 (2.2)	17.1 (1.9)	17.9 (2.3)	16.8 (1.8)	11.6 (1.9)	13.8 (1.9)	11.1 (1.8)	14.0 (2.1)
Alberta	16.0 (1.9)	12.1 (2.0)	12.0 (1.8)	13.6 (1.6)	9.3 (1.7)	15.7 (2.1)	11.2 (1.8)	8.2 (1.3)	9.4 (1.7)	4.7 (1.1)	7.6 (1.5)
British Columbia	13.0 (1.7)	10.8 (1.6)	12.1 (1.9)	9.5 (1.9)	8.5 (1.4)	5.9 (1.2)	8.5 (1.6)	8.4 (1.7)	5.9 (1.4)	4.7 (1.2)	5.1 (1.4)

Note: Smoking prevalence values are marginal effect estimates derived from a logistic regression model with year, province, and their cross product terms as covariates. Standard errors are reported in parentheses.

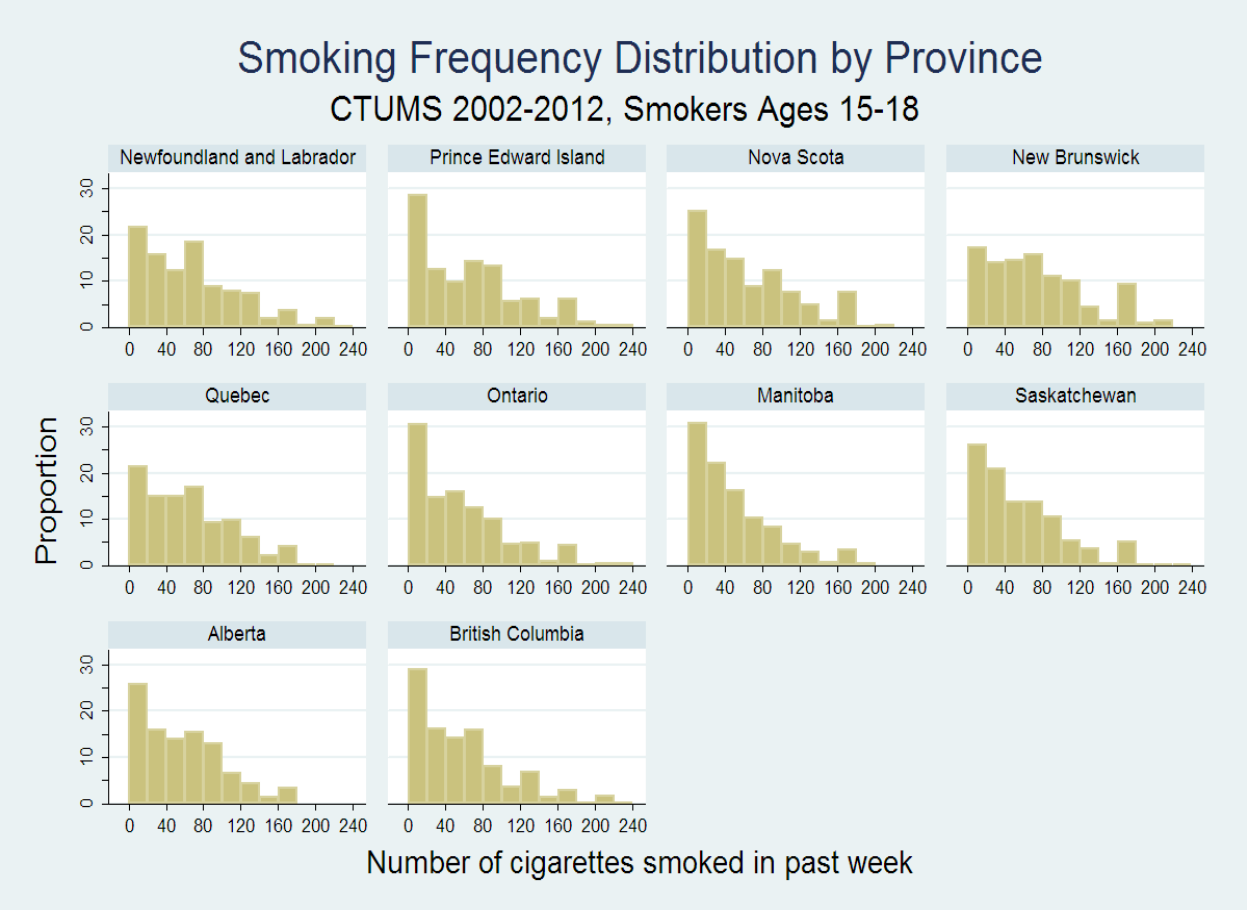
Appendix Table 4: Mean Smoking Frequency (Past-week) Trends by Province, Ages 15-18

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	12.3 (1.8)	12.4 (1.8)	12.2 (2.3)	9.7 (1.7)	7.9 (1.6)	8.3 (1.4)	8.0 (1.6)	7.0 (1.7)	7.7 (2.1)	6.8 (1.6)	6.1 (1.4)
Prince Edward Island	12.9 (2.2)	11.0 (2.4)	6.6 (1.2)	7.0 (1.4)	8.3 (2.2)	6.0 (1.1)	5.3 (1.1)	4.2 (1.1)	4.9 (1.3)	3.9 (1.1)	1.4 (0.7)
Nova Scotia	11.1 (1.6)	10.2 (1.9)	8.1 (1.9)	5.9 (1.3)	6.4 (1.2)	5.7 (1.3)	6.4 (1.4)	5.4 (1.0)	4.1 (1.0)	5.7 (1.5)	2.2 (0.6)
New Brunswick	9.2 (1.3)	14.9 (2.7)	9.1 (1.7)	11.9 (3.0)	6.8 (1.3)	8.3 (1.6)	8.9 (1.6)	9.0 (1.9)	3.7 (1.1)	9.4 (2.8)	5.0 (1.5)
Quebec	20.3 (2.3)	13.7 (2.2)	10.4 (1.4)	11.4 (1.6)	8.3 (1.3)	8.8 (1.4)	7.2 (1.1)	9.6 (1.4)	6.5 (1.3)	5.1 (1.2)	5.2 (1.2)
Ontario	10.5 (1.2)	5.8 (1.2)	4.5 (0.8)	3.6 (0.9)	4.5 (0.9)	4.4 (1.0)	2.7 (0.7)	1.8 (0.5)	3.6 (0.9)	1.4 (0.4)	2.5 (1.5)
Manitoba	11.1 (1.3)	6.5 (1.1)	8.3 (1.4)	8.2 (1.6)	6.9 (1.5)	4.3 (0.6)	7.5 (1.6)	5.7 (1.3)	5.4 (1.1)	4.4 (1.0)	2.8 (0.7)
Saskatchewan	15.8 (2.1)	16.6 (2.4)	11.4 (1.6)	10.7 (1.6)	9.5 (1.5)	9.1 (1.7)	8.1 (1.3)	6.7 (1.6)	8.8 (1.6)	5.4 (1.1)	7.8 (1.6)
Alberta	11.8 (1.9)	7.1 (1.4)	7.0 (1.5)	9.4 (1.4)	4.8 (1.0)	9.9 (2.3)	5.5 (1.1)	3.5 (0.8)	5.0 (1.3)	3.1 (0.9)	5.3 (1.6)
British Columbia	10.1 (1.9)	7.2 (1.7)	5.8 (1.2)	4.7 (1.4)	4.3 (0.9)	3.0 (0.8)	4.3 (1.1)	6.6 (2.2)	2.4 (0.8)	3.1 (1.2)	3.1 (1.3)

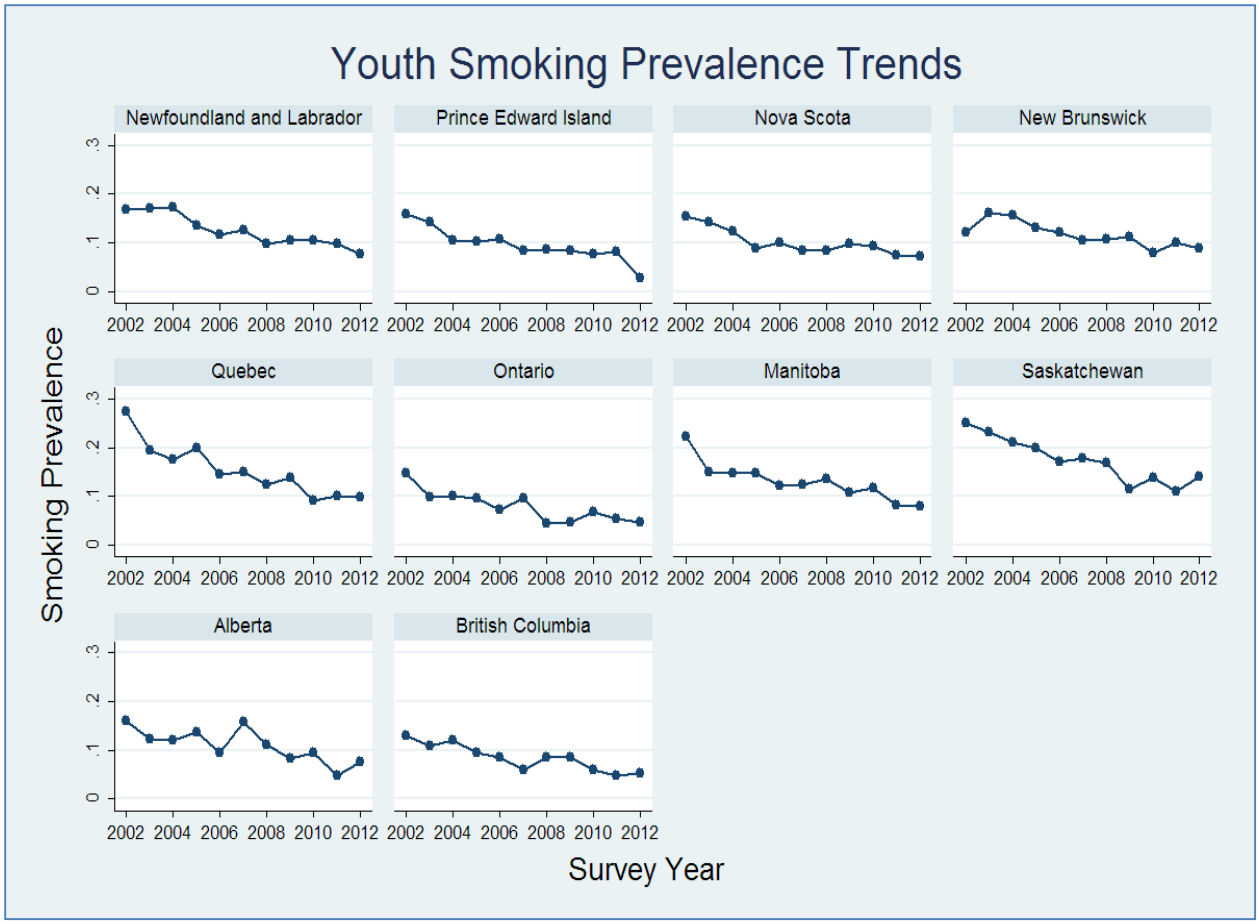
Note: Mean smoking frequency values are marginal effect estimates derived from a logistic-Poisson, two-part regression model with year, province, and their cross product terms as covariates. Standard errors are reported in parentheses.



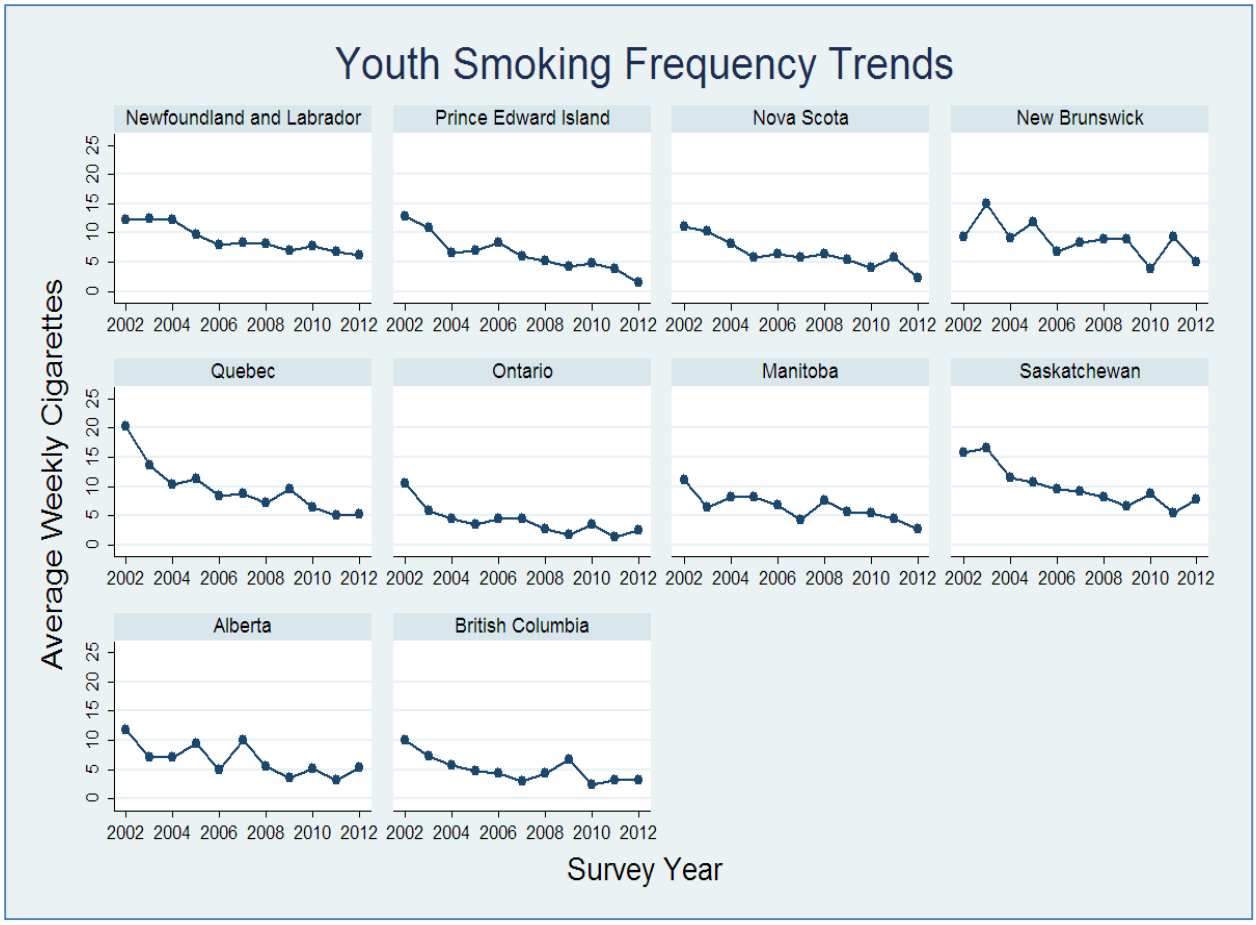
Appendix Figure 1. Histograms of past-week cigarette quantity by year



Appendix Figure 2. Histograms of past-week cigarette quantity by province.



