Estimating Smoking Attributable Health Care Costs using the Canadian Community Health Survey (2012)

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Major paper presented to the

Department of Economics of the University of Ottawa

In Partial Fulfillment of the Requirements of the M.A. Degree

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ECO 6999

May, 2014

University of Ottawa

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Abstract: Tobacco consumption is the leading preventable cause of death in Canada and most countries in the world. In addition to mortality and the cost of premature deaths, studies show that smoking imposes an economic burden on the health care system. Using an econometrics approach, this study examines the hypothesis that the health care utilization associated with smoking is economically meaningful and concludes that 12.5 percent of physician visits and 15.5 percent of hospital stays in Canada in 2012 are attributable to smoking, which translates into more than $14 billion dollars of health care expenditures. Thus, even though smoking rates have dropped in the recent years (from about 50 percent in 1965 to approximately 20 percent in 2012), the costs of smoking on the health care system are still high.

1. Introduction:

According to the World Health Organization (WHO 2014a), the tobacco epidemic is one of the biggest threats the world has ever faced, responsible for the death of up to one half of its users. In Canada, although there has been a decline in the rate of smoking in recent years, 20.3 percent of Canadians aged 12 and older, roughly 5.9 million people, smoked either daily or occasionally in 2012 (Statistics Canada 2012). Smoking is a risk factor for lung cancer, heart diseases, stroke, chronic respiratory disease and other conditions. Cancer (various forms), heart disease and stroke combined accounted for 56 percent of all deaths in 2009 in Canada (Statistics Canada 2009), suggesting that smoking has a considerable mortality effect.

Researchers have looked at many aspects of tobacco smoking including the health effects of smoking on smokers and on passive smokers, the addictiveness of smoking, the prevalence of smoking amongst different categories of people such as different types of workers, the impact of advertising, the impact of smoking policies such as smoking bans, and various other issues, (e.g., Shetty et al. 2011, Gaudette et al. 1998, Kabir et al. 2013, Sen 2011). There is also evidence regarding the effect of smoking on health care system use with several studies demonstrating that smoking results in greater health care use (e.g., Hodgson 1992, Miller 1998). The existing literature in this area is mostly based on the US data (e.g., Rice et al. 1986, Coller et al. 2002, Kahende et al. 2009), although there are a few Canadian studies as well.

The main contribution of this paper is to add to the few existing Canadian papers on the health care cost of smoking. In particular, this paper is the first to look at the fraction of health care usage attributable to smoking across all provincial jurisdictions in Canada, following the lines of Harrison et al. (2003) who estimate cost fractions for the province of Newfoundland and Labrador. In addition, this paper uses the most recent data set as opposed to the data from 1995 used in the Newfoundland study, therefore can capture the smoking attributable cost fractions based on the recent smoking rates in Canada.

Smoking attributable fractions of health care expenditure or (SAFs) can help to translate the well-known adverse effects of smoking on health into dollar values which is essential if one is to contribute to the policy discussion on this issue. Perhaps investments into better smoking cessation programs are warranted, and in programs that target young people before they start smoking. In this paper it is estimated that 12.5 percent of physician visits and 15.5 percent of hospital stays are attributable to smoking which accounts for more than $14 billion health care dollars in Canada in 2014.

This paper proceeds as follows. In the next section an overview of the literature on the cost of smoking and the two main approaches existing in the literature to estimate SAFs is presented. The method used in this paper is explained in the third section and the data set and variables used are fully discussed in the fourth section. The fifth section gives all the estimated results and finally the overall conclusion of the paper is presented in the sixth section.

2. Literature Review: Smoking and Health Care Use:

In addition to examining a host of issues surrounding tobacco use, like its health effects, addictiveness, prevalence, and so on, some researchers have looked directly at the effect of smoking on health care utilization. Those who have ever smoked at each age or sex cohort need more medical care than those who have never smoked (Rice et al. 1986). There are a large number of studies verifying this effect. (e.g., Hodgson 1992; Miller et al. 1998; Bartlett et al. 1994; Zhang et al. 1999; Miller et al. 1999; Kahende et al.2009, Fishman et al. 2003; Martinson et al. 2003). For instance, Neubauer et al. (2006) conclude that in 2003 in Germany €7.5 billion for acute hospitalization, inpatient rehabilitation care, ambulatory care and prescribed drugs is attributable to smoking. Miller et al. (1998) find that in 1993, 11.8 percent of the total medical expenditure in the United States is associated to smoking. And according to Haapanen-Niemi et al. (1999), among the Finnish men of 19-63 years old being hospitalized from 1980 to 1995 those who smoke had 70 percent more hospital days due to any cause than did nonsmokers.

Primary health care in Canada is delivered largely through a publicly funded system; however several aspects of health care are financed mostly on a private basis, including prescription drugs and a host of services like physiotherapy outside of hospitals. From Canadian Institute for Health

Information (CIHI 2014) we see that total health expenditures are expected to exceed $211 billion in 2013 which amounts to over 11 percent of Canada's gross domestic products. Spending on health care is spread over nine different areas. Hospital spending constitutes the highest share with 29.5 percent of health care expenditures in 2011. Drugs with 16.5 percent and physicians with 14.6 percent stand in the second and third place respectively. Although drugs are primarily financed by the private sector, 91.2 percent of hospital expenditures and 98.7 percent of the expenditures on physicians are financed by the public sector making these two categories the main recipients of public health dollars (CIHI 2014). Therefore, it is important to identify how much of these publicly-funded health care expenses are attributable to smoking behavior.

Studies that try to estimate the fraction of medical expenditures attributable to smoking can be divided into two broad categories: those that take the 'prevalence' approach and those that take an 'incidence' approach (Miller et al. 1998). In the incidence approach researchers estimate the expected lifetime medical care expenses for smokers while in the prevalence approach they analyze how much of the current realized health care expenses are attributable to smoking in the past.

