THE ONTARIO TOBACCO RESEARCH UNIT
UNITÉ DE RECHERCHE SUR LE TABAC DE L'ONTARIO

Generating knowledge for public health

The Effect of Tobacco Control Strategies and Interventions on Smoking Prevalence and Tobacco Attributable Deaths in Ontario, Canada

Technical Report of the Ontario SimSmoke

Bo Zhang
Robert Schwartz

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Executive Summary

Tobacco control is perhaps the most successful public health endeavor in developed countries over the past 50 years.[1] Much of the success in tobacco control is attributable to policies relating to economic incentives, law and regulation, and public education.[1] This paper describes the development of a simulation model examining the effect of past and projecting the effect of future tobacco control policies and interventions in Ontario on smoking prevalence and associated future premature mortality.

The model is adapted from the *SimSmoke* simulation model of tobacco control policies, previously developed for the U.S. and other countries. The model uses population, smoking rates and tobacco control policy data for Ontario, Canada. It assesses, individually, and in combination, the effect of seven types of policies: taxes, clean air, mass media, advertising bans, warning labels, cessation treatment, and youth access policies.

The model shows that significant inroads to reducing smoking prevalence and premature mortality can be achieved through tax increases, a high intensity media campaign promoting healthy behavior and the enforcement of clean air laws, a comprehensive cessation treatment program, and stronger advertising bans. The model forecasts that implementation of all of these changes would result in a reduction in smoking prevalence to 11.4% over a 10 year period by 2023 (a 30% relative reduction from the prevalence in 2012) and to 8.9% over 30 years by 2043 (a 46% relative reduction from the prevalence in 2012). In 2043, 2,464 deaths would be averted in that year alone with the stronger set of policies. Without stronger policies (no changes from policy levels in 2012), close to 50,000 more people in Ontario would die prematurely due to smoking in the next 30 years.

The model allows for demonstrating how the effect of policies depends on the population composition, the existence of other policies, and the length of time that policies are in effect. In addition, it identifies gaps in surveillance and points to the need for some additional research and evaluation efforts that could further demonstrate the effectiveness of tobacco control strategies and interventions in Ontario.

Introduction

Globally, it is estimated that 5 million deaths each year are attributable to smoking, with trends driving a rise to 10 million deaths per year by the 2030s.[2] In response, the World Health Organization (WHO) has set out the Framework Convention for Tobacco Control (FCTC). The FCTC and its guideline provide the foundation for countries and health regions to implement and manage tobacco control.[3] To help make this a reality, the MPOWER package of measures was introduced by WHO in 2008. The MPOWER Report[4] has defined a set of policies that are consistent with the FCTC, which includes Monitor tobacco use and prevention policies, Protect people from tobacco smoke, Offer help to quit tobacco use, Warn about the dangers of tobacco, Enforce bans on tobacco advertising, promotion and sponsorship, and Raise taxes on tobacco.

Substantial evidence indicates that higher cigarette taxes, clean air laws, advertising bans, and media campaigns can appreciably reduce adult smoking rates, especially when combined as a comprehensive strategy.[5-8] Evidence is mounting for health warnings and cessation treatment coverage. These policies not only reduce smoking initiation, but also lead current smokers to quit. Quitting can halt or even reverse many of the health problems associated with smoking.[9,10] MPOWER guidelines require that each nation imposes taxes on cigarettes that constitute 75% of the retail price; implements comprehensive smoke-free indoor air laws and advertising/ marketing restrictions; requires large, bold and graphic health warnings; provides broad access to cessation treatments; and implements well-funded tobacco control media campaigns.

Indicators in MPOWER include

- Adult daily smoking prevalence (highest score 4)
- Monitoring (prevalence data; highest score 3)
- Smoke-free policies (highest score 4)
- Cessation programs (highest score 4)
- Health warning on cigarette packages (highest score 4)
- Anti-tobacco mass media campaigns (highest score 4)
- Advertising bans (highest score 4)
- Taxation (highest score 4)
- Compliance with smoke-free policies (highest score 3)
- Marketing bans (highest score 3)

For these 10 indicators, each is assigned a score to indicate the level of each policy. The highest score of 4 can be assigned to 7 indicators and a score of 3 for other 3 indicators. The higher the score, the better the policy level. The highest score for the 10 indicators is 37.

Based on the Canadian Community Health Survey (CCHS) 2012 data[11] and adjusted population census data by age and gender by the Ontario Ministry of Finance, the adult (aged 20+) daily smoking prevalence was 15.6% in 2012 in Ontario, which means that a score of 3 should be assigned (the highest score of 4 can be assigned if the daily smoking prevalence is <15%). For the indicators of monitoring, smoke-free legislation, health warning labels, the highest score should be assigned to Ontario. For the indicator of cessation programs, a score of 3 should be assigned, because the cost of NRT and other cessation medication are not covered by the Ontario Drug Plan. With regard to anti-tobacco mass media campaigns, there have not been any major mass media campaigns launched on TV or radio since January 2011 in Ontario or Canada, although there are some online campaigns (a score of 0.5). For the indicator of advertising bans, a score of 3 should be assigned (not the highest score of 4), because direct mail to adult readers, cigarette brand names on non-tobacco products and appearance of tobacco products in TV and/or files exist in Canada and Ontario. For the indicator of taxation, the percentage of tobacco taxes in Ontario was 63.5% of the total retail price in 2012[12] (a score of 3) which is lower than the recommended 75%. Regarding compliance with smoke-free policies and advertising ban, no direct information on compliance is available. Based on the CTUMS 2011 data, 2% of Ontario population exposed to secondhand smoke inside a restaurant, 4% inside a bar, 8% at school properties, 19% at workplaces, and 32% in other public places such as a shopping mall, arena, bingo hall, and concert or sporting event. A score of 2 may be assigned to this indicator for Ontario. For compliance with advertising ban, no recent data are available. No monitoring systems are available and no regular and spot investigations have been conducted in Ontario. Thus a score of 1 is assigned. The total MPOWER score for Ontario is 26.5, which is much lower than the recommended 37 by MPOWER. Although progress has been made in Ontario, there is significant room for improvement, especially in sections on taxation (raising the tax to 75% of retail price), mass media campaigns (large ongoing campaigns on major media, such as TV and radio), cessation programs (coverage of cessation medications), advertising bans (ban all types

of ad), and compliance with smoke-free policies and advertising bans (monitoring systems and regular inspections are needed).

Canada's public education and tobacco control efforts can be traced back to 1962, when the report of the Royal College of Physicians & Surgeons on Smoking & Health was publicized linking smoking to disease and premature death. Since then, Canada has had many tobacco control initiatives, including multi-year federal strategies that began in 1986. However, none have been comprehensive strategies until April 2001, when the Federal Tobacco Control Strategy (FTCS) was launched.[13] Ontario was an early leader in tobacco control, introducing the Tobacco Control Act (TCA) in 1994. The 1994 TCA gave municipalities the power to implement more restrictive smoke-free bylaws.[14] A more comprehensive approach to tobacco control was introduced through the Smoke-Free Ontario Act (SFOA), which has banned smoking in all enclosed workplaces and public places including restaurants and bars across Ontario as of May 31, 2006. Before the implementation of SFOA, approximately 90% of the Ontario population was covered by municipal smoke-free bylaws.[15]

Although smoking prevalence has been declining from 24.9% in 1996/97 based on the National Population Health Survey (NPHS) to 18.9% in 2010 based on the Canadian Community Health Survey (CCHS) in the Ontario population aged 15 and over, much remains to be done to further reduce smoking prevalence and smoking-related mortality. This report uses the *SimSmoke* model to examine the effect of tobacco control policies and interventions implemented since 1996 and to forecast the effects of implementing stricter policies that would be fully consistent with the FCTC.

This report uses a simulation model to examine the effect of tobacco control strategies and interventions in Ontario, Canada. Most statistical models have examined the effect of only one or two policies. Simulation models combine information from different sources to provide a useful tool for examining how the effects of public policies unfold over time in complex social systems.[16,17] Simulation models examining the effect of tobacco control policies have been developed by Mendez and Warner,[18,19] Tengs et al.,[20-22] Ahmad[23-25] and Levy et al.[17,26-28] The *SimSmoke* model by Levy et al. simultaneously considers a broader array of public policies than

other models[29] and has been validated in several countries[30-34]_ENREF_31_ENREF_31 and states.[35-37]

In order to examine past trends in smoking rates and to examine the potential effect of tobacco control policies on future smoking rates, we have developed a modified version of *SimSmoke* for Ontario called *Ontario SimSmoke*. Using data from Ontario on population, birth rates, death rates, and smoking rates, the model predicts future smoking rates in total, as well as by age and gender. Using data on relative death risks, the model also estimates the number of deaths attributable to smoking. *Ontario SimSmoke* assesses the effect of tobacco control strategies and interventions, including tax increases on cigarettes, smoke-free air laws, media campaigns, advertising bans, health warnings, cessation treatment policies, and youth access enforcement, on smoking rates and smoking-attributable deaths. *Ontario SimSmoke* can be used to explore how the effect of policies depends on factors including: the age and gender group considered, the manner in which policies are implemented, the other policies in effect, and the length of time considered. The model is also used to identify where further information is needed on tobacco control policies, smoking rates and smoking-attributable deaths, and their inter-relationships.

This report describes the development of *Ontario SimSmoke*. The model shows future trends in smoking and deaths due to smoking in the absence of policy change, thus justifying the need for tobacco control policies. The model also shows the effect of policies implemented in the past 17 years (1996-2012) in Ontario and of a set of additional policies consistent with the FCTC, thus justifying the need for specific policies.

Methods

SimSmoke has population, smoking, smoking-attributable death, and policy modules. We chose 1996 for the baseline year in our *Ontario SimSmoke* model because the requisite data were available for that year and trends could be established before major policy changes occurred (such SFOA). All data entry was double checked by two people.

Basic Model

SimSmoke includes a population model, a smoking model, a smoking-attributable death model, and policy modules.[17,27,28] The simulation model begins in a baseline year with the population divided into smokers, never smokers, and former smokers by age and gender. The baseline year is usually chosen as a recent year before major policy changes occur and in which a large scale survey of smoking rates was conducted to provide the requisite data. The Ontario model starts in 1996, because of the availability of the large scale National Population Health Survey (NPHS) for that year and the lack of major changes in policy prior to that year, except for a tobacco tax cut.

A discrete time, first-order Markov process is employed to project future population growth and smoking rates from the base year to future years. Population growth evolves through births and deaths, and smoking rates evolve through smoking initiation, cessation, and relapse rates. Smoking rates may shift due to changes in tobacco control policies. Smoking-attributable deaths in the *SimSmoke* model are estimated using smoking rates and the risks of smokers and former smokers relative to never smokers, similar to standard attribution measures.[38,39] The primary mathematical equations used in the model are provided in an Appendix and the data are summarized in Table 8 of Appendix.

Population Model

The 1996 population and mortality data by gender and 1-year age group were obtained from the Canadian Human Mortality Database.[40] Ages 85 and above were grouped together and assigned a single mortality rate. The fertility data for years of 1996, 2000-2010 were from Statistics Canada for Ontario,[41,42] and for years of 1997-1999 for Ontario from Peel Public Health[43] (Table 10 in Appendix). The fertility rates in 2010 were used for future years. The number of newborns were

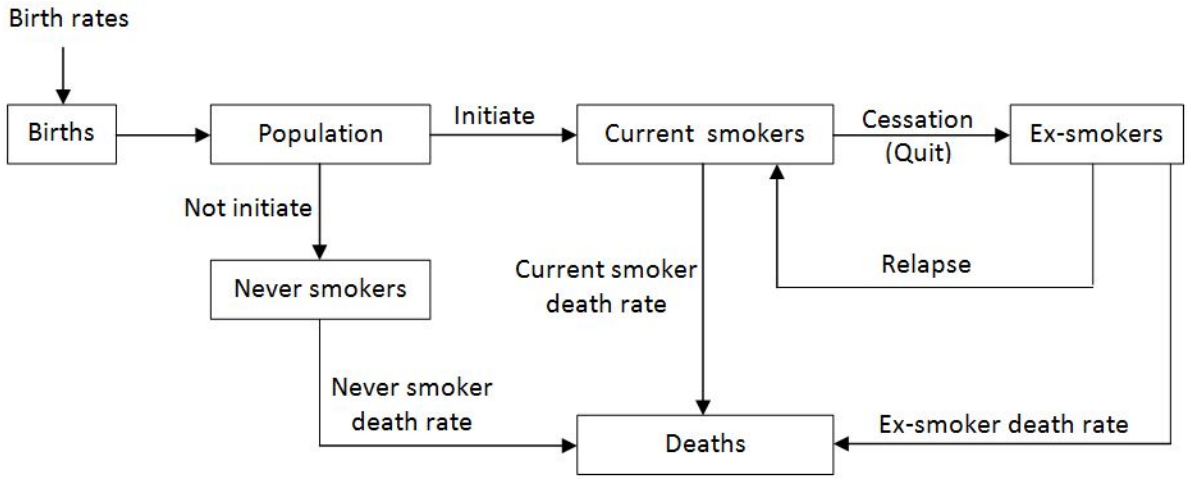
based on fertility rates by female age group (15-19, 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49) and it was assumed that half the births were of each gender (i.e., both male and female infants).

The population evolves over time due to deaths and births. Although Ontario has a relatively high rate of international net migration (e.g., 29.2% of Ontario population were foreign born in 2006),[44] information about smoking rates among immigrants is generally not available. Therefore, the effect of immigration is not taken into account in the current *Ontario SimSmoke* model. The model predicts a slow decline in the male and female populations as observed in recent years. We compared model predicted population and the real population in Ontario (data provided by the Ministry of Finance), and found that model predicted population was smaller than the real population. However, if immigrants were added to the model, the predicted population would be very similar to the real population estimates (Table 14, page 86). The largest difference was in 2007 (n=132,000) and smallest in 2012 (‹20,000), indicating that the difference on population estimates was almost entirely due to immigrants not included in the model.

Smoking Model

Within the smoking model, individuals are classified as never smokers from birth until they initiate smoking or die. They may evolve from current to former smokers through cessation or may return to smokers through relapse. The extent of relapse depends on the number of years since quitting. Figure 1 shows the Markov model and transitions between states.

Figure 1: Population Growth and Smoking Status Change



Survey Data

The smoking data was from the 1996/97 NPHS cross-sectional survey. The NPHS was designed to collect information related to the health of the Canadian population. The target population for this survey included household residents aged 12 and older in all provinces, with the principal exclusion of populations on Indian Reserves, Canadian Forces Bases, and some remote areas in Quebec and Ontario.[45] The NPHS cross-sectional sample design provides cross-sectional estimates for the country as a whole and by province. The sample size was increased through provincial buy-ins, allowing for sub-provincial estimates. Data collection was carried out in June, August, and November 1996, and February 1997. The NPHS survey collected most information from a single household member, but also collected limited health-related information, including socioeconomic characteristics, health care utilization, restriction of activities, and chronic conditions, for all household members.[46] In all provinces except Quebec, the NPHS used a multi-stage stratified sample of dwellings selected within clusters. For the 1996/97 NPHS survey, two cross-sectional files were produced: General and Health. The General file contains socio-demographic and some health information for each member of participating households, while the Health file contains additional, in-depth health information about one randomly selected household member, as well as the information from the General file about that individual.[47] The smoking data were calculated using the NPHS cross-sectional Health file. The sample size for the 1996/97 NPHS Health file was 81,804 in Canada and 39,393 in Ontario. The household response rate was 82.6% at the Canada level (78.8% in Ontario) and the person response rate was 95.6% at the Canada level (94.4% in Ontario) for the 1996/97 NPHS cross-sectional survey Health file.[48]

Smoking Prevalence

For the prevalence of current and former smokers, we used the 1996/97 NPHS cross-sectional Health file to develop estimates by gender for the age groups 15-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and above. A three year moving average was applied through age 25, followed by a five year moving average. We further subdivided former smokers by year quit using data from the U.S. We obtained former smoker rates comparable to those found in the 1996/97 NPHS. Current smokers were those who smoked at least 100 cigarettes in lifetime and smoked daily or occasionally at the time of survey or in the past 30 days. Because no question about 100 cigarettes in lifetime was asked in the 1996/97 NPHS, we used the CCHS data to estimate the

smoking prevalence in 1996/97 using the 100 cigarettes in lifetime definition. The CCHS and NPHS cross-sectional surveys are very similar in design and have the same target population. The CCHS covers approximately 97% of the Canadian population 12 years old or older.[49] The CCHS has the same questions about smoking to those in the NPHS, and in addition, has the question about 100 cigarettes in lifetime. The approximate difference in the estimates using the two definitions (with and without 100 cigarettes in lifetime) for the whole population is 1.2 percentage points, with some variation by gender and age, while the prevalence without 100 cigarettes in lifetime was higher. The smoking prevalence in 1996/97 was estimated by gender and age and adjusted based on the variations, using the average differences by age and gender for the two definitions of current smoking of CCHS 2000/01, 2003, 2004, and 2005 data.

