Supplement 1

HealthPartners Institute

ModelHealth™: Tobacco

Technical documentation

Model Version 3.2

July 02, 2019

Contents

Introduction

The HealthPartners Institute ModelHealth™:Tobacco was developed to evaluate the health impact and cost-effectiveness of implementing evidence-based clinical and community preventive services for diverse populations over varying time-frames and from multiple perspectives. A prior version ModelHealth:Tobacco has been successfully used to assess clinical, local, state and federal policy changes.[1-3] Substantial updates for this version of the model include: updated tobacco use status equations combined with retired calibration of the model to the smoking prevalence trend estimated by the Congressional Budget Office; updated estimates of smoking-attributable medical conditions; and addition of smoking intensity, cigarette sales and cigarette taxes.

ModelHealth:Tobacco estimates the behavioral changes, health and economic impact, and the cost-effectiveness of tobacco control programs and policy. The model employs a flexible microsimulation framework in which the impact of the intervention under analysis is evaluated at the individual level. These individual effects are aggregated up to the population level to estimate health and economic impact.

This document provides an overview of the base model's structure, the development of the inputs to the base model, and a detailed discussion of the modeling framework and embedded algorithms. Inputs that are specific to clinical interventions, policies and programs (counseling, tobacco taxes, media campaigns etc.) are discussed in reports specific to their analysis.

Model structure

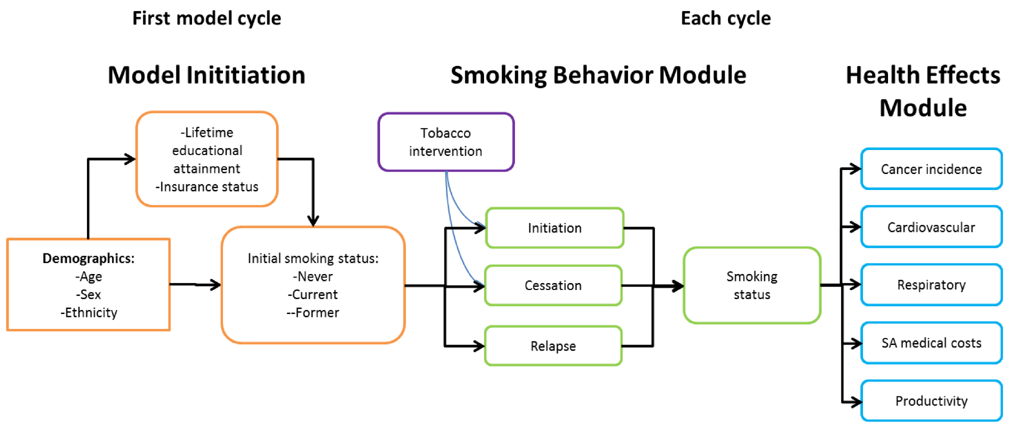
Overview

ModelHealth:Tobacco is a Markovian individual-based simulation model (i.e. Markov microsimulation). In the health care context, a Markov microsimulation is a model in which simulated individuals age over time, while facing period-specific probabilities ('risks') of changing health behaviors and experiencing related health outcomes and economic impact. In each cycle (one year in ModelHealth:Tobacco), individuals will either remain in their current state (other than changing age) or transition to a different one, with probabilities of transitioning obtained from literature and analyses of relevant data. In the model, the state (age, smoking status, health, etc.) of each individual is tracked over time.

The model can be conceptualized as having three distinct parts that are shown in Figure 2 and are described further below. The first part, Model Initiation, defines the population to be modeled. It was designed to allow analyses of different populations and to facilitate both birth cohort and cross-sectional analyses. The second part, the Smoking Behavior Module, determines transitions in smoking status over time, and the third part, the Health Effects

Module, determines health and economic outcomes associated with cigarette smoking. A fourth part, the Health Insurance Module, is integrated into the other modules.

Figure 1: Structure of the Smoking Prevention Microsimulation Model



Software

The model is constructed in TreeAge PRO 2015. The structure of the model reflects some of the capabilities and limitations of TreeAge PRO with respect to microsimulation modeling. Within TreeAge PRO, the model uses multiple custom Python functions in both the base model and in implementing programs and policies for analyses. Outside of TreeAge PRO, we employ Java to import some model inputs and we frequently process model results in R. Finally, many implementations of the model employ an Excel front-end that facilitates running multiple scenarios without waiting for user input between scenarios.

Model Initialization and population characteristics

ModelHealth: Tobacco starts by generating a population of heterogeneous simulated individuals, or agents. Four broad racial/ethnic groups are currently represented: black, Hispanic, white, and other. An agent's lifetime educational achievement at age 25 is determined based on the three basic demographic factors of sex and ethnicity. Three broad levels of lifetime educational achievement are contained in the model: No high school diploma, high school degree with or without additional years of education with less than a bachelor's degree, and bachelor's degree or higher. Broad categories of race/ethnicity and educational status were used because they are consistently defined and identifiable across the multiple data sources used to parameterize the model. The likelihood of agents attaining a certain level of education at age 25 was set by sex and race/ethnicity in proportion to published data from the 2010 National Center for Educational Statistics (NCES).[4]

The initial model population can vary on two important dimensions:

1) The model can be initialized with a single-birth cohort or a cross-sectional population

2) The model can be initialized to be representative of a particular population or with equally sized population strata that can be weighted in post processing analyses to created estimates that are representative of selected populations

1) Initialization for birth cohort vs cross-sectional analyses

Members of the population are created by assigning individual characteristics of age, sex, race-ethnicity, lifetime educational attainment, and US Census region according to probabilities derived from the Current Population Survey (CPS).[5] For the insurance module, characteristics of initial employment status, disability status, family poverty level and insurance type are also assigned. The demographics of the US population were associated with employment status, poverty status, disability status and health insurance type using relationships between demographics and these characteristics that we estimated for the United States from the Public Use Microdata Series of the US Current Population Survey[5] and the Survey of Income and Program Participation.[6] The beta coefficients from logistic regressions are provided in tables at the end of this supplement starting on page 25.

In a cross-sectional set-up, individuals are assigned an age and then assigned other characteristics according to their age. A cross-section is, in effect, an analysis of multiple birth cohorts with the cohorts starting a different ages. To allow projections of population impact in future years, cohorts of individuals who are not yet alive are defined at model initiation and they are born into the model over time. At initiation these cohorts are represented with negative ages if needed and they age into the age window of analysis. For example, cohorts with an initial age of -5 represent a future birth cohort that will be born in year 5 of the simulation. In an analysis of adults ages 18 and older with an analytical horizon of 30 years, the model can be initiated with a cross-section of 0 to 99 year olds, plus cohorts ages -12 to -1 years of age. Those with negative ages during any model cycle (or those at any age outside the age range of interest for a particular analysis) are excluded in post-model processing of model output.

As the simulation progresses, the model population grows over time because young cohorts (including unborn cohorts) are introduced in numbers that represent their relative size compared to the older birth cohorts pre- World War cohorts who they replace. The model does not incorporate projections of net migration.

2) Initialization for representative population vs weighted analysis

The simulated population in ModelHealth:Tobacco is initialized using probabilities of population characteristics. These can be set to any value. When initializing the model to represent a U.S. population, the probabilities are drawn from the Current Population Survey. They can also be set to mimic the population characteristics of participants in a randomized trial or observational study of a smoking intervention in order to predict the long-term health and economic impact of study findings. In cross-sectional analyses of a representative population, cohorts that are initiated with negative ages (see discussion in previous section) are typically assigned the characteristics of the most recent births.

The population can also be initialized assigning strata of equal size, where each strata represents a unique combination of population characteristics - for example, college-educated Hispanic women with starting age of 57 in the South census region. With strata size set to 500 and defined by sex, one of 130 ages (if initiating with negative ages to -30 years), one of three lifetime education levels, and one of four US census regions, the model would be initialized with a population of 1,560,000 (500 x 2 x 130 x 3 x 4).

Conducting model runs of equal sized strata has two advantages. First, in post-model processing model results can be easily processed using weighted analyses to represent multiple populations with a single model run. Second, equally sized strata effectively over-sample smaller population groups, allowing more reliable estimates by population group in post-model processing. This is the approach taken in the Community Health Advisor to allow users to obtain more reliable estimates by population group.

The smoking behavior module

The impact on smoking behavior of a clinical intervention, program or policy is determined by comparing the smoking behavior of each agent in a simulation scenario with the policy or program change to smoking behaviors in a "baseline" scenario (an environment *without* policy or program change). An individual agent's smoking behavior may or may not change with a change in smoking behavior, and if an agent's smoking behavior does change their health outcomes may or may not be affected. Population wide effects are determined from summing the experience of all agents, those who do and do not experience change as the result of a policy or program.