In the incidence approach, the cost of smoking is the additional health care cost a smoker, as compared to a nonsmoker, requires during his/her lifetime for the treatment of illnesses that are due to smoking. Oster et al. (1984a, 1984b) consider lung cancer, coronary heart disease and emphysema as the illnesses caused by smoking, and conclude that if people who smoked at 1980 continue smoking throughout their life at the same level as they did in 1980, they will generate higher medical expenses for those three diseases than a nonsmoker. The additional cost for smokers as compared to nonsmokers depends on age, sex and type of smoker and can be as high as $61,304 in 1980 dollars. Some studies in the incidence approach take into account that although smokers use more health care relative to nonsmokers during their life, nonsmokers live longer and the health care used by them during these extra years can compensate the excessive health care use by smokers. A few attempts to analyze this situation have reached contradictory conclusions. For example Leu and Schaub (1985) and Lippiatt (1990) conclude that the higher health care use of nonsmokers due to their longer life expectancy outweighs the more intense health care use of smokers in their shorter life span and it is unlikely that smoking increase health care cost. However, Hodgson (1992) conclude that the aggregate of higher health care needs by smokers while they are alive outweighs their shorter life expectancy. Manning et al. (1989) also find a positive relationship between expected lifetime health care cost and smoking. The disparities existing in the results of studies based on incidence approach might be due to the difference in the data sets that they are based on, (Miller et al. 1998). Since the negative consequences of smoking on health are revealed and can be diagnosed a long time after the individual starts smoking, an appropriate data set to capture the effect of smoking on individuals' health care needs during their lifetime needs to monitor their health care utilization for a long period of time, (Miller et al. 1998).

The prevalence approach analyzes the realized health care expenses in a specific period of time (mostly in one year) and tries to disentangle the fraction of this cost that is the result of smoking. In other words, it looks at how much of the current costs to health care system are attributable to smoking in the past years. Studies using the prevalence approach employ two different methods to determine smoking attributable fractions (SAFs): an epidemiological approach and an econometrics approach. The latter approach is applied in this paper. The two methods will be briefly reviewed next.

2.1: Epidemiological approach:

Some diseases are proven to be causally related to smoking in the medical literature. For instance, cancers, cardiovascular diseases and respiratory diseases are the main causes of smoking-related deaths, (Rehm et al. 2002; Surgeon General, 2004). The relative risk (RR) for smokers to develop each of those diseases is defined as the rate of patients exposed to smoking over the rate of patients not exposed from epidemiological evidence. Using those relative risk factors and the distribution of smokers, the SAF is calculated for different cohorts of age and sex by:

$$SAF=\frac{\sum_{i=1}^{k} Fi(RRi-1)}{\sum_{i=0}^{k} Fi(RRi-1)} \qquad (1)$$

Where, i indicates different categories of smoking in the population (like daily smokers, occasionally smokers and so on) and i=0 for nonsmokers. RR_i is the relative risk for the people in the ith category to develop the disease in question compared to nonsmokers and Fi is the fraction of people exposed to the ith level of smoking.

One of the first studies to use this approach were Luce and Schweitzer (1978) who simply employed the cost of treatment of smoking related diseases from Cooper and Rice (1976), and the relative risk of developing those diseases from Boden (1976) and computed the SAFs by multiplying those figures together, (Miller et al. 1999). The Office of Technology Assessment (OTA 1985) improved this approach and estimated the SAFs for three major diseases associated with smoking, cancers, heart diseases and chronic respiratory diseases by using an age distribution of mortality rates. They calculate the number of deaths related to smoking in each of the three disease categories for different age cohorts and multiply those fractions by the cost of the corresponding illness category. Rice et al. (1986) use medical data instead of mortality data and introduce different individual categories based on their smoking habits and estimate the SAFs for each category.

Most of the studies in Canada on the health care cost of smoking are based on the epidemiological approach including, Forbes and Thompson (1983), Collishaw and Myers (1984), Choi and Nethercott (1988), Raynauld and Vidal (1992), Choi and Pak (1996), Kaiserman (1997), Xie et al. (1999), and Baliunas et al. (2007). The estimated costs in these studies vary from a low of $18.06 per capita by Raynauld and Vidal (1992) to a high of $107.22 per capita from Collishaw and Myers (1984) with the average of $79.93 per capita (Harrison et al. 2003). These figures are adjusted by the price index to 1999 and are expressed in per capita basis since it is a burden imposed by the smokers on the health care system and the society as whole (Harrison et al. 2003). The difference in their results might be due to the different assumptions they have, different definitions of smokers, different data, and the different range of smoking related diseases they take into account.

2.2: Econometrics Approach:

The econometrics approach to determine the portion of health care costs attributable to smoking can resolve the epidemiological problem of determining the health conditions caused by smoking since we can estimate the impact of smoking on health care utilization without limiting this effect to specific diseases. While it is well established that some diseases such as cancers, cardiovascular diseases and respiratory diseases are mainly caused by smoking (Surgeon General, 2004), there are many other health problems that smoking can cause but are not considered as smoking-related diseases. For instance smoking can make it harder for a woman to become pregnant and can also affect babies' health. Smoking can increase the risk for cataracts (clouding of the lens of the eye which makes it hard to see) or it can affect bone health and dental health. In general there are many health conditions that smoking can cause or can exacerbate, hence requiring more health care. Therefore, studies based on few acute conditions associated with smoking are unlikely to capture all of the potential costs. In the econometrics approach instead of analyzing the health care cost of treatment for those conditions that are caused by smoking, a broader measure of health care is defined. Thus the effect of smoking on health care utilization through different pathways can be captured.

In this approach health care utilization is defined as a function of smoking and other individual and socio-demographic characteristics. When the model is estimated with sufficient data, the predicted value of health care utilization for each person based on his/her smoking behavior, age, sex, education, income, weight, and all other variables included in the model can be estimated. Smoking Attributable Fraction (SAF) is defined as the relative difference between two predicted values for health care utilization: The predicted value based on the actual values from the data set and, the hypothetical predicted value of health care utilization based on the assumption that no one smokes, that is, the predicted value of health care utilization when all other variables have the same values as before but the smoking variables are zero for everybody. The relative difference between these two predictions is the smoking attributable fraction. If Y is a measure of health care use (the dependent variable in the model) then the SAF for each individual is,

$$SAF_i = \frac{\hat{Y}Ai - \hat{Y}NSi}{\hat{Y}Ai} \qquad (2)$$

Where $\hat{Y}_i^A$ is the predicted value of health care utilization for each individual based on their actual characteristics and $\hat{Y}_i^{NS}$ is the predicted value of health care utilization for them based on the assumption that no one smokes. The aggregate SAF is obtained by summing the SAFs for individuals and will be discussed in section three.