Appendix Figure 3.Youth smoking prevalence trends based on ***Appendix Table 3****.*



Appendix Figure 4. Youth smoking frequency trends based on ***Appendix Table 4****.*

Appendix Table 5: Smoking Prevalence and Smoking Frequency, Ages 25 and Over

Year	Current Smoker		Past-week Smoker		Smoking Frequency	
	Proportion	**SE**	**Proportion**	**SE**	**Mean**	**SE**
2002	19.6	0.5	19.4	0.5	20.9	0.8
2003	19.2	0.7	18.7	0.7	19.2	0.8
2004	18.7	0.7	17.6	0.6	17.3	0.8
2005	17.3	0.6	16.9	0.6	17.5	0.9
2006	17.2	0.6	16.6	0.6	16.0	0.7
2007	17.9	0.6	17.5	0.6	17.5	0.7
2008	16.4	0.6	16.1	0.6	14.7	0.6
2009	16.6	0.6	16.1	0.6	14.4	0.6
2010	15.8	0.6	15.2	0.6	14.7	0.7
2011	16.5	0.7	16.2	0.7	15.0	0.7
2012	14.7	0.7	14.3	0.7	12.9	0.7

Note: Mean smoking frequency values are marginal effect estimates derived from a logistic-Poisson, two-part regression model with year fixed effects.

Appendix Table 6: Past-Week Smoking Prevalence by Education, Ages 25 and Over

Year	Less Than Secondary		Completed Secondary		Completed College		Completed University	
	Estimate	**SE**	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
2002	23.0	1.2	22.0	1.2	19.9	1.3	11.3	1.6
2003	21.4	1.6	21.7	1.0	19.6	1.8	11.5	1.2
2004	20.4	1.5	20.2	1.1	18.8	1.6	11.3	1.2
2005	19.7	1.9	20.7	1.1	18.4	1.5	9.6	0.9
2006	20.8	1.6	21.2	1.0	17.5	1.4	8.7	0.8
2007	19.6	1.5	21.5	1.1	18.3	1.3	10.8	0.9
2008	19.9	1.4	20.6	1.2	16.5	1.2	9.4	1.0
2009	23.9	1.7	21.7	1.1	14.4	1.2	8.0	0.8
2010	21.5	1.9	19.6	1.1	13.2	1.2	9.0	0.9
2011	24.1	1.9	20.1	1.3	18.2	1.5	7.8	0.9
2012	20.3	1.8	16.2	1.2	16.4	1.5	8.6	1.1

Note: Smoking prevalence values are marginal effect estimates derived from a logistic regression model with year, education, and their cross product terms as covariates.

Appendix Table 7: Mean Smoking Frequency by Education, Ages 25 and Over

Year	Less Than Secondary		Completed Secondary		Completed College		Completed University	
	Estimate	**SE**	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
2002	29.4	2.1	24.0	1.5	17.4	1.4	10.3	1.6
2003	25.5	2.1	22.9	1.3	18.8	1.9	9.2	1.2
2004	25.0	2.3	20.1	1.4	17.7	1.8	8.1	0.9
2005	24.0	3.0	22.9	1.6	17.1	1.7	7.2	0.9
2006	21.7	1.9	21.5	1.3	14.7	1.4	7.8	0.9
2007	23.5	2.0	21.5	1.4	16.8	1.3	9.7	0.9
2008	22.8	2.3	20.3	1.4	13.9	1.3	5.8	0.9
2009	25.5	2.0	20.6	1.2	11.2	1.1	5.5	0.6
2010	25.3	2.4	19.2	1.3	12.5	1.5	6.7	0.8
2011	27.8	2.6	19.0	1.5	15.7	1.5	5.3	0.6
2012	20.5	2.0	16.7	1.5	13.4	1.7	5.9	0.8

Note: Mean smoking frequency values are marginal effect estimates derived from a logistic-Poisson, two-part regression model with year, education, and their cross product terms as covariates.

Appendix Table 8: Past-week Smoking Prevalence Trends by Province, Ages 25 and Over

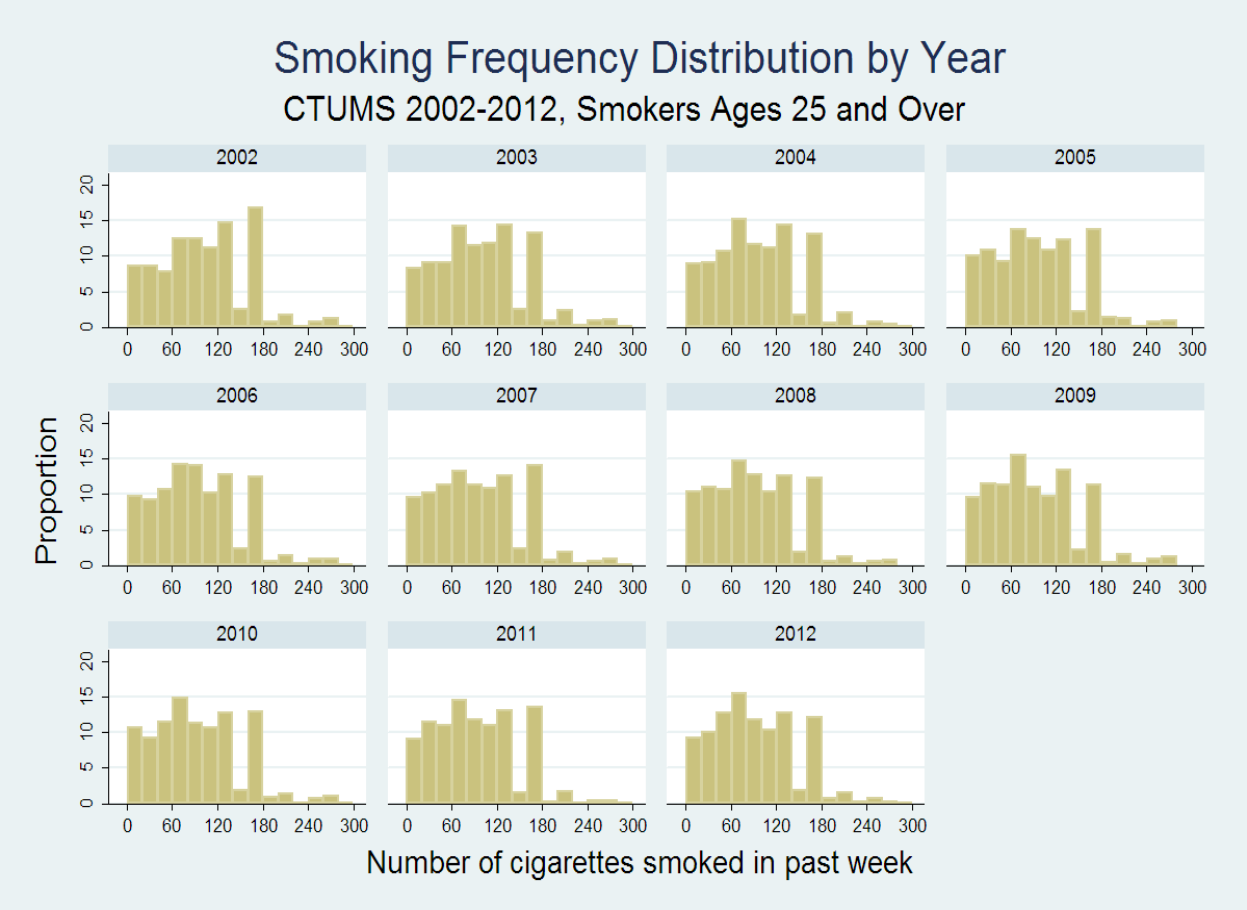
Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	22.1 (1.4)	21.0 (1.4)	19.6 (1.4)	17.6 (1.3)	18.9 (1.2)	19.0 (1.3)	19.4 (1.2)	18.4 (1.3)	18.4 (1.2)	18.2 (1.2)	18.8 (1.4)
Prince Edward Island	21.5 (1.9)	19.8 (1.3)	19.6 (1.3)	17.3 (1.3)	17.3 (1.2)	16.9 (1.2)	17.5 (1.1)	16.2 (1.1)	14.5 (1.1)	17.5 (1.2)	14.3 (1.3)
Nova Scotia	23.9 (1.5)	20.3 (1.4)	17.9 (1.3)	18.7 (1.3)	20.4 (1.4)	19.4 (1.2)	18.0 (1.2)	18.5 (1.3)	18.8 (1.3)	16.8 (1.2)	15.6 (1.1)
New Brunswick	19.7 (1.2)	23.4 (1.4)	22.4 (1.4)	19.6 (1.3)	20.5 (1.2)	20.1 (1.2)	18.3 (1.2)	20.0 (1.3)	16.6 (1.2)	17.2 (1.4)	15.8 (1.3)
Quebec	23.5 (1.2)	21.5 (1.4)	19.1 (1.3)	20.4 (1.4)	18.1 (1.1)	20.3 (1.3)	17.4 (1.2)	19.1 (1.3)	16.2 (1.2)	18.2 (1.2)	14.9 (1.3)
Ontario	17.7 (0.9)	18.1 (1.3)	16.7 (1.3)	15.2 (1.3)	14.5 (1.1)	16.6 (1.1)	15.0 (1.1)	14.0 (1.2)	13.8 (1.2)	15.4 (1.3)	14.1 (1.3)
Manitoba	17.5 (1.2)	17.7 (1.4)	18.5 (1.3)	19.4 (1.3)	18.0 (1.3)	16.5 (1.1)	19.6 (1.3)	16.6 (1.2)	19.2 (1.2)	16.1 (1.2)	15.5 (1.3)
Saskatchewan	17.6 (1.3)	21.2 (1.4)	19.9 (1.4)	18.2 (1.3)	21.0 (1.3)	21.3 (1.4)	18.0 (1.3)	19.5 (1.3)	19.4 (1.2)	16.1 (1.2)	14.8 (1.2)
Alberta	21.0 (1.5)	17.0 (1.4)	18.4 (1.1)	19.0 (0.9)	19.6 (1.4)	18.0 (1.3)	18.2 (1.2)	16.4 (1.2)	17.5 (1.3)	16.8 (1.4)	15.9 (1.5)
British Columbia	15.3 (1.2)	14.6 (1.1)	14.5 (1.1)	12.5 (1.1)	14.0 (1.2)	13.3 (1.1)	12.9 (1.1)	14.0 (1.3)	12.3 (1.2)	13.7 (1.5)	10.9 (1.2)

Note: Smoking prevalence values are marginal effect estimates derived from a logistic regression model with year, province, and their cross product terms as covariates. Standard errors are reported in parentheses.

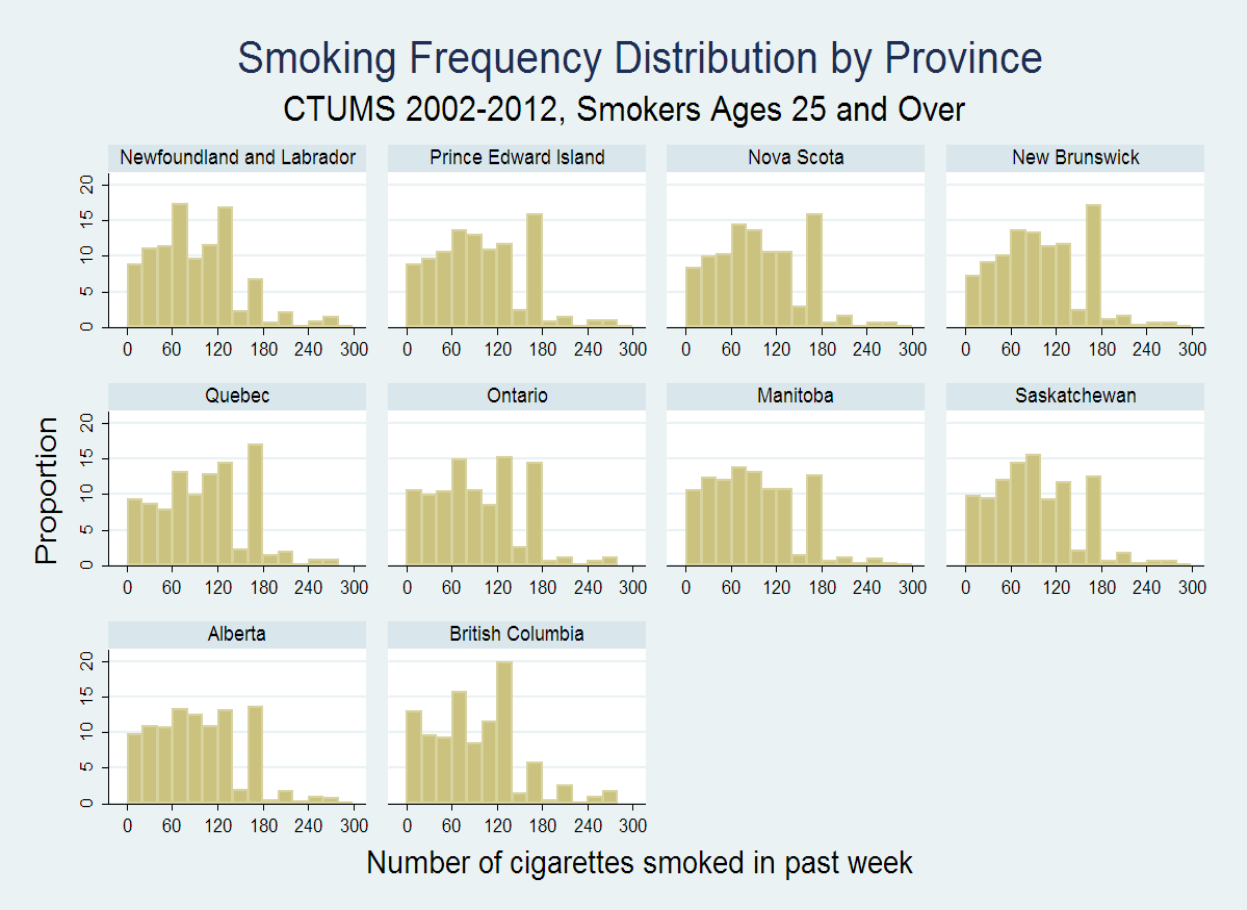
Appendix Table 9: Mean Smoking Frequency Trends by Province, Ages 25 and Over