Smoking Initiation Rate

Due to empirical challenges in measuring initiation rates in order to insure stability and internal consistency of the model, initiation rates at each age are measured as the difference between the smoking rate at that age year and the rate at the previous age year. For example, in the year 1996/97, smoking rates were 24.5% for males aged 15-19 and 31.6% for males aged 20-24. These prevalence rates were assigned to each individual age group (e.g., aged 15, 16, 17, 18, and 19) and smoothed by 5-year moving average for people aged 18 to 30 and by 10-year moving average for people aged 31 and older. The smoothed current smoking prevalence rate was 24.5%, 24.5%, 26.0%, and 27.4% for males aged 20, 21, 22, and 23, respectively. Then the initiation rate was estimated as 0% for males from age 20 to 21, 1.5% from age 21 to 22, and 1.4% from age 22 to 23. In calibrating the model, we checked smoking rates for ages 15-30 to confirm our choice of maximum initiation age and minimum cessation age.

Smoking Cessation Rate

Data were not available for those who quit in the last year in the 1996/1997 NPHS cross-sectional data. We used the closest year of CCHS 2000/01 data instead. Last year cessation rate was calculated as:

$$Last\ year\ cessation\ rate = \frac{No.of\ last\ year\ quitters}{No.of\ last\ year\ quitters + No.of\ current\ smokers}$$

where last year quitters were those who quit smoking for at least one month but less than 12 months. Because the sample size for last year quitters was small for Ontario in the CCHS 2000/01 survey (overall‹ 1000), CCHS 2000/01 data for all Canada were used (sample size for last year quitters ›2,000). The estimated last year cessation rates are listed below.

Table 1: Last Year Cessation Rate, CCHS 2000-2001, Canada

Age	Male (%)	Female (%)	Both Sexes (%)
25-34	8.54	11.78	9.97
35-44	7.15	7.80	7.45
45-54	8.74	6.76	7.84
55-64	8.49	9.34	8.89
65-74	9.54	8.23	8.87
75+	12.60	7.50	9.72
All ages	8.29	8.72	8.49

A study[19] by Shields using the NPHS longitudinal data from 1994/1995 to 2002/2003 reports that 9.6% of daily smokers aged 18 or older quit smoking in a two-year period from 1994/95 to 1996/97, 11.8% from 1996/97 to 1998/99, 13.9% from 1998/99 to 2000/01, and 16.8% from 2000/01 to 2002/03. The yearly quit rate would be 4.8% from 1994/95 to 1996/97, 5.9% from 1996/97 to 1998/99, 7.0% from 1998/99 to 2000/01, and 8.4% from 2000/01 to 2002/03. It is obvious that the cessation rate increased over time. Based on the 2000/01 CCHS data, we estimated a rate of 8.49% of current and former cigarette smokers successfully quit smoking (quit ≥1 month) in the last 12 months. This rate (8.49%) was for all smokers and close to the later year cessation rate from 2000/01 to 2002/03 reported by Shield's study, keeping the cessation trend consistent.[19] Based on the CCHS 2000/01 data, we estimated that 94% of last year quitters were former daily smokers and 6% were former occasional smokers. A population-based study using the 1990 California Tobacco Survey estimated that the rate for trying to quit in past 12 months was 67.4% among occasional smokers and 38.5% among regular daily smokers, and the rate for quitting for at least one year was 43.3% among occasional smokers and 24.2% among regular daily smokers.[50] Approximately, the quit rate is 1.8 times higher among occasional smokers than regular daily smokers. The cessation rate for all Canadian smokers in 1996/97 could be estimated as 6.18% (i.e., last year cessation rate of 5.9% for daily smokers in NPHS from 1996/97 to 1998/99 multiplying 94% of quitters from daily smokers and 5.9% times

1.8 and multiplying 6% of quitters from occasional smokers). The overall cessation rate (8.49%) from CCHS 2000/01 over-estimated the cessation rate in 1996/1997 (i.e., 6.18). To correct the over-estimation, we used an adjusting factor of 0.7279 (i.e., 6.18/8.49) to multiply the original cessation rates. The adjusted last year cessation rates simulating the 1996/97 Canadian population's cessation experience are listed below.

Table 2. Simulated Last Year Cessation Rate for Canadian Population in 1996/97, Using the CCHS 2000/01 Data and an Adjusting Factor of 0.7279

Age	Male (%)	Female (%)	Both Sexes (%)
25-34	6.22	8.57	7.26
35-44	5.20	5.68	5.42
45-54	6.36	4.92	5.71
55-64	6.18	6.80	6.47
65-74	6.94	5.99	6.46
75+	9.17	5.46	7.08
All ages	6.03	6.35	6.18

Smoking Relapse Rate

Because no relapse data by years of quitting were available for Ontario or Canada, we used U.S. relapse rates.[10,51-54] We examined smoker and former smoker rate trends and made adjustments accordingly to calibrate the model. Relapse rates used in the *Ontario SimSmoke* model are listed in Table 3 below.

Table 3: Relapse Rate by Years Since Quitting for Both Sexes

Age	Years Since Quitting	Relapse Rate
18-24	<1 year	80.0%
	1-2 years	20.0%
	3-5 years	10.0%
	6-10 years	5.0%
	11-15 years	3.0%
	>15 years	2.0%
25-34	<1 year	75.0%
	1-2 years	20.0%
	3-5 years	10.0%
	6-10 years	5.0%

Age	Years Since Quitting	Relapse Rate
	11-15 years	3.0%
	>15 years	2.0%
35-44	<1 year	70.0%
	1-2 years	16.0%
	3-5 years	8.0%
	6-10 years	4.0%
	11-15 years	2.7%
	>15 years	1.6%
45-54	<1 year	65.0%
	1-2 years	14.0%
	3-5 years	7.0%
	6-10 years	3.5%
	11-15 years	2.3%
	>15 years	1.4%
55-64	<1 year	65.0%
	1-2 years	12.0%
	3-5 years	6.0%
	6-10 years	3.0%
	11-15 years	1.9%
	>15 years	1.2%
65-85	<1 year	60.0%
	1-2 years	10.0%
	3-5 years	5.0%
	6-10 years	2.5%
	11-15 years	1.5%
	>15 years	1.0%

Data source: US studies.[9,52-55]

Smoking Attributable Deaths

Smoking attributable deaths are determined by excess smoking risks of male and female smokers and former smokers, which are calculated as the differences between estimated mortality risk of smokers (or former smokers) and of never smokers. Death rates were first calculated by age, gender, and smoking categories (never, current, and the 6 former smoker groups) using the data on death rates, smoking rates, and relative risks (see Appendix). The

number of smokers at each age was then multiplied by the death rate of smokers minus the death rate of never smokers to obtain the excess deaths due to being a smoker. The same procedure was applied to each former smoker group, and the results were summed over smoking groups for all ages to obtain the number of smoking attributable deaths.

Because measures of relative risk were not available for Canada and Canada has a similar smoking profile to the US, we use relative risk estimates from the U.S. Cancer Prevention Study II (CPS-II), which are close to 2.1. Doll and Peto[55,56] find similar relative risks, but their analysis is confined to British doctors. For former smokers, we allow relative risks to decline at the rate observed in U.S. studies,[57] which is similar to the British studies. Relative risks used in the *Ontario SimSmoke* model are listed in Table 4 below.

Table 4: Relative Risk of All-Cause Mortality by Age and Gender,

Age	Male	Female
35-49	2.80	1.70
50-59	2.80	2.09
60-64	2.80	2.20
65-69	2.40	2.20
70-79	2.30	1.90
80-85	1.90	1.60

Policy Effects

The policy parameters in the model used to generate the predicted effects are based on thorough reviews of the literature and updates, and the advice of an expert panel. The effects of tobacco control policies for Ontario are determined primarily from studies for Canada and high income nations. Policies and potential effect sizes are summarized in Table 9 of Appendix.

As described in the Appendix, policy effect sizes are in terms of percentage reductions. They are applied to the smoking prevalence in the year in which the policy is implemented and, unless otherwise specified, are applied to initiation and cessation rates in future years if the policy is sustained. Unless synergies are specified, the effects of a second policy simultaneously implemented are reduced by (1- the effect of the first policy).

In the model, the effect of a policy in a particular nation depends on its initial level in that nation (e.g., the incremental effect of a new complete work site ban is less when a nation already has a partial worksite ban), and, unless otherwise specified, the effect size corresponds to the effect relative to no policy, a weak policy, or otherwise. Because changes in policy affect the future path of smoking prevalence in *SimSmoke*, we track policy levels from the date that the model begins, 1996, to the most recent date, 2012. The level of each policy is based on information from various sources that are described in Table 11 of Appendix.

Cigarette Taxes

Cigarette taxes are considered one of the most potent tobacco control policies by World Health Organization.[59] When taxes change, an equation translates changes in the tax rate (as a percent of price) into changes in price. Changes in price are then translated into changes in smoking prevalence through an equation dependent on price elasticities as described in Levy et al.[60] Price elasticities, standard measures obtained from demand studies, have been extensively studied.[61] Chaloupka et al.[61] found that high income nations have total price elasticities between -0.3 and -0.5, averaging -0.4. This means that for a 10% increase in the price of cigarettes, the demand for cigarettes will be reduced by 4%.

Cigarettes are taxed at both the federal and provincial levels in Canada.[62] In February 1994, cigarette taxes were substantially reduced by approximately 50% by the federal government and five provinces including Ontario in an attempt to fight smuggling of cigarettes.[63] Although this eliminated smuggling issues,[64] these reductions in cigarettes were a catastrophe from a health perspective. Tobacco consumption increased significantly and more young adults initiated smoking due to tax cut.[63] Since 2001, cigarette taxes have been increased steadily in Canada and Ontario, as a major instrument to achieve the objectives of the Federal Tobacco Control Strategy (FTCS), launched in April 2001.[62] However, Ontario tax has been kept constant since 2007. Sen and Wirjanto[65] estimated the participation elasticities (from -0.10 to -0.14 for daily and occasional smoking) for Canadian youths aged 15-19, using the Canadian data from 1991 to 1999. A recent study using the Canadian longitudinal NPHS data from 1998/99 to 2008/09 reports the tax elasticity for the whole Canadian population is -0.23, while the tax elasticity is -0.322 for males and -0.120 for females. The age specific tax elasticity is -0.7576 for those aged 12-24, -

0.0352 for those aged 25-44, and -0.4028 for those aged 45-65. These results indicate that middle-aged people (aged 25-44) are less responsive to taxes, but youth and older people are more sensitive to tobacco taxes. The inconsistency of price sensitivity may be the result of the low prices of cigarettes during early 1990s in Canada and Ontario and the wide range of cigarette prices, which allow smokers to switch to a cheaper brand. Another factor affecting price elasticity is rising income. Canadian studies suggest that the elasticity of cigarette demand appears to be from -0.1 to -0.8, but there is much uncertainty. We adopt the US elasticities of -0.3 for ages under 18, -0.2 for ages 18-24, -0.15for ages 25-34, and -0.1 for ages 35 and above.

Statistics Canada regularly surveys the retail price of cigarettes in major Canadian cities. They release data on cigarette prices at the national level but for the provincial level, only cigarette price indices are released. The 2002 cigarette retail prices for three cities (Ottawa, Toronto, and Thunder Bay) in Ontario were previously purchased from Statistics Canada (they no longer release provincial cigarette price now) and the Ontario cigarette price index[66] were used to compute the annual cigarette prices from 1996 to 2012. These prices were then adjusted for inflation to 2012 November dollar using the Ontario Consumer Price Index (CPI) for all items, excluding tobacco products.[66] Cigarette tax data were collected from taxation authorities. Taxes included tobacco tax (unit tax) and sales tax (ad valorem) at the federal and provincial levels. Annual taxes were a weighted average of the taxes prevailed in a year with the proportion of dates within a year as weights. Annual taxes were then adjusted for inflation to November, 2012 dollars using the Ontario CPI, all items excluding tobacco products.[66] Details on cigarette prices and taxes from 1996 to 2012 used in our *Ontario SimSmoke* model are described in Table 11 of Appendix.

Smoke Free Laws

The smoke-free air module consists of bans on: 1) worksites, 2) restaurants, pubs and bars, and 3) other public places. *SimSmoke* distinguishes the level of worksite bans by none, partial (work areas, but not common areas) or in all workplaces except in ventilated areas (e.g., designated smoking rooms, DSRs), and complete; and the level of restaurant and bar bans as none, bans with DSRs, and smoke free in all indoor areas. A ban in other public places is designated if there are bans in bingo halls, bowling alleys, billiards, and municipality buildings (but not specifically

for bans on smoking near doorway). For each of the bans, the effects depend on enforcement and publicity. Enforcement is a policy option. Three levels of enforcement (strong, medium, and limited) are based on the MPOWER report: the clean indoor smoking bans are considered to have strong enforcement if the score is between 8 and 10 (out of 10), medium enforcement if the score is between 3 and 7, and low enforcement if the score is between 0 and 2. The level of publicity is automatically established based on the level of tobacco control media campaigns, and thus reflects a synergy related to a broader tobacco control media campaign (e.g., through greater awareness of the dangers of second hand smoke).

With a high level of enforcement and publicity in a high income county, a restaurant ban has a 2% effect, a pub and bar ban has a 1% effect, a full worksite ban has a 6% effect (a ban in indoor offices only has a 2% effect and a ban in 2 of the 3 of health facilities, universities and government facilities has a 2% effect), and a ban in other public places has a 1% effect. Unless otherwise specified, the same percentage effect is applied as a percentage reduction in the prevalence and initiation rate and a percentage increase in the cessation rate, and is applied to all ages and both genders. The effects are shown relative to the absence of any policy. They are based on literature reviews, advice of an expert panel and model validation.

The effect sizes are based primarily on studies of restrictions by private worksites and clean air laws for high income countries. The basis for these estimates is described in Levy et al.[67,68] For worksites, the effect size is consistent with Fichtenberg and Glantz[69] after converting their 3.8 percentage point prevalence reduction into relative terms and scaling for percent of the workers affected. Effects of similar or larger impact in relative terms have been observed in recent studies for Korea,[70] Norway,[71] Finland,[72] and Spain.[73] The effects of bans in restaurants, bars and other public places and of enforcement have received little attention. The effects are scaled based on the value of the MPOWER smoke-free air law enforcement variable and publicity (e.g., the effects are halved in the absence of any enforcement and publicity).

The effects of the worksite laws apply only to those who are currently working and work indoors. Retirees and people on disability benefits are excluded from workplace policy, but are covered by public place smoke-free bylaws. The percent of the workers employed in agriculture was low, at 2%[74] in September 2012 in Ontario, so that the majority of workers in Ontario are covered by

smoke-free workplace bans. The unemployment rate has increased from 5.7% in 2000[75] to 7.8% in September 2012[76] in Ontario. The unemployment rate in September 2012 in Ontario was slightly higher than that in the US (6.6% among people aged 25 years and over in September 2012).[76] In 1990, the *Smoking in the Workplace Act* came into force on January 1 in Ontario, which prohibited smoking in all enclosed workplace, except for designated smoking area (DSA) or smoking rooms (DSR) and in areas used primarily by the public or for lodging.[77] Before 1999, the worksite smoking ban was not complete (i.e., with DSA or DSR). Since 1999, the complete worksite smoking ban gradually increased. In 2006, the Smoke-Free Ontario Act (SFOA) was implemented, which bans smoking in all public spaces and workplaces. Before the 2006 SFOA, some municipalities implemented smoke-free bylaws[78] (either with DSRs or 100% smoke-free) in restaurants, bars, and other public places (e.g., bingo halls, bowling alleys, billiards, and municipality buildings). The population coverage by smoke-free bylaws was calculated for different type of bylaws, i.e., worksite, restaurants and bars, and other public places. The effect sizes of smoke-free policies were then multiplied by the population coverage to obtain the effect of these smoke-free policies. The enforcement level was set to 1, because the smoke-free bylaws require designated bylaw enforcement officers and penalty is applied to any offence to the bylaw (Table 11 in Appendix).

Marketing Bans

The marketing ban policy module in *SimSmoke* corresponds to the bans on advertising, promotion and sponsorship and have the following categories: 1) partial ban on advertising: bans only applied to some of TV, radio, print, or billboard; 2) ban on advertising: bans are applied to all media, including TV, radio, print, and billboard; and 3) comprehensive ban: bans applied to all media, including TV, radio, print, billboard. In Addition, bans applied to in-store display, sponsorships, free samples, and all types of prints, including magazines for adults only.

The effect sizes for marketing bans are based on a review by Levy et al.,[6] relying primarily on the more comprehensive studies by Saffer and Chaloupka[79] and Blecher.[80] Based on those studies (especially Blecher et al), a complete ban on direct and indirect marketing in a high income nation reduces prevalence by 5%, increases cessation by 3% and reduces initiation by 6%. With a ban on direct advertising only, prevalence is reduced by 3%, cessation is increased by 2% and

initiation is reduced by 3%. With a partial ban on advertising, prevalence is reduced by 1%, cessation is not affected and initiation is reduced by 1%. The effects of enforcement have not been studied. Like for smoke-free laws, the effects in *SimSmoke* are scaled back for incomplete enforcement (the effects are halved when MPOWER value of enforcement is zero).