Perhaps Center for Disease Control and Prevention (CDC 1991) was the first to publish estimates of smoking attributable fractions (SAFs) by state using this econometric approach. Miller et al. (1998) extended the primary model to find SAFs by state in 1993 for different type of expenditures (Miller et al. 1999). Since then, this approach has been used in various studies in the United States, for example in Miller et al. (1998a and 1998b), V. P. Miller et al. (1999), Harrison (1998a and 1998b), Coller et al. (2002), Zhang et al. (1999), and Kahende et al. (2009).

Although widely studied using United States data, only a few studies examine the effect of smoking on health care utilization at the individual level in Canada. Harrison et al. (2003) applied this approach for the first time in Canada. They consider two core elements of health care, hospital and physicians, and apply econometrics approach to the data from Newfoundland Adult Health Survey 1995 to estimate that over 12 percent of hospital utilization and approximately 7 percent of visits to physicians in Newfoundland in 1995 were attributable to smoking. They link the data from the survey to the medical care information of respondents for seven years and estimate the per capita cost of smoking for each of those years. The resulting estimates for cost of smoking are large ranging from approximately \$110 to \$140 per capita.

Azagba et al. (2013) also examine the association between smoking status and the utilization of health services in Canada. However, the SAFs are not estimated in their paper and hence their study is not as comparable to the present study as the paper by Harrison et al. (2003). Comparing the utilization of high-use smokers and low-use smokers with nonsmokers using the 2007 Canadian Community Health Survey (CCHS), Azagba et al. find that heavy smokers visit more general physicians (GPs) and specialists (SPs) than nonsmokers but among the light group, smokers have less GP and SP visits when compared to those who do not smoke. In both the high-use and low-use group, smokers have more hospitalization than never smokers.

3. Methodology:

To find the predicted values of health care utilization in order to estimate SAF (equation 2), the two-equation model used in the papers by Harrison et al. (2003) and Miller et al. (1999) is applied here. This model is a standard approach in health economics to estimate the demand for health care, and was pioneered by Duan et al. (1983). The problem with the distribution of health care services is the large number of nonusers, and this approach is an attempt to resolve this problem. For instance, in the CCHS data set employed in the present study, 23 percent of people did not see a general physician in the 12 months prior to the survey and 90 percent of people did not spend a night at hospital during that period. With this number of nonusers the lower tail of the distribution of the error term cannot be homoscedastic normal (Duan et al. 1983).

In this model two equations are estimated for any given measure of health service. While the covariates remain the same in both equations, the dependent variable in one of them is a dummy variable indicating whether or not the service is used, and the dependent variable in the other equation is the level of service used conditional on its being positive. These two equations are written as:

$$Pi = C + \alpha Si + \beta Xi + ui \qquad (3)$$

Where P is a dummy variable that takes 1 if the person used the health service at any level and is zero if not and,

$$Li = C + \alpha Si + \beta Xi + \eta i \qquad (4)$$

is a conditional regression where L is the number of times the person used the service given that the service is used. S denotes smoking variables in which we are interested, in order to capture their effect on health care use and is assumed to be exogenous. X is a matrix of other control variables like sex and age that are assumed to affect health care use. u and η are the vectors of error terms that are assumed to have normal distributions and both models include a constant term C.

This two-equation model is an extension of the tobit model. The tobit model assumes that the covariates affect the probability of an outcome to the same extent as they affect the level of outcome, that is, with the same estimated coefficients. This extension of the tobit model relaxes the assumption that the coefficients are the same across two equations (Harrison et al. 2003).

Equation (3) determines the probability that a person uses any health care service and equation (4) determines the level of utilization given that services are used. After estimating both equations, four predicted values are obtained for each individual as follows:

P^A: The predicted probability that a given person uses any health service from the first equation based on his/her actual characteristics;

P^{NS}: The predicted probability that a person uses any health service from the first equation assuming that the individuals do not smoke (smoking variables are zero for everyone) but all other variables have their actual values for the individual (for nonsmokers the predicted value based on actual behavior is the same as the predicted value based on the assumption that they do not smoke, $P^{NS} = P^{A}$);

L^{A}: The predicted level of health care used by the individual based on his/her actual characteristics conditional on the individual having some utilization; and

L^{NS}: The predicted level of health care used by the individual conditional on the individual having some utilization and based on the assumption that no one smokes (smoking variables are zero, but all other variables have their actual values, which imply that $L^{NS} = L^{A}$).

In the two equation model the predicted utilization is the multiplication of the two predicted values from equations (3) and equation (4). The predicted utilization based on actual behavior is $\hat{Y}^{A} = P^{A} * L^{A}$ and the predicted utilization based on the assumption that no one smokes is $\hat{Y}^{NS} = P^{NS} * L^{NS}$. Substituting these values into equation (2), the SAF for each individual is obtained. Following Harrison et al. (2003), to find the aggregate SAF, the SAF for each individual is multiplied by his/her actual level of utilization, L, and then summed. The aggregate SAF is the ratio of this summation to the total predicted values of all individual's utilization, $\hat{Y}^{A}$.

4. Variables and Data:

Two types of health care utilization indicators are studied in this paper: physician visits and hospital stays. As discussed earlier these two categories of health care in Canada constitute the largest share of publicly funded health care expenditures. Equations (3) and (4) are estimated twice, once for each of these measures of health care use, and then the same exercise as described above is done to find the aggregate smoking attributable fraction (SAF) for both physician visits and hospitalization.

Both equations include a constant term and 38 independent variables defined in Table 1. There are five smoking variables that indicate the type of smoker the respondent is, based on their smoking habits: daily smoker, current occasionally but former daily smoker, only occasionally smoker, former occasionally smoker and never smoked (reference group). In addition, a number of other variables that can affect the left hand side variable are controlled for, including the individual's health and socio-demographic characteristics. Age has four categories, 18-34, 35-49, 50-64, and 65 and older (reference group). Dummy variable (male=1, female=0) indicates the gender. Marital status has three groups: married, divorced and single (reference group). Race is captured by two dummy variables: visible minority and white (reference group). Body mass index (BMI) and BMI squared are included. Self-perceived health status has five categories: excellent, very good, good, fair and poor (reference category). The level of activity is grouped in three categories: regular exercise, occasional exercise and infrequent exercise (reference group). Whether or not the person has a regular doctor is captured by a dummy variable and is included in the model. There is evidence that having a family doctor and the level of health care use have a positive relationship (Newacheck et al. 1996). The level of education is grouped in four categories: Less than secondary school graduation (reference group), secondary school graduation, some post-secondary school graduation and post-secondary graduation. Three dummy variables classify the individual habits' in alcohol consumption in 12 months prior to the survey: regular drinking, occasional drinking and not drinking in the past 12 months. The household's income from all resources has three categories: low income with less than $40,000 (reference group), medium income with the income between $40,000 and $80,000, and high income with more than $80,000. Provincial fixed effects are included in the model to capture the health care differences that are due to cultural and regional factors and British Colombia is the reference category. All the regressions are weighted according to the survey weights.