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	23.7 (2.1)	21.4 (1.8)	17.8 (1.6)	17.7 (1.7)	19.2 (1.5)	16.8 (1.4)	17.2 (1.3)	18.1 (1.6)	17.0 (1.7)	15.8 (1.3)	18.6 (1.6)
Prince Edward Island	22.9 (1.9)	21.1 (1.7)	20.4 (1.6)	19.0 (1.7)	17.1 (1.3)	18.0 (1.6)	16.4 (1.2)	15.9 (1.4)	14.9 (1.4)	16.6 (1.4)	14.6 (1.7)
Nova Scotia	27.8 (2.3)	20.6 (1.6)	16.7 (1.4)	18.3 (1.5)	21.4 (1.9)	19.2 (1.4)	18.4 (1.5)	17.8 (1.6)	20.7 (1.7)	16.1 (1.3)	13.6 (1.2)
New Brunswick	21.5 (1.6)	25.3 (1.9)	25.2 (1.8)	21.7 (1.7)	20.5 (1.5)	22.5 (1.7)	18.3 (1.5)	20.9 (1.7)	18.8 (1.8)	17.6 (1.6)	15.8 (1.5)
Quebec	27.7 (1.8)	24.0 (1.8)	19.4 (1.5)	23.3 (1.9)	18.5 (1.3)	20.4 (1.5)	16.6 (1.3)	18.0 (1.4)	15.9 (1.4)	17.8 (1.5)	14.3 (1.4)
Ontario	18.0 (1.2)	17.8 (1.6)	16.5 (1.6)	15.7 (1.8)	13.1 (1.3)	16.7 (1.3)	13.4 (1.4)	12.3 (1.1)	13.3 (1.3)	13.8 (1.3)	12.6 (1.5)
Manitoba	18.3 (1.6)	17.0 (1.5)	18.7 (1.6)	17.1 (1.4)	16.0 (1.3)	15.2 (1.2)	16.2 (1.3)	13.3 (1.3)	16.4 (1.3)	14.2 (1.3)	13.4 (1.5)
Saskatchewan	18.1 (1.9)	23.3 (1.8)	18.0 (1.4)	17.7 (1.8)	19.1 (1.5)	19.6 (1.5)	16.8 (1.4)	18.1 (1.4)	18.5 (1.4)	15.4 (1.4)	13.8 (1.3)
Alberta	21.4 (1.9)	16.2 (1.6)	18.0 (1.4)	17.2 (1.0)	20.0 (1.6)	19.1 (1.7)	16.1 (1.3)	14.2 (1.3)	16.2 (1.5)	15.3 (1.3)	14.0 (1.5)
British Columbia	15.1 (1.5)	14.3 (1.4)	13.1 (1.3)	11.6 (1.4)	13.4 (1.3)	12.4 (1.2)	10.9 (1.2)	11.4 (1.2)	11.9 (1.5)	12.2 (1.7)	8.7 (1.2)

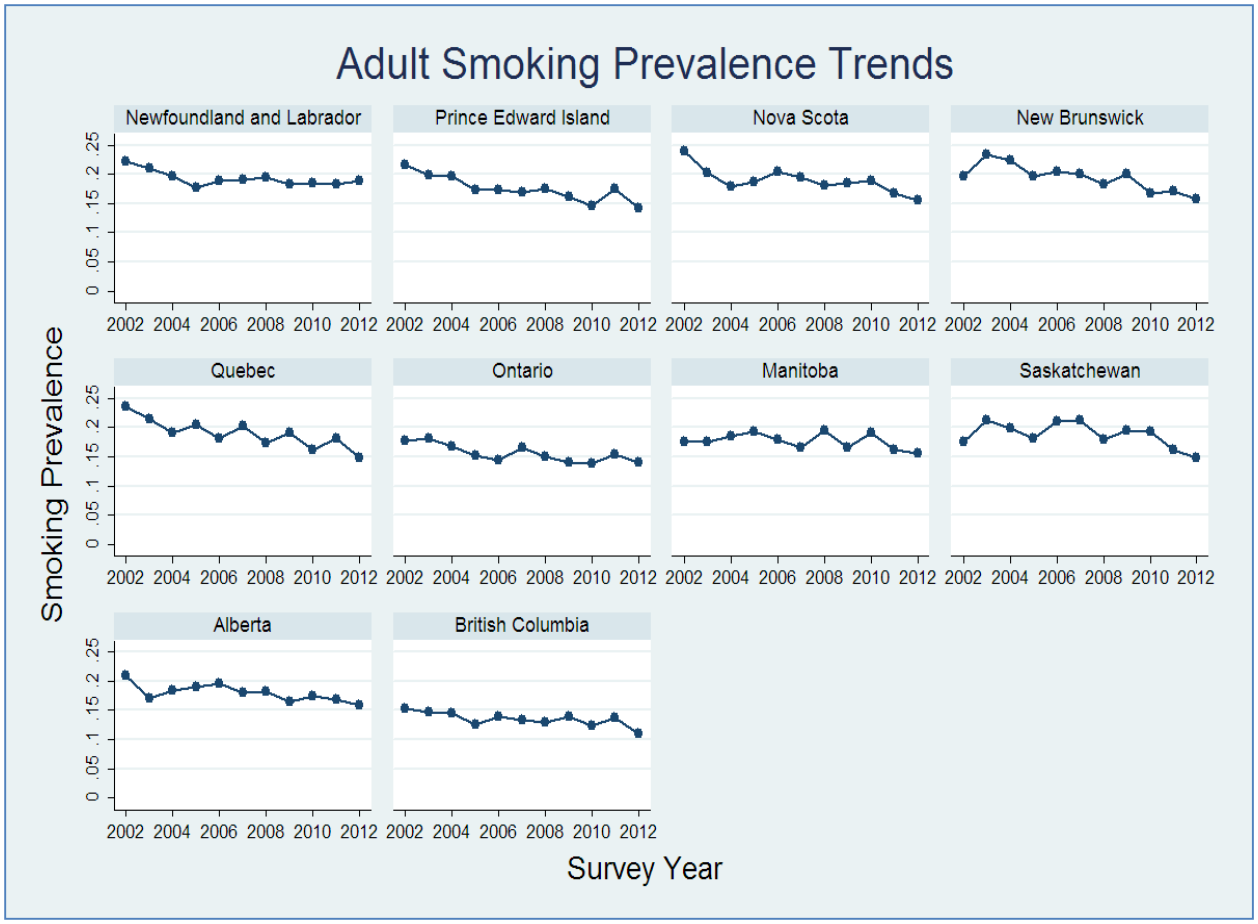
Note: Mean smoking frequency values are marginal effect estimates derived from a logistic-Poisson, two-part regression model with year, province, and their cross product terms as covariates. Standard errors are reported in parentheses.



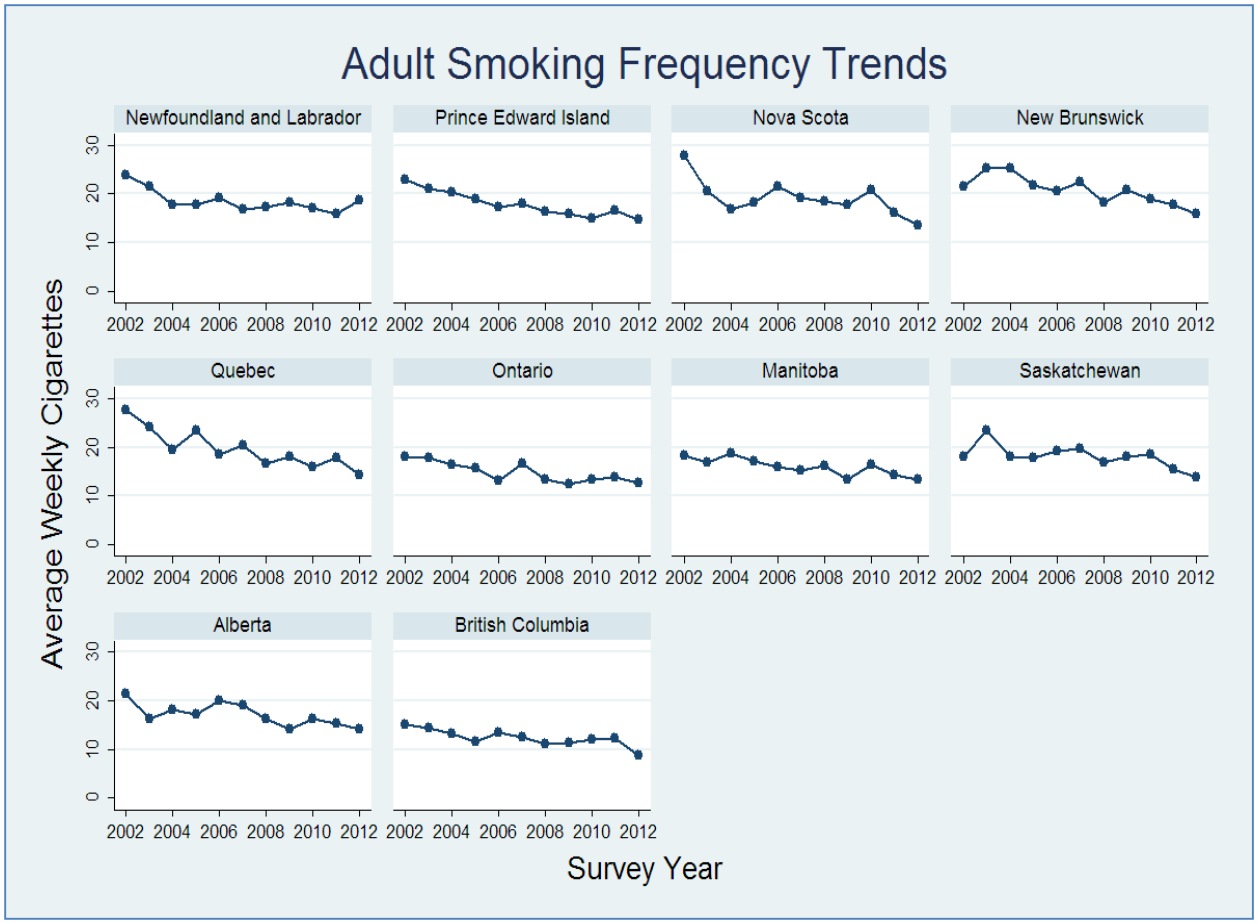
Appendix Figure 5. Histograms of past-week cigarette quantity by year



Appendix Figure 6. Histograms of past-week cigarette quantity by province.



Appendix Figure 7. Adult smoking prevalence trends by province based on ***Appendix Table 8****.*



Appendix Figure 8. Adult smoking frequency trends based on ***Appendix Table 9****.*

A-2 Excise Tobacco Taxes

Appendix Table 10: Federal and Provincial Cigarette Taxes per Carton of 200 Cigarettes

Province	Effective Date	Federal	Provincial	All Taxes
Newfoundland and Labrador	2002-01-01	$15.85	$22.00	$37.85
Newfoundland and Labrador	2002-03-22	$15.85	$27.00	$42.85
Newfoundland and Labrador	2003-03-27	$15.85	$30.00	$45.85
Newfoundland and Labrador	2004-03-31	$15.85	$32.00	$47.85
Newfoundland and Labrador	2005-03-22	$15.85	$34.00	$49.85
Newfoundland and Labrador	2006-03-31	$15.85	$36.00	$51.85
Newfoundland and Labrador	2006-07-01	$16.41	$36.00	$52.41
Newfoundland and Labrador	2008-01-01	$17.00	$36.00	$53.00
Newfoundland and Labrador	2010-03-30	$17.00	$38.00	$55.00
Prince Edward Island	2002-01-01	$15.85	$17.88	$33.73
Prince Edward Island	2002-03-26	$15.85	$22.88	$38.73
Prince Edward Island	2003-04-11	$15.85	$29.88	$45.73
Prince Edward Island	2004-03-31	$15.85	$34.90	$50.75
Prince Edward Island	2006-07-01	$16.41	$34.90	$51.31
Prince Edward Island	2008-01-01	$17.00	$34.90	$51.90
Prince Edward Island	2008-04-24	$17.00	$39.90	$56.90
Prince Edward Island	2009-04-17	$17.00	$44.90	$61.90
Prince Edward Island	2011-04-07	$17.00	$50.80	$67.80
Nova Scotia	2002-01-01	$15.85	$16.04	$31.89
Nova Scotia	2002-04-02	$15.85	$21.04	$36.89
Nova Scotia	2003-04-03	$15.85	$26.04	$41.89
Nova Scotia	2004-03-17	$15.85	$31.04	$46.89
Nova Scotia	2006-07-01	$16.41	$31.04	$47.45
Nova Scotia	2007-03-24	$16.41	$33.04	$49.45
Nova Scotia	2008-01-01	$17.00	$33.04	$50.04
Nova Scotia	2009-06-23	$17.00	$43.04	$60.04
New Brunswick	2002-01-01	$15.85	$19.50	$35.35
New Brunswick	2002-12-11	$15.85	$23.50	$39.35
New Brunswick	2006-07-01	$16.41	$23.50	$39.91
New Brunswick	2008-01-01	$17.00	$23.50	$40.50
New Brunswick	2011-03-23	$17.00	$34.00	$51.00
Quebec	2002-01-01	$15.85	$18.10	$33.95
Quebec	2004-03-20	$15.85	$20.60	$36.45
Quebec	2006-07-01	$16.41	$20.60	$37.01
Quebec	2008-01-01	$17.00	$20.60	$37.60
Quebec	2011-01-01	$17.00	$21.20	$38.20
Quebec	2012-01-01	$17.00	$21.80	$38.80
Quebec	2012-11-21	$17.00	$25.80	$42.80
Ontario	2002-01-01	$15.85	$12.20	$27.05
Ontario	2002-06-18	$15.85	$17.20	$33.05
Ontario	2004-05-19	$15.85	$22.20	$38.05
Ontario	2005-01-19	$15.85	$23.45	$39.30
Ontario	2006-02-01	$15.85	$24.70	$40.55
Ontario	2006-07-01	$16.41	$24.70	$41.11
Ontario	2008-01-01	$17.00	$24.70	$41.70