Between 1989 and 1995, the Tobacco Products Control Act (TPCA) was implemented in Canada, prohibiting all forms of direct advertising, but exempt sponsorship, adult magazines, and point of sale advertising.[81] Tobacco ban on billboard advertising came into force in 1991.[82] The TPCA was struck down on September 21, 1995 and tobacco advertising increased during this period (September 1995 and April 1997).[82,83] The Tobacco Act[84] came into force as of April 27, 1997, which banned all forms of promotion, but allowed direct mail, publications with adult readership 85% or more. Self-service displays were banned under the Tobacco Act in 1997. All sponsorship advertising was banned as of October 1, 2003.[85] In 2007, the tobacco industry resumed direct advertising in print, bars, and through direct mail.[86] In 2008, Ontario implemented a complete ban on the display of tobacco products by retailers,[87,88] and an Act to amend the Tobacco Act banned all print advertising as of October 8, 2009.[89,90] The TPCA contains powers of entry, inspection, examination, sampling and seizure and since 1997 government agency is designated to enforce the laws. The enforcement was set at 5 for all years, based on MPOWER scores (range from 0 = no enforcement, to 10 = complete enforcement) (Table 11 in Appendix).

Health Warnings

The health warnings policy module in *SimSmoke* corresponds to the Health Warnings in the MPOWER report. The MPOWER report provides 4 levels for health warnings: no policy, minimal policy (< 30% of the principal display area of the pack), moderate policy (a warning that covers at least 30% of the principal display area of the pack and includes 1 to 7 of the seven pack warning criteria outlined in the Technical Note of Appendix II), and strong policy (a warning that covers at least 50% of the principal display area of the pack and includes all seven pack warning criteria outlined in the Technical Note I, as well as a ban on deceitful terms). The effect of health warnings also depends on the level for tobacco control campaigns, as found in the tobacco control campaign/mass media module.

With strong health warnings in a high income nation, prevalence is reduced by 2%, cessation is increased by 5% and initiation is reduced by 2%. When the level is set to moderate, prevalence is reduced by 1%, cessation is increased by 2.5% and initiation is reduced by 1%. When the level is set to mild for minimal policy, prevalence is reduced by 0.5%, cessation is increased by 1%, and initiation is reduced by 0.5%. Evidence on the effects of health warnings on cessation behaviors is provided in Levy et al.[6] and has been strengthened based on more recent articles.[91-97] Nevertheless, knowledge on the effects of health warnings, particularly on prevalence and initiation, is indirect.

The first health warnings on cigarette packets were imposed by federal law in 1989 in Canada, with four text-only messages.[98] In 1994, a new set of eight messages (no graphs) came into effect, occupying the top 35% of each main display surface of a cigarette pack.[98] In 2001, Canada became the first country to implement pictorial health warning labels on cigarette packages, covering 50% of front and back of the package with 16 graphic health warnings rotation.[99] Therefore, the category is "moderate" for the period between 1996 and 2000 and "strong" from 2001 to 2010, and the publicity is weak for moderate policy and well for strong policy (Table 11, Appendix).

Tobacco Control Campaigns

The *SimSmoke* tobacco control/media campaign module has 3 levels of campaigns: well-funded, moderately-funded, and low-funded, and has been tailored to information in MPOWER. To qualify for a low level campaign, there must be a national or provincial agency and at least some levels of funding and/or number of employees greater than zero. To qualify for a moderate level campaign, the nation or province must meet the requirements for a low level campaign plus have either more than 10 employees devoted to tobacco control or per capita expenditures over $0.25 USD per capita. To qualify for a well-funded campaign, the nation or province must meet the requirements for a low level campaign plus have per capita expenditures over $1.00 USD per capita. In developing these measures, we consider supplementary information on the extent of campaigns, and national, provincial, and local organizations using criteria from previous versions of *SimSmoke*.

The intent of this module is not only to capture the establishment of an organized tobacco control campaign, but to also incorporate the impact of funded programs. An important part of

most campaigns is the level of communication through media and other sources, including publicity generated and local programs. We also consider characteristics of the media campaign specific to the country or the province, such as the extent of the media campaign in terms of media covered, the percent of the year that messages are promoted, whether the campaign has been tested, and the topics that are covered. The module also incorporates the synergies from the effects of publicity from other tobacco control policies, independent of media expenditures. An indicator for other policies is computed with a value of 1 if two of the following four policies are in effect: the tax is greater than 50% of the retail price, there is a complete workplace ban, there is at least a complete advertising ban (=3 or 4), or at least strong health warnings (=3 or 4) and otherwise has a value of 0.5.

The campaigns with demonstrated effectiveness are those that have involved a strong media component and grassroots organization, such as those in California, Arizona, Australia, and Massachusetts. With a well-funded tobacco control campaign in place in conjunction with other policies, the effect size is 6.5%. A moderately funded campaign yields an effect size of 4.25%, and a low funded campaign yields an effect size of 1%. Without other policies in place, the effects are reduced by half. The effect of mass media campaigns has been described in Levy et al.,[6,100,101] with consistent results in a recent review[102] and some other recent studies.[103-105]

From 1996 to 1999, the expenditure on anti-advertising campaigns was $0.47 per capita in Canada, but data were missing on the number of people employed (categorized as "moderately-funded").[106] Between 2000 and 2008, government at federal and provincial levels and non-government organizations embarked on several aggressive and heavily publicized campaigns on TV, radio, and other media (posters, video, websites), and spent approximately Cnd $1.00 per capita on anti-tobacco mass media campaigns in Canada and/or Ontario (categorized as "well-funded").[107-112] From 2009 to 2012, only a few but no major ongoing campaigns existed in Ontario (categorized as "moderately-funded")[15,113]_ENREF_110 (Table 11 in Appendix).

Cessation Treatment Policies/Programs

The cessation treatment policy module in *SimSmoke* corresponds to the section "Cessation Programs: Treatment of Tobacco Dependence" in Appendix II of the MPOWER report. In the

revised cessation treatment policy module, we have four primary sub-policies included: pharmacotherapy (PT) availability, financial coverage of treatments, quit lines and brief interventions.

The PT availability sub-policy option corresponds to the information in the MPOWER Report regarding whether nicotine replacement treatment (NRT) and/or non-nicotine replacement therapy, such as Bupropion (Zyban) and Varenicline (Champix), are available and where they may be obtained. If PT is available for NRT and non-nicotine replacement therapy, the prevalence is reduced by 30% in the first year of the policy and the pre-policy cessation rate is increased by 25% and the relapse rate is reduced by 25% in all years after the first. If NRT is available both by prescription and over-the counter, the prevalence is reduced by 40%; relapse rate is reduced by 30%; and cessation rate is increased by 30%. If a free population-based quitline is available, the prevalence is reduced by 25%; the relapse rate is reduced by 30%; and the cessation rate is increased by 30%. If both a toll free quitline and cessation medications are available, the prevalence is reduced by 15%; the relapse rate is reduced by 30%; and the cessation rate is increased by 30%. If brief interventions are provided, the prevalence is reduced by 40%; the relapse rate is reduced by 20%; and the cessation rate is increased by 20%. There is no effect on initiation.

For treatment coverage policies, we follow the MPOWER Report which distinguishes place of provision of cessation treatments by the following: primary care facilities, hospitals, offices of health professionals, community, and other. We designate either “yes in some (half effect)” or “yes in most (full effect)” and zero otherwise. We sum the scores to get the proportional effect with a maximum of 4. The synergistic effect of publicity on financial coverage is captured by whether there is a strong or medium level tobacco control campaign. With a high level campaign, prevalence is reduced by 2.25% in the first year of the policy and the cessation rate is increased by 12% in all future years. In the absence of a campaign, the effects are reduced by 25%. The effects are consistent with those in previous versions of *SimSmoke.* [6,114-116] Some recent evidence from Brazil[117] and Great Britain[118-124] provide results consistent with the above postulated effects.

In the MPOWER Report, quitlines are distinguished by whether or not the population has access to a toll free quitline. In previous versions of *SimSmoke*, quitlines were distinguished by type of

quitline, with the quitline categorized as passive, active, or active with a follow-up. We now only consider an *active* quitline, which is consistent with the MPOWER Report. The effect of quitlines also depends on publicity, using the same equation as used for the financial access sub-policy. Prevalence is reduced by 0.5% in the first year of the policy, and the cessation rate is increased by 5% in all years after the first year of the implemented policy, as based on evidence provided in Levy et al.[6]

Before 1991, NRT, bupropion and varenicline for smoking cessation were unavailable in Canada. Nicotine gum was available by prescriptions only in 1991 and nicotine patch in 1992 in Canada.[125] In 1998, Zyban was introduced to the market in Canada.[126] Nicotine patch was available over the counter in 1998 and nicotine lozenges in 2006 in Canada.[127,128] In 2000, the first population-based toll free quitline in Canada was available to all smokers and the Canadian "Smoking Cessation Guidelines" recommended brief interventions for smoking cessation.[83,129] In 2003, the majority of Ontario health units had smoking cessation programs, including self-help materials, telephone counseling, web-based resources, face-to-face counseling, groups programs, workshops, and Quit and Win contests, and approximately 19% of the health units subsidized the cost for smoking cessation pharmacotherapy.[130] The Smoking Treatment for Ontario Patients (STOP) program was launched in 2005, which provides free smoking cessation medication and counseling support.[131] However, the reach of these cessation programs was low; it was estimated that all Ontario provincial cessation programs combined reached about 4% of smokers in Ontario in 2008-2009.[132] In October 2012, pharmacists were given the authority to prescribe Zyban and Champix, which were estimated to help more smokers quit smoking by pharmacists association.[133] The cessation treatment policy in Ontario for the period of 2000-2012 can be found in Table 11 of Appendix.

Youth Access

Youth access takes into account enforcement, publicity and self-service and vending machine bans. A strongly enforced policy can reduce smoking prevalence by those under the age of 18 by as much as 25%. Three categories are applied to this policy: 1) low – compliance checks are not conducted regularly, with weak penalties and no publicity (compliance rate ‹ 70%); 2) well – compliance checks are conducted sporadically, with potent penalties and little publicity

(compliance rate: 70 - ‹ 90%); and strong – compliance checks are conducted regularly, with heavy penalties and strong publicity (compliance rate ≥90%). The tobacco control community has speculated that to have a real impact on youth access to tobacco, a compliance rate of 90% of better should be achieved.[134]

The minimum age for purchasing cigarettes in Ontario was set to 18 years old in 1892[135] and increased to 19 years old in 1994.[136] The level for youth access policy was categorized as "low enforcement" in 1997 and 1998 (compliance rate ‹70% in Ontario), "well enforced" in 1996 and 1999-2006, 2009-2010 (compliance rate ≥70% but ‹90% in Ontario), "strongly enforced and publicized" in 2007, 2008, 2011, and 2012 (compliance rate ≥90%).[132,136-139]_ENREF_58_ENREF_60_ENREF_132_ENREF_66 The TCA's passage in 1994 eliminated the sale of tobacco in vending machines in Ontario,[140] and self-service sales of tobacco products was prohibited in 1997 when the federal Tobacco Act came into effect.[137]

The Model Outcomes

The model estimates the effects over time for two primary outcomes: smoking prevalence and smoking-attributable deaths. Smoking prevalence is provided for the population ages 15 and above, but the model also has the capability to provide breakdowns by age. Separate results are provided for males and females and for both combined. The model estimates these outcomes for the tracking period, which is from 1996 to 2012, and projects future outcomes for 2013 to 2043.

To examine the potential effect of future policies that may be implemented consistent with the FCTC, we first present the *status quo* case, where tobacco control policies are maintained at their 2012 levels. We then consider the effect of tobacco control policies in isolation and through a comprehensive tobacco control strategy, which in all cases are implemented in 2012 and maintained over time. In comparing the effect of policies to the *status quo*, we focus on the relative change in smoking prevalence, i.e., the change in smoking prevalence from the *status quo* to the future policy scenario divided by the *status quo* smoking prevalence. For smoking attributable deaths, death averted is calculated as the difference between the number of deaths under the new policy and the number of deaths under the *status quo*.

Results

Validation and Calibration

Two large tobacco use surveys were used to validate our *Ontario SimSmoke* model: Canadian Community Health Survey (CCHS) and Canadian Tobacco Use Monitoring and Survey (CTUMS). Overall our model predicted prevalence corresponds well with the two large survey estimates (R^2 = 0.89 between model predicted and CCHS data and R^2 = 0.87 between model predicted and CTUMS data) (Figure 2). R^2 is a statistic that provides a measure of how well observed outcomes are replicated by the model. Generally, a value close to one is the best and a value close to zero is the worst. Although no specific values (cutoff values) can be linked to a quality measure (e.g., low or high threshold), some people may consider 0.85-1.0 as high and <0.7 as low.

Among males, our model predicted a larger decline in current smoking prevalence (-30.5%) than CCHS (-18.6%) from 1996 to 2010, but very close to that in CTUMS (-26.5% in our *SimSmoke* model vs. -29.7% in CTUMS) from 1999 to 2010 (CTUMS data only available since 1999) among males. Among females, our model predicted a similar decline (-29.7%) to that in CCHS (-30.9%) from 1996 to 2010, but much lower than that in CTUMS (-25.5% in our model vs. -49.3% in CTUMS) (Table 5). The two surveys use different sampling frames and the sample size is different too (39,278 in 2000-2001 CCHS and 13,184 in 2010 CCHS for Ontario, and 1,957 in 1999 CTUMS and 1,927 in 2010 CTUMS for Ontario). Smoking questions are asked in the context of a wide range of health-related behaviors in CCHS but all questions are related to smoking in CTUMS. These factors can affect prevalence estimates produced at a single point in time. However, the trends produced by the two surveys have been very consistent over time.

Although both surveys should provide valid estimates for smoking prevalence, CCHS data have larger sample sizes than CTUMS (about 3-10 times higher, varying in each year). In order to make our model predicted prevalence closer to the estimate from CCHS, we allowed smoking initiation starting up to 29 years of age and smoking cessation occurring after 30 years of age.

Figure 2: Smoking Prevalence, Both Sexes, 15+, Ontario, 1996-2011, Model Predicted Compared to CCHS and CTUMS

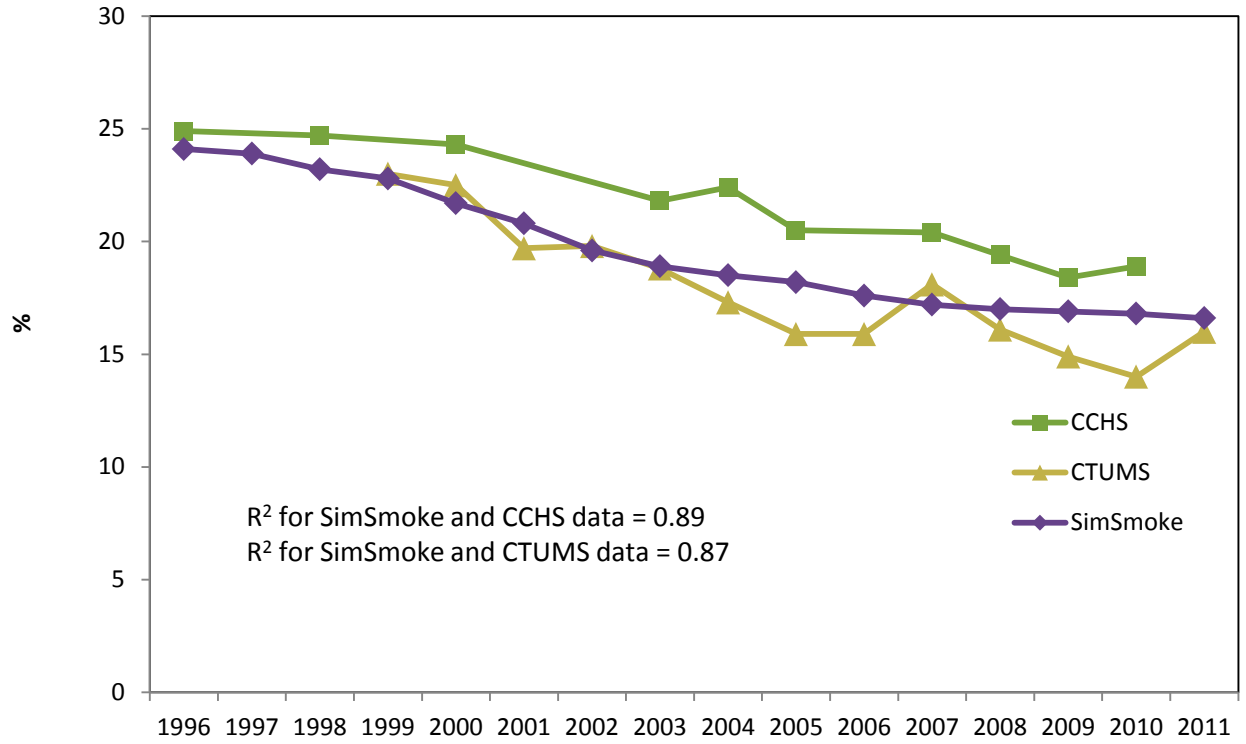


Table 5: Validation of the Ontario SimSmoke: Predictions Versus Survey Estimates of Smoking Prevalence, 1996-2010