The data set used in this study is the Canadian Community Health Survey (CCHS) 2012, a cross sectional survey that collects information about health status, health care utilization and health determinants as well as many other socio-demographic and economic variables. The CCHS data are collected on respondents age 12 and over and cover approximately 98 percent of Canadian population. The sampling does not include individuals living on Indian Reserve and on Crown Lands, institutional residents, full-time members of the Canadian Forces, and residents of certain remote regions, (CCHS 2012: Annual Components).

CCHS 2012 is a large data set including 61,707 people. Following most studies in this literature (e.g., Miller et al. 1999, Azagba et al. 2013) I restricted the sample to individuals aged 18 and above because effects of smoking for young individuals are not apparent until several years later. People who did not respond to the questions of interest are dropped from the sample. For example, 458 missing observation exist in the smoking variables. Hence, 48,309 observations are left to study making this sample an appropriate one for analyzing the health care cost of smoking with sufficient variables affecting health care use and large number of observations.

The smoking variables are derived variables in the CCHS survey based on four questions (CCHS 2012: Annual Component, Study Documentation):

In your lifetime have you smoked a total of 100 or more cigarettes?

Have you ever smoked a whole cigarette?

At the present time do you smoke cigarettes daily, occasionally or not at all?

Have you ever smoked cigarette daily?

These four questions generate sufficient information to derive the five variables used in the model. All of the variables are defined in Table 1 and their descriptive statistics are provided in Table 2.

Individuals in the sample are classified into five different categories based on their smoking habits. According to Table 2 non-smokers constitute the largest group at 33.6 percent of the sample. 29.6 percent of the sample is former daily smokers who do not smoke anymore at the time of responding to the survey. It is expected that belonging to this group of individuals will have an impact on health care use, because at some point in their life they smoked on a daily basis; they have thus been exposed to tobacco sufficiently in the past to incur its negative health effects at the moment. Daily smokers have the third highest share at 16.7 percent of the sample. It is ambiguous how many of people in this category have been daily smokers for a long time and how many started daily smoking recently, nevertheless, it is expected that daily smoking has a meaningful effect on health care use.

86 percent of people in the sample are white and the rest are from visible minority racial groups. The mean of the BMI for people in this sample is 26.5 which is considered as overweight or pre-obese in the BMI classifications, (WHO 2014). Approximately 60 percent of the sample are individuals aged 50 years and over. It is expected that the negative consequences of smoking on health increases with age, because smokers usually starts smoking in their youth and by age 20 (Statistics Canada 2011). More than 85 percent of people in the sample perceive their health as

excellent, very good or good and 87 percent have regular doctors. 71 percent of people have post-secondary education. The ratio of people in three different income categories is almost the same at approximately 33 percent in each low, medium or high income group. 63 percent of people drink alcohol regularly and 68 percent of them have regular physical activity.

5. Results:

Since the dependent variable, P, in equation (3) is a dummy variable we can no longer assume that the random error is normally distributed. Therefore, we need an appropriate Generalized Linear Model (GLM) to estimate equation (3). Logit and probit models are special cases of GLM appropriate for binary variables which can be applied here. Both models estimate the probability that the outcome, here the health care use, happens and give predicted values between 0 and 1. In practice probit, which is applied in this paper, and logit give virtually the same results in most cases.

The dependent variables for the level of utilization, L, in equation (4) are either the number of physician visits or the number of nights spent at a hospital. Both of them take the values from 0 to 31 for the number of utilization in this range (where all values greater than 31 are censored as 31)[1]. A tobit model (censored on both ends) is employed to estimate equation (4) due to the nature of the dependent variable (i.e., it cannot take negative values or values higher than 31). Following the approach of Harrison et al. (2003) a semi-log specification is used for equation (4) to mitigate the effect of extremely high values.

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[1] There are 67 observations at 31 for physician visits, and 151 observations at 31 for hospital nights.

The results of the probit model for physician visit and hospital nights are given in Table 3 and the marginal effects associated with the estimated coefficients from the probit model are presented in Table 4. The estimated parameters and their corresponding p-values for physician visits are presented in the second column of the tables and for the hospitalization in the third column. The test for the hypothesis that all smoking variables are jointly zero is conducted for both regressions. The χ^2 (chi-squared) statistics for this test in the probit model is given at the end of each column. The result of the test indicates that smoking variables are significantly meaningful in the probability of seeing a physician specification. The χ^2 critical value is 14.72 with the p-value of 0.0053. The test for the jointly significance of smoking variables for hospital stays also indicate that they are meaningful in determining the probability of being hospitalized. The χ^2 value is 21.64 with the p-value of 0.0002.

The estimated results of equation (4) are given in Table 5 which provides the effect of smoking on the level of utilization. The second column shows the estimated coefficients from the tobit model for the number of physician visit and the third column contains the results of the tobit model for the quantity of hospital utilization. The hypothesis that smoking variables are jointly zero is tested for both regressions and the F-statistics and the corresponding p-values are given at the end of each column. The results of the test support the hypothesis that the number of physician visits as well as the quantity of hospital nights is related to smoking behavior. The F-statistics for physician visit is 4.58 with the p-value of 0.0011 and the F-statistics for hospitalization is 5.69 with the p-value of 0.0001.

The estimated coefficient for daily smoking is positive and significant for the probability of being an overnight patient at a hospital. However, the estimated coefficient of this variable is significantly negative in the probability of seeing a doctor. One explanation for that could be people's attitude towards health; those who smoke on a daily basis and do not care about its negative effects are also less likely to take care about their own health sufficiently to be willing to consult with a doctor until they need acute care, or they may be reluctant to see a doctor and be told to quit smoking. On the other hand, we should not forget the fact that there is a time lag between starting smoking and having the health conditions associated with smoking; those who are current smokers are all classified in the same category whether it has been a long time since they started smoking on a daily basis or not. Daily smoking is positive and meaningful in determining the level of doctor visits. In other words, although daily smoking may not positively affect the probability that an individual consult with a physician, for those who see a physician, it increases the level of utilization.