Appendix Table 10: Continued

Province	Effective Date	Federal	Provincial	All Taxes
Manitoba	2002-01-01	$15.85	$24.00	$39.85
Manitoba	2002-04-22	$15.85	$29.00	$44.85
Manitoba	2003-04-23	$15.85	$31.00	$46.85
Manitoba	2004-04-20	$15.85	$35.00	$50.85
Manitoba	2006-07-01	$16.41	$35.00	$51.41
Manitoba	2008-01-01	$17.00	$35.00	$52.00
Manitoba	2009-03-26	$17.00	$37.00	$54.00
Manitoba	2010-03-24	$17.00	$41.00	$58.00
Manitoba	2011-04-13	$17.00	$45.00	$62.00
Manitoba	2012-04-17	$17.00	$50.00	$67.00
Saskatchewan	2002-01-01	$15.85	$17.20	$33.05
Saskatchewan	2002-03-27	$15.85	$32.00	$47.85
Saskatchewan	2004-04-01	$15.85	$35.00	$50.85
Saskatchewan	2006-07-01	$16.41	$35.00	$51.41
Saskatchewan	2006-10-28	$16.41	$36.60	$52.41
Saskatchewan	2008-01-01	$17.00	$36.60	$53.60
Saskatchewan	2010-03-25	$17.00	$42.00	$59.00
Alberta	2002-01-01	$15.85	$14.00	$29.85
Alberta	2002-03-19	$15.85	$32.00	$47.85
Alberta	2006-07-01	$16.41	$32.00	$48.41
Alberta	2007-04-20	$16.41	$37.00	$53.41
Alberta	2008-01-01	$17.00	$37.00	$54.00
Alberta	2009-04-08	$17.00	$40.00	$57.00
British Columbia	2002-01-01	$15.85	$30.00	$45.85
British Columbia	2003-02-19	$15.85	$32.00	$47.85
British Columbia	2003-12-20	$15.85	$35.80	$51.65
British Columbia	2006-07-01	$16.41	$35.80	$52.21
British Columbia	2008-01-01	$17.00	$35.80	$52.80
British Columbia	2009-02-18	$17.00	$37.00	$54.00

A-3 Adjusting Federal and Provincial Cigarette Taxes by the CPI

To adjust (deflate) cigarette tax levels to year 2000 dollars, let T = Tax level, Y = Year, and CPI = Consumer Price Index, then the general cigarette tax inflation formula becomes,

$$T_Y = T_{2002} * CPI_Y$$

where T_{2002} = cigarette tax level in 2002 dollars. From the above, we can derive the following,

(a) $T_{2002} = T_Y / CPI_Y$, and

(b) $T_{2000} = T_{2002} * CPI_{2000}$

where T_{2000} = cigarette tax level in 2000 dollars. Combining the two, we have the following,

$$T_{2000} = (T_Y / CPI_Y) * CPI_{2000}$$

for Y = 2002-2012.

Appendix Table 11: Canadian Consumer Price Index (CPI) of General Goods (2002 Reference)

Province	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	96.6	100.0	102.9	104.8	107.6	109.5	111.1	114.3	114.6	117.4	121.4	123.9
Prince Edward Island	94.9	100.0	103.5	105.8	109.1	111.6	113.6	117.5	117.3	119.5	123.0	125.5
Nova Scotia	95.3	100.0	103.4	105.3	108.2	110.4	112.5	115.8	115.7	118.2	122.7	125.1
New Brunswick	95.1	100.0	103.4	104.9	107.4	109.2	111.3	113.2	113.5	115.9	120.0	122.0
Quebec	95.8	100.0	102.5	104.5	106.9	108.7	110.4	112.7	113.4	114.8	118.3	120.8
Ontario	95.1	100.0	102.6	104.6	106.9	108.8	110.8	113.3	113.7	116.5	120.1	121.8
Manitoba	95.9	100.0	101.8	103.8	106.6	108.7	110.9	113.4	114.1	115.0	118.4	120.3
Saskatchewan	94.4	100.0	102.3	104.6	106.9	109.1	112.2	115.9	117.1	118.7	122.0	123.9
Alberta	94.5	100.0	104.4	105.9	108.1	112.3	117.9	121.6	121.5	122.7	125.7	127.1
British Columbia	96.1	100.0	102.2	104.2	106.3	108.1	110.0	112.3	112.3	113.8	116.5	117.8
Canada	95.4	100.0	102.8	104.7	107.0	109.1	111.4	114.1	114.4	116.5	119.9	121.7

We initially considered two ways to adjust cigarette tax levels by the CPI as the effect of cigarette taxes/prices on smoking is sensitive to the choice of deflator (Godefroy Emmanuel Guindon, 2013). One way is to adjust the sum of federal and provincial cigarette tax levels at the time of interview (standardized by provincial CPI only). Another way is to first adjust tobacco tax components separately by federal and provincial indices, allowing for tax components to change differently within province (Azagba & Sharaf, 2011). Using these two approaches, the minimum and maximum differences for any pair of adjusted tax means (by province and year) were -$0.10 and $0.06 (per package of 20), respectively. Since both versions yielded very similar adjusted cigarette tax levels, we ultimately used Azagba & Sharaf's method of adjustment for all analyses.

Although we used the same method of adjustment, our calculations were generally more conservative. This discrepancy is most likely due to differences in the basket of goods for their CPI calculation. The eight major components of the CPI basket of goods in our study included food, shelter, household items, clothing & footwear, transportation, health & personal care, recreational & education items, and alcoholic & tobacco products (Statistics Canada, 2012). See **Appendix Table 11** for CPI values of general goods by year and province. Azagba & Sharaf do not report CPI values nor the components of their CPI. After scaling both measures to amounts per package of 20 cigarettes, our means of adjusted cigarette tax levels were similar to that of Azagba & Sharaf's Table 1 for years of overlap (2002, 2004, 2006 and 2008). See **Appendix Table 12** for a comparison of values for years of overlap. The minimum and maximum differences between our province-year means were -$0.37 and -$0.06, respectively. There is, however, a 99% correlation between the means of our cigarette tax measure and Azagba & Sharaf's measure.

Appendix Table 12: Comparison of Cigarette Tax Level Means Per Package of 20 (In Year 2000 Dollars)

Province	Year	Manivong et al.	Azagba & Sharaf	Difference
Newfoundland and Labrador	2002	4.03	3.82	0.21
Newfoundland and Labrador	2004	4.36	4.16	0.20
Newfoundland and Labrador	2006	4.56	4.33	0.23
Newfoundland and Labrador	2008	4.46	4.27	0.19
Prince Edward	2002	3.59	3.32	0.28
Prince Edward	2004	4.49	4.13	0.36
Prince Edward	2006	4.38	4.02	0.36
Prince Edward	2008	4.53	4.18	0.35
Nova Scotia	2002	3.39	3.24	0.15
Nova Scotia	2004	4.17	3.96	0.21
Nova Scotia	2006	4.09	3.87	0.21
Nova Scotia	2008	4.14	3.94	0.20
New Brunswick	2002	3.36	3.01	0.36
New Brunswick	2004	3.57	3.41	0.16
New Brunswick	2006	3.46	3.28	0.18
New Brunswick	2008	3.39	3.24	0.15
Quebec	2002	3.24	2.90	0.34
Quebec	2004	3.29	3.20	0.09
Quebec	2006	3.23	3.07	0.16
Quebec	2008	3.17	3.04	0.13
Ontario	2002	2.93	2.66	0.27
Ontario	2004	3.29	3.23	0.07
Ontario	2006	3.56	3.28	0.28
Ontario	2008	3.49	3.34	0.16
Manitoba	2002	4.16	3.81	0.35
Manitoba	2004	4.57	4.36	0.21
Manitoba	2006	4.50	4.28	0.22
Manitoba	2008	4.38	4.19	0.19
Saskatchewan	2002	4.28	4.01	0.27
Saskatchewan	2004	4.53	4.35	0.18
Saskatchewan	2006	4.46	4.25	0.21
Saskatchewan	2008	4.40	4.22	0.19
Alberta	2002	4.22	3.90	0.32
Alberta	2004	4.30	4.08	0.22
Alberta	2006	4.10	3.87	0.23
Alberta	2008	4.30	4.07	0.23
British Columbia	2002	4.39	4.13	0.26
British Columbia	2004	4.74	4.59	0.15
British Columbia	2006	4.59	4.42	0.17
British Columbia	2008	4.48	4.34	0.14

A-4 Assessing the Viability of Cigarette Taxes as a Policy Variable

In order to assess the amount of exogenous variation of cigarette taxes across Canada, we ran a linear regression model where the means of CPI-adjusted cigarette tax levels (by province and year) were the outcome, and province and year were included in the model as fixed effects The computed R-squared value was 0.88 indicating that about 88% of the variation in cigarette tax levels can be accounted for by differences in province and year. The corresponding variance inflation factor (VIF) was 8.3. (We calculated the VIF as the reciprocal of 1 – R-squared.) A VIF larger than 10 suggests that there may not be adequate within-province tax variation (DeCicca & McLeod, 2008). Thus, our study had sufficient exogenous within-province tax variation.

In order to evaluate the appropriateness of using changes in average cigarette price (ACP) to infer changes in taxes, we assessed the amount of variation of ACP explained by cigarette taxes with province and year fixed effects. We used two different sources for ACP. The first source was the Tobacco Use in Canada report which contained unadjusted ACP data for years 2006-2012. The second source was the Gospodinov & Irvine (2009) study which contained adjusted ACP data for years 2000-2005 (November 2001 dollars). We excluded the first two years as we did not have the corresponding tax data.

Since ACP data for years 2006-2012 was unadjusted, we used unadjusted tax levels (means) in our model. Since ACP data for years 2002-2005 was already adjusted, we used adjusted tax levels (means) in our model. For the earlier years, cigarette taxes accounted for over 99% of the variation in ACP, but only about 82% in later years. This discrepancy is most likely due to differences in their calculations of ACP. It is unclear for both sources the actual methodology used to calculate ACP with one already adjusted for inflation, which makes it difficult to combine ACP data and to compare results between these two sources.

A-5 Smoke-free Legislation

Appendix Table 13: Municipal Workplace and Public Place Smoke-free Legislation

Municipality	Province	Workplace	Public Place	Level	Effective Date	Policy Name
St. John's	NL	1	1	P	2005-06-01	Smoke-free Environment Act
Charlottetown	PE	1	1	P	2009-09-15	Smoke-free Places Act
Halifax	NS	1	1	P	2006-12-01	Smoke-free Places Act
Fredericton	NB	1	1	P	2004-10-01	Smoke-free Places Act
Montreal	QC	1	1	P	2006-05-31	Tobacco Act
Quebec City	QC	1	1	P	2006-05-31	Tobacco Act
Sherbrooke	QC	1	1	P	2006-05-31	Tobacco Act
Hamilton	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Kingston	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Kitchener-Waterloo	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
London	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Niagara	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Oshawa	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Ottawa	ON	0	1	M	2001-08-01	Public Places Bylaw
Ottawa	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Sudbury	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Toronto	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Windsor	ON	1	1	P	2006-05-31	Smoke-Free Ontario Act
Winnipeg	MB	1	1	P	2004-10-01	Non-Smokers' Health Protection Act
Regina	SK	1	1	P	1993-01-01	Occupational Health and Safety Regulations
Saskatoon	SK	1	1	P	1993-01-01	Occupational Health and Safety Regulations
Calgary	AB	1	1	P	2008-01-01	Smoke-Free Places (Tobacco Reduction) Amendment Act
Edmonton	AB	1	1	P	2008-01-01	Smoke-Free Places (Tobacco Reduction) Amendment Act
Surrey	BC	1	1	P	2008-03-31	Tobacco Act
Vancouver	BC	1	1	P	2008-03-31	Tobacco Act
Victoria	BC	1	1	P	2008-03-31	Tobacco Act

Appendix Table 14: Provincial Workplace and Public Place Smoke-free Legislation

Province	Effective Date	Policy Name
Newfoundland and Labrador	2005-06-01	Smoke-free Environment Act
Prince Edward Island	2009-09-15	Smoke-free Places Act
Nova Scotia	2006-12-01	Smoke-free Places Act
New Brunswick	2004-10-01	Smoke-free Places Act
Quebec	2006-05-31	Tobacco Act
Ontario	2006-05-31	Smoke-Free Ontario Act
Manitoba	2004-10-01	Non-Smokers' Health Protection
Saskatchewan	1993-01-01	Occupational Health and Safety
Alberta	2008-01-01	Smoke-Free Places (Tobacco
British Columbia	2008-03-31	Tobacco Act

A-6 Other Provincial Level Data

Appendix Table 15: Provincial Retail Tobacco Display Ban

Province	Effective Date	Notes
Newfoundland and Labrador	2010-01-01	
Prince Edward Island	2006-06-01	
Nova Scotia	2006-12-01	
New Brunswick	2009-01-01	
Quebec	2008-05-31	
Ontario	2008-05-31	
Manitoba	2005-08-25	
Saskatchewan	2002-10-01	Ban initially implemented
Saskatchewan	2004-03-01	Ban suspended
Saskatchewan	2005-01-15	Ban resumed
Alberta	2008-01-01	
British Columbia	2008-03-31	

Appendix Table 16: Means of Retail Sales Tax Rates (HST or GST + PST/QST)