Sex	Data	1996 or 1999	2003	2010	Percentage change 1996 (1999) -2003	Percentage change 2003-2010	Percentage change 1996 (1999) -2010
All males	CCHS	28.0% in 1996	24.8%	22.8%	-11.4%	-8.1%	-18.6%
	SimSmoke	27.2% in 1996	21.3%	18.9%	-21.7%	-11.3%	-30.5%
	CTUMS	25.6% in 1999	22.2%	18.0%	-13.3%	-18.9%	-29.7%
	SimSmoke	25.7% in 1999	21.3%	18.9%	-17.1%	-11.3%	-26.5%
All females	CCHS	22.0% in 1996	18.9%	15.2%	-14.1%	-19.6%	-30.9%
	SimSmoke	21.2% in 1996	16.6%	14.9%	-21.7%	-10.8%	-29.7%
	CTUMS	20.1% in 1999	15.5%	10.2%	-22.9%	-34.2%	-49.3%
	SimSmoke	20.0% in 1999	16.6%	14.9%	-17.0%	-10.8%	-25.5%
Both sexes	CCHS	24.9% in 1996	21.8%	18.9%	-12.4%	-13.3%	-24.1%
	SimSmoke	24.1% in 1996	18.9%	16.8%	-21.6%	-11.1%	-30.3%
	CTUMS	23.0% in 1999	18.8%	14.0%	-18.3%	-25.5%	-39.1%
	SimSmoke	22.8% in 1999	18.9%	16.8%	-17.1%	-11.1%	-26.3%

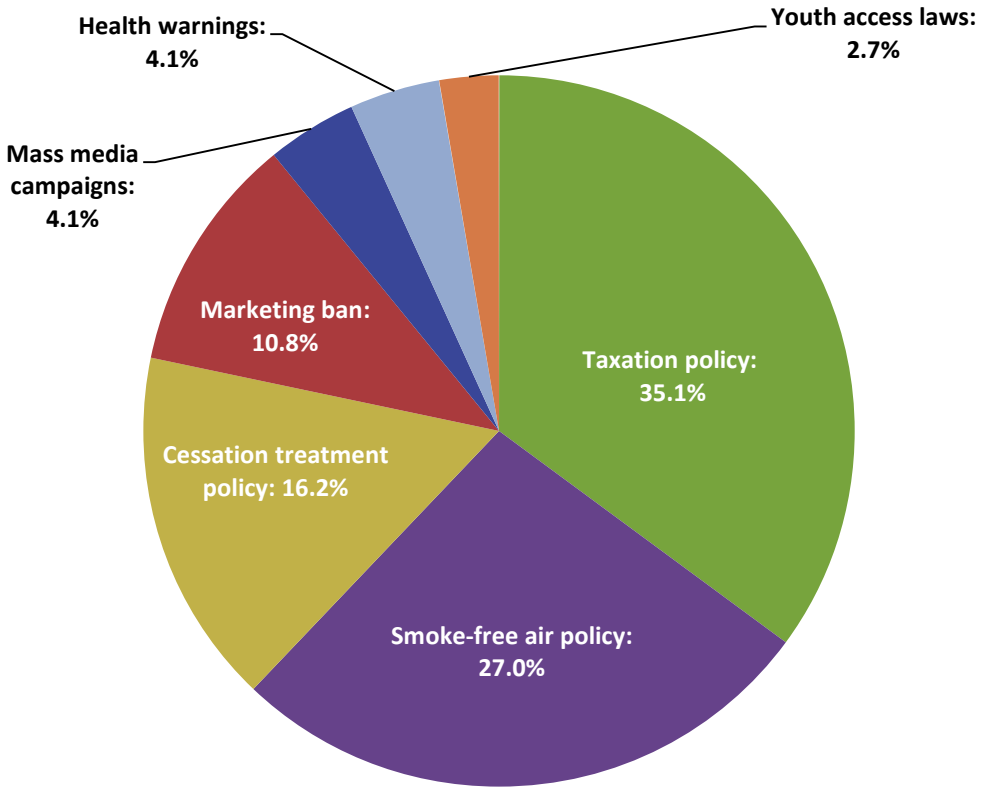
Adjustment of Discount Cigarettes

Smoking prevalence is reported as a percent of the population ages 15 and above. The model predicts smoking rates from the period 1996 to 2012, taking into account policy changes over that period. During that period inflation adjusted cigarette prices increase by about 138.4%. Ontario has been facing an issue of the availability of low-cost cigarettes (discount cigarettes) in recent years. The discount cigarette market share has grown significantly since 2003, and discount cigarettes selling for $10-$32 less per carton than premium brands.[141,142] To take into account the impact of discount cigarettes on cigarette price, we used the price of discount cigarettes and their market share in Canada (no data available for Ontario) to estimate cigarette prices adjusted for discount cigarettes and the adjusted prices were used in our final model (see Table 12 in Appendix).

Role of Past Policies

We estimated the contribution from each policy between 1996 and 2012 in the reduction of smoking prevalence in Ontario, for both sexes, aged 15 and older, while excluding the natural reduction in prevalence (i.e., kept all policies at their 1996 levels up to 2012, which counts for 15.6% and all policies together for 84.4% in the overall prevalence reduction). We found that taxation policy contributed the most at 35.1%, followed by smoke-free air laws at 27.0%. Other policy contribution was 16.2% for cessation treatment policy, 10.8% for marketing ban, and 4.1% for each of mass media campaigns and health warning labels. Youth access laws only contributed 2.7% to the prevalence reduction during this period (Figure 1). If all policies had been kept at their 1996 level, the cumulative smoking attributable deaths would be 253,100 for the period between 1996 and 2012. With all policies in place for this period, the cumulative smoking attributable deaths are projected to be 241,780, indicating that 11,320 lives were saved by these policies. (Details about calculation of each policy role are described in Table 13 of Appendix).

Figure 3: Contribution of Each Individual Policy in the Reduction of Smoking Prevalence from 1996 to 2012, Ontario SimSmoke, Excluding Natural Reduction in Prevalence



Role of Policies Implemented in 2012 in Reducing Future Smoking Prevalence and Deaths

The estimates of smoking prevalence under the *status quo* and under varying policy scenarios are shown in Table 6 for both sexes. The total number of projected smoking attributable deaths for a specific year and the cumulative total for 2013-2043 (to obtain the total number of premature deaths avoided over that period.) is displayed in Table 7.

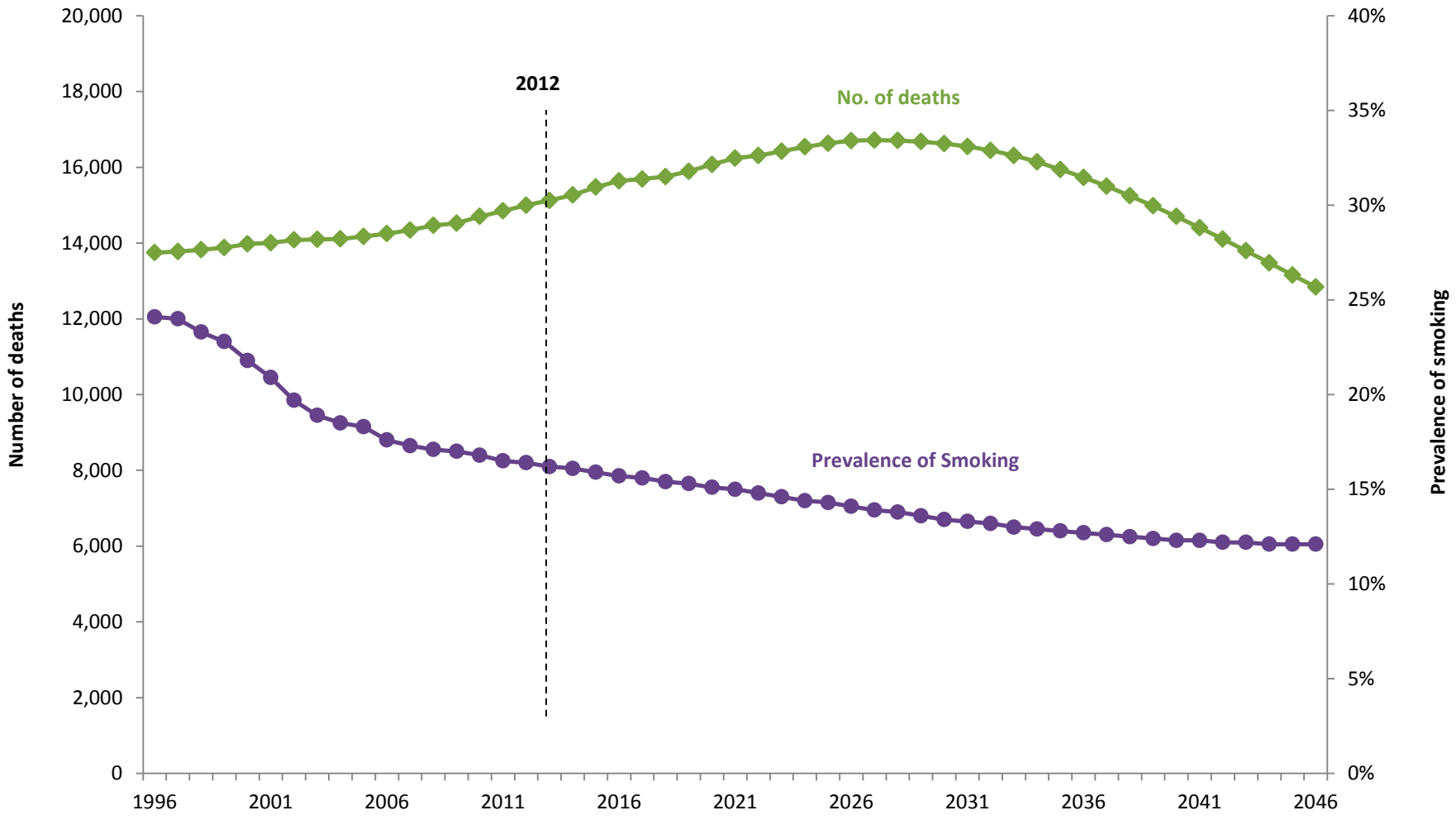
Status Quo Scenario

If tobacco control policies remain unchanged from their 2012 levels, as in the *status quo* scenario, Ontario smoking is projected to decrease in absolute terms by 0.1 percentage points (a 0.6% relative decline) from 16.2% to 16.1% between 2013 and 2014, by 4 percentage points

(24.7% relative) to 12.2% over a 30 year projection to 2043. Before 2012, the decline was faster (lots of policy changes), but is slower after 2012 (no policy changes) (Figure 4).

The estimated number of smoking attributable deaths in 2013 is 15,125. Deaths per year for both sexes are projected to increase through 2027, after which they begin to decline, reaching below the 2012 level in 2039. Relative to 2012, smoking attributable deaths are projected to increase by 8,920 over the 10-year period by 2023, and 24,840 over the 20-year period by 2033. Compared to 2012, there will be 1,210 smoking attributable deaths fewer in 2043 (Figure 4).

Figure 4. Model Predicted Smoking Prevalence and Smoking-Attributable Deaths for Ages 15 to 85, Both Sexes, Ontario SimSmoke (Policies at Status Quo)



The Effects of Individual MPOWER Policies

Potential future policy impacts with and without MPOWER polices on smoking prevalence and smoking attributable deaths, are described in Tables 6 and 7, and figure 3.

Among the available policy measures, tax policy is especially effective in reducing smoking prevalence.[5,143] We consider the case where excise tax is increased to 70% of the retail price as suggested by the MPOWER report. The current excise tax in Ontario is 52% of the retail price. Smoking rates for both sexes are projected to decline to 14.6% in 2014, compared to 16.0% in 2014 with the *status quo* scenario. By the end of a 30-year projection period, the smoking prevalence is projected to reach 10.4% in 2043, while the *status quo* prevalence is projected at 12.2% in 2043. With this stronger policy (increasing excise tax to 70% of the retail tax), 20,270 lives are projected to be saved for the period from 2014 to 2043. Compared to any other MPOWER individual policy, increasing excise tax to 70% of the retail price contributes the most in smoking prevalence reduction and in lives saved.

Comprehensive smoke-free air laws with stronger enforcement are projected to reduce smoking prevalence by 0.1 percentage point in 2043, from 12.2% with the *status quo* scenario to 12.1% with stronger smoke-free air laws. Over the period of 30 years from 2014 to 2043, 1,220 smoking attributable deaths are projected to be averted. This might be because Ontario already had comprehensive smoke-free air laws with strong enforcement in 2012.

A comprehensive tobacco marketing ban as being directed at all marketing as well as media advertising and as having strong enforcement is predicted to reduce smoking prevalence by 0.4 percentage points in 2043, from 12.2% with the *status quo* scenario to 11.8% with a comprehensive tobacco marketing ban. For the period from 2014 to 2043, a cumulative total of 2,230 lives are projected to be saved.

For a well-funded and publicized campaign that is sustained over time, the model is predicted to reduce smoking prevalence by 0.6 percentage points in 2043, from 12.2% with the *status quo* scenario to 11.6% with stronger tobacco control mass media campaigns. The model projects

8,440 fewer smoking attributable deaths for the 30 year period from 2014 to 2043, compared to the *status quo*.

Similar to the stronger tobacco control mass media campaigns, comprehensive smoking cessation treatment policies are projected to reduce smoking prevalence by 0.6 percentage points in 2043, compared to the *status quo*. The combined cessation policies are projected to avert 13,640 smoking attributable deaths for the period from 2014 to 2043, which is the second largest number for lives saved among all individual MPOWER tobacco policies.

Compared to *status quo* (all policies set at their 2012 levels), health warnings and youth access laws will not decline smoking prevalence any further, because these policies were at strong levels already in 2012. Although these policies will not produce any further decline in smoking prevalence, maintaining these policies at their strong levels is important.

Research has shown that the most effective tobacco control campaigns use a comprehensive set of policy measures,[144] targeting different populations and filling different needs to reduce smoking prevalence and subsequent deaths. The final scenario projects the effect for a combination of all the policies above. The smoking prevalence is projected to drop by 18% in 2014 (actual prevalence: 13.2% with the stronger policy set vs. 16.0% with the *status quo scenario*) and by 27% in 2043, relative to *status quo.* The model projects the smoking prevalence will be lower than 10% by 2032 (9.9%), and the projected prevalence will be 8.9% in 2043. Only the combination of all policies at their strong levels will decline the smoking prevalence lower than 10%; no individual policy will lower the prevalence below 10%. The model projects close to 50,000 fewer smoking attributable deaths, relative to *status quo* policies, for the period from 2014 to 2043, if all tobacco policies are implemented at their strong levels with excise tax increased to 70% of the retail price for cigarettes.

Table 6: SimSmoke Model Predicted Smoking Prevalence, for Both Sexes, Ages 15-85, With and Without MPOWER Policies, Ontario, 2013-2043

Policy/Years	2013	2014	2023	2033	2043
Status Quo Policies[a]	16.2%	16.1%	14.6%	13.0%	12.2%
Independent Policy Effects					
Excise tax at 70% of retail price	16.2%	14.6%	13.0%	11.4%	10.4%
Complete smoke-free air law	16.2%	16.0%	14.5%	12.9%	12.1%
Comprehensive marketing ban	16.2%	15.7%	14.2%	12.6%	11.8%
High-intensity tobacco control campaign	16.2%	15.6%	14.1%	12.5%	11.7%
Strong health warnings (already strong in 2012)	16.2%	16.1%	14.6%	13.0%	12.2%
Strong youth access enforcement (already strong in 2012)	16.2%	16.1%	14.6%	13.0%	12.2%
Cessation treatment policies	16.2%	15.5%	13.9%	12.3%	11.6%
Combined Policy Effects					
All above, with 70% of excise tax in retail price	16.2%	13.2%	11.4%	9.7%	8.9%
% Change in Smoking Prevalence from the *Status Quo*					
Independent Policy Effects					
Strong health warnings (already strong in 2012)		0.0%	0.0%	0.0%	0.0%
Strong youth access enforcement (already strong in 2012)		0.0%	0.0%	0.0%	0.0%
Complete smoke-free air law		-0.6%	-0.7%	-0.8%	-0.8%
Comprehensive marketing ban		-2.5%	-2.7%	-3.1%	-3.3%
High-intensity tobacco control campaign		-3.1%	-3.4%	-3.8%	-4.1%
Cessation treatment policies		-3.7%	-4.8%	-5.4%	-4.9%
Excise tax at 70% of retail price		-9.3%	-11.0%	-12.3%	-14.8%
Combined Policy Effects					
All above, with 70% of excise tax in retail price		-18.0%	-21.9%	-25.4%	-27.0%

[a] Status quo policies meant that all policies are set at their 2012 levels.