Being a former daily smoker has a positive and statistically significant effect in all four equations making this variable a strong predictor of the level of health care use. Former daily smoking is even significant in determining the level of hospital use while daily smoking is not. This suggest that although daily smokers may not suffer from acute conditions that need hospital care, and they only generate more physician visits, former daily smokers are now suffering from the consequences of smoking at a more severe level that needs hospitalization.

The variable denoting current occasional smokers who are former daily smokers is positive in all four equations, although it is only statistically significant in the quantity of hospital use. The estimated coefficient of this covariate in determining the level of hospitalization is also the highest among all smoking variable coefficients illustrating that for those who have spent at least one night at hospital during the past 12 months, the number of stays is higher if they used to be a daily smoker and still smoke occasionally. Being current occasional smoker as well as former occasional smoker does not play a significant role in determining the health care use which is not unexpected.

There are other noteworthy conclusions that can be made from the tables. The coefficient estimate for male is negative across the board. Compared to the low level of physical activity of the reference group with infrequent exercise, having regular exercise as well as occasional exercise decreases both physician visits and hospital stays. The impact of education on health care utilization varies in the literature among different studies. For instance, while Deb and Trivedi (2002) find a positive relationship between education and outpatient visits, Sari (2009) finds family doctor visits decreases with higher education. The results from the four equations estimated in this paper mostly support the negative relationship. Having a regular doctor has a positive effect on the level of health care utilization which is consistent with the results in the previous literature. Among the controlled variables in the model, the parameters estimated for the series of self-perceived health status variables, as well as those for income levels are the strongest ones being statistically significant at any level.

In the previous studies, the effect of self-perceived health status is shown to be an important determinant of health care use (e.g. Chern et al. 2002; Al-Windi et al. 2002).Comparing the results from Table 4 and Table 5 we can conclude that the healthier the individuals see themselves as, the less likely they are to use health care. Given that they use the service, the healthier individuals utilize less health care for both the number of physician visits and the quantity of hospital nights, and all coefficients estimated are significant at the one percent significance level. As for the impact of income, the results suggest a negative relationship between income and the level of health care use for both measures of health service. People from visible minority groups use more physician visits than white people (reference group) while this variable has a negative relationship with hospitalization meaning that white people use more hospital care. Generally the results are consistent with the expectations suggesting the model specification is sound.

6.1: SAFs and Smoking Attributable Costs

Once the equations are estimated for each measure of health care use and four predicted values are obtained, it is a simple arithmetic exercise to find the SAF for that type of health service. Using the procedure described earlier the SAF for physician visits is 0.125 meaning that approximately 12.5 percent of physician visits are associated to smoking. The SAF for hospital use is 0.155 indicating that roughly 15.5 percent of days spent in a hospital are attributable to smoking. The SAFs are higher than the ones found in the paper by Harrison et al. (2003) where 12.4 percent of hospital stays and 7 percent of physician visits are estimated to be attributable to smoking in Newfoundland and Labrador in 1995. This may be due to the difference in the control variables included in the model. For instance, in this paper, following the specification used in the study by Miller et al. (1999), smoking-related chronic conditions such as cancer, or emphysema are not controlled for.

After finding the SAFs, the next step is to estimate the monetary health care cost of smoking implied by these fractions. Following Harrison et al. (2003) two estimates of the health care cost are developed here. One is the portion of national health expenditures on the health care category of interest that is estimated to be attributable to smoking. That measure is developed by applying the SAFs that were obtained based on the CCHS 2012 to the national health expenditures for that year. In the second estimation the death benefit, the expected health care expenditure that is not realized due to the premature death, is deducted from the cost attributable to smoking which will be discussed further.

Total health spending in Canada is obtained from the Canadian Institute for Health Information (CIHI 2014). The expenditures figures for 2012 are forecasted from those in 2010. Hospital expenditure has the highest share of total health care expenditure in Canada in 2010. Canadians spent $56.3 billion on hospitals accounting for 29.1 percent of the total health cost in 2010. Hospital spending is forecast to be $60.5 billion in 2012, accounting for 29.2 percent of total health expenditure. Physician visits constituted the third largest category of health expenditure in 2010 at $27.4 billion representing 14.6 percent of total health expense in that year and is forecast to grow to reach to $30.0 billion, reflecting 14.4 percent of total health expenditure, (CIHI 2014). Based on these predicted costs from CIHI and by applying the SAFs obtained in the previous section to them, total cost of physician visits attributable to smoking in 2012 is calculated to be $3.8 billion and hospital cost attributable to smoking is estimated to be $9.4 billion in the same year. Table 1.1 summarizes these estimations. Column four of the table reflects the estimated costs on a per capita basis.

Table 1.1: Smoking Attributable Hospital and Physician Cost, Canada, 2012

	SAF	Total Smoking Attributable Cost ($ billion)	Per-capita Smoking Attributable Cost
Physician Visit	12.50%	$9.40	$266.90
Hospitalization	15.50%	$3.80	$107.30

The estimated health care expenditures associated with smoking that are illustrated in Table 1.1 are higher than those obtained in previous Canadian studies (e.g., Kaiserman 1997, Xie et al. 1999) whose estimates are mostly found through the epidemiological approach. In this approach, as discussed earlier, the estimated cost of smoking on health care is limited only to the treatment costs of diseases that are proven to be causally related to smoking. However, there are many other medical costs that smoking imposes to the health care system. For instance, smoking can complicate the treatment of some conditions that are not themselves caused by smoking. The econometrics approach allows smoking to affect the health care use and in turn health care cost through all other pathways. The results in Table 1.1 are also higher than those obtained by Harrison et al. (2003) for Newfoundland 1995. There are two main reasons for that. The first reason, as discussed earlier, might be the difference in the specification of models used in the two studies. More importantly, in the present paper following the specification used in the study by Miller et al. (1999), chronic conditions like heart diseases and cancer are not controlled for. Second, the national health expenditure figures from CIHI that are used here to estimate the monetary cost of smoking include some other areas that are not captured by the dependent variables of this study and may yield overestimation of the expenditures . Further detail is needed to have more accurate estimations.

Whether or not to adjust the health care cost of smoking to account for death benefits is a controversial issue. It is not desirable to consider the premature deaths as a saving in health care cost, because while it may reduce future medical costs, early death is still a cost to the society (Harrison et al. 2003). Nevertheless it is an issue discussed in tobacco litigation cases, and for completeness they are estimated here and given in Table 1.2.