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and	15.0	15.0	15.0	15.0	14.5	14.0	13.0	13.0	13.0	13.0	13.0
Prince Edward Island	17.0	17.0	17.0	17.0	16.5	16.0	15.0	15.0	15.0	15.0	15.0
Nova Scotia	15.0	15.0	15.0	15.0	14.5	14.0	13.0	13.0	13.9	15.0	15.0
New Brunswick	15.0	15.0	15.0	15.0	14.5	14.0	13.0	13.0	13.0	13.0	13.0
Quebec	14.5	14.5	14.5	14.5	14.0	13.5	12.5	12.5	12.5	13.5	14.5
Ontario	15.0	15.0	15.0	15.0	14.5	14.0	13.0	13.0	13.0	13.0	13.0
Manitoba	14.0	14.0	14.0	14.0	13.5	13.0	12.0	12.0	12.0	12.0	12.0
Saskatchewan	13.0	13.0	13.7	14.0	13.2	11.0	10.0	10.0	10.0	10.0	10.0
Alberta	7.0	7.0	7.0	7.0	6.5	6.0	5.0	5.0	5.0	5.0	5.0
British Columbia	14.5	14.5	14.4	14.0	13.5	13.0	12.0	12.0	12.0	12.0	12.0

Appendix Table 17: Unemployment Rate, Ages 15-19

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	23.5	24.0	25.2	24.5	23.2	19.7	21.1	25.7	24.6	23.7	21.8
Prince Edward Island	16.7	16.4	18.6	15.5	17.9	12.7	19.0	18.6	17.2	18.6	21.1
Nova Scotia	21.0	18.0	19.8	19.8	16.7	17.1	17.6	21.9	19.6	23.1	20.8
New Brunswick	17.6	18.4	18.9	17.0	18.4	13.6	15.3	17.5	19.8	21.3	22.7
Quebec	19.2	18.5	20.8	18.7	18.7	17.0	15.7	20.7	19.0	17.7	19.1
Ontario	17.8	19.8	18.8	18.6	18.2	16.8	18.4	22.3	22.9	22.2	23.8
Manitoba	12.8	12.4	15.0	12.4	13.6	13.0	13.3	14.9	15.7	16.9	16.9
Saskatchewan	14.3	13.7	14.3	12.4	10.8	10.9	11.0	12.9	12.1	14.6	13.5
Alberta	15.6	13.0	11.5	9.6	9.2	10.4	11.1	16.6	16.7	15.5	13.3
British Columbia	20.7	20.1	18.9	14.2	12.2	10.0	11.6	17.8	19.5	19.8	19.4

Appendix Table 18: Unemployment Rate, Ages 25 and Over

Province	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Newfoundland and Labrador	15.4	15.0	14.4	14.0	13.4	12.4	12.2	14.4	13.3	11.3	11.4
Prince Edward Island	11.2	10.2	10.0	9.5	10.3	9.5	9.5	10.8	10.2	10.5	9.9
Nova Scotia	7.9	7.7	7.5	7.1	6.7	6.9	6.5	7.6	8.0	7.4	7.3
New Brunswick	9.1	9.0	8.6	8.6	7.7	6.7	7.4	7.7	8.1	8.1	8.9
Quebec	7.7	8.2	7.4	7.3	7.1	6.3	6.3	7.2	6.9	6.7	6.7
Ontario	5.8	5.5	5.3	5.2	5.0	5.1	5.2	7.5	7.1	6.4	6.2
Manitoba	4.0	3.9	4.0	3.7	3.3	3.4	3.1	4.1	4.2	4.1	4.1
Saskatchewan	4.5	4.4	4.1	3.9	3.7	3.4	3.3	3.7	4.3	3.9	3.8
Alberta	4.1	4.2	3.8	3.2	2.7	2.7	2.8	5.4	5.5	4.5	3.8
British Columbia	7.2	6.8	5.9	5.0	4.1	3.6	3.9	6.6	6.5	6.3	5.6

A-7 Stata Code for Statistical Analyses

For data analyses, we first used the **SVYSET** Stata command for balanced repeated replicates (BRR) with the **FAY** option set to 0.7764 to indicate that each weight itself was an average based on 20 bootstrap samples, as recommended by Statistics Canada for use of their survey data (Statistics Canada, 2011). We used the **SVY** command to produce model estimates with bootstrap SEs and 95% CIs using.

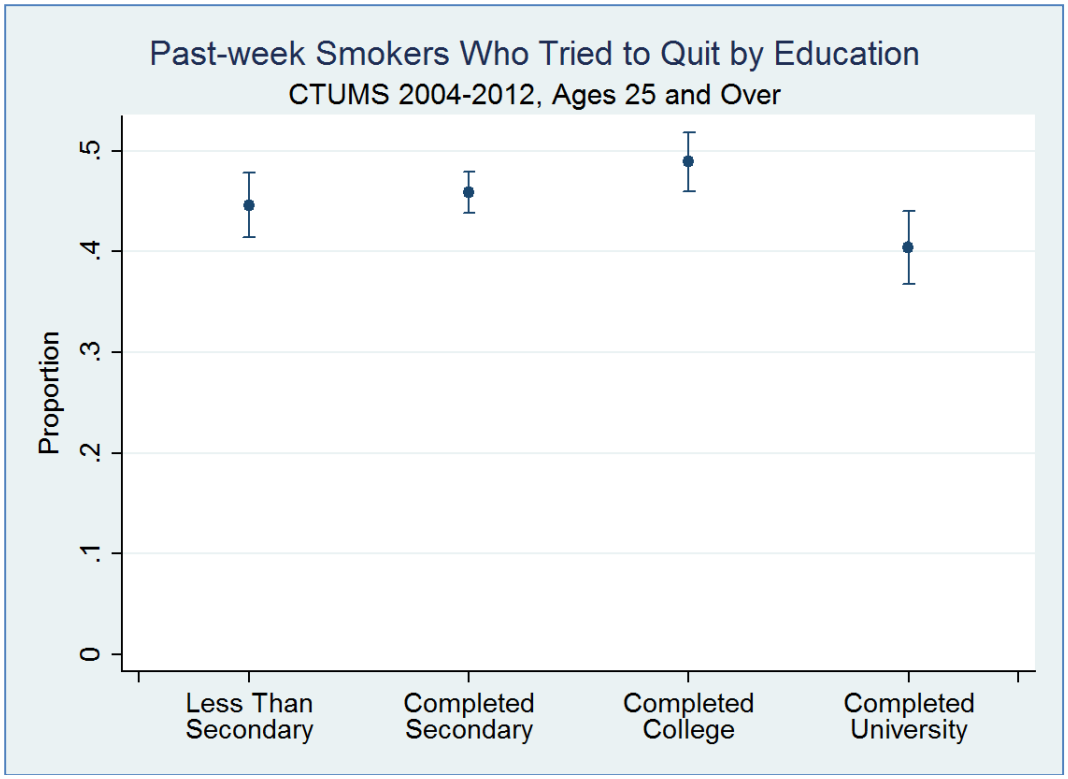
For logistic models we used the **LOGISTIC** command. For our logistic-Poisson two-part models we used the **TPM** command with the option **F(LOGIT) S(GLM, FAM(POISSON))**. Marginal effect estimates were derived using the **MARGINS** command, and for continuous variables such as cigarette taxes, we used the **DYDX** option. (Note, however, that using **MARGINS** after the **TPM** command will only produce values for predicted quantity.) Elasticity estimates were derived using the margins command with the **EYEX** option.

To calculate the Wald test of joint significance for the heterogeneous effect of taxes by education, we used the MARGINS command with the following option **AT(DVEDUC=(4 1 2 3) CONTRAST(ATCONTRAST(R._AT) WALD)** where DVEDUC is our categorical variable for education.

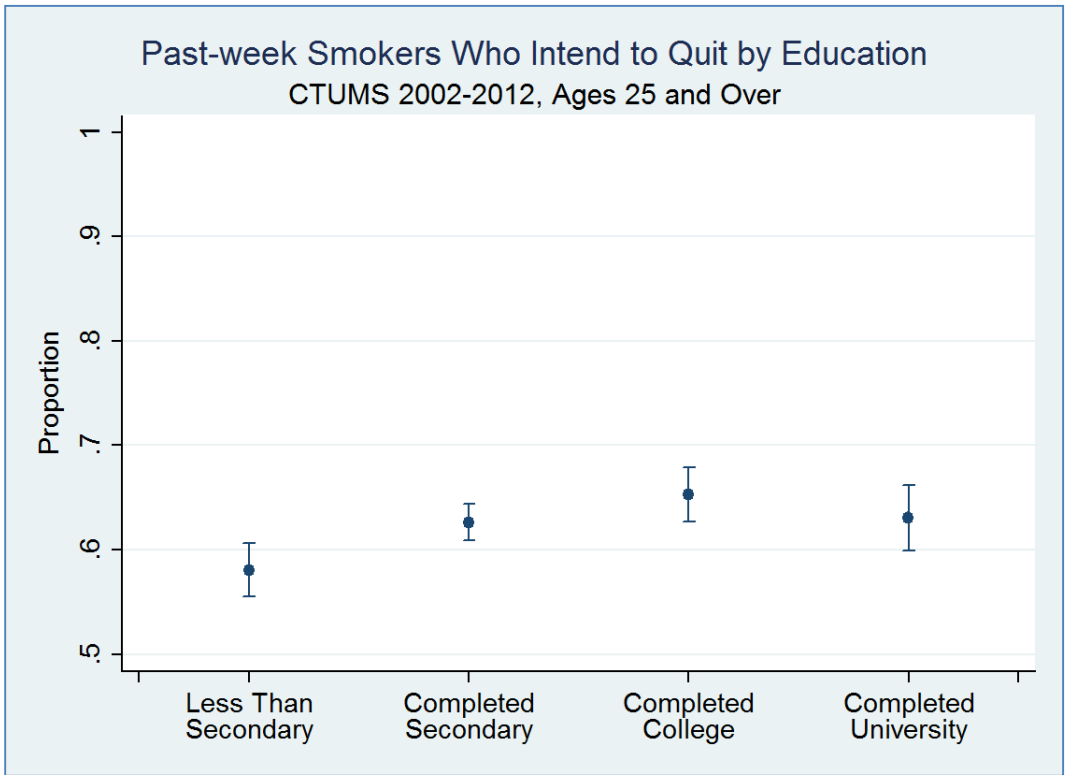
A-8 Assessment of Hardening Effect within Past-week Smokers

For prior quit attempts, we derived a binary variable based on a question regarding the number of attempts to quit for at least 24 hours within the past year. For those with non-missing data, we assigned 1 if the number of quit attempts was 1 or greater, and 0 otherwise. (We only used survey years 2004 and after because coverage for this question was different for years prior to 2004.) A binary variable for intention to quit in the immediate future was based on the intention to quit within the next 6 months. We defined a long-term smoker as someone who smoked daily for at least 5 years. (Data on the age when survey participants started smoking daily was available only for years 2004 and after.) The total sample size of past-week smokers for 2004-2012 was 16,481. The sample size was 15,279 where data on all these components were available. There was about 7.3% with missing data. Among them, however, the distribution of education was similar to that of the overall adults CTUMS sample.

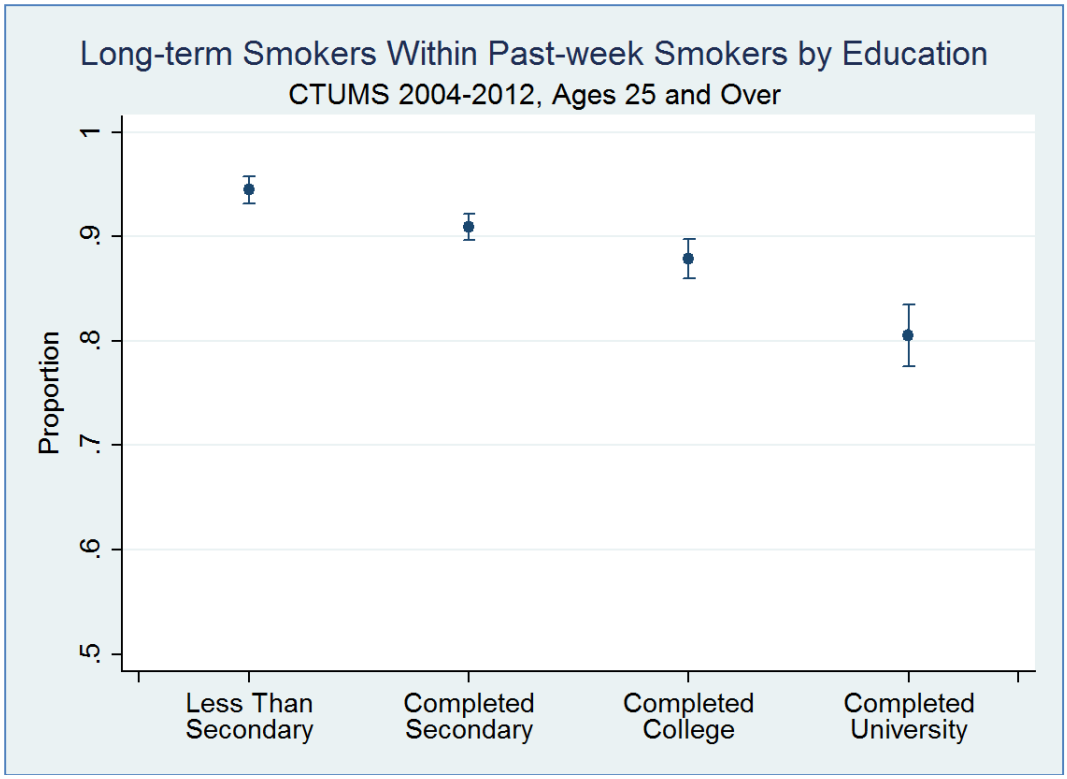
We modelled hardcore smoker and each of its components using logistic regression with individual-level covariates as described in *Model 1* in Section 4-2. We then derived marginal estimates for the proportion of each hardcore smoker component by education. See **Appendix Figure 9** - **Appendix Figure 11** for figures of these proportions by education.



Appendix Figure 9. Marginal estimates for the proportion of past-week smokers who attempted to quit within the past year by education.



Appendix Figure 10. Marginal estimates for the proportion of past-week smokers who intend to quit within the next 6 months by education.



Appendix Figure 11. Marginal estimates for the proportion of long-term smokers by education.