For example, *the Community Guide to Preventive Services* recommends increasing the unit price of tobacco products. Some youth who would have started smoking without the increase will not start smoking with a tax increase. Of those who do not start smoking as youth with the tax increase, some will still start smoking as young adults and others will avoid a lifetime of tobacco use. Some smokers never experience significant harms of smoking; some by chance and others by quitting in time to reduce their risks. For those smokers who would never experience harm, avoiding initiation will have no impact on health outcomes. Other would-be smoking initiators will avoid smoking-attributable disease and may have significantly longer lives. Similarly, taxes also increase the probability that current smokers will quit, and whether or not a tax impacts a particular smoker's health depends on what would happened to them without a tax increase and how they respond to the tax increase. Through a series of probabilities, the microsimulation produces these heterogeneous individual experiences with and without policy change, and we calculate the population-wide impact by summing these experiences.

Initial smoking status

In ModelHealth:Tobacco adults may be in one of three smoking states: *never smoker*, *current smoker* and *former smoker*. Youth (younger than age 18), may be never or current smokers. Cessation and status as former smokers is not tracked for youth in the model due to the experimental nature of youth smoking and associated limitations of the data that quantify youth smoking. Adult smoking status is defined using the usual criteria of ever having smoked 100 cigarettes:

- **Never smoker:** Having smoked fewer than 100 cigarettes in their lifetime
- **Current smoker:** Having smoked at least 100 cigarettes in their lifetime and having smoked in the last week
- **Former smoker:** Having smoked at least 100 cigarettes in their lifetime and not currently a smoker

Probabilities for adult smoking status are derived from the 2013 National Health Interview Survey.[7] Youth smoking surveys ask different questions, and hence smoking prevalence rates estimated from youth surveys can yield substantially different estimates of prevalence at age 18 than do adult surveys based on the definitions above. We base our youth smoking prevalence on the 2011 Youth Risk Behaviors Survey (YRBS),[8] including self-report of age of first cigarette, to estimate initiation at ages younger than the high school students who are surveyed. However, we calibrate these rates to avoid discontinuity of smoking prevalence at age 18. As a result of the calibration, we believe the model's youth smoking prevalence approximates the definitions used in adult surveys. YRBS is limited in regard to age range and exclusion of youth who are not is school. However its large sample size allows for more detailed estimation of smoking status by age, sex and race-ethnicity, including interaction terms, than do other youth surveys. The calibration adjusts the overall rates while preserving relative differences by age, sex and race-ethnicity. The calibration was updated in the model when 2013 NHIS data for adults was introduced.

In a birth cohort analysis that starts before age 9, all individuals are initialized as never smokers. In a birth cohort analyses that starts at an older age, and in cross-sectional analyses, individuals are initialized as being never or current smokers from aged 9-18, or never, current or formers smokers from ages 19 and older.

At model initiation, the likelihood that an agent is in any one of the three smoking states is conditioned on his/her age, gender, ethnicity, and – for those older than age 25 – the lifetime educational attainment at introduction into the model. Similarly, the likelihood that an agent who is currently in the never smoker state begins smoking within a given cycle is conditioned upon his/her age, gender, ethnicity, and – if older than age 25 – lifetime educational attainment. Our model specification intends no causal inference regarding the relationship between smoking behavior and educational attainment, merely an association.

Although the specific final multivariable risk equations vary in terms of covariates and dependent variables, several criteria were applied consistently across analyses. The statistical relationships between each covariate and other predictors were screened prior to its inclusion in a final risk equation. If the inclusion of a covariate violated assumptions (e.g., co-linearity, normality, disproportionate cell size) appropriate adjustments (e.g., center around mean, transformation, re-categorization) were made or its inclusion reconsidered. Interaction terms (e.g. differential rates of initiation between young women and young men, differential rates of cessation between African-Americans with higher education and those without a high-school diploma, etc.) were considered based on the following criteria: representing at least 10% of the larger groups (e.g. at least 10% of women *and* at least 10% of those under the age of 18, at least 10% of African Americans within each educational category, etc.), and a coefficient significant at the 10% level.

A multinomial logistic regression with outcomes corresponding to the three smoking states was used to estimate the likelihood of an individual having an initial smoking status given his/her age, gender, ethnicity, and lifetime educational attainment. The estimated distribution across potential smoking states was then used to determine each agent's initial smoking status at introduction into the model.

Assigning age of smoking initiation and cessation

An age of smoking initiation must be assigned to all agents initialized as either a current smoker or a former smoker. An age of cessation must be assigned for those initialized as a former smoker.

Figure 2: Determination of age of initiation and cessation

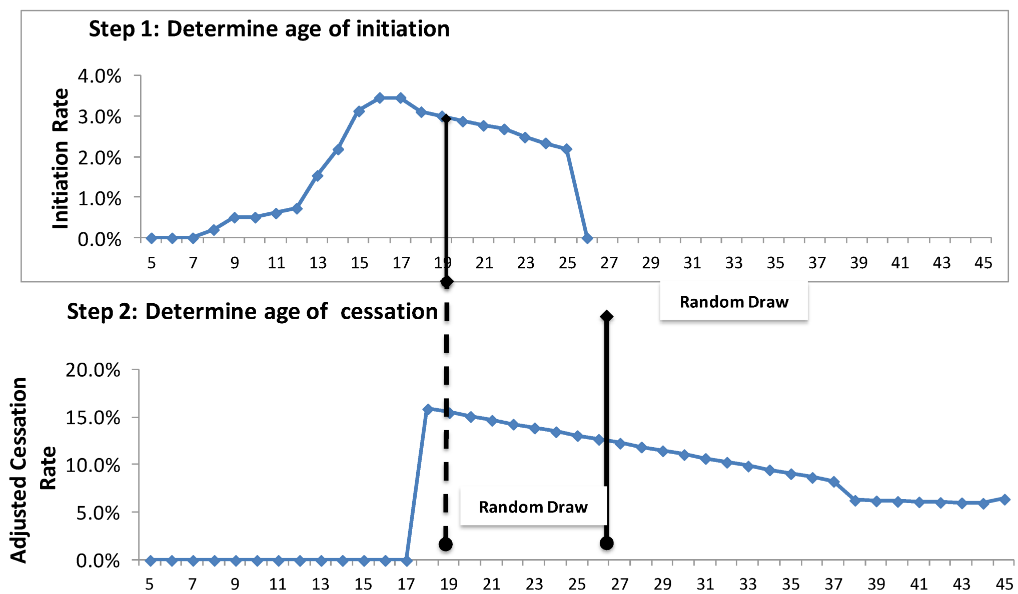
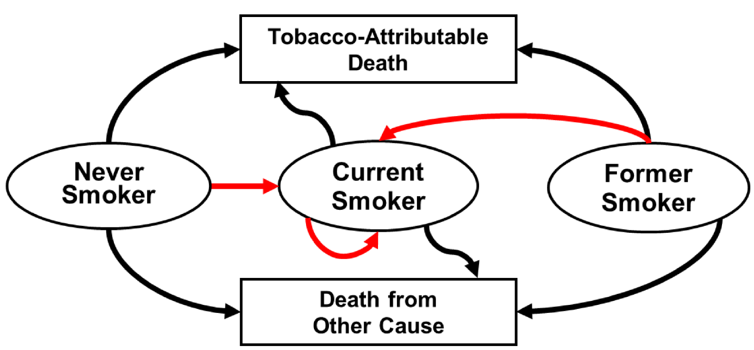


Figure 2 depicts the process for an agent initialized into the model as a 45-year old former smoker. The figure depicts hypothetical annual initiation and cessation rates without incorporating long-term relapse, and therefore it does not by itself determine change in prevalence over time for 45 year olds in the model. First, in Step 1, a random draw determines the age at which a current or former smoker first started smoking (age 19 in the example of Figure 2). That draw is from a distribution configured to initiation rates estimated from the National Health Interview Survey (NHIS). Then, for those initialized as former smokers (Step 2), a random draw determines the age of cessation (age 26). That draw is from a second distribution configured to cessation rates estimated from NHIS and truncated at the age of initiation. These two ages are used to determine the time spent smoking and time since quit. Time since quit is used in the model to assign the probability of relapse to each former smoker in each year, the year in which disease risks are reduced from current-smoker risks to former smoker risks, and to calculate the portion of excess disease and productivity costs of smoking incurred by a former smoker each year.

Estimating changes in smoking status

Individuals who have never smoked can either remain in the never smoker state or begin smoking and transition to the current smoker state. A current smoker can remain in the current smoker state or quit and transition to the former smoker state. The utilization of smoking cessation medication by adults varies by insurance status. Therefore insurance status influences the probability of adult cessation. A former smoker either relapses into the current smoker state or remains in the former smoker state. In addition, all individuals are faced with a risk of dying of either a tobacco-related illness or some other cause. Figure 3 illustrates this conceptual framework of the natural history of smoking tobacco use.