The same procedure to account for death benefits that is used in the paper by Harrison et al. (2003) is applied here. Following them 41.8 percent of the two-thirds of the health care costs attributable to smoking is assumed to be the death benefits of smoking and is deducted from the whole cost. The reasoning to apply this number is explained in their paper, as follows.

Table 1.2: Smoking Attributable Hospital and Physician Cost Less Death-Benefit Adjustment, Canada, 2012

	Total Smoking Attributable Cost ($ billion)	Per-capita Smoking Attributable Cost
Physician Visit	$6.80	$192.60
Hospitalization	$2.70	$77.40

Based on Coller et al. (2002) two-thirds of the health care cost of smoking is associated with the smoking-related diseases, and the remaining one-third is attributable to the excess cost of treatment for the other health problems that become more complicated due to smoking. Since the smoking-related diseases such as cancer or heart disease are associated with early deaths, only the two-third of the cost which is related to those diseases is adjusted to account for early death-benefits. The other one-third portion is not adjusted for death savings because it is assumed that in those cases the ultimate cause of death is not smoking.

For the death-adjustment factor Harrison et al. (2003) relied on the result from Raynauld and Vidal (1992), a Canadian study that incorporated the benefits and the costs of smoking. Using the relative-risk approach (epidemiological approach), Raynauld and Vidal (1992) estimated that the additional medical cost due to smoking is $614.6 million, and $256.9 million of this amount is offset due to early death savings, all in 1986 dollars. The ratio of these two values is 41.8 percent. That is, 41.8 percent of the additional health care cost due to smoking is compensated by the savings associated with premature deaths. The Raynauld and Vidal (1992) study was financed by the tobacco industry which may explain why their results are substantially different from most other studies in Canada, giving the lowest estimated per capita cost of smoking. Other possible reasons for this difference are as follows. First, they only analyzed the health care utilization by current smokers at the year of study, 1986, giving no weight to former smokers. Second, they only considered 11 diseases from International Classification of Diseases-Ninth Revision (ICD-9). However most of the studies based on relative-risk approach are based on a broader range of smoking related diseases. In addition, the estimated death benefit in Raynauld and Vidal (1992) is possibly biased upward due to their choice of discount factor. As discussed earlier, there is evidence that non-smokers live longer compared to smokers. The amount of health care they utilize during those excessive years could be considered as savings due to the early deaths caused by smoking. Therefore the early-death-cost-benefits for the health care, are the present values of the future costs associated to those treatments and health services that presumably a person would need if she/he did not die prematurely. Raynauld and Vidal (1992) used 3 percent discount factor based on 1946-1990 real return on Canadian bond which is much less than for example, the 10 percent discount rate recommended by Treasury Board of Canada (1976). The lower discount rate yields higher estimation on death-benefits of smoking (Harrison et al. 2003).

However, following Harrison et al. (2003), since the purpose of this adjustment is only to illustrate the effect of so-called early death-benefits, there is no need to account for the possible biases in estimating the ratio of 41.8 percent. The results in Table1.2 are computed by deducting 41.8 percent of two-third of the whole cost for each category.

6. Discussion:

The rate of smoking in Canada has dropped in recent years. Nonetheless, 23.1 percent of males and 17.5 percent of females smoked in 2012. The negative effect of smoking on health is well-established (e.g., World Health Organization 2011). Some studies suggest that smokers generate more health care utilization and impose an economic burden on society. The Canadian Community Health Survey provided a rich data set with which to study the effects of tobacco consumption on the amount of health care use in Canada. The results of this paper suggest that smoking affects medical cost to a substantial degree. The smoking attributable fractions, 12.5 percent for physicians and 15.5 percent for hospitalization, translate into over $14.2 billion dollars per year in health care expenditures attributable to smoking. It is to be noted that much of these expenditures, 91.2 percent of hospital expenditures and 98.7 percent of the expenditures on physicians, is publicly funded (CIHI 2014). Hence, smokers impose a substantial external cost to the public at large. Anti-smoking public policies to mitigate the prevalence of smoking and its over-consumption is merited.

One question worth studying is whether smokers pay for their excessive health care cost through tobacco taxes. The Canadian revenue from tobacco taxes in 2012 is over $18.5 billion seasonally adjusted at annual rates (Statistics Canada Table 380-0081). In comparing this number with the $14.2 billion cost of smoking that is estimated in this paper, some considerations must be noted. The excessive health care expenditures due to smoking obtained in this paper reflect only those imposed on hospital care and physician visits. While these two categories combined constitute a large share of total health expenditure at 44.1 percent of the whole, there are still seven other categories for use of funds in health care, including prescription drugs, public health or other professionals, (CIHI 2014). The total cost of smoking might be substantially higher than what is estimated here if the extent to which smoking increases costs in these other categories are determined and added to the two estimated here.

After adjusting the health care costs attributable to smoking to account for premature death benefits, even with the highest death-benefit rate of 41.8 percent from Raynauld and Vidal (1992), smoking attributable fractions translate into over $9 billion cost on health care system in 2012 which is considerable.

The coefficients estimated for the level of physician visits as well as hospital nights in Table 5 are higher for former daily smokers than for current smokers. This is in accordance with some studies that suggest, in the short run, former smokers generate more health care use than current smokers and quitting does not necessarily mean less health care utilization (e.g., Wagner et al. 1995, Barendregt et al.1997, Fishman et al. 2003). To examine the effect of quitting on health care use accurately, a study must be conducted observing people over time after a successful cessation, such as the paper by Fishman et al. (2003). The results obtained here are only based on cross sectional data, nonetheless they support the conclusions of the previous studies.

The current study has some limitations. Primarily, it is based on a cross sectional data set, however, since the consequences of smoking on health are not revealed until many years later in life, a longitudinal data set observing people over time can help to better capture the causal relationship of smoking on health and consequently on health care utilization. Secondly, physician visits occur both for treatment and preventive care and it is not clear in the CCHS how many of the visits are preventive in nature. Finally, the results might be skewed due to response bias because the variables used in the study are self-reported. These are the same limitations as outlined by (Azagba et al. 2013).

Nevertheless, this study represents the first one to look at the smoking attributable fractions (SAFs) across all Canadian provinces using an econometrics approach. It is thus the first to determine the health care costs associated with smoking based on the most recent data set available on health care utilization of people and their smoking habits, the CCHS 2012. The results illustrate that despite the decline in the smoking rates in recent years, the health care costs attributable to smoking is still high. This might be because the smoking related health care needs today reflect the smoking behavior of previous years.