A-9 Other Marginal Estimates From Survey-weighted Regression Models

Appendix Table 19: Marginal Estimates from Models Assessing Taxes on Smoking Prevalence, Ages 15-18

Variable	Model 1			Model 2			Model 3		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-2.8%	-4.3%	-1.4%	-2.5%	-3.8%	-1.1%	-2.8%	-4.9%	-0.7%
Nova Scotia	-2.3%	-3.9%	-0.7%	-2.1%	-3.6%	-0.7%	-2.3%	-4.0%	-0.5%
New Brunswick	-0.8%	-3.3%	1.7%	-1.2%	-3.6%	1.2%	-1.1%	-3.8%	1.6%
Quebec	2.9%	-0.5%	6.4%	3.1%	-0.9%	7.0%	3.1%	-1.0%	7.2%
Ontario	-4.5%	-7.1%	-1.9%	-3.3%	-5.8%	-0.9%	-3.3%	-5.9%	-0.7%
Manitoba	0.7%	-0.8%	2.3%	0.5%	-1.0%	2.0%	0.5%	-2.8%	3.7%
Saskatchewan	5.0%	3.1%	6.9%	4.2%	2.5%	5.9%	4.6%	0.1%	9.1%
Alberta	-1.5%	-3.1%	0.1%	-1.4%	-2.9%	0.0%	-1.7%	-4.8%	1.4%
British Columbia	-4.0%	-5.4%	-2.6%	-3.2%	-4.5%	-1.9%	-3.4%	-5.6%	-1.2%
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-4.6%	-7.1%	-2.1%	-4.9%	-7.2%	-2.5%	-4.7%	-7.1%	-2.3%
2004	-4.9%	-7.7%	-2.2%	-4.7%	-7.4%	-1.9%	-4.5%	-7.2%	-1.9%
2005	-5.1%	-7.6%	-2.6%	-5.1%	-7.7%	-2.6%	-4.9%	-7.7%	-2.2%
2006	-7.9%	-10.4%	-5.5%	-7.6%	-9.9%	-5.2%	-6.9%	-9.9%	-4.0%
2007	-6.7%	-9.1%	-4.3%	-6.5%	-8.8%	-4.1%	-5.6%	-8.9%	-2.3%
2008	-9.4%	-11.8%	-7.1%	-9.0%	-11.3%	-6.8%	-8.1%	-11.4%	-4.7%
2009	-9.5%	-11.8%	-7.2%	-9.1%	-11.4%	-6.9%	-8.1%	-11.3%	-4.8%
2010	-9.9%	-12.2%	-7.6%	-9.6%	-11.9%	-7.3%	-8.6%	-11.9%	-5.4%
2011	-11.3%	-13.4%	-9.1%	-10.6%	-12.8%	-8.4%	-9.6%	-12.7%	-6.5%
2012	-11.2%	-13.3%	-9.0%	-10.6%	-12.7%	-8.5%	-9.6%	-12.7%	-6.5%
Age (Years)									
15				*Reference*			*Reference*		
16				2.6%	1.6%	3.6%	2.6%	1.6%	3.6%
17				7.0%	5.9%	8.2%	7.0%	5.9%	8.2%
18				13.6%	11.8%	15.4%	13.6%	11.8%	15.4%
Male				-0.2%	-1.1%	0.8%	-0.2%	-1.1%	0.8%
Education-Student Status									
No H.S. & not current student				*Reference*			*Reference*		
No H.S. & current student				-18.0%	-20.7%	-15.3%	-18.0%	-20.7%	-15.3%
H.S. grad & not current student				-17.8%	-20.8%	-14.8%	-17.8%	-20.8%	-14.8%
H.S. grad & current student				-23.2%	-25.9%	-20.5%	-23.2%	-25.9%	-20.5%
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				0.8%	-1.4%	3.0%	0.8%	-1.4%	3.0%
English and French				5.5%	-1.1%	12.0%	5.4%	-1.1%	12.0%
Other				-3.5%	-5.1%	-1.9%	-3.5%	-5.1%	-1.9%
Household Size									
1				*Reference*			*Reference*		
2				3.9%	-0.3%	8.1%	3.9%	-0.3%	8.1%
3				0.3%	-3.9%	4.4%	0.3%	-3.9%	4.4%
4				-1.7%	-5.8%	2.4%	-1.7%	-5.8%	2.4%
5 or more				-2.4%	-6.5%	1.7%	-2.4%	-6.5%	1.7%
Unemployment Rate (15-19)							0.0%	-0.3%	0.3%
Provincial Smoke-free Law							0.0%	-2.8%	1.0%
Provincial Tobacco Display Ban							-0.9%	-1.7%	1.7%

Appendix Table 20: Marginal Estimates from Models Assessing Taxes on Smoking Frequency, Ages 15-18

Variable	Model 1			Model 2			Model 3		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-2.5	-3.9	-1.1	-2.0	-3.2	-0.8	-2.7	-4.8	-0.5
Nova Scotia	-2.5	-4.1	-0.9	-2.1	-3.4	-0.7	-2.5	-4.2	-0.8
New Brunswick	-0.1	-2.6	2.3	-0.6	-2.7	1.6	-0.7	-3.2	1.8
Quebec	0.5	-2.4	3.4	1.0	-2.0	4.1	0.9	-2.3	4.2
Ontario	-4.9	-7.2	-2.7	-3.6	-5.6	-1.6	-3.9	-6.2	-1.6
Manitoba	-2.5	-3.8	-1.2	-2.3	-3.5	-1.1	-2.9	-5.7	-0.2
Saskatchewan	1.1	-0.3	2.5	0.8	-0.4	2.1	-0.1	-3.8	3.6
Alberta	-2.3	-3.8	-0.9	-2.0	-3.2	-0.7	-2.6	-5.4	0.3
British Columbia	-4.0	-5.3	-2.7	-3.1	-4.3	-1.9	-3.6	-5.7	-1.4
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-4.3	-6.4	-2.2	-4.6	-6.6	-2.6	-4.8	-7.0	-2.7
2004	-6.0	-8.1	-3.8	-5.8	-7.8	-3.8	-5.9	-8.2	-3.7
2005	-6.1	-8.1	-4.1	-6.3	-8.2	-4.3	-6.5	-9.0	-4.1
2006	-7.1	-9.1	-5.2	-7.3	-9.2	-5.3	-7.4	-10.1	-4.7
2007	-6.8	-8.7	-4.8	-6.9	-8.8	-4.9	-6.9	-10.0	-3.9
2008	-8.1	-10.0	-6.2	-8.1	-10.0	-6.2	-8.4	-11.5	-5.3
2009	-8.0	-10.0	-6.0	-8.1	-10.0	-6.2	-8.5	-11.4	-5.6
2010	-8.3	-10.3	-6.3	-8.4	-10.4	-6.4	-8.8	-11.8	-5.8
2011	-9.7	-11.4	-7.9	-9.5	-11.2	-7.7	-9.8	-12.6	-7.1
2012	-9.2	-11.2	-7.2	-8.9	-10.9	-7.0	-9.3	-12.2	-6.4
Age (Years)									
15				*Reference*			*Reference*		
16				1.3	0.8	1.9	1.3	0.8	1.9
17				4.7	3.9	5.6	4.7	3.9	5.6
18				9.2	7.5	10.9	9.2	7.5	10.9
Male				0.7	0.0	1.4	0.7	0.0	1.4
Education-Student Status									
No H.S. & not current student				*Reference*			*Reference*		
No H.S. & current student				-16.0	-18.4	-13.6	-16.0	-18.4	-13.6
H.S. grad & not current student				-15.5	-18.2	-12.8	-15.5	-18.2	-12.8
H.S. grad & current student				-19.6	-22.0	-17.2	-19.6	-22.0	-17.2
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				0.4	-1.0	1.8	0.4	-1.0	1.8
English and French				5.2	-0.2	10.7	5.2	-0.2	10.7
Other				-3.2	-4.1	-2.2	-3.2	-4.1	-2.2
Household Size									
1				*Reference*			*Reference*		
2				1.8	-1.9	5.5	1.8	-1.9	5.5
3				-1.4	-5.0	2.2	-1.4	-5.0	2.2
4				-2.9	-6.5	0.6	-2.9	-6.5	0.6
5 or more				-3.6	-7.1	0.0	-3.6	-7.2	0.0
Unemployment Rate (15-19)							0.0	0.7827	-0.3
Provincial Smoke-free Law							-0.5	0.5476	-2.0
Provincial Tobacco Display Ban							0.8	0.2676	-0.6

Appendix Table 21: Marginal Estimates from Models Assessing the Average Effect of Taxes on Smoking Prevalence, Ages 25 and Over

Variable	Model 1			Model 2			Model 3		
	Estimate	95% C.I.		Estimate	95% C.I.		Estimate	95% C.I.	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-1.7%	-2.7%	-0.7%	-0.6%	-1.5%	0.3%	-1.3%	-4.0%	1.4%
Nova Scotia	-0.4%	-1.5%	0.8%	0.9%	-0.1%	1.9%	-0.1%	-4.4%	4.2%
New Brunswick	-0.2%	-2.1%	1.7%	1.3%	-0.5%	3.0%	0.6%	-3.2%	4.4%
Quebec	-0.8%	-3.1%	1.5%	3.4%	0.7%	6.2%	2.7%	-2.0%	7.4%
Ontario	-4.1%	-6.1%	-2.2%	-0.6%	-2.5%	1.2%	-1.6%	-6.9%	3.7%
Manitoba	-1.4%	-2.5%	-0.3%	-0.1%	-1.1%	1.0%	-1.7%	-8.5%	5.0%
Saskatchewan	-0.4%	-1.5%	0.7%	0.7%	-0.3%	1.7%	-1.1%	-8.0%	5.7%
Alberta	-1.3%	-2.4%	-0.1%	0.6%	-0.4%	1.6%	-0.8%	-7.3%	5.8%
British Columbia	-5.8%	-6.9%	-4.6%	-2.7%	-3.7%	-1.6%	-3.8%	-9.3%	1.7%
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-0.7%	-2.4%	1.0%	-0.2%	-1.9%	1.4%	-0.3%	-2.0%	1.4%
2004	-1.7%	-3.5%	0.0%	-0.6%	-2.3%	1.0%	-0.8%	-2.5%	1.0%
2005	-2.3%	-4.1%	-0.5%	-0.6%	-2.4%	1.1%	-0.8%	-2.8%	1.1%
2006	-2.7%	-4.3%	-1.1%	-1.0%	-2.5%	0.6%	-1.3%	-3.3%	0.8%
2007	-1.8%	-3.4%	-0.1%	-0.1%	-1.7%	1.6%	-0.4%	-2.9%	2.0%
2008	-3.2%	-4.7%	-1.6%	-1.0%	-2.5%	0.5%	-1.9%	-4.3%	0.5%
2009	-3.2%	-4.9%	-1.5%	-0.9%	-2.6%	0.8%	-1.8%	-4.3%	0.6%
2010	-4.1%	-5.7%	-2.4%	-1.9%	-3.5%	-0.2%	-2.9%	-5.3%	-0.4%
2011	-3.1%	-4.9%	-1.4%	-0.4%	-2.1%	1.4%	-1.4%	-4.0%	1.2%
2012	-5.0%	-6.7%	-3.4%	-2.2%	-3.9%	-0.4%	-3.2%	-5.8%	-0.6%
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				18.5%	17.0%	20.0%	18.5%	17.0%	20.0%
Completed college				11.3%	10.4%	12.2%	11.3%	10.4%	12.2%
Completed university				6.5%	5.6%	7.3%	6.5%	5.6%	7.3%
Age Group									
25-34				*Reference*			*Reference*		
35-44				-1.5%	-3.0%	0.0%	-1.5%	-3.0%	0.0%
45-54				-4.0%	-5.4%	-2.6%	-4.0%	-5.4%	-2.6%
55-64				-9.5%	-11.0%	-8.0%	-9.5%	-11.0%	-8.0%
65+				-18.3%	-19.6%	-17.0%	-18.3%	-19.6%	-17.0%
Male				4.2%	3.4%	4.9%	4.2%	3.4%	4.9%
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				10.6%	9.3%	11.9%	10.6%	9.3%	11.9%
Single				7.5%	6.1%	8.9%	7.5%	6.1%	8.9%
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-3.1%	-4.6%	-1.5%	-3.1%	-4.6%	-1.5%
English and French				-1.6%	-5.9%	2.6%	-1.6%	-5.9%	2.6%
Other				-8.0%	-9.2%	-6.7%	-7.9%	-9.2%	-6.7%
Household Size									
1				*Reference*			*Reference*		
2				1.4%	0.3%	2.4%	1.4%	0.3%	2.4%
3				0.9%	-0.4%	2.1%	0.9%	-0.4%	2.1%
4				-0.5%	-1.9%	0.9%	-0.5%	-1.9%	0.9%
5 or more				-1.6%	-3.0%	-0.1%	-1.6%	-3.0%	-0.1%
Unemployment Rate (25+)							-0.1%	-0.8%	0.5%
Provincial Smoke-free Law							0.1%	-1.3%	1.4%
Provincial Tobacco Display Ban							0.9%	-0.6%	2.4%

Appendix Table 22: Marginal Estimates from Models Assessing Average Effect of Taxes on Smoking Frequency, Ages 25 and Over