Figure 5: SimSmoke Model Predicted Smoking Prevalence, for Both Sexes, Ages 15-85, With and Without MPOWER Policies, Ontario, 2012-2046

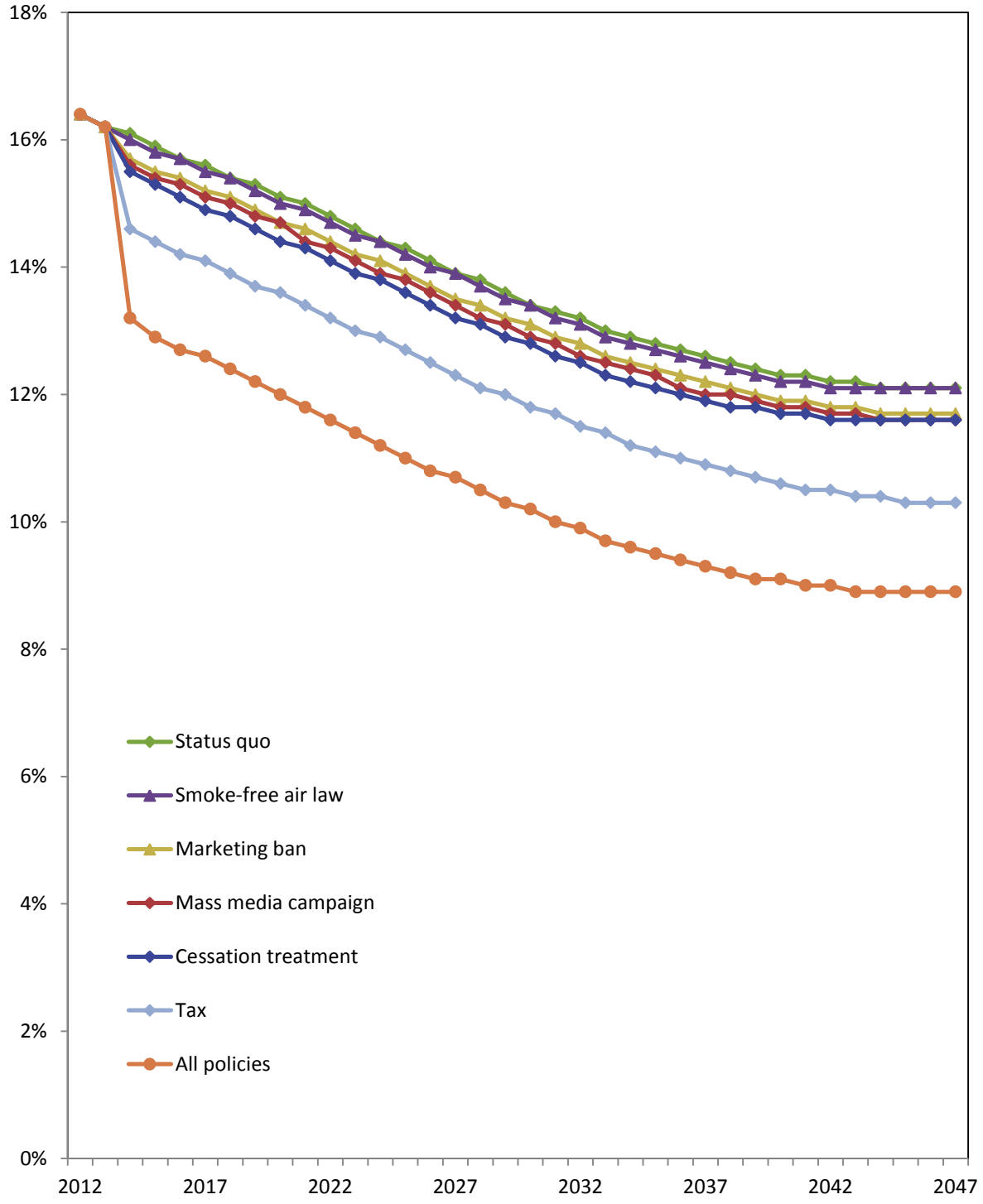


Table 7: SimSmoke Model Predicted Total Smoking-Attributable Deaths, for Both Sexes, Ages 15-85, With and Without MPOWER Policies, Ontario, 2013-2043

Policy/Years	2013	2015	2023	2033	2043	Cumulative (2014-2043)
Status Quo Policies[a]	15,130	15,480	16,420	16,310	13,790	475,200
Independent Policy Effects						
Excise tax at 70% of retail price	15,130	15,390	15,990	15,330	12,810	454,930
Complete smoke-free air law	15,130	15,470	16,400	16,250	13,740	473,970
Comprehensive marketing ban	15,130	15,470	16,380	16,200	13,690	472,960
High-intensity tobacco control campaign	15,130	15,440	16,250	15,900	13,370	466,760
Strong health warnings (already strong in 2012)	15,130	15,480	16,420	16,310	13,790	475,200
Strong youth access enforcement (already strong in 2012)	15,130	15,480	16,420	16,310	13,790	475,200
Cessation treatment policies	15,130	15,430	16,150	15,650	13,080	461,560
Combined Policy Effects						
All above, with 70% of excise tax in retail price	15,130	15,320	15,380	13,880	11,330	425,400
Lives Saved (*Status Quo* Deaths Minus Deaths Under New Policy) (2014-2043)						
Independent Policy Effects						
Excise tax at 70% of retail price		90	440	980	990	20,270
Complete smoke-free air law		10	30	60	60	1,220
Comprehensive marketing ban		10	50	110	110	2,230
High-intensity tobacco control campaign		30	172	420	420	8,440
Strong health warnings (already strong in 2012)		0	0	0	0	0
Strong youth access enforcement (already strong in 2012)		0	0	0	0	0
Cessation treatment policies		160	280	670	710	13,640
Combined Policy Effects						
All above, with 70% of excise tax in retail price			1,040	2,430	2,460	49,800

[a] Status quo policies meant that all policies are set at their 2012 levels.

Discussion

This report presents the results for the *SimSmoke* tobacco control simulation model as applied to Ontario, Canada. The model applies population, smoking prevalence, and policy data for Ontario and modified parameter values to the established *SimSmoke* model. The model's credibility is supported by validation in countries with sufficient data to confirm predicted trends.

Key findings are summarized below.

- 85% of the reduction in smoking prevalence from 1996 to 2012 in Ontario was attributable Ontario Tobacco Control Strategy
- For the reduction in smoking prevalence by policy changes from 1996 to 2012 in Ontario, tax increase contributed the most (35%), followed by smoke-free air policy (27%), cessation treatment policy (16%) and marketing ban (11%), then by mass media campaigns and health warning labels on cigarette packages (4% each), and then youth access laws (3%)
- Approximately 11,300 lives were save during the same period by the Ontario Tobacco Control Strategies (likely under-estimated because immigrants and secondhand smoke exposure factors were not taken into account)
- Increasing excise tax to 70% of retail cigarette price will produce the largest reduction in smoking prevalence and smoking-attributable deaths, compared to any other individual tobacco control policy; cessation treatment policy and high-intensity tobacco control campaigns will also contribute significantly in smoking prevalence reduction
- If all tobacco control policies can be set at the levels recommended by MPOWER, the guidelines for tobacco control policy by World Health Organization, Ontario should be able to see a low smoking prevalence (<10%) by 2032

Smoking prevalence in Ontario (aged 15+) has fallen by 24% from 24.9% in 1996 to 18.9% in 2010, based on CCHS estimates. *Ontario SimSmoke* predicts a similar reduction (30%) for the same time period. We calibrated our model based on the CTUMS data from 1999 to 2011 as well. The relative reduction based on CTUMS was 39.1% from 1999 to 2010 (actual prevalence: 23% in 1999 and 14% in 2010). Because the differences in sampling frames, sample size, and context for smoking questions in these two large population-based surveys, the point estimates for smoking

prevalence should not be expected to be the same. In model calibration, we allowed smoking cessation occurring after ages 30 and initiation up to 29 years of age. This increased predicted prevalence higher. We also adjusted cigarette price based on discount cigarettes in Ontario, which increased predicted prevalence a bit higher too. These changes made the model predicted prevalence closer to the estimate based on CCHS data. Because CCHS had large sample sizes and higher response rates than CTUMS. We believe CCHS data should provide more accurate estimates than CTUMS. By this kind of model calibration, we believe that our model predicted prevalence should be closer to the actual prevalence. Although there are some discrepancies in prevalence estimates, the trend in prevalence reduction are consistent in the two surveys. Our model predicted prevalence is generally between the estimates by the two surveys (closer to CTUMS data in earlier years but almost in the middle between the two survey estimates in later years). Overall our *SimSmoke* model predicted actual prevalence change over time well (R^2=0.89 with CCHS and R^2=0.87 with CTUMS data, generally indicating good correlation).

Ontario SimSmoke shows that policies played a major role in the decline, contributing to 85% of the overall reduction (15% of the overall reduction was not explained by policy changes during this period, potentially due to aging population or existing policies before 1996). Over one-third (35%) of the projected reduction is from price increases, 27% from smoke-free air laws, 16% from cessation treatment, 11% from marketing restrictions, 4% each from mass media campaigns and health warnings, and 3% from youth access laws. As a result of the policies implemented between 1996 and 2012, *SimSmoke* estimates that a total of 11,320 deaths had been averted.

Because of the natural progression of tobacco-related illnesses, early reductions in smoking prevalence have a relatively small impact on the number of smoking-attributable deaths in the short-term. The relative impact of a comprehensive tobacco policy in five years is small compared to the potential impact after 20 or 30 years. By 2043, close to 2,500 deaths can be averted in that year alone and close to 50,000 deaths for the period of 2013 and 2043 with the stronger set of policies.

While Ontario has implemented many strong tobacco control policies in recent years, there is still scope to strengthen tobacco control policies consistent with the MPOWER policy guidelines. Using the *SimSmoke* model, we have presented a short and long-term projection of the role of

various tobacco control policies in reducing smoking prevalence and, subsequently, the number of deaths attributable to smoking. The smoking prevalence can be decreased by as much as 18% in 2014, increasing to 27% reduction in the next 30 years. If all stronger policies can be implemented, a lower than 10% of the prevalence can be expected by 2032. Increasing excise tax to 70% of the retail price is projected to avert over 20,000 smoking attributable deaths over the next 30 years, and to bring down the prevalence close to 10% (10.4%). Strong cessation treatment policy and high-intensive mass media campaigns are projected to save lives and bring down the smoking prevalence, although the magnitude is not as large as for price increase. Youth access laws and health warning labels are not projected to further reduce smoking prevalence and smoking attributable deaths, compared to their status quo levels, which are because their status quo levels are strong according to our current version of the *Ontario SimSmoke* model. However, this does not mean that we cannot improve these policies in future. A recent study has indicated that plain packaging could be a strong policy tool to reduce the number of adolescents starting smoking.[145] Smoking on patios and other public places (such as doorways and parks) is not banned in many jurisdictions. Banning smoking in these places may further bring down smoking prevalence. However, this will need to modify our current *SimSmoke* model to incorporate other policies. Maintaining strong youth access laws, smoke-free air laws, and marketing bans with strong enforcement is important. Without strong enforcement, high rates of compliance with these laws cannot be achieved.

Limitations

We recommend interpreting these projections in a conservative manner. The model's results depend on the reliability of the data, and the estimated parameters and assumptions used in the models. The cessation rates are based on data from Canada rather than Ontario and the relapse rates are from the US[10,51-53] due to the unavailability of Ontario data. It will be important to monitor cessation rates and the distribution of former smokers by years quit to gauge the impact of tobacco control policies. Smoking prevalence data are not accurate due to small sample size issues for certain age-gender groups. The 1996-1997 NPHS data did not ask the question about “100+ cigarettes smoked lifetime”. The current smoking prevalence for the 1996-97 NPHS data was adjusted for the 100+ cigarettes/lifetime, using the CCHS 2000-01, 2003, 2004, and 2005

average difference between the two definitions for current smoking (i.e., with and without 100+ cigarettes/lifetime). The definition with 100+ cigarettes/lifetime is generally used to distinguish never smokers[146] and using this definition for smokers works well with the *SimSmoke* model. This might introduce some bias in estimating smoking prevalence for 1996/97 NPHS data. CCHS data are biannual data in early years before 2007. CTUMS data are yearly based, but the sample size is too small for prevalence estimates by age and gender (sample size for Ontario about 2,000). Yearly based with large sample size survey data for Ontario will be needed to provide more accurate prevalence data.

The model assumes no effect of income on smoking rates. Past studies yield conflicting effects on the role of income,[144] and the effect of income may vary for different income groups leading to varying effects as income changes for the population as a whole. Ontario has a higher rate of immigrant population, but the impact of immigration was not considered in our current *SimSmoke* model, due to lack of information about smoking prevalence in immigrant population. Population growth from the model was smaller than the actual Ontario population, mainly due to immigrants not included in the model. If cumulative immigrants were included in the population growth, the model predicted population would be very close to the real population. Nevertheless this is a limitation of the model and it might under-estimate the smoking-attributable deaths averted by tobacco control policies implemented in Ontario, especially among immigrants. However, we believe that the under-estimation should not be large. On the other hand, because smoking prevalence is generally lower among immigrants than the overall population, the model predicted smoking prevalence reduction by policy changes might be over-estimated. However, when comparing model predicted to the actual prevalence by CCHS and CTUMS, they correlated well. The CCHS and CTUMS use large representative population to estimate smoking prevalence and immigrants should be included. Thus, if there is any difference in smoking prevalence between model predicted and actual prevalence, the difference should be small.

The estimated relative risks for total mortality of smokers is based on studies from the US.[10,53,57,147-149] However, the relative risks for females may be expected to increase as those who have begun smoking at an earlier age reach age 50 and beyond.[55,150] Notably, the projections also do not include the additional deaths averted due to reductions in second hand smoke

exposure. In countries with a high number of male smokers and a low number of female smokers, a large number of female non-smokers are exposed to smoke in the home. This limitation (not including secondhand smoke exposure in the model) might under-estimate the impact of Ontario tobacco control policy, especially the smoke-free policy, on the smoking-attributable deaths averted. Unfortunately, it is too difficult to incorporate the impact of reductions in SHS exposure into the *SimSmoke*.

The policy modules also depend on underlying assumptions, estimated parameters of the predicted effect on initiation and cessation, and assumptions about the interdependence of policies. Knowledge of the different effects of each policy varies.[6] For example, many studies, with relatively consistent results, have been done of the effects of price. There are also many studies of clean air laws, with results somewhat less consistent than those of prices/taxes, but still falling into similar ranges. Studies on media/tobacco control campaigns and advertising bans provide a broad range of estimates. Information on the effect of health warnings and cessation treatment policies is very limited.

We have assumed that taxes will be increased in roughly the same proportion for all brands. However, the lack of enforcement against smuggling and internet sales could lead to substitution to lower priced brands and our estimates may over-predict the actual effects of a tax increase. Although we tried to adjust the impact of discount cigarettes, data for Ontario are not available. We only used the information about market share of discount cigarettes in Canada. The price for discount cigarettes was only roughly estimated over time. The impact of contraband cigarettes may have a larger impact on our model estimates than discount cigarettes, but was not considered in the current version of our *Ontario SimSmoke* model.

Many physicians still do not ask regularly their patients if they smoke, and are even less likely to follow-up with advice to quit and suggestions on how best to quit. When fully implemented alone (a value of one), past work indicates that the prevalence is reduced by 0.5% in the first year (equivalent to an additional 5% of smokers making a quit attempt with a 10% average success rate net of relapse) and the pre-policy cessation rate is increased by 10% (equivalent to quit attempts increasing by 50% with the new treatment users having a 20% first year success rate)

in all years after the first. These values are based on data from the United States, and thus estimates of the effect of physician involvement should be viewed as tentative.

Better understanding of the interactive effects of policies is also needed. We have made the conservative assumption that the effects of each policy are a constant proportion of the smoking rate independent of other policies. Research indicates that public policies may be synergistic through their cumulative impact on social norms and their reinforcing effects on smokers' motivation to quit.[151] Studies need to be done among different policies, and for different age groups and gender, not only to gauge the initial effect of policies, but also to understand how those policies unfold over time and depend on the other policies in effect.

In sum, the model relies on simplifying assumptions because of insufficient data availability. Some of the important data gaps are:

- Detailed information on smoking prevalence, so that accurate rates can be determined by age and gender. In particular, smoking rates at early ages, such as 15-17, 18-21, 21-24, and 25-29 are needed;
- Information on the prevalence of former smokers, distinguishing by years quit, so that cessation rates can be estimated and quitting can be tracked. In addition, it would be useful to have information on quit attempt behaviors and the use of pharmacotherapies;
- Changes in policies over time for all of the tobacco control policies outlined in the MPOWER report and compliance data on marketing restrictions and smoke-free air laws;
- Cigarette prices of the premium and discount brands and the amount of smuggled cigarettes;
- Policy effect sizes of each individual policy and in combination on smoking prevalence, initiation, cessation, and relapse rates, using local data (Ontario or Canada);
- Relative risk of smoking related deaths by age-gender and years of smoking, using local data (Ontario or Canada);
- Immigration data on population and their smoking behavior (prevalence, cessation, initiation, relapse rates) for Ontario;
- Smoking behavior data (prevalence, cessation, initiation, relapse rates) and relative risk of smoking related deaths by socioeconomic status and by age and gender for Ontario.

In collecting the data, consistent definitions of the measures should be applied over time. When data become available on smoking prevalence, the model can be validated to see how well it has predicted trends in recent years. Highlighting the data gaps should guide future smoking surveillance efforts, enabling model users or researchers building a different model, to approach policy evaluation from a more comprehensive baseline. Most important, improved data can be used to better monitor and evaluate policies, so that policies can be modified and adapted in reaction to success and failures.

Conclusions

The *SimSmoke* results highlight the relative contribution of numerous policies to reducing the tobacco-related health burden. The model predicts that many lives can be saved by a large increase in taxes. When the tax increases by large percentages, stronger clean air and youth access laws are implemented, publicized and enforced, a strict advertising and marketing law is promulgated and enforced, strong warning labels are required, a high publicity media campaign is coordinated with the other policies, and a strong comprehensive cessation treatment program is implemented, the smoking rate is projected to fall by 27% in relative terms and close to 50,000 deaths are projected to be averted over the next 30 years. A large increase in taxes alone would substantially reduce the number of lives lost to smoking. Tax increases are also likely to increase government tax revenues,[152] part of which can and should be earmarked to implement cessation treatment and media policies and to enforce and publicize other policies.