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Table 1: Variable Definitions

Dependent Variable	
Visit	1=Consulted with family doctor/general practitioner, 0=otherwise
Visit Number	Number of consultations to a family doctor/general practitioner
Overnight	1=Have been a patient overnight in a hospital/nursing home or convalescent home, 0=otherwise
Overnight Number	Number of nights as patient at hospital /nursing home or convalescent home
Independent Variable	
Age18_34	1=age>=18 and age<=34 , 0=otherwise **reference group**
Age35_49	1=age>=35 and age<=49, 0= otherwise
Age50_64	1=age>=50 and age <=64, 0=otherwise
Age65plus	1= age 65 or above , 0= otherwise
Female	1=female, 0=otherwise **reference group**
Male	1=male, 0=otherwise
Married	1=married or common law, 0=otherwise
Single	1=single or never married or separated or divorce, 0=otherwise **reference group**
Separated	1=Divorced or separated, 0=otherwise
White	1=Has white racial origin, 0=otherwise **reference group**
Minority	1=Not one of the majority race, 0=otherwise
BMI	BMI= body mass index
BMI2	BMI squared
DailySmk	1= daily smoker, 0=otherwise
OccSmkFormerDaily	1=occasional smoker and former daily smoker, 0=otherwise
OccSmkAlways	1= always an occasional smoker, 0=otherwise
FormerDaily	1= former daily smoker, 0=otherwise
FormerOcc	1= former occasional smoker, 0=otherwise
NvrSmk	1=never smoked, 0=otherwise **reference group**
Health_excellent	1=Self-Perceived Health Status is Excellent, 0=otherwise
Health_vgood	1=Self-Perceived Health Status is very good, 0=otherwise
Health_good	1=Self-Perceived Health Status is good, 0=otherwise
Health_fair	1=Self-Perceived Health Status is fair, 0=otherwise
Health_poor	1=Self-Perceived Health Status is poor, 0=otherwise **reference group**
RegExc	1=Regular physical activity, 0=otherwise
OccExc	1=Occasional physical activity, 0=otherwise
InfrExc	1=Infrequent physical activity, 0=otherwise **reference group**
RegDoc	1=Has a regular medical doctor, 0=otherwise
Educ1	1=Less than secondary school graduation, 0=otherwise **reference group**
Educ2	1=Secondary school graduation, 0= otherwise
Educ3	1=Some post-secondary school education, 0= otherwise

Educ4	1=Post-secondary graduation, 0= otherwise
	Total household income from all resources
Low Income	1=no income or less than $39’999, 0=otherwise **reference group**
Medium Income	1= $39’999 and $79’999, 0=otherwise
High Income	1=80’000 or more , 0=otherwise
Alcohol Reg	1= regular drinker, 0 otherwise
Alcohol Occ	1=occasional drinker, 0= otherwise
Alcohol Not	1=did not drink in the last 12 months, 0= otherwise **reference group**
ON	1=Ontario, 0=otherwise
PE	1=Prince Edwards Island, 0=otherwise
NL	1=Newfoundland , 0= otherwise
NS	1=Nova Scotia, 0= otherwise
NB	1= New Brunswick, , 0= otherwise
QB	1=Quebec, 0= otherwise
MB	1=Manitoba, 0= otherwise
SK	1=Saskatchewan, 0= otherwise
AB	1=Alberta, 0= otherwise
BC	1=British Columbia, 0= otherwise **reference group**
YT	1= Yukon/Northwest/Nunavut territories, 0=otherwise

Table 2: Variable Means

Variable	Mean	Standard Deviation
Age18_34	0.204	0.403
Age35_49	0.203	0.402
Age50_64	0.303	0.459
Age65plus	0.291	0.454
Male	0.444	0.497
Female	0.556	0.497
Married	0.563	0.496
Separated	0.222	0.416
Single	0.215	0.411
Minority	0.131	0.337
White	0.869	0.337
BMI	26.595	5.287
BMI2	735.227	315.821
Health_excellent	0.183	0.387
Health_vgood	0.380	0.485
Health_good	0.299	0.458
Health_fair	0.103	0.304
Health_poor	0.034	0.182
DailySmk	0.167	0.373
OccSmkFormDaily	0.028	0.166
OccSmkAlways	0.015	0.120
FormerDaily	0.296	0.457
FormerOcc	0.157	0.364
NvrSmk	0.337	0.473
RegExc	0.681	0.466
OccExc	0.144	0.351
InfrExc	0.175	0.380
RegDoc	0.870	0.336
Educ1	0.115	0.319
Educ2	0.131	0.338
Educ3	0.035	0.184
Educ4	0.719	0.450
Alcohol Reg	0.630	0.483
Alcohol Occ	0.170	0.376
Alcohol Not	0.200	0.400
Low Income	0.326	0.469
Medium Income	0.339	0.474

High Income	0.334	0.472
BC	0.123	0.328
NL	0.028	0.165
PE	0.015	0.120
NS	0.038	0.190
NB	0.042	0.200
QB	0.193	0.394
ON	0.339	0.473
SK	0.057	0.232
AB	0.090	0.285
YT	0.022	0.147

Table 3: Estimated Coefficients from Probit Model: Dependent Variables: Visit to Physicians and Hospital Visits. CCHS (2012)

	Visits to Physicians (N=48,309)		Hospital Visits (N=48,309)	
	Coefficient	P>|z|	Coefficient	P>|z|
Age18_34	-0.515	0.000	0.190	0.002
Age35_49	-0.418	0.000	-0.177	0.000
Age50_64	-0.251	0.000	-0.233	0.000
Male	-0.354	0.000	-0.153	0.000
Married	-0.048	0.188	0.214	0.000
Separated	-0.063	0.211	0.225	0.000
Minority	0.026	0.502	-0.063	0.202
BMI	0.020	0.226	0.034	0.047
BMI2	0.000	0.506	-0.001	0.039
Health_excellent	-0.747	0.000	-1.140	0.000
Health_very good	-0.574	0.000	-0.995	0.000
Health_good	-0.476	0.000	-0.822	0.000
Health_fair	-0.205	0.044	-0.439	0.000
DailySmk	-0.104	0.014	0.145	0.010
OccSmkFormDaily	0.091	0.255	0.102	0.235
OccSmkAlways	-0.041	0.703	0.155	0.192
FormerDaily	0.137	0.000	0.175	0.000
FormerOcc	0.068	0.093	0.005	0.924
RegExc	0.010	0.805	-0.082	0.080
OccExc	-0.018	0.723	-0.056	0.349
RegDoc	1.027	0.000	0.205	0.001
Educ2	-0.016	0.770	-0.014	0.828
Educ3	0.218	0.009	-0.044	0.683
Educ4	0.173	0.000	0.002	0.978
Alcohol Reg	0.104	0.013	-0.183	0.000
Alcohol Occ	0.107	0.037	-0.041	0.415
Medium Income	-0.011	0.779	-0.065	0.157
High Income	0.045	0.277	-0.086	0.113
NL	-0.012	0.881	0.024	0.818
PE	-0.121	0.157	0.086	0.437
NS	-0.201	0.005	-0.233	0.002