Variable	Model 1			Model 2			Model 3		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	0.1	-1.2	1.4	0.3	-0.9	1.4	0.8	-1.6	3.2
Nova Scotia	1.8	0.5	3.1	1.8	0.5	3.0	3.1	-0.8	7.1
New Brunswick	2.1	0.2	3.9	2.7	0.9	4.5	3.9	0.5	7.2
Quebec	2.0	-0.5	4.5	4.0	1.0	7.0	5.3	0.8	9.8
Ontario	-1.6	-3.7	0.5	0.4	-1.7	2.4	2.2	-2.9	7.3
Manitoba	-1.3	-2.5	0.0	-0.6	-1.8	0.6	1.9	-5.1	8.9
Saskatchewan	0.3	-1.0	1.5	0.8	-0.3	2.0	3.5	-3.8	10.9
Alberta	0.7	-0.5	2.0	1.1	-0.1	2.3	3.6	-3.2	10.3
British Columbia	-4.1	-5.4	-2.8	-2.7	-4.0	-1.4	-0.8	-6.2	4.6
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-1.0	-3.2	1.2	-1.1	-3.4	1.1	-1.1	-3.3	1.1
2004	-2.5	-4.5	-0.4	-2.1	-4.2	0.0	-1.8	-4.0	0.3
2005	-2.0	-4.2	0.2	-1.3	-3.6	1.0	-1.0	-3.4	1.5
2006	-3.2	-5.2	-1.2	-2.7	-4.8	-0.7	-2.0	-4.6	0.6
2007	-1.9	-3.9	0.1	-1.5	-3.7	0.6	-0.5	-3.6	2.6
2008	-4.1	-6.0	-2.3	-3.7	-5.6	-1.8	-2.8	-5.8	0.3
2009	-4.4	-6.3	-2.4	-3.7	-5.7	-1.6	-3.4	-6.1	-0.6
2010	-4.2	-6.1	-2.2	-3.7	-5.8	-1.6	-3.4	-6.4	-0.4
2011	-3.7	-5.7	-1.6	-2.4	-4.7	-0.2	-1.9	-5.2	1.3
2012	-5.8	-7.8	-3.8	-4.8	-6.9	-2.8	-4.3	-7.4	-1.2
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				24.3	22.1	26.4	24.3	22.1	26.4
Completed college				13.4	12.4	14.4	13.4	12.4	14.4
Completed university				6.9	6.0	7.8	6.9	6.0	7.8
Age Group									
25-34				*Reference*			*Reference*		
35-44				2.8	1.2	4.4	2.8	1.3	4.4
45-54				2.6	1.0	4.3	2.6	1.0	4.3
55-64				-3.9	-5.7	-2.1	-3.9	-5.7	-2.1
65+				-14.2	-15.6	-12.8	-14.2	-15.5	-12.8
Male				7.6	6.7	8.5	7.6	6.7	8.5
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				11.1	9.4	12.9	11.1	9.4	12.9
Single				7.9	6.4	9.4	7.9	6.4	9.5
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-2.0	-3.7	-0.2	-2.0	-3.8	-0.2
English and French				-2.1	-6.8	2.7	-2.1	-6.8	2.7
Other				-10.6	-11.9	-9.3	-10.6	-11.9	-9.3
Household Size									
1				*Reference*			*Reference*		
2				0.4	-0.9	1.7	0.4	-0.9	1.7
3				-0.4	-1.9	1.1	-0.4	-1.9	1.1
4				-1.9	-3.7	-0.2	-1.9	-3.7	-0.2
5 or more				-3.1	-4.9	-1.4	-3.1	-4.9	-1.4
Unemployment Rate (25+)							0.3	-0.5	1.1
Provincial Smoke-free Law							-0.7	-2.3	1.0
Provincial Tobacco Display Ban							0.3	-1.4	2.0

Appendix Table 23: Marginal Estimates from Models Assessing Heterogeneous Effects of Taxes on Smoking Prevalence by Education

Variable	Model 1			Model 2			Model 3		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-1.4%	-2.4%	-0.4%	-1.0%	-1.9%	0.0%	-1.2%	-3.8%	1.4%
Nova Scotia	0.3%	-0.8%	1.5%	0.6%	-0.4%	1.7%	0.5%	-3.7%	4.7%
New Brunswick	-0.3%	-2.2%	1.6%	0.8%	-1.0%	2.6%	0.9%	-2.8%	4.6%
Quebec	-0.1%	-2.4%	2.3%	3.1%	0.3%	5.9%	3.1%	-1.5%	7.8%
Ontario	-2.8%	-4.8%	-0.7%	-0.9%	-2.8%	1.0%	-0.8%	-6.1%	4.4%
Manitoba	-0.9%	-2.0%	0.3%	-0.3%	-1.4%	0.7%	-0.5%	-7.2%	6.2%
Saskatchewan	-0.3%	-1.4%	0.9%	0.3%	-0.7%	1.4%	0.0%	-6.8%	6.8%
Alberta	0.0%	-1.2%	1.2%	0.3%	-0.8%	1.4%	0.4%	-6.0%	6.9%
British Columbia	-4.5%	-5.7%	-3.3%	-2.9%	-4.0%	-1.8%	-2.8%	-8.2%	2.5%
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-0.4%	-2.0%	1.2%	-0.2%	-1.8%	1.4%	-0.2%	-1.9%	1.4%
2004	-1.1%	-2.8%	0.6%	-0.6%	-2.3%	1.0%	-0.6%	-2.4%	1.1%
2005	-1.6%	-3.3%	0.2%	-0.7%	-2.4%	1.1%	-0.7%	-2.6%	1.2%
2006	-1.7%	-3.3%	-0.1%	-1.0%	-2.6%	0.5%	-1.1%	-3.1%	0.9%
2007	-1.0%	-2.6%	0.7%	-0.1%	-1.7%	1.5%	-0.2%	-2.6%	2.3%
2008	-2.0%	-3.6%	-0.5%	-1.1%	-2.6%	0.4%	-1.7%	-4.1%	0.8%
2009	-1.9%	-3.6%	-0.2%	-0.8%	-2.5%	0.9%	-1.8%	-4.2%	0.7%
2010	-3.0%	-4.6%	-1.3%	-1.9%	-3.5%	-0.3%	-2.9%	-5.3%	-0.4%
2011	-1.8%	-3.5%	0.0%	-0.3%	-2.1%	1.4%	-1.3%	-3.9%	1.3%
2012	-3.8%	-5.5%	-2.1%	-2.3%	-4.0%	-0.6%	-3.2%	-5.8%	-0.6%
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				19.2%	17.5%	20.8%	19.2%	17.5%	20.8%
Completed college				11.3%	10.4%	12.2%	11.3%	10.4%	12.2%
Completed university				6.5%	5.7%	7.4%	6.5%	5.7%	7.3%
Age Group									
25-34				*Reference*			*Reference*		
35-44				-1.6%	-3.1%	-0.1%	-1.6%	-3.1%	-0.1%
45-54				-4.0%	-5.5%	-2.6%	-4.0%	-5.5%	-2.6%
55-64				-9.5%	-11.0%	-8.0%	-9.5%	-11.0%	-8.0%
65+				-18.3%	-19.6%	-17.1%	-18.3%	-19.6%	-17.1%
Male				4.1%	3.4%	4.9%	4.1%	3.4%	4.9%
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				10.6%	9.2%	11.9%	10.6%	9.2%	11.9%
Single				7.4%	6.0%	8.9%	7.4%	6.0%	8.8%
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-2.9%	-4.4%	-1.4%	-2.9%	-4.4%	-1.4%
English and French				-1.6%	-5.9%	2.6%	-1.6%	-5.9%	2.6%
Other				-8.0%	-9.3%	-6.7%	-8.0%	-9.2%	-6.7%
Household Size									
1				*Reference*			*Reference*		
2				1.3%	0.2%	2.4%	1.3%	0.2%	2.4%
3				0.9%	-0.4%	2.1%	0.9%	-0.4%	2.1%
4				-0.4%	-1.9%	1.0%	-0.5%	-1.9%	1.0%
5 or more				-1.6%	-3.0%	-0.1%	-1.6%	-3.0%	-0.1%
Unemployment Rate (25+)							0.0%	-0.7%	0.7%
Provincial Smoke-free Law							0.0%	-1.3%	1.3%
Provincial Tobacco Display Ban							1.0%	-0.6%	2.5%

Appendix Table 24: Marginal Estimates from Models Assessing Heterogeneous Effects of Taxes on Smoking Frequency by Education

Variable	Model 1			Model 2			Model 3		
	Estimate	95% C.I.		Estimate	95% C.I.		Estimate	95% C.I.	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	0.1	-1.2	1.4	0.3	-0.9	1.4	0.8	-1.6	3.2
Nova Scotia	1.8	0.5	3.1	1.8	0.5	3.0	3.1	-0.8	7.1
New Brunswick	2.1	0.2	3.9	2.7	0.9	4.5	3.9	0.5	7.2
Quebec	2.0	-0.5	4.5	4.0	1.0	7.0	5.3	0.8	9.8
Ontario	-1.6	-3.7	0.5	0.4	-1.7	2.4	2.2	-2.9	7.3
Manitoba	-1.3	-2.5	0.0	-0.6	-1.8	0.6	1.9	-5.1	8.9
Saskatchewan	0.3	-1.0	1.5	0.8	-0.3	2.0	3.5	-3.8	10.9
Alberta	0.7	-0.5	2.0	1.1	-0.1	2.3	3.6	-3.2	10.3
British Columbia	-4.1	-5.4	-2.8	-2.7	-4.0	-1.4	-0.8	-6.2	4.6
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-1.0	-3.2	1.2	-1.1	-3.4	1.1	-1.1	-3.3	1.1
2004	-2.5	-4.5	-0.4	-2.1	-4.2	0.0	-1.8	-4.0	0.3
2005	-2.0	-4.2	0.2	-1.3	-3.6	1.0	-1.0	-3.4	1.5
2006	-3.2	-5.2	-1.2	-2.7	-4.8	-0.7	-2.0	-4.6	0.6
2007	-1.9	-3.9	0.1	-1.5	-3.7	0.6	-0.5	-3.6	2.6
2008	-4.1	-6.0	-2.3	-3.7	-5.6	-1.8	-2.8	-5.8	0.3
2009	-4.4	-6.3	-2.4	-3.7	-5.7	-1.6	-3.4	-6.1	-0.6
2010	-4.2	-6.1	-2.2	-3.7	-5.8	-1.6	-3.4	-6.4	-0.4
2011	-3.7	-5.7	-1.6	-2.4	-4.7	-0.2	-1.9	-5.2	1.3
2012	-5.8	-7.8	-3.8	-4.8	-6.9	-2.8	-4.3	-7.4	-1.2
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				24.3	22.1	26.4	24.3	22.1	26.4
Completed college				13.4	12.4	14.4	13.4	12.4	14.4
Completed university				6.9	6.0	7.8	6.9	6.0	7.8
Age Group									
25-34				*Reference*			*Reference*		
35-44				2.8	1.2	4.4	2.8	1.3	4.4
45-54				2.6	1.0	4.3	2.6	1.0	4.3
55-64				-3.9	-5.7	-2.1	-3.9	-5.7	-2.1
65+				-14.2	-15.6	-12.8	-14.2	-15.5	-12.8
Male				7.6	6.7	8.5	7.6	6.7	8.5
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				11.1	9.4	12.9	11.1	9.4	12.9
Single				7.9	6.4	9.4	7.9	6.4	9.5
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-2.0	-3.7	-0.2	-2.0	-3.8	-0.2
English and French				-2.1	-6.8	2.7	-2.1	-6.8	2.7
Other				-10.6	-11.9	-9.3	-10.6	-11.9	-9.3
Household Size									
1				*Reference*			*Reference*		
2				0.4	-0.9	1.7	0.4	-0.9	1.7
3				-0.4	-1.9	1.1	-0.4	-1.9	1.1
4				-1.9	-3.7	-0.2	-1.9	-3.7	-0.2
5 or more				-3.1	-4.9	-1.4	-3.1	-4.9	-1.4
Unemployment Rate (25+)							0.3	-0.5	1.1
Provincial Smoke-free Law							-0.7	-2.3	1.0
Provincial Tobacco Display Ban							0.3	-1.4	2.0

Appendix Table 25: Marginal Estimates from Models Assessing Average Effect of Provincial Smoke-free Laws on Smoking Prevalence

Variable	Model 1			Model 2			Model 3		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-1.6%	-2.7%	-0.6%	-0.6%	-1.5%	0.4%	-1.3%	-4.0%	1.4%
Nova Scotia	-0.2%	-1.4%	0.9%	1.0%	-0.1%	2.0%	-0.1%	-4.4%	4.2%
New Brunswick	0.2%	-1.0%	1.3%	1.5%	0.4%	2.6%	0.6%	-3.2%	4.4%
Quebec	-0.2%	-1.3%	0.8%	3.8%	1.9%	5.7%	2.7%	-2.0%	7.4%
Ontario	-3.6%	-4.7%	-2.6%	-0.3%	-1.3%	0.7%	-1.6%	-6.9%	3.7%
Manitoba	-1.5%	-2.5%	-0.5%	-0.1%	-1.1%	0.8%	-1.7%	-8.5%	5.0%
Saskatchewan	-0.5%	-1.7%	0.6%	0.6%	-0.4%	1.6%	-1.1%	-8.0%	5.7%
Alberta	-1.1%	-2.3%	0.0%	0.6%	-0.5%	1.7%	-0.8%	-7.3%	5.8%
British Columbia	-5.7%	-6.8%	-4.5%	-2.6%	-3.7%	-1.5%	-3.8%	-9.3%	1.7%
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-0.8%	-2.4%	0.9%	-0.3%	-1.9%	1.3%	-0.3%	-2.0%	1.4%
2004	-1.9%	-3.5%	-0.3%	-0.7%	-2.3%	0.8%	-0.8%	-2.5%	1.0%
2005	-2.5%	-4.2%	-0.8%	-0.7%	-2.4%	0.9%	-0.8%	-2.8%	1.1%
2006	-3.0%	-4.7%	-1.4%	-1.1%	-2.7%	0.5%	-1.3%	-3.3%	0.8%
2007	-2.1%	-4.0%	-0.3%	-0.2%	-2.0%	1.5%	-0.4%	-2.9%	2.0%
2008	-3.6%	-5.4%	-1.7%	-1.2%	-3.0%	0.6%	-1.9%	-4.3%	0.5%
2009	-3.6%	-5.7%	-1.5%	-1.1%	-3.1%	0.9%	-1.8%	-4.3%	0.6%
2010	-4.5%	-6.6%	-2.4%	-2.1%	-4.1%	-0.1%	-2.9%	-5.3%	-0.4%
2011	-3.5%	-5.6%	-1.4%	-0.5%	-2.6%	1.5%	-1.4%	-4.0%	1.2%
2012	-5.4%	-7.5%	-3.3%	-2.3%	-4.3%	-0.3%	-3.2%	-5.8%	-0.6%
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				18.5%	17.0%	20.0%	18.5%	17.0%	20.0%
Completed college				11.3%	10.4%	12.2%	11.3%	10.4%	12.2%
Completed university				6.5%	5.6%	7.3%	6.5%	5.6%	7.3%
Age Group									
25-34				*Reference*			*Reference*		
35-44				-1.5%	-3.0%	0.0%	-1.5%	-3.0%	0.0%
45-54				-4.0%	-5.4%	-2.6%	-4.0%	-5.4%	-2.6%
55-64				-9.5%	-11.0%	-8.0%	-9.5%	-11.0%	-8.0%
65+				-18.3%	-19.6%	-17.0%	-18.3%	-19.6%	-17.0%
Male				4.2%	3.4%	4.9%	4.2%	3.4%	4.9%
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				10.6%	9.3%	11.9%	10.6%	9.3%	11.9%
Single				7.5%	6.1%	8.9%	7.5%	6.1%	8.9%
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-3.1%	-4.6%	-1.5%	-3.1%	-4.6%	-1.5%
English and French				-1.6%	-5.9%	2.6%	-1.6%	-5.9%	2.6%
Other				-8.0%	-9.2%	-6.7%	-7.9%	-9.2%	-6.7%
Household Size									
1				*Reference*			*Reference*		
2				1.4%	0.3%	2.4%	1.4%	0.3%	2.4%
3				0.9%	-0.4%	2.1%	0.9%	-0.4%	2.1%
4				-0.5%	-1.9%	0.9%	-0.5%	-1.9%	0.9%
5 or more				-1.6%	-3.0%	-0.1%	-1.6%	-3.0%	-0.1%
Unemployment Rate (25+)							-0.1%	-0.8%	0.5%
Provincial Tobacco Display Ban							0.9%	-0.6%	2.4%
Excise Cigarette Taxes per 20-pack							-0.1%	-1.7%	1.5%