Appendix

SimSmoke: Mathematical Appendix

The *SimSmoke* model begins with the population in a baseline year divided into current, former, and never smokers. Assuming a discrete, first-order Markov process, population evolves over time through births and deaths, and the smoking population evolves through initiation, cessation, and relapse.

Demographics Model

SimSmoke is built first on a demographic model. The total population (*Pop)* is distinguished by time period **t** and age **a** (and is further distinguished in the model by gender)**.** Mortality rates (*MR)* are distinguished by age and gender. Newborns depend on first year deaths rates and fertility rates (*Fert)* of females by age with equal birth rates for males and females. Births through the first year (age 0) for each gender are:

$$Pop_{t,0} = 0.5*(1-MortRate_0)* \Sigma^a (Pop_{t,a,1} * Fert_a), \text{ where } t=1,\ldots,40;\ a=14,\ldots,49.$$

After the first year, the population evolves as:

$$Pop_{t,a} = Pop_{t-1,a-1} * (1 - MortRate_a).$$

Smoking Model

SimSmoke divides the population in the base year into (1) never smokers, (2) smokers, and (3) 16 categories of former smokers (n=1,…,16+) corresponding to years since last time smoking. After the base year, individuals are classified as never smokers from birth until they initiate smoking or die, as shown by:

$$Neversmokers_{t,a} = Neversmokers_{t-1,a-1} * (1 - MortRate_{a,ns})*(1\text{-}Initiation\ rate_a).$$

From never smokers, individuals can become smokers through initiation, leave smoking through cessation and return to smoking through relapse. The number of smokers (designated by s) is tracked as:

$$Smokers_{t,a} = Smokers_{t-1,a-1}*(1 - MortRate_{t.a,s})*(1\text{-}Cessation\ rate_a)$$

$$+ Neversmokers_{t-1,a-1}*(1 - MortRate_{a,ns})*Initiation\ \ rate_a.$$

$$+ \Sigma^{16}_{n=1} Formersmokers_{t-1,a-1,n}*(1 - MortRate_{t,a,n})*(Relapse\ rate_{a,n}).$$

First year former smokers are determined by the first year cessation rate applied to surviving smokers in the previous year. After the first year quit, individuals who have been former smokers for between n= 2,…, 15 are defined as:

$$Formersmokers_{t,a,n} = Former\ smokers_{t-1,a-1,n-1} * (1 - MortRate_{a,n}) * (1\text{-}Relapse\ rate_{a,n-1}).$$

For those who have ceased smoking for more than fifteen years, we add to the above equation the former smokers from the previous year who have quit for more than fifteen years and have not died or relapsed in the previous year.

Smoking-Attributable Death Models

Smoking-attributable deaths are estimated for each age and smoking group by multiplying the number of smokers in that group by the difference between the death rate of that smoking group and the death rate of never smokers. To estimate the age and smoking group specific death rate $DR_{a,s}$, we used the age and gender specific prevalence (*Prev*), relative risks ($RR_{a,s}$) and death rates (DR_a). The death rate of an age group can be expressed as:

$$DR_a = PrevNeversmokers_{a,ns} * DR_{a,ns} + PrevSmokers_{a,s} * DR_{a,s} + \Sigma^n (PrevFormersmokers_{a,n} * DR_{a,n}),$$

Dividing both sides by $DR_{a,ns}$, we obtain:

$$DR_a / DR_{a,ns} = PrevNeversmokers_{a,ns} + PrevSmokers_{a,s} * RR_{a,s} + \Sigma^n (PrevFormersmokers_{a,n} * RR_{a,n}),$$

because $RR_{a,s} = DR_{a,s}/DR_{a,ns}$ and similarly for former smokers, and $RR_{a,ns} = 1$. Rearranging terms, the death rate for never smokers becomes:

$$DR_{a,ns} = DR_a / [PrevNeversmokers_{a,ns} + PrevSmokers_{a,s} * RR_{a,s} + \Sigma^n (PrevFormer\ smokers_{a,n} * RR_{a,n}].$$

For any smoking group s^* (of either smokers or former smokers), we multiply both sides by $DR_{a,s*}/DR_{a,ns}$ to obtain the death rate:

$$DR_{a,s*} = DR_a * RR_{a.s*} / [PrevNeversmokers_{a,ns} + PrevSmokers_{a,s} * RR_{a,s} + \Sigma^n (PrevFormer\ smokers_{a,n} * RR_{a,n})].$$

Policy Modules

The effects of policies are calculated as percent reductions, PR, relative to the initial rates, i.e., [PR= (post-policy rate - initial rate)/initial rate, where PR< 0]. Policies generally have the greatest effect in

the first years. The effects are modeled as a permanent additive effect on smoking prevalence in the first year that the policy is implemented, i.e., $Smokers_{t,a} * (1+PR_{i,t,a})$ for policy **i** at time period **t** and which may vary by age **a**.

After the first year, policies affect initiation and cessation rates. If the policy affects initiation, the effects of the policy are sustained through lower initiation rates. Throughout the years in which the policy **i** is in effect, the percentage reduction lowers the initiation rate by $(1+PR_{i,a})$. The effects of a policy **i** may also be augmented over the same time period through increases in the first year cessation rate by $(1-PR_{i,a})$. First-year quit rates remain elevated for each of the policies (except youth access policies), as justified by the higher propensity to quit among individuals who smoke less[153-155] as a result of policies and other factors (e.g., economic and informational) creating incentives to quit. It is assumed that the proportion of individuals who relapse increases in direct proportion with any added cessation, implying that the rates of relapse are unaffected by policy changes. Thus, policies have their greatest effect on cessation (directly through the prevalence rate) in the first year that the policy is in effect. Each of the policies also continues to affect initiation and first-year cessation rates during the period over which a policy is in effect.

When more than one policy is in effect, there may be synergies built into the model as described below. Otherwise, it is generally assumed that there are constant proportional reductions, i.e., $(1+PR_i)*(1+PR_j)$ for policies **i** and **j**. This formulation implies that the relative effect of a policy is independent of other policies in effect, but the absolute reduction is smaller when another policy is in effect (due to the reduction in smoking rate from the other policy).

Direct modifications are made in some of the policy effects for individual countries, especially as they relate to low and middle-income countries (LMICs) relative to high income countries (HICs). Two main types of adjustments that pertain primarily to LMICs are made using scale factors. The first, **URBAN** ($> 0, \leq 1$), is for the degree of urbanization and is generally meant to capture difficulties in reaching populations that are in more rural areas. This variable is measured as [(1-the percent of economy in rural trades [agriculture] in a country/percent of economy in rural trades). The other scale factor, **AWARENESS** (≥ 1) is for the potentially a greater impact of awareness about the dangers of smoking in countries where such information is at a lower base level than in the U.S. The level of **AWARENESS** depends on the policy, as designated below. The level of **AWARENESS** is applied to LMICs where information is less well-disseminated than in HICs. These scale factors are applied multiplicatively, so that the effect sizes become $(1+URBAN_{i*} AWARENESS_{i} *PR_{i,a})$ for the prevalence and initiation effects and $(1+URBAN_{i*} AWARENESS_{i} *PR_{i,a})$ for the cessation effect.

Taxation Policies

The tax policy module in *SimSmoke* follows the MPOWER Report and specifies the excise tax in percentage terms relative to the retail price. In keeping with the recent recommendations under MPOWER, we consider the effect of increasing excise taxes to 70% or 75% of the retail price.

The taxation effect works through price. In *SimSmoke*, the effect of price depends on price elasticities (obtained from relevant studies), which are assumed to be constant in *SimSmoke*. The formula for constant price elasticity, *E*, is defined in terms of the price, **P**, and quantity, **Q**, both distinguished by their new level, designated by subscript **n**, and their initial level, designated by subscript **t**. The formula is written as:

$$E = [(Q_{t+1} - Q_t)/(Q_{t+1} + Q_t)]/[(P_{t+1} - P_t)/(P_{t+1} + P_t)], \quad E < 0.$$

To solve for Q_t, the equation is rewritten as:

$$[(Q_{t+1} - Q_t)/(Q_{t+1} + Q_t)] = E*[(P_{t+1} - P_t)/(P_{t+1} + P_t)]$$

Denoting $\Delta = [(P_{t+1} - P_t)/(P_{t+1} + P_t)]$, the equation can be solved for

$$Q_{t+1} - Q_t = \Delta(Q_{t+1} + Q_t), \text{ or}$$

$$Q_{t+1} = Q_t *(1 + \Delta)/(1 - \Delta).$$

Since we focus on participation rates, **Q** translates to the number of smokers for relatively small changes in population. In order to distinguish the effects for different periods, let Δ_t denote the effects of a price change between periods **t** and periods **t-1**.

Let $\delta_t = (1+\Delta_t)/(1-\Delta_t)$, then

$$Q_{t+1} = \delta_t * Q_t.$$

The elasticities vary by age based on U.S. data (as described in the text) and are scaled by country relative to the U.S., usually in terms of overall elasticity (participation and conditional quantity), depending on the type of elasticity available. For example, the average overall elasticity for the U.S. is 0.4.[156]

Actual prices adjusted for inflation are used for the tracking period. Future price changes occur through tax increases, which are specified as a portion of price. Future inflation adjusted prices are assumed constant in the absence of a tax change.

The model assumes that prices increase in absolute terms with the amount of the cigarette tax, based on Sung[157] and evidence from other countries.[158] Let $\boldsymbol{T_t}$ be the tax rate as expressed as a percent of price in period **t**. To derive future prices, we first estimate the price net of taxes, P**NT,** as the retail price, $\mathbf{P_t}$, multiplied by (1-***T***) for the last year before projection. Assuming that the factory price (after adjusting for inflation), the import and value added tax and the average percent markup by the manufacturers and foreign tobacco firms remains constant, the amount of the total tax will be equal to ***T***/ (1-***T***) times the price net of taxes.[159] Then the retail price can be re-written:

$$\mathbf{P_t} = \mathrm{P}\mathbf{NT} + \mathrm{P}\mathbf{NT} * T_t/(1-T_t),$$

where the second term is the amount of the price that is taxed. We assume that the net of tax price remains constant and that prices increase by the amount of the tax, so that the new price is obtained by substituting the new tax T_{t+1} for $\boldsymbol{T_t}$ in the second term.

Taxes on cigarettes may include value added taxes, import taxes and excise taxes. We generally ignore import taxes in our analysis, since they are rare or a small percent of price. Excise taxes apply only to cigarettes and may be implemented in percentage terms, i.e., ad valorem taxes, or fixed amounts per unit, i.e. specific taxes. In our analysis, the value added tax (in percentage terms) is held constant, since it applies to all goods, not just cigarettes, and it is applied to excise taxes as well as the price net of taxes. Consequently, it amplifies the effect of an excise tax increase, so that the excise tax as a percent of price diminishes when price adjusts to a new level. Consequently, we consider the situation, where the excise tax is increased to 70% of the final retail price. When the effect of the value added tax is incorporated, the value added tax is included in $\mathbf{T_t}$ in calculating the price net of tax and amount of the tax. To exclude the amplifying effect of total taxes, we only consider excise taxes in $\mathbf{T_t}$ in calculating both the price net of tax and amount of the tax.

Smoke-Free Air Policies

Three types of smoke-free air policies (worksite, restaurant, and bars) are included in MPOWER *SimSmoke*, with the effect of worksite further distinguished by its stringency. Worksite bans are distinguished corresponding to data provided in the MPOWER Report as: 1) partial as designated by a ban in 2 of the 3 types of facilities: health, university, and government facilities, 2) ban in indoor offices only, and 3) ban in all indoor workplaces (including offices and other indoor workplaces, universities, and government). These policies are cumulative, i.e., inclusive of the previous policy, with the MPOWER target policy a complete ban. Consistent with the MPOWER Report, the model distinguishes only a total restaurant ban and a total ban in bars and restaurants. The MPOWER model includes a ban in pubs and bars. The model includes bans in other public places, based on the corresponding MPOWER variables, public transport, and supplementary information. An enforcement index is based

on the MPOWER Report, whereby enforcement is scored between 1 and 10, with10 the highest level. In addition, publicity is directly dependent on the level of tobacco control campaigns.

The effects for HICs with a high level of publicity and enforcement are: worksites = 6%, restaurants = 2%, and bars = 1%. For LMICs, the effects are adjusted downward by using the URBAN index to account for the percent of the population not affected due to lower rates of labor working in indoor workplaces and increased by 50% in a country in an LMIC without previously active tobacco control (then **AWARENESS** = 1.5, and otherwise = 1). In addition, while half of the effects occur automatically through passage of the law (e.g., due to a change in norms), the other half of the effects depend on enforcement ($0 \leq$ **ENF** ≤ 1, using the MPOWER index=1,…10 divided by 10 to be scaled to 1) and a publicity index based on tobacco control spending (= .5 if no tobacco control spending is low or non-existent, 0.75 if tobacco control spending is medium, and 1 if tobacco control spending is high). Letting *SFL'* equal the effect size of type **k** for a HIC with high enforcement and publicity, the effect SFL_i for country **i** is:

$$SFL_{i,k} = SFL_k' * URBAN_i * AWARENESS_i * 0.5\ (1+ENF_i * PUB_i).$$

Marketing Restrictions

Four levels of marketing restriction policies are distinguished: none, minimal, moderate, and comprehensive. The effects differ for prevalence, cessation, and initiation, and also depend on enforcement.

While a lower degree of urbanization may reduce the effectiveness of advertising by making it more difficult to reach those in rural areas, Blecher[160] found that the effects of comprehensive bans are at least 4 times as great in LMICs as in HICs. In the model, this phenomenon is attributed to lack of awareness of the dangers of smoking and anti-smoking attitudes. The effect in the LMICs is doubled relative to HMICs. As for smoke-free laws, a total lack of enforcement reduces the impact by half ($0 \leq$ **ENF** ≤ 1, using the MPOWER index = 1…10 divided by 10 to be scaled to 1). For marketing restrictions at a level **k** for HICs with high enforcement designated as MR', the effect for country **i** will be:

$$MR_{i,k} = MRK_k' * AWARENESS_i * 0.5\ (1+ENF_i).$$

Health Warnings

The MPOWER *SimSmoke* distinguishes four levels of policy (none, mild, moderate, and strong) and the effects depend on the awareness factor. Because this policy is geared toward the dangers of smoking, the level of initial awareness is expected to play an important role. For LMICs, the effects are doubled

due to the lower initial level of awareness (**AWARENESS** =2 in that case, **AWARENESS**= 1 otherwise). For effect size *HW'* at level **k** for health warning in a HIC, the effect for country **i** is:

$$HW_{i,k} = HW_k' * AWARENESS_i.$$

Tobacco Control Campaigns

Previously in the *SimSmoke* tobacco control/media campaign model, 3 levels of a campaign are specified: high, medium, and low. The degree of urbanization affects the ability to reach rural populations through the media and even local campaigns, and is taken into consideration in examining the effect of tobacco control spending. However, the level of awareness is expected to be low in LMICs that have not had prior policies, and for those countries is accorded a value of 1.5. For tobacco control spending at level **k** at effect size *TC'* in a HIC, the effect for country **i** is:

$$TC_{i,k} = TC_k' * URBAN_i * AWARENESS_i$$

Description of the New Cessation Treatment Policy Module

The new PT availability sub-policy option corresponds to the information in the MPOWER Report regarding whether nicotine replacement treatment (NRT) and/or Buproprion are available and where they may be obtained. The availability indicators are first developed separately for each PT by setting them equal to:

PT1 = 2 if NRT is yes, 0 if no

PT2 = 1 if Buproprion is yes, 0 if no

When pharmacotherapy is available, the MPOWER Report distinguishes whether each PT is available in a general store or pharmacy and if a prescription (Rx) is required. We do not distinguish effect sizes (they are each assigned a value 1) by these sources except when NRT is only available by prescription. Since access is thus more limited, the NRT variable is multiplied by 0.5, indicating that the effect is reduced by 50%. To get an overall effect, the indicators for NRT and Buproprion (PT1 and PT2) are summed and divided by 3 to obtain an overall indicator with a value between 0 and 1 that is used to scale the percentage effect of the new treatment availability sub-policy. If the value of the sub-policy is 1 (the policy is effect in full), then prevalence is reduced by 1.0% in the first year of the policy (which is roughly equivalent to the effect of 15% of smokers using either or both of the PTs with a 10% average success rate net of relapse in the first year) and the pre-policy cessation rate is increased by 6% in all years after the first (equivalent to quit attempts increased by 30% due to new PT users with those

users having a 20% first year success rate). Therefore, there is no effect on initiation.

Unlike in previous *SimSmoke* models, treatment coverage does not distinguish pharmacotherapy and behavioral therapy, but rather focuses on where the treatment is provided. We followed the MPOWER Report that distinguishes place of provision of cessation treatments by the following: primary care facilities, hospitals, offices of health professionals, community and other. For each location, we designate a value of score for each of the above locations: 0 = None, 1 = Yes in some, and 2 = Yes in most. We then sum the scores. The highest possible score is 10, but a full effect is designated if at least 4 of the 5 places have indicated yes, whereby a score of 8 is for the full effect. To scale to 1, we multiply by 0.125 (1/8). That indicator is used to scale the effect of the financial coverage of treatment sub-policy.