NB	-0.219	0.002	-0.106	0.211
QB	-0.156	0.002	0.109	0.058
ON	-0.159	0.001	-0.132	0.010
SK	-0.043	0.505	0.006	0.934
AB	-0.125	0.041	0.014	0.846
YT	0.121	0.109	0.264	0.002
MB	-0.049	0.528	-0.019	0.826
_cons	0.443	0.094	-1.050	0.000
	chi2(4) = 14.72		chi2(4) = 21.64	
	Prob > chi2 = 0.0053		Prob > chi2 = 0.0002	

Table 4: Marginal Effects of the Probit Model from Table 3

	Visits to Physicians (N=48,309)		Hospital Visits (N=48,309)	
	dy/dx	P>|z|	dy/dx	P>|z|
Age18_34	-0.162	0.000	0.027	0.003
Age35_49	-0.131	0.000	-0.022	0.000
Age50_64	-0.076	0.000	-0.028	0.000
Male	-0.103	0.000	-0.020	0.000
Married	-0.014	0.186	0.027	0.000
Separated	-0.019	0.220	0.033	0.001
Minority	0.008	0.499	-0.008	0.189
BMI	0.006	0.226	0.004	0.048
BMI2	0.000	0.505	0.000	0.040
Health_excellent	-0.250	0.000	-0.096	0.000
Health_very good	-0.174	0.000	-0.118	0.000
Health_good	-0.149	0.000	-0.086	0.000
Health_fair	-0.064	0.056	-0.044	0.000
DailySmk	-0.031	0.017	0.020	0.016
OccSmkFormDaily	0.026	0.237	0.014	0.266
OccSmkAlways	-0.012	0.707	0.023	0.238
FormerDaily	0.039	0.000	0.025	0.000
FormerOcc	0.019	0.087	0.001	0.924
RegExc	0.003	0.805	-0.011	0.088
OccExc	-0.005	0.724	-0.007	0.335
RegDoc	0.360	0.000	0.024	0.000
Educ2	-0.005	0.771	-0.002	0.826
Educ3	0.058	0.004	-0.006	0.673
Educ4	0.052	0.001	0.000	0.978
Alcohol Reg	0.031	0.014	-0.025	0.000
Alcohol Occ	0.030	0.032	-0.005	0.405
Medium Income	-0.003	0.780	-0.008	0.150
High Income	0.013	0.275	-0.011	0.109
NL	-0.004	0.881	0.003	0.821
PE	-0.037	0.174	0.012	0.463
NS	-0.063	0.009	-0.026	0.000
NB	-0.069	0.003	-0.013	0.177

QB	-0.047	0.003	0.015	0.070
ON	-0.047	0.001	-0.017	0.009
SK	-0.014	0.534	-0.002	0.824
AB	-0.013	0.511	0.001	0.935
YT	-0.038	0.048	0.002	0.847
MB	0.034	0.093	0.042	0.009

Table 5: Estimated Coefficients from Tobit Model: Dependent Variables: Visit to Physicians and Hospital Visits. CCHS (2012)

	Visits to Physicians (N=37,817)		Hospital Visits (N=4,681)	
	Coefficient	P>|z|	Coefficient	P>|z|
Age18_34	0.028	0.233	-0.376	0.000
Age35_49	-0.043	0.038	-0.318	0.000
Age50_64	-0.072	0.000	-0.325	0.000
Male	-0.150	0.000	-0.025	0.000
Married	0.008	0.696	-0.138	0.699
Separated	0.002	0.922	-0.036	0.123
Minority	0.033	0.115	-0.054	0.719
BMI	0.003	0.740	0.006	0.490
BMI2	0.000	0.775	0.000	0.831
Health_excellent	-1.058	0.000	-0.647	0.683
Health_very good	-0.931	0.000	-0.543	0.000
Health_good	-0.708	0.000	-0.359	0.000
Health_fair	-0.461	0.000	-0.278	0.001
DailySmk	0.073	0.002	0.064	0.019
OccSmkFormDaily	0.000	0.999	0.293	0.478
OccSmkAlways	0.082	0.176	-0.174	0.021
FormerDaily	0.085	0.000	0.140	0.343
FormerOcc	-0.002	0.934	-0.158	0.060
RegExc	-0.039	0.056	-0.077	0.051
OccExc	-0.023	0.378	-0.202	0.303
RegDoc	0.175	0.000	0.154	0.017
Educ2	-0.001	0.985	-0.146	0.099
Educ3	0.039	0.391	-0.344	0.117
Educ4	0.014	0.602	-0.221	0.087
Alcohol Reg	-0.121	0.000	-0.066	0.007
Alcohol Occ	-0.044	0.087	0.017	0.330
Medium Income	-0.070	0.000	-0.024	0.826
High Income	-0.104	0.000	-0.071	0.767
NL	0.035	0.399	0.201	0.406
PE	-0.153	0.000	0.300	0.242
NS	-0.053	0.121	-0.075	0.111
NB	-0.223	0.000	-0.033	0.552
QB	-0.444	0.000	-0.136	0.821
ON	-0.168	0.000	-0.126	0.202

SK	-0.175	0.000	0.078	0.190
AB	-0.091	0.003	-0.214	0.517
YT	-0.025	0.550	0.262	0.061
MB	-0.142	0.000	-0.067	0.641
_cons	1.847	0.000	2.097	0.000
	F(4, 37779) = 4.58		F(4, 4643) = 5.69	
	Prob > F = 0.0011		Prob > F = 0.0001	