Figure 3: Natural History of Smoking Tobacco Use



Three separate logistic regressions determined the risk of smoking initiation among never smokers. The first, which used YBRS data,[8] applies to ages younger than 18. The second and third, which used NHIS data,[7] apply to ages 18-24 and 25 and older, respectively. The estimation for ages 25 and older includes lifetime educational achievement as a predictor.

Youth who start smoking are presumed to remain smokers until they reach age 18. Non-smoking youth have a probability of initiating smoking. That probability is estimated to reflect the probability of initiating smoking, less cessation that does occur during that year of age. This estimate of "net initiation" allows accurate simulation of the prevalence of youth smoking from available data, but does not track former smoking status for youth.

We estimated two cessation risk equations for adults. From the NHIS data, we identified as quitters those who reported that they had ceased cigarette use within the last 12 months without having relapsed at the time of survey administration. Two logistic regressions (18-24 and 25 and older) compared Quitters to Current Smokers to determine the likelihood of smoking cessation. Again, the estimation for ages 25 and older includes lifetime educational achievement.

Quit-types and smoking cessation medications

Cessation rates directly account for the relative effectiveness of the agent's quit strategy using a three-step process. First, one of six quit strategies is assigned to each person according to probabilities of self-reported methods used to quit smoking in the NHIS, accounting for differences in method by demographics and insurance status.[9] Then, the unassisted quit rate for all persons of similar age, sex, and education level is determined using Bayes' Rule. Finally, the agent's actual cessation rate is determined by scaling the estimated unassisted quit rate by the relative rate of agent's assigned quit type. The relative quit rates of brief medical counseling,[10,11] Rx NRT[12], bupropion[12], and varenicline[12] are 1.32, 1.60, 1.69, and 2.27. That of OTC NRT is equal to Rx NRT based on mixed evidence on equivalence of effectiveness.[12-17]

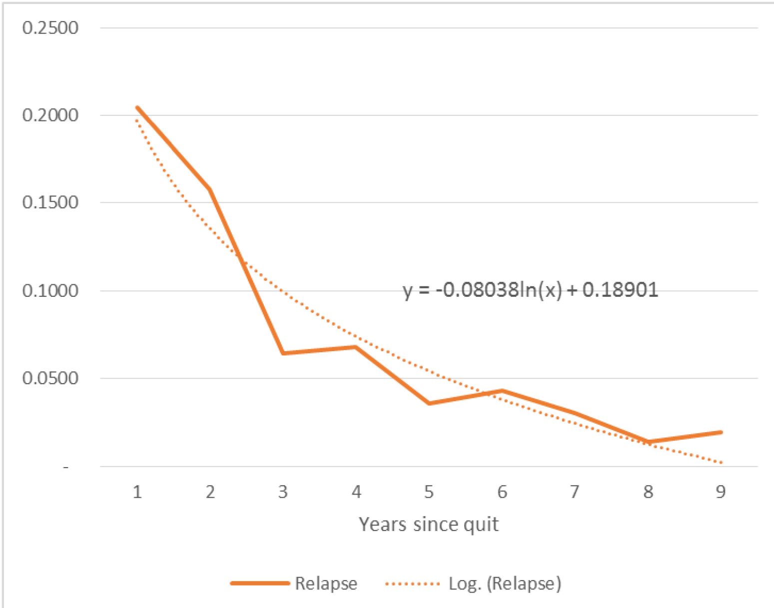
Cessation probabilities are not modeled as a conditional probability of a quit attempt. Rather they are estimated as described above, and quit attempt probabilities are derived by age, sex, and race-ethnicity from the National Health Interview Survey. To determine costs, failed attempts are defined as the difference between quit attempts and cessation.

Relapse rates

Relapse after quitting tobacco use is time-sensitive. The longer a person has successfully quit smoking, the less likely they are to relapse. We constructed the relapse curve represented by the conditional relapse probabilities by averaging estimates from five retrospective and prospective studies and reviews as shown by the solid line in Figure 4.[18-22] We fit a log-linear relapse curve with respect to time (time = x in the equation shown in the figure) to these estimates for use in the model. These relapse rates are applied to all quits in the model, whether they are part of the baseline model or are induced a clinical intervention, program or policy change.

In using relapse estimates from the literature, it was important to recognize that the probability of cessation we estimated from the NHIS reflects smokers who quit anytime in the year prior to the survey and remained non-smoking at the time of the survey. Therefore, these cessation probabilities already reflect some initial relapse. The estimates reflect a range of former smokers who quit from between one week and 51 weeks prior to the survey. Therefore, in applying relapse rates from the literature, we sought an estimate for the first year of relapse that reflected the probability of relapse conditional on having not relapsed for an average of six months.

Figure 4. Relapse curve - probability of relapse for former smokers in the previous year



Determination of cigarette consumption and tax revenue

The final component of the smoking behavioral sub-module is determination of cigarette consumption among current smokers. Upon entering the "smoking state" (i.e. upon smoking initiation of relapse), the agent's daily cigarette consumption (CPD) is determined by a random draw from a Poisson distribution conditioned on age, sex, ethnicity, and education-based averages estimated from the 2014 NHIS survey. Table 1 summarizes the distribution of cigarettes per day (CPD) by key demographics and consumption categories.

As shown in Table 1, cigarette consumption among smokers tends to increase with age. To accommodate this trend, the smokers's CPD is reset by a new random draw every five years they remain in the smoking state. For those who relapse, CPD is also determined by another random draw upon returning to the smoking state.

The total number of packs consumed per agent during the year (TPY), as well as per-pack tax revenue, is calculated by dividing the product of CPD x 365 days per year by 20 cigarettes per pack. However, cigarette consumption is under-reported in surveys. Therefore, we calibrated cigarette consumption to produce US total packs sold per year[23] by multiplying each agent's CPD by a scalar while maintaining demographic specific differences in consumption. In the model, the number of cigarettes smoked does not change agents' health risks or smoking-attributable medial costs. This calibration only serves to obtain accurate revenues from taxes for reporting the revenue impact of tax increases and for determining the amount of earmarked tax revenue that a tax might make available to fund additional tobacco control programs and policies in relevant analyses.

For smokers initiating or quitting during a year, a proportion of their TPY is applied using a random draw from a uniform distribution.

Table 1: Cigarettes per day (CPD)

Cigarettes per day (CPD)		1-9	10-19	20-29	30+
	Overall	37.51%	33.02%	23.61%	5.86%
Sex	Male	35.50%	30.99%	26.21%	7.30%
	Female	40.06%	35.59%	20.32%	4.03%
Age (M)	0-18*	80.00%	10.00%	10.00%	0.00%
	18-24	50.83%	31.68%	15.51%	1.98%
	25-44	41.06%	31.11%	23.86%	3.96%
	45-64	27.11%	31.17%	30.52%	11.20%
	65+	30.46%	29.31%	29.31%	10.92%
Age (F)	0-18*	80.00%	10.00%	10.00%	0.00%
	18-24	52.41%	34.48%	12.07%	1.03%
	25-44	42.48%	36.98%	17.83%	2.71%
	45-64	35.47%	34.83%	23.76%	5.94%
	65+	37.78%	34.38%	23.58%	4.26%
Ethnicity (M)	1 (White)	24.53%	32.32%	33.01%	10.14%
	2 (Black)	45.58%	35.77%	15.96%	2.69%
	3 (Hispanic)	64.62%	21.54%	12.75%	1.10%
	4 (Other)	54.68%	26.60%	14.29%	4.43%
Ethnicity (F)	1 (White)	31.94%	38.73%	24.39%	4.93%
	2 (Black)	52.05%	35.45%	11.01%	1.49%
	3 (Hispanic)	67.80%	20.34%	9.83%	2.03%
	4 (Other)	62.70%	18.25%	15.08%	3.97%
Education (M)	1 (No HS)	34.35%	28.12%	28.55%	8.99%
	2 (HS)	31.07%	33.59%	28.04%	7.30%
	3 (Post-Secondary)	41.84%	29.42%	22.58%	6.16%
Education (F)	1 (No HS)	37.29%	33.28%	23.08%	6.35%
	2 (HS)	37.18%	34.29%	23.72%	4.81%
	3 (Post-Secondary)	46.43%	33.67%	17.19%	2.71%

**Not in NHIS data and derived from YRBS*

The Health Impact Module

The Health Impact Module determines how the smoking behavior of simulated individuals affects disease incidence, morbidity and mortality. In assessing policy or program impact, we compare the disease outcomes of each agent that occur in the baseline scenario (without the policy or program) to those that occur in the policy or program scenario. Population-wide estimates of an intervention's impact are determined by aggregating individual effects.