Previously the financial access sub-policy in *SimSmoke* included the level of publicity, which is no longer an option in this module. The level of publicity is now automatically set based on the level of tobacco control campaigns. The effect of publicity on financial coverage of treatment is (1- 0.25 *(1- publicity)); where publicity = 1 if a high level tobacco control campaign, 0.5 if medium level, and 0.25 if low level)) so that the effects of treatment availability are scaled as much as a 25% reduction by this variable if publicity is less than high (equivalent to an additional 15% of smokers using treatment with a 15% success rate net of relapse) in the first year of the policy and the cessation rate is increased by 12% (equivalent to quit attempts increased by 40% with the new treatment users having a 30% first year success rate) in all years after the first.

In the MPOWER Report, quitlines are distinguished only by whether the population has access to a toll free quitline. In previous versions of *SimSmoke*, quitlines were distinguished by TYPE of quitline. We now enable the user to input supplementary information regarding whether the quitline is passive, active without follow-up or active with follow-up, with corresponding values of 1, 2 and 3 respectively. A default value for TYPE 2 (an active quitline without follow-up) is designated if no information is provided. In previous versions of *SimSmoke*, we also distinguished whether there was no cost NRT provided to callers, which is now excluded. The effect of quitlines also depends on publicity, which uses the same equation as for the financial access sub-policy.

If an active quitline with follow-up is implemented and the program is well publicized through a tobacco control campaign, then prevalence is reduced by 0.75% (equivalent to 5% of smokers using the quitline with a 15% success rate net of relapse) in the first year of the policy and the cessation rate is increased by 7.5% (quit attempts increased by 25% with users having a 30% first year success rate) in all years after the first. When the quitline is not active with follow-up, the effectiveness is reduced by (1- 0.5*TYPE/3). The MPOWER Report best case is only active quitlines.

In chapter 2 of the MPOWER Report, health care provider involvement is emphasized as a key element for successful cessation treatment services, but no information is provided in the MPOWER Reports on its level. This policy would involve at minimum a brief intervention by health care providers to advise and assist in cessation, and in more advanced forms would involve follow-up, training of the providers, charting, reminder systems, and integration with other services (quitlines, web-based cessation, and financial access). We include the health care provider involvement option as supplementary information provided by the user with a default value of zero, and the ability to scale the variable by between zero and one. The value should reflect the level of involvement, with 1 designating a required (or adequately subsidized) intervention with follow-up by all health care providers and with cessation treatment training, reminder systems and integration. When fully implemented alone (a value of one), prevalence is reduced by 0.5% in the first year (equivalent to an additional 5% of smokers making a quit attempt with a 10% average success rate net of relapse) and the pre-policy cessation rate is increased by 10% (equivalent to quit attempts increasing by 50% with the new treatment users having a 20% first year success rate) in all years after the first.

When more than one of the sub-policies is implemented, the effects are additive with the following exceptions. As in previous versions of *SimSmoke*, the effect of quitlines with NRT is reduced by 25% if there is also a policy of complete financial coverage of treatment, because NRT is then made available at no cost through other sources. In addition, a synergistic effect occurs between sub-policies 1-3 (which all provide for more treatment use) and brief interventions, as health care providers encourage treatment uses that have become more readily available. Brief intervention then increases the effect of sub-policies 1, 2 and 3 on prevalence by 10% and on the cessation rate by 30%. When all sub-policies are implemented, smoking prevalence is reduced by 4.75% and the first year cessation rate is increased by 39.3%. We allow for less effect if the country is rural because of less access to health care in rural areas, but we allow for a 50% greater effect in countries where awareness of health dangers is low. Thus, with effect size *CTP*' for cessation treatment policies in an HIC, the effect in country **i** is

$$CTP_{i,k} = CTP_k' * URBAN_i * AWARENESS_i$$

Table 8: Data used in Ontario SimSmoke

Input	Source	Specifications
I. Population		
A. Population	Canadian Human Mortality Database[40]	Breakdowns by age and gender groups
B. Fertility rates	Statistics Canada: age-specific fertility rate by province and territory, 1996, 2000-2010;[41,42] Peel Public Health: age-specific fertility rate, Ontario, 1997-1999;[43]	Breakdowns by age and gender groups
C. Mortality rates	Canadian Human Mortality Database[40]	Breakdowns by age and gender groups
II. Smoking and attributable deaths		
A. Baseline smoking rates	National Population Health Survey 1996/97, cross-sectional health file	Breakdown of current, former and never smokers by age and gender groups.
B. Initiation rates	Change in smoking rates between contiguous age groups	Breakdowns by age and gender groups.
C. First year cessation rates	Based on smoking cessation rate from the 2000-2001 Canadian Community Health Survey, and an adjusting factor from other studies	Breakdowns by age and gender groups.
D. Relapse rates	USDHHS (1989) and other studies	Breakdowns by age
E. Relative risks of current and former smokers	Cancer Prevention Study II (NCI 1997)	Breakdowns by age and gender
III. Policies		
A. Taxes	Based on the consumer price index and actual retail prices of cigarettes in Ontario	Prices and taxes
B. Clean air laws	Municipal smoke-free bylaws in Ontario by the Ontario Campaign for Action on Tobacco[78]	Types of laws (worksite, restaurant, and other places) and their stringency (by population coverage)
C. Media & other educational campaigns	Media campaigns in Ontario and Canada	Classification based on expenditures per capita, type of media and duration of the campaign
D. Advertising Bans	Tobacco Products Control Act in Canada,[81] Tobacco Act in Canada,[83] and Retail Display Bans in Ontario[161]	Extent of bans
E. Warning Labels	Health warnings on tobacco products in Canada by Non-Smokers' Rights Association,[98] tobacco use in Canada: patterns and trends[99]	Strictness of labels
F. Cessation Treatment Policies	Information about cessation treatment medications availability, free medications, and quitlines in Ontario and Canada[83,126,129]	Financial reimbursement, quitlines, and brief interventions
G. Youth access	Youth access to tobacco products by Ontario Tobacco Research Unit,[136] a critical analysis of youth access laws, and youth possession laws by Health Canada[162]	Enforcement checks, penalties, community campaigns, self-service and vending machine bans

Table 9: Policies, Description and Effect Sizes of the Ontario SimSmoke Model

Policy	Description	Potential Percentage Effect*
Tax Policy	Cigarette price index, tax measures in absolute terms	Through price elasticity: -0.3 ages <18 -0.2 ages 18-24 -0.15 ages 25-34 -0.1 ages 35 and above
Mass Media Campaigns		
Well-funded campaign	Campaign publicized heavily on TV (at least two months of the year) and at least some other media	6.5% effect
Moderately-funded campaign	Campaign publicized sporadically on TV and in at least some other media, and a local program	4.25% effect
Low-funded campaign	Campaign publicized only sporadically in newspaper, billboard or some other media.	1% effect
Advertising/Marketing Bans		
Comprehensive marketing ban (on direct and indirect marketing)	Ban is applied television, radio, print, billboard, in-store displays, sponsorships and free samples	5% reduction in prevalence, 6% reduction in initiation, 3% increase in cessation rates
Total Advertising Ban	Ban is applied to all media television, radio, print, billboard	3% reduction in prevalence, 3% reduction in initiation, 2% increase in cessation rates
Partial advertising ban	Ban is applied to some of television, radio, print, billboard	1% reduction in prevalence 1% reduction in initiation 0% reduction in cessation rates
Warning Labels		
Strong	Labels are large, bold and graphic, coverage over 50% of the package panels	2% reduction in prevalence 2% reduction in initiation 5% increase in cessation rates
Moderate	Labels are large, bold and graphic, coverage >1/3 but <50% of the package panels	1% reduction in prevalence 1% reduction in initiation 2.5% increase in cessation rates
Mild	Laws cover less than 1/3 of package, not bold or graphic	0.5% reduction in prevalence 0.5% reduction in initiation 1% increase in cessation rates
Publicity	Health information is well publicized	1% additional effect on prevalence and initiation rates
Youth Access Restrictions		On prevalence and initiation only
Vending machine ban	No vending machine service	Ages 10-15: Alone: 2%; With community publicity campaign (CPC): 3%;

Policy	Description	Potential Percentage Effect*
		With community programs for merchants (CPM): 2%; Ages 16-17: Alone: 1%; With CPC: 2%; With CPM: 1%;
Self-service ban	Ban on self service	Ages 10-15: Alone: 3%; With CPC: 6%; With CPM: 5%; Ages 16-17: Alone: 2%; With CPC: 4%; With CPM: 3%;
Strongly enforced & publicized	Compliance checks are conducted 4 times per year per outlet, penalties are potent and enforced, and with heavy publicity and community involvement	Ages 10-15: Alone: 15%; With CPC: 23%; With CPM: 17%; With vending machine (VM):18%; With self-service (SS): 20%; With CPC & VM: 24%; With CPM & VM: 18%; With CPC & SS: 29%; With CPM & SS: 23%; With CPC, VM, & SS: 33%; With CPM, VM, & SS: 24%; Ages 16-17: Alone: 10%; With CPC: 15%; With CPM: 11%; With VM:12%; With SS: 13%; With CPC & VM: 16%; With CPM & VM: 12%; With CPC & SS: 19%; With CPM & SS: 15%; With CPC, VM, & SS: 22%; With CPM, VM, & SS: 16%;
Youth Access Restrictions		On prevalence and initiation only
Well enforced	Compliance checks are conducted regularly, penalties are potent, and publicity and merchant training are included, but there is little community support	Ages 10-15: Alone: 8%; With CPC: 12%; With CPM: 9%; With VM:9%; With SS: 11%; With CPC & VM: 14%; With CPM & VM: 11%; With CPC & SS: 14%;

Policy	Description	Potential Percentage Effect*
		With CPM & SS: 11%; With CPC, VM, & SS: 21%; With CPM, VM, & SS: 15%; Ages 16-17: Alone: 5%; With CPC: 8%; With CPM: 6%; With VM:6%; With SS: 7%; With CPC & VM: 9%; With CPM & VM: 7%; With CPC & SS: 9%; With CPM & SS: 7%; With CPC, VM, & SS: 14%; With CPM, VM, & SS: 10%;
Low enforcement	Compliance checks are conducted sporadically, penalties are weak, there is little merchant awareness and minimal community participation	Ages 10-15: Alone: 2%; With CPC: 3%; With CPM: 2%; With VM:3%; With SS: 5%; With CPC & VM: 6%; With CPM & VM: 3%; With CPC & SS: 9%; With CPM & SS: 8%; With CPC, VM, & SS: 12%; With CPM, VM, & SS: 9%; Ages 16-17: Alone: 1%; With CPC: 2%; With CPM: 1%; With VM:2%; With SS: 3%; With CPC & VM: 4%; With CPM & VM: 2%; With CPC & SS: 6%; With CPM & SS: 5%; With CPC, VM, & SS: 8%; With CPM, VM, & SS: 6%;
Clean Air Policies		
Restaurants	Ban in all indoor areas	2% effect
Bar and pubs	Ban in all indoor areas	1% effect
Worksite total Ban	Ban in all indoor workplaces and government buildings	6% effect
Worksite partial ban	Ban indoor offices only or in health facilities, universities, and government buildings (2 of 3)	2% effect

Policy	Description	Potential Percentage Effect*
Other places bans	Ban in entertainment places such as bingo halls, bowling alleys, billiards	1% effect
Cessation Treatment Policy		
Treatment availability	Availability of NRT, Bupropion, and Varenicline	Prevalence: 30%; Relapse: 25%; Quit attempt: 30%; Success quit rate: 25%;
Treatment access	Access to treatment by prescription and over the counter	Prevalence: 40%; Relapse: 30%; Quit attempt: 40%; Success quit rate: 30%;
Quitlines	Free quitlines to the whole population	Prevalence: 25%; Relapse: 30%; Quit attempt: 25%; Success quit rate: 30%;
Quitlines with treatment access	See above	Prevalence: 15%; Relapse: 30%; Quit attempt: 15%; Success quit rate: 30%;
Brief interventions	Physicians providing brief interventions for cessation	Prevalence: 40%; Relapse: 20%; Quit attempt: 40%; Success quit rate: 20%;

Table 10: Age-Specific Fertility Rate (per 1,000 Women), Ontario, 1996-2010

Age group	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15-19	20.1	17.0	17.0	15.5	14.3	13.4	12.0	11.8	10.7	10.7	10.8	10.8	11.1	10.8	10.5
20-24	58.1	54.0	55.0	52.9	50.4	48.1	45.0	43.7	42.9	41.6	41.6	42.6	42.5	41.0	38.6
25-29	104.9	99.4	98.4	97.9	91.7	93.9	92.0	92.5	92.5	91.5	90.5	90.7	91.2	88.3	84.9
30-34	94.8	91.9	92.3	94.2	92.1	97.6	96.3	98.8	101.5	102.6	104.0	108.0	107.8	107.3	106.1
35-39	38.5	38.2	38.7	39.1	39.2	41.0	41.6	43.5	44.4	46.7	48.4	52.6	53.6	54.0	54.9
40-44	6.1	6.3	6.4	6.8	7.2	7.4	7.5	7.8	8.1	8.2	8.4	8.8	9.4	10.1	10.9
45-49	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.5	0.5	0.5	0.5

Note: Data for years of 1996, 2000-2010 from Statistics Canada;[42,43] data for years of 1997-1999 from Peel Public Health.[44]

Table 11: Policy Levels in Ontario, 1994-2010

Policy	1996	1997	1998	1999	2000	2001
Tax (excise tax only without sale tax), $	10.37	11.65	12.71	13.03	14.05	17.53
Adjusted retail price,[a] $	33.90	35.73	37.82	38.10	39.37	44.77
Retail price,[a] adjusted for discount cigarettes, $	33.90	35.73	37.82	38.10	39.37	44.55
Smoke-free air policies (%)						
Total work site ban,[b]	0	0	0	22.4	27.1	40.3
Worksite ban with DSRs,[b]	100	100	100	77.6	72.9	59.7
Restaurant & bar total ban,[b]	0	0	0	0	0.9	11.6
Restaurant & bar ban with DSRs,[b]	2.8	2.8	2.8	25.2	24.9	31.4
Other place total ban,[b,c]	0	0	0	0	4.8	11.6
Other place partial ban or with DSRs,[b,c]	3.6	4.4	4.6	28.1	27.4	34.6
Enforcement[d]	5	5	5	5	5	5
Mass media campaign[e] (%)						
Well-funded	0	0	0	0	100	100
Moderately funded	100	100	100	100	0	0
Low funded	0	0	0	0	0	0
Advertising ban[f] (%)						
Comprehensive marketing ban	0	0	0	0	0	0
Ban on advertising	0	0	100	100	100	100
Partial ban on advertising	100	100	0	0	0	0
No restrictions	0	0	0	0	0	0
Enforcement	5	5	5	5	5	5
Warning labels[g] (%)						
Strong health warnings	0	0	0	0	0	100
Moderate health warnings	100	100	100	100	100	0
Mild health warnings	0	0	0	0	0	0
No health warnings	0	0	0	0	0	0
Cessation treatment policy[h]						
Availability of NRT	1	1	1	2	2	2
Availability of Bupropion & Varenicline	0	0	1	1	1	1
Financial coverage						
In primary care facilities	0	0	0	0	0	0
In hospitals	0	0	0	0	0	0
In offices of health professionals	0	0	0	0	0	0
In community	0	0	0	0	0	0
In other places	0	0	0	0	0	0
Availability of quitline	0	0	0	0	1	1

Policy	1996	1997	1998	1999	2000	2001
Quitline type	0	0	0	0	1	1
Free NRT	1	1	1	1	1	1
Health care provider involvement	0.5	0.5	0.5	0.5	0.5	0.5
Youth access restrictions[i] (%)						
Vending machine ban	100	100	100	100	100	100
Self service ban	0	100	100	100	100	100
Strongly enforced & publicized	0	0	0	0	0	0
Well enforced	100	0	0	100	100	100
Low enforcement	0	100	100	0	0	0
Community based publicity campaign	0	0	0	0	50	50
Merchant awareness campaign	0	0	0	0	50	50
Tax (excise tax only without sale tax), $	27.62	33.30	37.10	39.24	40.72	41.11
Adjusted price,[a] $	57.94	65.82	72.19	74.84	76.97	78.06
Retail price,[a] adjusted for discount cigarettes, $	57.50	64.72	68.45	70.44	71.51	73.11
Smoke-free air policies (%)						
Total work site ban,[b]	48.8	72.1	81.5	82.5	100.0	100.0
Worksite ban with DSRs,[b]	51.2	27.9	18.5	17.5	0	0
Restaurant & bar total ban,[b]	14.8	27.3	39.5	40.3	100.0	100.0
Restaurant & bar ban with DSRs,[b]	39.4	55.0	52.5	52.3	0.0	0.0
Other place total ban,[b,c]	14.5	24.6	32.6	33.0	100.0	100.0
Other place partial ban or with DSRs,[b,c]	43.4	61.0	62.8	62.4	0	0
Enforcement[d]	5	5	5	5	8	8
Mass media campaign[e] (%)						
Well funded	100	100	100	100	100	100
Moderately funded	0	0	0	0%	0%	0%
Low funded	0	0	0	0	0	0
Advertising ban[f] (%)						
Comprehensive marketing ban	0	25	25	25	25	25
Ban on advertising	100	75	75	75	75	75
Partial ban on advertising	0	0	0	0	0	0
No restrictions	0	0	0	0	0	0
Enforcement	5	5	5	5	5	5
Warning labels[g]						
Strong health warnings	100	100	100	100	100	100
Moderate health warnings	0	0	0	0	0	0
Mild health warnings	0	0	0	0	0	0
No health warnings	0	0	0	0	0	0