Appendix Table 26: Marginal Estimates from Models Assessing Average Effect of Provincial Smoke-free Laws on Smoking Frequency

Variable	Model 1			Model 2			Model 3		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-0.8	-2.2	0.6	0.3	-0.9	1.5	0.5	-2.0	3.0
Nova Scotia	0.5	-0.9	1.9	1.9	0.7	3.1	2.4	-1.8	6.6
New Brunswick	2.3	0.9	3.6	3.0	1.8	4.3	3.4	-0.2	6.9
Quebec	1.0	-0.3	2.3	4.5	2.4	6.5	4.8	0.1	9.6
Ontario	-3.7	-4.9	-2.5	0.5	-0.6	1.6	1.1	-4.2	6.4
Manitoba	-2.4	-3.7	-1.2	-0.4	-1.5	0.7	0.4	-6.7	7.6
Saskatchewan	-0.2	-1.7	1.2	1.2	-0.1	2.4	2.0	-5.5	9.5
Alberta	-1.5	-2.8	-0.2	1.1	-0.1	2.2	1.9	-5.0	8.9
British Columbia	-6.3	-7.6	-4.9	-2.8	-4.0	-1.5	-2.1	-7.7	3.6
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-1.6	-3.9	0.8	-1.1	-3.3	1.0	-1.1	-3.3	1.1
2004	-3.4	-5.5	-1.4	-2.0	-3.9	-0.1	-1.9	-4.0	0.3
2005	-3.2	-5.4	-0.9	-1.2	-3.4	1.0	-1.1	-3.6	1.4
2006	-4.5	-6.6	-2.3	-2.4	-4.5	-0.3	-2.2	-4.8	0.4
2007	-2.8	-5.2	-0.4	-1.0	-3.3	1.2	-0.8	-3.8	2.3
2008	-5.5	-7.8	-3.2	-3.2	-5.4	-1.0	-3.1	-6.2	0.0
2009	-5.8	-8.2	-3.5	-3.5	-5.7	-1.2	-3.7	-6.4	-0.9
2010	-5.5	-8.0	-2.9	-3.3	-5.7	-0.8	-3.5	-6.5	-0.4
2011	-5.2	-7.7	-2.7	-2.1	-4.6	0.3	-2.3	-5.5	0.9
2012	-7.3	-9.7	-4.9	-4.2	-6.6	-1.8	-4.3	-7.5	-1.2
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				23.7	21.7	25.7	23.7	21.7	25.7
Completed college				13.5	12.4	14.5	13.5	12.4	14.5
Completed university				6.9	6.0	7.9	6.9	6.0	7.9
Age Group									
25-34				*Reference*			*Reference*		
35-44				2.9	1.4	4.5	2.9	1.4	4.5
45-54				2.8	1.1	4.4	2.8	1.1	4.4
55-64				-3.9	-5.7	-2.1	-3.9	-5.7	-2.1
65+				-14.1	-15.5	-12.8	-14.1	-15.5	-12.8
Male				7.6	6.7	8.5	7.6	6.7	8.5
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				11.2	9.4	12.9	11.1	9.4	12.9
Single				8.0	6.4	9.5	8.0	6.4	9.5
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-2.2	-3.9	-0.4	-2.2	-4.0	-0.4
English and French				-2.1	-6.8	2.6	-2.1	-6.8	2.6
Other				-10.5	-11.8	-9.2	-10.5	-11.9	-9.2
Household Size									
1				*Reference*			*Reference*		
2				0.5	-0.8	1.7	0.4	-0.8	1.7
3				-0.4	-1.9	1.1	-0.4	-1.9	1.1
4				-2.0	-3.7	-0.2	-2.0	-3.7	-0.3
5 or more				-3.2	-5.0	-1.5	-3.2	-5.0	-1.5
Unemployment Rate (25+)							0.1	-0.7	0.9
Provincial Tobacco Display Ban							0.3	-1.4	2.0
Excise Cigarette Taxes per 20-pack							-0.1	-1.9	1.7

Appendix Table 27: Marginal Estimates from Models Assessing Heterogeneous Effects of PSFL on Smoking Prevalence by Education

Variable	Model 1			Model 2			Model 3		
	Estimate	**95% C.I.**		**Estimate**	**95% C.I.**		**Estimate**	**95% C.I.**	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-1.3%	-2.3%	-0.3%	-0.9%	-1.9%	0.1%	-1.2%	-3.8%	1.4%
Nova Scotia	0.5%	-0.6%	1.6%	0.7%	-0.3%	1.7%	0.5%	-3.6%	4.6%
New Brunswick	0.2%	-0.8%	1.3%	1.1%	0.0%	2.2%	1.0%	-2.7%	4.6%
Quebec	0.8%	-0.3%	1.9%	3.6%	1.7%	5.5%	3.3%	-1.2%	7.9%
Ontario	-2.1%	-3.1%	-1.1%	-0.6%	-1.6%	0.5%	-0.7%	-5.9%	4.4%
Manitoba	-1.0%	-2.0%	0.1%	-0.4%	-1.4%	0.6%	-0.6%	-7.2%	6.0%
Saskatchewan	-0.3%	-1.4%	0.8%	0.3%	-0.8%	1.3%	-0.1%	-6.8%	6.6%
Alberta	0.2%	-0.9%	1.4%	0.5%	-0.6%	1.6%	0.5%	-5.9%	6.8%
British Columbia	-4.2%	-5.3%	-3.1%	-2.7%	-3.8%	-1.7%	-2.8%	-8.1%	2.5%
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-0.4%	-2.0%	1.2%	-0.2%	-1.8%	1.3%	-0.3%	-1.9%	1.4%
2004	-1.3%	-2.9%	0.3%	-0.7%	-2.3%	0.8%	-0.7%	-2.5%	1.1%
2005	-1.8%	-3.5%	-0.2%	-0.8%	-2.4%	0.8%	-0.8%	-2.7%	1.2%
2006	-2.1%	-3.8%	-0.5%	-1.3%	-2.9%	0.3%	-1.2%	-3.3%	0.8%
2007	-1.5%	-3.3%	0.4%	-0.4%	-2.1%	1.4%	-0.3%	-2.8%	2.2%
2008	-2.5%	-4.4%	-0.6%	-1.4%	-3.2%	0.4%	-1.8%	-4.3%	0.6%
2009	-2.4%	-4.4%	-0.3%	-1.1%	-3.1%	0.9%	-1.9%	-4.3%	0.6%
2010	-3.4%	-5.5%	-1.3%	-2.2%	-4.2%	-0.1%	-3.0%	-5.5%	-0.5%
2011	-2.2%	-4.4%	-0.1%	-0.6%	-2.7%	1.5%	-1.4%	-4.1%	1.2%
2012	-4.3%	-6.3%	-2.2%	-2.6%	-4.6%	-0.6%	-3.4%	-6.0%	-0.7%
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				19.1%	17.5%	20.7%	19.1%	17.5%	20.7%
Completed college				11.3%	10.4%	12.2%	11.3%	10.4%	12.2%
Completed university				6.5%	5.7%	7.3%	6.5%	5.7%	7.3%
Age Group									
25-34				*Reference*			*Reference*		
35-44				-1.6%	-3.1%	0.0%	-1.6%	-3.1%	0.0%
45-54				-4.0%	-5.5%	-2.6%	-4.0%	-5.5%	-2.6%
55-64				-9.5%	-11.0%	-8.0%	-9.5%	-11.0%	-8.0%
65+				-18.3%	-19.6%	-17.1%	-18.3%	-19.6%	-17.1%
Male				4.2%	3.4%	4.9%	4.2%	3.4%	4.9%
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				10.6%	9.2%	11.9%	10.6%	9.2%	11.9%
Single				7.4%	6.0%	8.9%	7.4%	6.0%	8.9%
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-2.9%	-4.5%	-1.4%	-2.9%	-4.5%	-1.4%
English and French				-1.6%	-5.9%	2.6%	-1.6%	-5.9%	2.6%
Other				-8.0%	-9.3%	-6.7%	-8.0%	-9.3%	-6.7%
Household Size									
1				*Reference*			*Reference*		
2				1.3%	0.2%	2.4%	1.3%	0.2%	2.4%
3				0.9%	-0.4%	2.1%	0.9%	-0.4%	2.1%
4				-0.4%	-1.9%	1.0%	-0.4%	-1.9%	1.0%
5 or more				-1.6%	-3.0%	-0.1%	-1.6%	-3.0%	-0.1%
Unemployment Rate (25+)							0.0%	-0.7%	0.7%
Provincial Tobacco Display Ban							1.0%	-0.6%	2.5%
Excise Cigarette Taxes per 20-pack							-0.1%	-1.7%	1.4%

Appendix Table 28: Marginal Estimates from Models Assessing Heterogeneous Effects of PSFL on Smoking Frequency by Education

Variable	Model 1			Model 2			Model 3		
	Estimate	95% C.I.		Estimate	95% C.I.		Estimate	95% C.I.	
Province									
Newfoundland	*Reference*			*Reference*			*Reference*		
Prince Edward Island	-0.1	-1.4	1.2	0.1	-1.1	1.3	0.7	-1.7	3.1
Nova Scotia	1.8	0.5	3.1	1.7	0.5	2.9	3.1	-0.9	7.1
New Brunswick	2.5	1.3	3.7	2.8	1.5	4.0	3.9	0.5	7.2
Quebec	2.5	1.3	3.7	4.0	2.0	6.1	5.4	0.8	9.9
Ontario	-1.2	-2.4	-0.1	0.4	-0.8	1.5	2.1	-3.0	7.2
Manitoba	-1.4	-2.6	-0.2	-0.6	-1.7	0.5	1.8	-5.2	8.8
Saskatchewan	0.4	-0.9	1.7	1.0	-0.2	2.3	3.5	-3.9	10.8
Alberta	0.7	-0.6	1.9	1.1	-0.1	2.3	3.5	-3.3	10.3
British Columbia	-4.0	-5.3	-2.7	-2.7	-4.0	-1.4	-0.8	-6.2	4.7
Survey Year									
2002	*Reference*			*Reference*			*Reference*		
2003	-1.0	-3.1	1.1	-1.1	-3.3	1.0	-1.1	-3.3	1.1
2004	-2.5	-4.4	-0.7	-2.1	-3.9	-0.2	-1.9	-4.0	0.2
2005	-2.2	-4.2	-0.1	-1.3	-3.5	0.9	-1.0	-3.5	1.5
2006	-3.1	-5.1	-1.1	-2.5	-4.5	-0.4	-2.0	-4.6	0.6
2007	-1.7	-3.9	0.5	-1.2	-3.4	1.1	-0.5	-3.6	2.6
2008	-3.8	-6.0	-1.6	-3.2	-5.4	-1.0	-2.8	-5.8	0.3
2009	-4.0	-6.2	-1.8	-3.2	-5.5	-1.0	-3.4	-6.1	-0.6
2010	-3.8	-6.2	-1.4	-3.2	-5.7	-0.8	-3.4	-6.4	-0.4
2011	-3.3	-5.7	-0.9	-1.9	-4.4	0.5	-1.9	-5.2	1.3
2012	-5.5	-7.8	-3.1	-4.3	-6.7	-2.0	-4.3	-7.4	-1.2
Education									
Less than secondary				*Reference*			*Reference*		
Completed secondary				24.3	22.1	26.4	24.3	22.1	26.4
Completed college				13.4	12.4	14.4	13.4	12.4	14.4
Completed university				6.9	6.0	7.8	6.9	6.0	7.8
Age Group									
25-34				*Reference*			*Reference*		
35-44				2.8	1.2	4.4	2.8	1.3	4.4
45-54				2.6	1.0	4.3	2.6	1.0	4.3
55-64				-3.9	-5.7	-2.1	-3.9	-5.7	-2.1
65+				-14.2	-15.5	-12.8	-14.2	-15.5	-12.8
Male				7.6	6.7	8.5	7.6	6.7	8.5
Marital Status									
Common-law/Married				*Reference*			*Reference*		
Widow/Divorced/Separated				11.2	9.4	12.9	11.1	9.4	12.9
Single				7.9	6.4	9.5	7.9	6.4	9.5
Language (Spoken at Home)									
English				*Reference*			*Reference*		
French				-2.0	-3.7	-0.2	-2.0	-3.8	-0.2
English and French				-2.1	-6.9	2.6	-2.1	-6.9	2.6
Other				-10.6	-11.9	-9.3	-10.6	-11.9	-9.4
Household Size									
1				*Reference*			*Reference*		
2				0.4	-0.9	1.7	0.4	-0.9	1.7
3				-0.4	-1.9	1.1	-0.4	-1.9	1.1
4				-1.9	-3.6	-0.2	-1.9	-3.7	-0.2
5 or more				-3.1	-4.8	-1.3	-3.1	-4.9	-1.3
Unemployment Rate (25+)							0.3	-0.5	1.1
Provincial Tobacco Display Ban							0.4	-1.3	2.0
Excise Cigarette Taxes per 20-pack							-0.2	-2.0	1.6