The Health Impact Module tracks outcomes across a variety of tobacco-related diseases simultaneously using age-, sex-, and smoking-status-based risks derived from the Smoking-Attributable Mortality, Morbidity, and Economic Costs (SAMMEC) as reported in the 2014 Surgeon General's report on tobacco.[24] This approach provides a broad accounting of smoking attributable risks and diseases.

Disease occurrence and burden estimation

Our approach to attributing events by age, sex and smoking status has been described elsewhere in the context of creating alternative estimates of smoking-attributable medical costs by age, sex and smoking status.[25] The mathematics used to implement the approach described below are available in the appendix of that article.

Smoking-attributable disease risk by age, sex and smoking status

To estimate disease events by smoking status we first assessed the number and distribution of smoking-attributable disease events in the US population by age and sex. Smoking related disease events were obtained from the Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute,[26] the National Hospital Discharge Survey[27] and compressed mortality files.[28] Hospitalizations were selected if their first-listed discharge diagnosis was for a smoking-attributable disease as defined in SAMMEC.[24] From SEER we derived cancer incidence rates for the same 5-year age ranges used for morality. To approximate the distribution of CVD, diabetes, and respiratory disease hospitalizations in the same age categories, we distributed hospitalizations according to the distribution of fatalities with in each disease.

Neither SEER cancer data nor the NHDS contain cigarette smoking status that could be used to calculate the distribution of non-fatal disease events by smoking status, and relative risks for nonfatal events are not available for a broad range of diseases from another standardized source. Therefore, mortality relative risks provided in SAMMEC were used to distribute the age- and sex-specific disease events among never, current and former smokers. Relative risks are assumed to equal1.0 for ages below 35 in SAMMEC and hence there is no smoking-attributable disease prior to age 35 in the model. The use of mortality relative risks implicitly assumes that the event-fatality rate is constant across smoking status groups. If this is not the case, then our calculations may over-state or under-state the benefits of quitting. The risks are available in the supplemental tables at the end of this document, starting on page 29.

Smoking-attributable mortality risk by age, sex and smoking status

We obtained the age-specific (5 year age groups from age 35 to 84, and 85+) and sex-specific mortality risks for smoking-attributable conditions from compressed mortality files.[28] Smoking-attributable conditions are the 12 cancers, 4 cardiovascular disease categories, diabetes, and 4 respiratory disease categories identified in Smoking-Attributable Mortality, Morbidity, and Economic Costs (SAMMEC)[24] shown in Table 2. To distribute mortality risk by age, sex and smoking status, we applied age and sex-specific smoking-attributable relative risks for each disease category that we also obtained from SAMMEC. These rates are available in the supplemental tables at the end of this document, starting on page 36.

Smoking-attributable diseases, health utilities, and duration

The Health Impact Module independently evaluates the incidence of each disease. Given incidence of a particular disease, severity, final outcome (death or recovery), and episode duration is determined. Disease-specific quality of life (QofL) decrements are imposed during disease episodes to capture morbidity. A maximum decrement of 0.5 quality adjusted life years (QALYs) is applied to concurrent episodes of disease.

Table 2 lists the diseases included in the health impact module with their assumed duration and quality of life decrement. The duration of terminal cancer episodes ranges from 1 to 5 years with applicable decrements applied during the terminal episode. The duration of a non-terminal cancer episode was assumed to be 5 years across all cancers. Quality of Life decrements were the same for both terminal and non-terminal cancer episodes and ranges from .2 to .3 QALYs based upon the standardized health utilities for chronic and acute conditions used in analyses for the National Commission on Prevention Priorities.[29] Once a non-terminal cancer episode ended, the individual is at risk of another episode of that cancer with no change in risk of remission.

Cardiovascular and respiratory disease are modeled as both terminal events and chronic episodes with quality of life decrements ranging from .01 (influenza) to .4 (stroke). Events resulting in death have duration of one year. The corresponding quality of life decrement for chronic cardiovascular and respiratory diseases is imposed every year following the event. Individuals experiencing a non-terminal cardiovascular and/or respiratory event could experience a repeat event. Their risk for such a repeat event was the same as that of experiencing the initial event. For example, a nonfatal cerebrovascular disease episode (i.e. stroke) results in a quality of life decrement of 0.4 QALYs every cycle following that event. The individual experiencing that initial stroke remains at risk of another stroke in subsequent years with a risk of the next stroke being fatal.

Use of case fatality rates

For external validity to the US population, we obtained the age and sex-specific mortality risks for smoking-attributable conditions from compressed mortality files.[28] For internal validity such that a person may not die from a smoking-attributable condition without having an event for that condition, we apply event-fatality rates calculated as the ratio of mortality incidence rates to event incident rates by age group and sex. These are approximate rates; events observed as occurring in one age group may precede a death that occurs during a later age group. Therefore event-fatality rates at younger ages are likely to be somewhat understated and those at older ages overstated. However, as applied in the simulation model, the timing of events and deaths (using the durations described above) remains reasonably accurate.

Table 2: Summary of diseases included in ModelHealth: Tobacco

	Episode Duration*		**Quality Adjusted Life Year Decrements**	
CANCERS	**Terminal**	**Non-Terminal**	**Initial Year of Event****	**Subsequent Years**
Lip, Oral Cavity, Pharynx	2	5	0.2	0.2
Esophagus	1	5	0.3	0.3
Stomach	1	5	0.3	0.3
Colorectal Cancer	2	5	0.2	0.2
Liver	1	5	0.3	0.3
Pancreas	1.24	5	0.3	0.3
Larynx	2	5	0.3	0.3
Trachea_Lung_Bronchus	2	5	0.3	0.3
Cervix Uteri	4	5	0.2	0.2
Kidney and Renal Pelvis	4.7	5	0.2	0.2
Urinary Bladder	4.7	5	0.2	0.2
Acute Myeloid Leukemia	4.6	5	0.2	0.2
CVD				
Ischemic Heart Disease	0	0.5	0.1500	
Other Heart Disease	5	0.0769	0.0231	
Cerebrovascular Disease Stroke+	1	until death	0.4000	0.4
Other Cardiovascular Disease	5	0.0769	0.0231	0.3
Diabetes	5	until death	0.1	
Respiratory Disease				0.1
Pneumonia, Influenza, TB	0	0.0384	0.0115	
Bronchitis Emphysema+	5	until death	0.2	0.2

**Durations are rounded up to the nearest cycle. Episodes with 0 duration indicate instant death and no decrement applied.*

***For CVD and Respiratory Diseases, the initial year decrement is scaled to reflect partial year episode*

+Following initial episode, agent remains at risk for death in future cycles.

Competing causes of death

During each cycle, individuals are also subject to age-specific probabilities of death from other causes. These probabilities are approximated by subtracting the combined probabilities of death from smoking-attributable conditions obtained from compressed mortality data[28] from overall mortality rates by age obtained from U.S. life tables.[30]

'Recent quitters' and lagged change in disease risk

Recent quitters have smoking-attributable health risks that is within 25% of that of current smokers for approximately 4 years after quitting although the delay for cardiovascular disease benefits may be less.[31] Therefore, ModelHealth:Tobacco imposes a 4-year lag between the time a smoker quits to the time a smokers disease risks for cancers and respiratory disease are reduced from those of current smokers to those of former smokers.

Costs and productivity

Model health tracks both direct medical care expenditures and indirect productivity impacts of smoking, though productivity impacts are not necessarily used in all analyses.

Smoking cessation medication costs

The costs of smoking cessation medications were estimated from the MarketScan® database[32] for 2014 by the Centers for Disease Control and Prevention as shown in Table 3. MarketScan is proprietary family of databases that includes claims data, with amounts paid by insurers and patients for participating employers, private insurers, and fee-for-service state Medicaid programs. The costs borne by Medicaid are estimated among fee-for-service beneficiaries in the states included in the MarketScan Medicaid database. The included states are not disclosed to Market Scan users. Medication costs borne by both private insurers and Medicare in the model are estimated among individuals covered by employer-sponsored health insurance in the MarketScan Commercial Encounters database. While there may be differences between Medicare and privately insured medication payments, the difference may be small as pharmacy benefit management and managed care companies that provide Medicare Part D benefits negotiate with manufactures for both privately insured and Medicare Part D participants. The costs shown in Table 3 are based on a 12-week course to keep costs aligned with effectiveness data from trials that are used in the model to tabulate relative probabilities of cessation by quit type. Costs for all other insured are based on private payer costs

Table 3: Smoking cessation medication costs vary by primary insurance type ($2015)

	Medicaid		All other insured	
	Copay	Insurer	Copay	Insurer
OTCNRT	$6.64	$211.59	$7.86	$180.21
RxNRT	$2.89	$1,218.43	$111.84	$1,058.85
Bupropion	$3.50	$107.24	$18.55	$71.97
Varenicline	$5.88	$698.04	$42.23	$620.93