Policy	1996	1997	1998	1999	2000	2001
Cessation treatment policy[h]						
Availability of NRT	2	2	2	2	2	2
Availability of Bupropion & Varenicline	1	1	1	1	1	2
Financial coverage						
In primary care facilities	1	1	1	1	1	1
In hospitals	1	1	1	1	1	1
In offices of health professionals	0	0	0	0	0	0
In community	1	1	1	1	1	1
In other places	0	0	0	0	0	0
Availability of quitline	1	1	1	1	1	1
Quitline type	1	1	1	1	1	1
Free NRT	1	1	1	2	2	2
Health care provider involvement						
Youth access restrictions[i]						
Vending machine ban	100	100	100	100	100	100
Self service ban	100	100	100	100	100	100
Strongly enforced & publicized	0	0	0	0	0	100
Well enforced	100	100	100	100	100	0
Low enforcement	0	0	0	0	0	0
Community based publicity campaign	0	0	0	0	0	0
Merchant awareness campaign	0	0	0	0	0	0
Tax (excise tax only without sale tax), $	41.70	41.70	41.70	41.70	41.70	41.70
Adjusted price,[a] $	78.20	79.56	80.98	81.82	80.83	80.83
Retail price,[a] adjusted for discount cigarettes, $	70.95	72.06	69.98	70.82	69.83	69.83
Smoke-free air policies (%)						
Total work site ban,[b]	100.0	100.0	100.0	100.0	100.0	100.0
Worksite ban with DSRs,[b]	0	0	0	0	0	0
Restaurant & bar total ban,[b]	100.0	100.0	100.0	100.0	100.0	100.0
Restaurant & bar ban with DSRs,[b]	0.0	0.0	0.0	0.0	0.0	0.0
Other place total ban,[b,c]	100.0	100.0	100.0	100.0	100.0	100.0
Other place partial ban or with DSRs,[b,c]	0	0	0	0	0	0
Enforcement[d]	8	8	8	8	8	8
Mass media campaign[e] (%)						
Well funded	100	0	0	0	0	0
Moderately funded	0%	100	100	100	100	100
Low funded	0	0	0	0	0	0
Advertising ban[f] (%)						

Policy	1996	1997	1998	1999	2000	2001
Comprehensive marketing ban	25	25	25	25	25	25
Ban on advertising	75	75	75	75	75	75
Partial ban on advertising	0	0	0	0	0	0
No restrictions	0	0	0	0	0	0
Enforcement	5	5	5	5	5	5
Warning labels[g]						
Strong health warnings	100	100	100	100	100	100
Moderate health warnings	0	0	0	0	0	0
Mild health warnings	0	0	0	0	0	0
No health warnings	0	0	0	0	0	0
Cessation treatment policy[h]						
Availability of NRT	2	2	2	2	2	2
Availability of Bupropion & Varenicline	2	2	2	2	2	2
Financial coverage						
In primary care facilities	1	1	1	1	1	1
In hospitals	1	1	1	1	1	1
In offices of health professionals	0	0	0	1	1	1
In community	1	1	1	1	1	1
In other places	0	0	0	0	0	0
Availability of quitline	1	1	1	1	1	1
Quitline type	1	1	1	1	1	1
Free NRT	2	2	2	2	2	2
Health care provider involvement	0.5	0.5	0.5	0.5	0.5	0.5
Youth access restrictions[i]						
Vending machine ban	100	100	100	100	100	100
Self service ban	100	100	100	100	100	100
Strongly enforced & publicized	100	0	0	100	100	100
Well enforced	0	100	100	0	0	0
Low enforcement	0	0	0	0	0	0
Community based publicity campaign	0	0	0	0	0	0
Merchant awareness campaign	0	0	0	0	0	0

[a] Price is converted to 2012 base year dollars.
[b] Values are calculated as population coverage percentages by the municipal smoke-free bylaws.
[c] Other places including bingo halls, bowling alleys, billiards, and municipality buildings. Partial ban means that smoke-free bylaws was implemented in some public places but not at all or with DSRs.
[d] All municipal bylaw enforcement officers, policy officers or appointed persons may make inspections at any reasonable time. No person shall obstruct an inspector carrying out inspections. Any person who contravenes this bylaw is guilty of an offence and will be fined. Score from MPOWER: range 0 = no enforcement, … 10=complete enforcement.
[e] "Well funded" means highly publicized campaign, in which campaigns are publicized heavily with funding of $1US per

capita; "Moderately funded" means moderately publicized campaign, in which campaigns are publicized sporadically with funding of $0.10 per capita; and "Low funded" means low publicity campaign, in which campaigns are publicized only sporadically in newspaper, billboard or some other media;

[f] "Comprehensive" means comprehensive marketing ban, in which ban is applied to TV, radio, print, billboard, in-store displays, sponsorships and free samples; "Ban on advertising" means moderate marketing ban, in which ban is applied to all media, TV, radio, print, and billboard; and "Partial ban on advertising" means weak marketing ban, in which ban is applied to some of TV, radio, print, billboard.

Enforcement based on MPOWER, ranging from 0=no enforcement, … 10=complete enforcement.

[g] "Strong" means labels are large, bold and graphic; "Moderate" means warning covers at least 1/3 of both sides of package, not bold or graphic; and "Mild" means labels cover less than one-third of package, not bold or graphic.

[h] Availability of pharmacotherapy: score = 1 for NRT provided by either general store or pharmacy w/Rx; score =2 if NRT is provided by general store or pharmacy (no Rx required); score =3 for no availability of NRT;

Bupropion and Varenecline: score = 2 if both are provided by Rx; score = 1 if only one is provided by Rx; and score = 0 if none is provided;

Financial coverage of treatment (including pharmacotherapy and behavioural therapy): 0 = none; 1 = yes in some; 2 = yes in most fro primary care facilities, hospitals, offices of health professionals, community, or in other places.

Qutline: 0 = none; 1 = yes;

Qulitline type: 1 = passive; 2 = active; 3 = active w/ followup;

Free NRT: 1 = no free NRT; 2 = free NRT provided;

Health care provider involvement: 1 = required or adequately subsidized intervention with followup by health care providers and with training and reminder system; can vary between 0 and 1.

[i] "Strong" – "strongly enforced and publicized", meaning that compliance checks are conducted regularly, penalties are heavy, publicity is strong, and vending machines and self-services are banned; "Well" – "well enforced", meaning that compliance checks are conducted sporadically, penalties are potent, and little publicity; and "Low" – "Low enforcement", meaning that compliance checks are not conducted, penalties are weak, and no publicity.

Table 12: Estimated Cigarette Price, Adjusted for Discount Cigarettes in Canada

	Market Share Of Discount Cigarettes in Canada	Discount Cigarette Price Less Than That of Premium Brands	Original Cigarette Price, Ontario (by Rita, OTRU)	Estimated Discount Cigarette Price	Cigarette Price adjusted for Discount Cigarettes
Year	(1)	(2)	(3)	(4)	(5)
1996	0%	NA	$33.90		$33.90
1997	0%	NA	$35.73		$35.73
1998	0%	NA	$37.82		$37.82
1999	0%	NA	$38.10		$38.10
2000	0%	NA	$39.37		$39.37
2001	2.0%[a]	$11.0[c]	$44.77	$33.77	$44.55
2002	4.0%[a]	$11.0[c]	$57.94	$46.94	$57.50
2003	10.0%[b]	$11.0[c]	$65.82	$54.82	$64.72
2004	34.0%[b]	$11.0[c]	$72.19	$61.19	$68.45
2005	40.0%[b]	$11.0[c]	$74.84	$63.84	$70.44
2006	49.6%[b]	$11.0[c]	$76.97	$65.97	$71.51
2007	45.0%[b]	$11.0[c]	$78.06	$67.06	$73.11
2008	58.0%[b]	$12.5[d]	$78.20	$65.70	$70.95
2009	60.0%[b]	$12.5[d]	$79.56	$67.06	$72.06
2010	50.0%[b]	$22.0[e]	$80.98	$58.98	$69.98
2011	50.0%[b]	$22.0[e]	$81.82	$59.82	$70.82
2012	50.0%[b]	$22.0[e]	$80.83	$58.83	$69.83

Note: Data in columns 1-3 are from different sources (see below);
Columns (4) = (3) – (2);
(5) = [100% – (1) * (3) + (1) * (4)], while for 1996-2000, using the original price data.

[a] Alberta Health Services. Market share of discount cigarettes in Canada (http://www.albertahealthservices.ca/2534.asp).

[b] Non-Smokers' Rights Association (NRSA). Backgrounder on the Canadian tobacco industry and its market for 2002-2011 (assuming 2012 has the same as in 2011; http://www.nsra-adnf.ca/cms/page1150.cfm).

[c] NSRA's backgrounder on the Canadian tobacco industry and its market. "Discount brands such as Number 7, … selling at anywhere from $10-$12 less per carton than premium brands …", using its median value $11 (http://www.nsra-adnf.ca/cms/file/files/pdf/Backgrounder_2006_07_final.pdf).

[d] NSRA's backgrounder on the Canadian tobacco industry and its market. "Discount brands such as Number 7, … selling at anywhere from $10-$15 less per carton than premium brands …", using its median value $12.5 (http://www.nsra-adnf.ca/cms/file/files/pdf/Backgrounder2008_09.pdf).

[e] NSRA's backgrounder on the Canadian tobacco industry and its market. "Discount brands such as Number 7, … selling at anywhere from $12-$32 less per carton than premium brands …", using its median value $22 (http://www.nsra-adnf.ca/cms/file/files/pdf/Backgrounder_2011.pdf).

Table 13: Policy Role Calculation, Ontario SimSmoke, 1996-2012

Policy level	Sex	Model predicted prevalence in 1996	Model predicted prevalence in 2012	Prevalence reduction 1996 to 2012	Overall reduction	Reduction by all policies	Reduction by each policy	Role of each policy	Role of each policy, adjusted to 100%
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy vs. no policy changes									
No policy change (all in 1996 levels)	Male	27.2%	25.7%	-1.5%	-8.9%			16.9%	
	Female	21.2%	20.1%	-1.1%	-6.7%			16.4%	
	Both	24.1%	22.9%	-1.2%	-7.7%			15.6%	
All policies in place	Male	27.2%	18.4%	-8.9%	-8.9%	-7.4%		83.1%	
	Female	21.2%	14.5%	-6.7%	-6.7%	-5.6%		83.6%	
	Both	24.1%	16.4%	-7.7%	-7.7%	-6.5%		84.4%	
Individual policy role									
Tax policy only (other policies at 1996 levels)	Male	27.2%	22.7%	-4.5%		-7.3%	-3.0%	40.5%	35.3%
	Female	21.2%	17.9%	-3.3%		-5.6%	-2.2%	39.3%	36.7%
	Both	24.1%	20.3%	-3.8%		-7.3%	-2.6%	40.0%	35.1%
Clean air policy only (other policies at 1996 levels)	Male	27.2%	23.4%	-3.8%		-7.3%	-2.3%	31.1%	27.1%
	Female	21.2%	18.4%	-2.8%		-5.6%	-1.7%	30.4%	28.3%
	Both	24.1%	20.9%	-3.2%		-7.3%	-2.0%	30.8%	27.0%
Mass media campaign only (other policies in 1996 levels)	Male	27.2%	25.4%	-1.8%		-7.3%	-0.3%	4.1%	3.5%
	Female	21.2%	19.9%	-1.3%		-5.6%	-0.2%	3.6%	3.3%
	Both	24.1%	22.6%	-1.5%		-7.3%	-0.3%	4.6%	4.1%
Advertising ban only (other policies at 1996 levels)	Male	27.2%	24.8%	-2.4%		-7.3%	-0.9%	12.2%	10.6%
	Female	21.2%	19.5%	-1.7%		-5.6%	-0.6%	10.7%	10.0%
	Both	24.1%	22.1%	-2.0%		-7.3%	-0.8%	12.3%	10.8%
Health warnings only	Male	27.2%	25.3%	-1.9%		-7.3%	-0.4%	5.4%	4.7%

Policy level	Sex	Model predicted prevalence in 1996	Model predicted prevalence in 2012	Prevalence reduction 1996 to 2012	Overall reduction	Reduction by all policies	Reduction by each policy	Role of each policy	Role of each policy, adjusted to 100%
(other policies at 1996 levels)	Female	21.2%	19.9%	-1.3%		-5.6%	-0.2%	3.6%	3.3%
	Both	24.1%	22.6%	-1.5%		-7.3%	-0.3%	4.6%	4.1%
Youth access policy only (other policies at 1996 levels)	Male	27.2%	25.5%	-1.7%		-7.3%	-0.3%	4.1%	3.5%
	Female	21.2%	20.0%	-1.2%		-5.6%	-0.1%	1.8%	1.7%
	Both	24.1%	22.7%	-1.4%		-7.3%	-0.2%	3.1%	2.7%
Cessation treatment only (other policies at 1996 levels)	Male	27.2%	24.4%	-2.8%		-7.3%	-1.3%	17.6%	15.3%
	Female	21.2%	19.1%	-2.1%		-5.6%	-1.0%	17.9%	16.7%
	Both	24.1%	21.7%	-2.4%		-7.3%	-1.2%	18.5%	16.2%
All policies in place	Male	27.2%	18.3%	-8.9%		-7.3%	-7.4%	100.0%	
	Female	21.2%	14.5%	-6.7%		-5.6%	-5.6%	100.0%	
	Both	24.1%	16.4%	-7.7%		-6.5%	-6.5%	100.0%	

Note: Columns (1) and (2) are estimated by the *Ontario SimSmoke* model;
Column (3) = (2) – (1);
Column (4) = (3) – (1) for all policies in place;
Column (5) = (5) in all policies rows – (5) in no policy changes rows for males, females and both sexes, respectively;
Column (6) = (3) in individual policy rows – (3) in no policy changes rows for males, females and both sexes, respectively;
Column (7) for no policy change = (3) / (4) * 100%; and for all policies in place = (5) / (4) * 100%;
Column (7) for other individual policies = (6) / (5) * 100% as well for all policies in place under individual policy role;
Column (8) is adjusted to 100%, because the sum of individual policy roles may add up over 100% due to reduced effects for multiple policy effects for the all policies in place situation. The sum of individual policy roles are 115.1% for males, 107.1% for females, and 101.4% for both sexes. The individual role is then adjusted by this factor, i.e., the individual policy role in column (7) is multiplying by the factor (100%/115.1%) for males, (100%/107.1%) for females, and (100%/101.4%) for both sexes.

Table 14: Population Comparison

Year	Population predicted by the model (1)	Real Population (2)	Immigrants in each year (3)	Death rate in each year (4)	Deaths among immigrants (5)	Cumulative immigrants – deaths (6)	Population of model predicted plus cumulative immigrants (7)	Comparison (8)
1996	11,013,961	11,082,903	115,961	0.007433	862	115,099	11,129,060	46,157
1997	11,082,983	11,227,651	119,401	0.007319	874	233,626	11,316,609	88,958
1998	11,143,280	11,365,901	106,419	0.007242	771	339,274	11,482,554	116,653
1999	11,199,448	11,504,759	91,899	0.007227	664	430,509	11,629,957	125,198
2000	11,250,534	11,683,290	116,744	0.007137	833	546,420	11,796,954	113,664
2001	11,292,168	11,896,663	149,998	0.007040	1056	695,362	11,987,530	90,867
2002	11,332,036	12,091,029	152,823	0.007139	1091	847,094	12,179,130	88,101
2003	11,364,703	12,242,273	109,814	0.007074	777	956,131	12,320,834	78,561
2004	11,394,691	12,390,599	127,942	0.007053	902	1,083,171	12,477,862	87,263
2005	11,421,339	12,528,480	129,785	0.006841	888	1,212,068	12,633,407	104,927
2006	11,444,379	12,665,346	133,062	0.007006	932	1,344,198	12,788,577	123,231
2007	11,464,237	12,791,032	115,445	0.006984	806	1,458,837	12,923,074	132,042
2008	11,484,412	12,932,480	115,051	0.006976	803	1,573,085	13,057,497	125,017
2009	11,501,405	13,068,845	105,423	0.007039	742	1,677,766	13,179,171	110,326
2010	11,514,201	13,223,789	116,572	0.007202	840	1,793,498	13,307,699	83,910
2011	11,522,221	13,366,294	105,015	0.007361	773	1,897,740	13,419,961	53,667
2012	11,527,533	13,505,900	101,179	0.007361	745	1,998,175	13,525,708	19,808

Note: (1) Population estimated by the *Ontario SimSmoke* model;
(2) Real population estimates provided by the Ministry of Finance;
(3) Immigrant population estimates provided by the Ministry of Finance
(4) Death rate in each year for the whole population provided by the Ministry of Finance;
(5) Deaths = (3) * (4), assuming the same death rate for immigrants as other populations;
(6) Cumulative immigrants minus death in each year, e.g., 339,274 = 115,961 - 862 + 119,401 – 874 + 106,419 -771;
(7) = (1) + (6);
(8) Comparison between model predicted population plus cumulative immigrants minus deaths among immigrants and real population.

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