Smoking-attributable medical costs

The model includes only the costs of smoking-attributable medical care. It does not assign costs to never smokers, and the costs of current and former smokers included in the model are net of average-costs for like individuals who are never smokers. For the United States as a whole, we estimated the medical costs of smoking from observed associations between smoking status and medical costs in the Medical Expenditure Panel Survey (MEPS), using smoking status from linked National Health Interview Survey (NHIS) responses.[33] We followed the method of Levy et al.,[34] including controlling for potentially confounding factors in a two-part model using a gamma distribution and a log-link in the second part. However, we combined multiple years of data (2001-2010) to create more stable estimates for age, sex and smoking status subgroups; we also estimated separate models by primary insurer to determine smoking costs by the primary insurer type. MEPS and other claims

Table 4. Smoking-attributable medical costs by age, gender, smoking status ($2012)

Age categories (in years)	Male Current Smoker	Female Current Smoker	Male Former Smoker*	Female Former Smoker*
Private Insurance				
0-34	0	0	0	0
35-44	987	1,210	604	740
45-54	1,265	1,499	774	917
55-64	1,597	1,843	977	1,128
65-74	1,994	2,253	1,220	1,379
75-84	2,465	2,743	1,509	1,679
85+	2,734	3,024	1,673	1,851
Medicare Insurance				
0-34	0	0	0	0
35-44	1,301	1,531	796	937
45-54	1,639	1,879	1,003	1,150
55-64	2,040	2,296	1,248	1,405
65-74	2,518	2,795	1,541	1,710
75-84	3,089	3,391	1,890	2,075
85+	3,414	3,733	2,090	2,284
Medicaid Insurance				
0-34	0	0	0	0
35-44	1,823	2,117	1,115	1,296
45-54	2,283	2,593	1,397	1,587
55-64	2,830	3,162	1,732	1,935
65-74	3,480	3,842	2,130	2,351
75-84	4,258	4,656	2,606	2,850
85+	4,702	5,123	2,878	3,136
Uninsured				
0-34	0	0	0	0
35-44	374	548	229	335
45-54	517	710	316	435
55-64	695	906	426	554
65-74	914	1,138	559	697
75-84	1,180	1,415	722	866
85+	1,332	1,571	815	962
Other/Multiple Insurance				
0-34	0	0	0	0
35-44	1,536	1,783	940	1,091
45-54	1,922	2,184	1,177	1,337
55-64	2,384	2,664	1,459	1,630
65-74	2,932	3,236	1,795	1,980
75-84	3,587	3,922	2,195	2,400
85+	3,961	4,315	2,424	2,641

*Costs of former smokers are determined by time since quit as described in the text. Former smoker costs here are illustrated by those with 5 years since their quit.

data are complicated by higher utilization of some former smokers whose quits were prompted by diagnoses that lead to increased healthcare utilization in the years following their successful quits. For former smokers, we fit an exponential function to the relationship of current and former risk based on time since quit, as reported by the Congressional Budget Office (Figure 3-5 in CBO report). We applied this function to the costs for current smokers that we estimated from MEPS data to obtain estimates of what the medical costs of former smokers would be by age, sex and time since quit if they had a proactive quit:

$$y = 0.9927 - 1.086e(-0.1171t) ,$$

where y is the portion of a current smokers' smoking-attributable costs that is reduced according to years since quit (=t). Thus each former's smoker cost is calculated as a portion of current smokers' costs with the same age, sex and insurance status as estimated from MEPS. The function implies that 50% of the excess medical costs of smoking are eliminated in the 7th year after quit (the functions' "half-life"), and 90% sre eliminated by the 21st year.

The CBO 'index' was constructed based on a literature review of the relationship between time since quit and reduction in mortality risk for smoking-attributable diseases, weighted by each disease's share of smoking-attributable mortality. In their analysis, the CBO applied its index to both mortality risk and medical care expenditures due to lack of better information on the expenditure trend of healthy quitters. Therefore, smoking-attributable medical costs of former smokers based on the function above must be recognized as an approximation.

Table 4 provides the resulting smoking-attributable costs for current smokers by age and sex. In the model, former smoker costs will vary be age, sex and year since quit per the equation specified above. For illustrative purposes, Table 4 provides costs of former smokers who have been quit for 5 years. The cost estimates in Table 4 are expressed in 2012 dollars, but may be adjusted to a different base year for specific analyses.

Productivity

The simulation model incorporated three sources of productivity loss: premature mortality; absenteeism, or days of lost productivity not associated with exit from labor force; and presenteeism, or being at less-than-full working capacity during days of work. Each of these categories can have two dimensions: lost labor force productivity and lost non-labor force productivity. Non-labor force productivity could be further divided into time spent producing goods and services outside the formal labor market, and time spent in leisure activity. However, productivity losses in the model are limited to lost labor force productivity and time spent producing services outside of the labor force.

Productivity loss from premature mortality

The model assigns a positive productivity for each year of adult life that varies by age but not sex or smoking status as shown in Table 5. The productivity estimates in Table 5 are expressed in 2012 dollars, but may be adjusted to a different base year for specific analyses. Current and former smokers are assigned a decrement to this productivity to account for absenteeism and presenteeism as described below. To estimate productivity losses of a scenario, we calculate the positive productivity of the scenario and compare it to the positive productivity of a scenario in which both former and current smoking are set to zero in all years.

Table 5. Annual Production of US Population ($2012)

Age Group	Per Person Annual Market Compensation ($)	Per Person Annual Household Production Value ($)	Per Person Annual Production Value ($)
35–39	51,843	18,683	70,526
40–44	53,865	17,699	71,564
45–49	54,297	16,207	70,505
50–54	53,480	14,745	68,225
55–59	43,855	15,709	59,564
60–64	31,612	16,440	48,052
65–69	11,334	17,498	28,831
70–74	6,021	17,264	23,285
75–79	3,131	16,389	19,521
80+	1,754	12,999	14,753

Source: [35,36].

We implemented an approach to productivity that combines the highest-quality literature sources available to estimate potential productivity losses from smoking. Simulated individuals may experience premature death from smoking-attributable disease. The difference between age of death with and without intervention determines the number of years of premature mortality. We valued the productivity of each year of life using estimates by age group (not differentiated by sex) reported by Grosse et al.[35] updated through 2012 for changes in national average of employee earnings and benefits.[36]

The estimates of Grosse et al.[35] include household productivity reported separately from workplace productivity, as measured by market compensation that includes employee pay and benefits. Both household and market productivity estimates are included in ModelHealth: Tobacco. These estimates reflect the average of those in and out of the labor force. We therefore we apply them to all individuals in the models, regardless of employment status.

Productivity loss from absenteeism and presenteeism

Few estimates of absenteeism and presenteeism are available across multiple conditions in a generalizable population. Mitchell and Bates[37] estimated combined absenteeism and presenteeism costs in one million employees for 13 conditions and four risk factors, based on Work Limitations Questionnaire (WLQ), but they did not report those costs separately. Mitchell and Bates[37] adjusted salary and benefit valuation up by a factor of 1.6 to reflect the "multiplier" impact of absenteeism and presenteeism on work team performance as estimated by Nicholson et al.[38] This multiplier is still reflected in our adjusted estimates. A more recent analysis suggests that compensating efforts by the ill employee in off-work hours and by coworkers may more than offset the negative impact of a team member on productivity of the rest of the work team.[39]

Several adjustments were needed to apply these estimates of absenteeism and presenteeism costs to the model. Mitchell and Bates[37] reported average days lost across all age groups (ages 18-70). In ModelHealth: Tobacco, all smoking-attributable disease occurs after age 35. To improve internal consistency between disease occurrence, disease costs and productivity costs, we assign zero absenteeism and presenteeism costs to ages 15-34, and we reapportion all absenteeism and presenteeism days to the 35+ age group. Another difference is that Mitchell and Bates[37] estimated the average days *per employee*; in comparison, Grosse et al.[35] reported average market productivity across all adults employed and not employed. To implement these estimates in the same manner in the model, we adjusted Mitchell and Bates' estimates downward by multiplying them by the portion of the U.S. population ages 25 to 64 who are employed. This allows us to apply the estimates of absenteeism and presenteeism to all individuals in the model, regardless of employment status, without overstating population effects. This in analogous to how population average market and household productivity estimates from Grosse et al.[35] are applied to all individuals, regardless of labor market status, as described above. As a result, population-wide effects from the model are accurate, but the model does not have the ability to accurately report productivity measures stratified by labor status. We also adjusted estimates to 2012 dollars and added productivity growth over time in the same manner described above for productivity losses associated with premature mortality. The result is 2012 US dollars is $357 per year in combined absenteeism and presenteeism per year for each current smoker. Absenteeism and presenteeism productivity losses for former smokers are calculated as a portion of those of current smokers, varying as a function of time since quit as described for smoking-attributable medical expenditures above.

Model validation

The simulation model has been confirmed to reproduce current and former smoking prevalence rates by age, sex and insurance status. The initiation rates, cessation rates and relapse rates used in the model, along with mortality rates, determine future prevalence rates. Therefore, the model does not seek to reproduce an arbitrary prediction of future smoking prevalence, but rather predicts expected smoking prevalence if there are no cultural, market-place or policy changes that substantially alter initiation, cessation and relapse rates.

The relative risks of smoking-attributable mortality in the model are those reported in the 2014 2014 Surgeon General's report[24] and, therefore the model generates similar estimates of smoking-attributable mortality. By design, the model produces conservative estimates of baseline costs of smoking attributable disease because 1) costs are based on MEPS data which are known to understate total health care expenditures as described above, and 2) no smoking-attributable costs are assigned to ages below 35 for internal model consistency with the tabulation of smoking-attributable disease. The baseline model produces $70 billion dollars in

Maciosek MV, *et al. Tob Control* 2021;0:1–7. doi: 10.1136/tobaccocontrol-2019-055482

smoking-attributable medical expenditures, compared to a range of $93 to 228 billion based on national health accounts as reported in the 2014 Surgeon General's report.[24]

References

1. Maciosek MV, Flottemesch TJ, Dehmer SP, LaFrance AB, McGree DA, O'Blenes SM. Community Health Advisor. 2015; http://www.communityhealthadvisor.org/drupal/cha/home.
2. Maciosek MV, LaFrance AB, Dehmer SP, et al. Health Benefits and Cost-Effectiveness of Brief Clinician Tobacco Counseling for Youth and Adults. *Ann Fam Med.* 2017;15(1):37-47.
3. Maciosek MV, LaFrance AB, Dehmer SP, et al. Updated Priorities Among Effective Clinical Preventive Services. *Annals of Family Medicine.* 2017;15(1):12-22.
4. National Center for Education Statistics: Data Tools in Sciences. 2014. http://nces.ed.gov/datatools.
5. King M, Ruggles S, Alexander JT, et al. Integrated Public Use Microdata Series, Current Population Survey: 2009-2012. Minneapolis, MN: Minnesota Population Center2014.
6. U.S. Census Bureau. Survey of Income and Program Participation. http://www.census.gov/programs-surveys/sipp/. Accessed September 18, 2018.
7. National Center for Health Statistics. National Health Interview Survey, 2007. Hyattsville, Maryland: National Center for Health Statistics, Centers for Disease Control and Prevention2008.
8. Centers for Disease Control and Prevention. Youth Risk Behavior Survey (YRBS). 2011. http://www.cdc.gov/healthyyouth/yrbs/index.htm. Accessed 2/27/2014.
9. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health Interview Survey. https://www.cdc.gov/nchs/nhis/. Accessed February 24, 2017.
10. Meyer C, Ulbricht S, Baumeister SE, et al. Proactive interventions for smoking cessation in general medical practice: a quasi-randomized controlled trial to examine the efficacy of computer-tailored letters and physician-delivered brief advice. *Addiction.* 2008;103(2):294-304.
11. Solberg LI, Maciosek MV, Edwards NM, Khanchandani HS, Goodman MJ. Repeated tobacco-use screening and intervention in clinical practice health impact and cost effectiveness. *Am J Prev Med.* 2006;31(1):62-71.
12. Cahill K, Stevens S, Perera R, Lancaster T. Pharmacological interventions for smoking cessation: an overview and network meta-analysis. *Cochrane Database Syst Rev.* 2013;5:CD009329.
13. Shiffman S, Rolf CN, Hellebusch SJ, et al. Real-world efficacy of prescription and over-the-counter nicotine replacement therapy. *Addiction.* 2002;97(5):505-516.
14. Hughes JR, Shiffman S, Callas P, Zhang J. A meta-analysis of the efficacy of over-the-counter nicotine replacement. *Tob Control.* 2003;12(1):21-27.
15. Amodei N, Lamb RJ. Over-the-counter nicotine replacement therapy: can its impact on smoking cessation be enhanced? *Psychol Addict Behav.* 2008;22(4):472-485.
16. Schnoll RA, Rukstalis M, Wileyto EP, Shields AE. Smoking cessation treatment by primary care physicians: An update and call for training. *Am J Prev Med.* 2006;31(3):233-239.
17. Shiffman S, Sweeney CT, Rohay JM, Ertischek MD. Physician involvement in recommending over-the-counter nicotine replacement therapy. *Am J Prev Med.* 2007;32(4):358-359.

18. *The Health Benefits of Smoking Cessation.* Rockville, MD: U.S. Department of Health and Human Services Public Health Service Centers for Disease Control Center for Chronic Disease Prevention and Health Promotion Office on Smoking and Health; 1990; No. DHHS Publication No. (CDC) 90-8416.
19. Wetter DW, Cofta-Gunn L, Fouladi RT, Cinciripini PM, Sui D, Gritz ER. Late relapse/sustained abstinence among former smokers: a longitudinal study. *Prev Med.* 2004;39(6):1156-1163.
20. Herd N, Borland R, Hyland A. Predictors of smoking relapse by duration of abstinence: findings from the International Tobacco Control (ITC) Four Country Survey. *Addiction.* 2009;104(12):2088-2099.
21. Hughes JR, Peters EN, Naud S. Relapse to smoking after 1 year of abstinence: a meta-analysis. *Addict Behav.* 2008;33(12):1516-1520.
22. Gilpin EA, Pierce JP, Farkas AJ. Duration of smoking abstinence and success in quitting. *J Natl Cancer Inst.* 1997;89(8):572-576.
23. *The Tax Burden on Tobacco.* Arlington, VA: Orzechowski and Walker;2015.
24. U.S. Department of Health and Human Services. The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General, 2014. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014.
25. Maciosek MV, Xu X, Butani AL, Pechacek TF. Smoking-attributable medical expenditures by age, sex, and smoking status estimated using a relative risk approach. *Prev Med.* 2015;77:162-167.
26. Horner MJ RL, Krapcho M, Neyman N, Aminou R, Howlader N, Altekruse SF, Feuer EJ, Huang L, Mariotto A, Miller BA, Lewis DR, Eisner MP, Stinchcomb DG, Edwards BK (eds). SEER Cancer Statistics Review, 1975-2006. 2009; http://seer.cancer.gov/csr/1975_2006/. Accessed April, 12 2011.
27. DeFrances CJ, Hall MJ. 2002 National Hospital Discharge Survey. *Adv Data.* 2004(342):1-29.
28. Centers for Disease Control and Prevention. Compressed Mortality File 1999-2006. CDC WONDER On-line Database, compiled from Compressed Mortality File 1999-2006 Series 20 No. 2L, 2009. http://wonder.cdc.gov/cmf-icd10.html. Accessed Dec 8, 2009 12:52:14 PM.
29. Maciosek MV, Coffield AB, McGinnis JM, et al. Methods for priority setting among clinical preventive services. *Am J Prev Med.* 2001;21(1):10-19.
30. Arias E. *United States Life Tables, 2010.* Centers for Disease Control and Prevention, Division of Vital Statistics; November 6, 2104 2014.
31. Congressional Budget Office. Raising the Excise Tax on Cigarettes: Effects on Health and the Federal Budget. Washington: Congressional Budget Office; 2012.
32. Truven Health Analytics. *The Truven Health MarketScan Databases for Health Services Researchers.* 2017.
33. Chowdhury S MS, Wun L. *Linking Medical Expenditure Panel Survey to the National Health Interview Survey: Weighting and Estimation. Working Paper No. 12005.* Rockville, MD: Agency for Healthcare Research and Quality;2012.
34. Levy DE, Newhouse JP. Assessing the effects of tobacco policy changes on smoking-related health expenditures. In: Bearman PS NK, Wright L, ed. *After Tobacco: What Would Happen If Americans Stopped Smoking?* New York: Columbia University Press; 2011:256–289.

35. Grosse SD, Krueger KV, Mvundura M. Economic productivity by age and sex: 2007 estimates for the United States. *Med Care.* 2009;47(7 Suppl 1):S94-103.
36. Bureau of Labor Statistics. Employment Cost Index for the Wages and Salaries of all Civilian Workers. Bureau of Labor Statistics. ftp://ftp.bls.gov/pub/suppl/eci.echistrynaics.txt. Accessed October 30, 2013.
37. Mitchell RJ, Bates P. Measuring health-related productivity loss. *Popul Health Manag.* 2011;14(2):93-98.
38. Nicholson S, Pauly MV, Polsky D, Sharda C, Szrek H, Berger ML. Measuring the effects of work loss on productivity with team production. *Health Econ.* 2006;15(2):111-123.
39. Krol M, Brouwer WB, Severens JL, Kaper J, Evers SM. Productivity cost calculations in health economic evaluations: correcting for compensation mechanisms and multiplier effects. *Soc Sci Med.* 2012;75(11):1981-1988.

Coefficients estimated for the health insurance submodel

Initialization Parameters ("Betas") for the Health Insurance Sub-system

	Age 15-25				Age 26-64				Age 65+			
	Medicaid	Medicare	Uninsured	All Other	Medicaid	Medicare	Uninsured	All Other	Medicaid	Medicare	Uninsured	All Other
Intercept	-4.3986	-6.8016	-2.6453	-1.5342	-5.1835	-6.5723	-3.0693	-4.0435	-5.7334	1.2229	-2.5905	-4.495
Male	-0.3078	-0.0802	0.1725	-0.049	-0.1783	0.2259	0.32	0.0756	-0.2814	-0.0261	-0.0252	0.3914
Centered Age*	0.00214	0.1519	0.2275	-0.00421	-0.0381	0.0189	-0.0244	-0.00372	-0.0177	0.0616	0.0298	-0.0291
Centered Age Squared*	-0.0015	-0.00134	-0.0216	-0.0191	0.000283	0.000911	0.000477	0.00105	-0.00853	-0.011	-0.00389	-0.00071
Hispanic	1.0258	0.8378	1.12	-0.0994	0.7639	0.2775	1.0178	0.0323	1.7463	-0.3487	1.4287	0.1349
Non-Hispanic Black	0.9684	1.0109	0.5924	0.0874	0.7938	0.5583	0.4572	0.4521	0.9734	-0.4422	0.5737	-0.0852
Other race/ethnicity	0.305	0.3336	0.4122	-0.1559	0.5161	0.0745	0.5137	0.1459	1.7913	-0.4956	1.1713	0.0524
Midwest	0.0501	0.3753	-0.151	-0.1497	-0.0791	0.0915	-0.1308	-0.2614	-0.3153	0.1481	-0.2374	-1.1067
Northeast	0.2576	0.1766	-0.26	-0.2721	0.437	0.2441	-0.191	0.048	0.1482	-0.1212	-0.287	-0.5105
South	-0.2095	0.0815	0.2065	-0.1706	-0.4803	0.1103	0.1783	-0.00674	-0.7793	0.0476	0.0183	0.1614
Not in Labor Force	0.4129	1.1	-0.0758	0.089	1.2565	2.8949	0.6655	0.9467	1.6041	2.8818	1.19	1.5033
Unemployed	0.8503	0.9355	0.5728	0.2176	1.2826	1.0387	1.0908	0.8723	1.0158	1.5433	1.2035	1.2933
High School or Less	1.9104	0.7606	1.3274	-0.2521	1.5547	0.8886	1.2321	0.4565	0.4398	0.4165	0.722	0.2428
Some postsecondary Ed.	1.0899	-0.302	0.648	0.0604	0.8822	0.4939	0.668	0.4927	-1.1412	0.2621	0.1374	0.2602
100%-129% of Poverty	2.1347	1.7641	1.5582	1.4305	2.1182	1.5203	1.5426	1.1786	1.7764	0.8156	1.63	0.9378
<100% of Poverty	2.9034	2.154	1.9965	1.8439	2.8878	1.424	2.0635	1.2615	1.2036	-0.4723	1.4463	0.5717
Disability	1.4956	2.9818	0.0808	0.8918	1.6913	2.676	0.3049	1.1011	0.8212	0.6411	-0.3242	0.6359

Based on 2009-2012 CPS Data. Parameters estimated in multinomial logistic regressions, with health insurances status as the outcome and with private insurance coverage as the reference group. Reference categories are: Female, non-Hispanic White, West, Employed, 4-year degree+, >=130% of poverty, and no disability. All estimated parameters significant at p <.0001. * For each age group, age is centered on the middle (mean value) of that age group.

Transitions to and from Disabled Status, ages 15-64		
	Betas from logistic regressions	
	Transition TO Disabled	Transition FROM Disabled
Intercept	-3.37023	-1.5067
Centered Age	0.0297	-0.0288
Centered Age Squared	0.0008	0.000478
Other race/ethnicity	0.5191	-0.1189
Based on 2008-2011 SIPP data		

Age 15-63: Labor Force Transitions						
	Betas from Logistic Regression					
Variable	From employed to unemployed	From employed to NILF	Stay unemployed	From unemployed to NILF	From NILF to employed	From NILF to unemployed
DisabledE*DisabledSt	-1.1267	-1.0376			-1.7103	-2.2262
Disabled End of year	0.8992	2.021			-0.6459	-0.0486
* For each age group, age is c	0.6531	0.7359			0.4911	0.7944
Reference categories are: Fe	-3.6948	-3.3714	-0.5208	-0.7574	-1.0088	-2.4722
Male	0.1586	-0.5026		-0.4872	0.4993	0.7968
Midwest	0.00713		-0.1775		0.1483	
Minority	0.4862	0.3039	0.272	0.3879	-0.2376	0.3209
YearsBefore25	0.1182	0.3156	-0.0269	0.124	-0.072	-0.0704
YearsPast45	-0.0241	0.0373	0.0584	0.0798	-0.1055	-0.0968
Based on 2008-2011 SIPP data. Parameters estimated in multinomial logistic regressions. NILF = not in labor force. If starting as employed or unemployed, the basis for comparison is ending up employed. If starting as NILF, the basis for comparison is remaining NILF.						

Age 15-63: Insurance Transitions (continued next page)

	Betas from logistic regressions											
	From Uninsured				From Private				From Medicaid			
Variable*	To Private	To Medicaid	To Medicare	To Other	To Unisured	To Medicaid	To Medicare	To Other	To Unisured	To Private	To Medicare	To Other
Currently disabled		1.1944	1.7523		0.724	1.7042	1.9767	1.0816	-0.4658	-1.4931	2.6172	
Currently disabled and disabl	-0.815	-0.5174			-0.6423	-1.3846	-1.0345		-0.8272		-1.803	
Disabled last year		0.418	0.6566	0.4133	0.6098	0.8054	1.4014	0.2349			2.1989	
Intercept	-0.8126	-1.6782	-7.8625	-3.8189	-2.9682	-4.6267	-9.9061	-4.0511	-0.8274	-1.5576	-5.5714	-2.7386
Stay NILF		-0.4725			-1.6698	-1.5195	-2.2255					
NILF to Unemployed					-1.607	-1.6314						
Unemployed to NILF					-1.6397	-0.9517						
Stay Unemployed					-1.9261	-1.6264						
Current NILF or Unemployed												
Currently NILF	-1.1637	0.7117	1.79	0.5435	1.3806	1.9272	2.5825	0.9085		-0.9147	0.3223	-0.6269
Currently Unemployed					2.5078	2.6247		1.0911		-1.6617	-0.7785	-0.7559
NILF last year		0.294	0.486		0.4759	0.7623	2.3772		-0.2835			
Unemployed last year			-1.0307		1.0168	0.6489		0.2832			-1.3208	
Male		-0.6526	0.487		0.3149	-0.3506	0.3915		0.312	0.3323	0.3497	
Non-Hispanic Black		0.2739			0.7754	1.3253	0.356	0.5732				
Non-Hispanic Black or Other			0.2954									
Hispanic	-0.7059	0.1279		-0.9347	0.9543	1.3161	0.5727	0.1518	0.288	-0.2271		
Non-Hispanic Black, Hispanic or Other												
Other race/ethnicity		0.2252			0.2587	0.4911	0.4277					
South or West Census Regior	-0.1979	-0.583	-0.4309		0.3215	-0.4559		0.2554	0.5676	0.4314		
Years after age 21	-0.00919	-0.0238	0.0621		-0.0328	-0.0414	0.088	-0.0289	-0.0101		0.0232	
Years before age 21	-0.0541	0.2117		0.2199	-0.2638			0.0377	-0.1761	-0.0692	-0.3767	0.1601

Based on 2008-2011 SIPP data. Parameters estimated in multinomial logistic regressions. NILF = not in labor force. *Disability status, labor force participation and race/ethnicity were categorized in alternate ways for each regression to obtain best fit from the survey sample.

Age 15-63: Insurance Transitions (continued from previous page)

	Betas from logistic regressions							
	From Medicare				From Other/Multi			
Variable*	To Unisured	To Private	To Medicaid	To Other	To Unisured	To Private	To Medicaid	To Medicare
Currently disabled		-1.144	-1.144		-0.3921	-0.7905	0.9589	2.0686
Currently disabled and disabled last year		-0.6987	-0.6987					-1.955
Disabled last year	-1.0034	-0.5457	-0.5457					2.8315
Intercept	-2.358	-1.203	-1.203	-3.2833	-0.9341	0.6992	-1.1832	-4.2135
Stay NILF					-1.3689			
NILF to Unemployed					-0.8283			
Unemployed to NILF					-2.4233			
Stay Unemployed					-1.3972			
Current NILF or Unemployed						-0.2093		
Currently NILF		-0.4056	-0.4056		0.6349			0.8089
Currently Unemployed				1.0866	1.1345		0.7022	
NILF last year					0.6544			
Unemployed last year					1.8568			
Male						-0.2551	-0.5194	
Non-Hispanic Black								
Non-Hispanic Black or Other								
Hispanic								
Non-Hispanic Black, Hispanic or Other		-0.7184	-0.7184		0.5723		0.5351	
Other race/ethnicity								
South or West Census Region					-0.4944	-0.3636	-0.8893	-0.5435
Years after age 21		0.027	0.027		-0.0349	-0.023	-0.0324	
Years before age 21	0.6193				-0.1153		0.2211	-1.0341

Based on 2008-2011 SIPP data. Parameters estimated in multinomial logistic regressions. NILF = not in labor force. *Disability status, labor force participation and race/ethnicity were categorized in alternate ways for each regression to obtain best fit from the survey sample.

Age 64-66: Insurance Transitions to Medicare

	Betas from logistic regressions for transitioning TO Medicare*			
Variable	From Uninsured	From Private	From Medicaid	From Other
Intercept	1.5108	1.039	1.2458	2.2422
Age65	-1.8855	-1.107	-1.514	-1.795
Age66	-3.1228	-1.6836	-1.794	-2.1934
Black		-0.3992	1.7268	
Male		-0.1869		

Age 67+: Probability of Transitioning to Medicare from any other state

$= 0.0044*(age-67)^2 - 0.0207*(age-67) + 0.1009$ -- capped at 1 for ages 84+

Based on 2008-2011 SIPP data. *Medicare is an absorbing state

Incident cases per 100,000 by disease, age, sex and smoking status

Cancer of the Oral Cavity and Pharynx*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	2.9	5.0	3.9	2.4	3.1	3.0
40-44	6.7	11.7	9.2	3.1	4.0	3.9
45-49	13.5	23.6	18.4	5.6	7.2	7.0
50-54	24.3	42.2	33.0	8.8	11.3	10.9
55-59	35.9	66.7	47.0	10.2	21.2	13.0
60-64	43.3	80.5	56.7	12.9	26.8	16.5
65-69	42.8	100.7	63.8	17.0	35.1	21.5
70-74	44.5	104.7	66.4	20.6	42.4	25.9
75-79	46.3	101.0	67.6	24.1	46.4	30.5
80-84	47.2	102.9	68.9	24.3	47.0	30.9
85+	45.9	100.1	67.0	27.7	53.5	35.2

Cancer of the Esophagus*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.4	0.7	0.5	0.2	0.2	0.2
40-44	1.1	2.0	1.5	0.4	0.5	0.5
45-49	3.2	5.5	4.3	0.6	0.8	0.8
50-54	6.2	10.8	8.4	1.6	2.1	2.0
55-59	11.1	20.6	14.5	2.5	5.2	3.2
60-64	19.0	35.2	24.8	3.3	6.9	4.2
65-69	21.9	51.6	32.7	5.3	10.9	6.7
70-74	25.5	60.0	38.1	7.3	15.0	9.2
75-79	31.7	69.2	46.3	9.1	17.5	11.5
80-84	31.5	68.7	46.0	11.0	21.3	14.0
85+	30.8	67.2	45.0	11.4	22.0	14.5

Cancer of the Stomach*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	1.4	2.5	2.0	1.7	2.1	2.1
40-44	2.7	4.7	3.7	2.7	3.4	3.3
45-49	4.8	8.4	6.6	3.6	4.7	4.5
50-54	8.1	14.1	11.0	5.4	6.9	6.6
55-59	12.0	22.3	15.7	6.1	12.7	7.8
60-64	18.6	34.5	24.3	8.5	17.8	10.9
65-69	24.5	57.5	36.5	13.7	28.3	17.3
70-74	33.7	79.3	50.3	20.1	41.3	25.3
75-79	43.7	95.3	63.8	25.7	49.6	32.6
80-84	50.6	110.2	73.8	31.6	60.9	40.1
85+	56.4	122.9	82.3	34.2	66.0	43.4

Incident cases per 100,000 by disease, age, sex and smoking status (Continued)

Cancer of the Colon and Rectum*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	7.3	12.7	9.9	8.2	10.5	10.2
40-44	14.3	24.8	19.4	15.4	19.7	19.0
45-49	26.5	46.1	36.1	26.4	33.8	32.8
50-54	51.6	89.7	70.1	46.4	59.4	57.5
55-59	63.8	118.7	83.6	45.9	95.5	58.7
60-64	90.0	167.4	117.9	61.4	127.7	78.6
65-69	112.5	264.3	167.6	94.1	193.9	118.6
70-74	147.3	346.1	219.5	129.1	265.9	162.7
75-79	182.0	396.8	265.8	169.5	327.1	215.3
80-84	219.8	479.2	320.9	212.5	410.1	269.9
85+	244.6	533.3	357.1	237.3	458.0	301.4

Cancer of the Liver and Intrahepatic Bile Duct*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	1.0	1.7	1.3	0.6	0.7	0.7
40-44	2.1	3.6	2.8	1.0	1.3	1.3
45-49	6.5	11.3	8.8	2.1	2.7	2.6
50-54	17.9	31.2	24.4	4.7	6.0	5.9
55-59	35.1	65.2	45.9	7.9	16.5	10.2
60-64	40.5	75.4	53.1	10.0	20.8	12.8
65-69	32.5	76.4	48.4	13.6	28.1	17.2
70-74	34.9	82.1	52.1	17.9	36.9	22.5
75-79	39.4	85.8	57.5	21.6	41.7	27.4
80-84	41.5	90.4	60.6	23.6	45.6	30.0
85+	34.9	76.1	50.9	20.6	39.7	26.1

Cancer of the Pancreas*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	1.0	1.8	1.4	0.9	1.2	1.1
40-44	2.2	3.9	3.1	2.2	2.8	2.7
45-49	5.1	8.8	6.9	4.4	5.6	5.4
50-54	10.5	18.2	14.2	8.0	10.2	9.9
55-59	18.0	33.5	23.6	12.5	26.0	16.0
60-64	29.3	54.6	38.4	20.2	42.1	25.9
65-69	37.2	87.4	55.4	33.2	68.4	41.8
70-74	49.0	115.1	73.0	46.9	96.6	59.1
75-79	62.7	136.6	91.5	63.2	121.9	80.2
80-84	75.4	164.4	110.1	76.2	147.0	96.7
85+	79.4	173.2	116.0	84.6	163.3	107.5

Incident cases per 100,000 by disease, age, sex and smoking status (Continued)

Cancer of the Larynx*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.4	0.7	0.5	0.2	0.2	0.2
40-44	1.0	1.8	1.4	0.4	0.5	0.5
45-49	2.6	4.5	3.6	1.0	1.3	1.2
50-54	5.9	10.2	8.0	2.1	2.7	2.6
55-59	9.6	17.8	12.5	2.4	5.0	3.1
60-64	15.0	27.9	19.6	2.8	5.9	3.6
65-69	16.9	39.7	25.2	4.0	8.2	5.0
70-74	20.3	47.6	30.2	4.5	9.3	5.7
75-79	21.5	46.9	31.4	4.6	8.9	5.9
80-84	20.8	45.4	30.4	3.2	6.2	4.1
85+	17.6	38.4	25.7	2.7	5.2	3.4

Cancer of the Lung and Bronchus*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.6	8.1	2.5	0.8	10.2	2.0
40-44	1.4	19.7	6.0	2.2	29.1	5.8
45-49	4.0	58.0	17.8	5.9	78.3	15.5
50-54	10.1	145.1	44.6	12.6	168.2	33.4
55-59	16.7	317.3	76.2	14.8	281.2	74.2
60-64	29.8	566.4	136.0	24.7	467.9	123.5
65-69	33.6	951.9	262.1	48.7	1,151.4	331.1
70-74	48.8	1,379.5	379.9	67.4	1,595.0	458.6
75-79	76.7	1,727.0	495.6	83.7	1,932.3	534.2
80-84	85.3	1,920.3	551.1	82.7	1,908.2	527.5
85+	73.5	1,654.6	474.8	58.2	1,344.3	371.6

Cancer of the Cervix Uteri*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	-	-	-	12.2	15.7	15.2
40-44	-	-	-	13.4	17.2	16.6
45-49	-	-	-	12.0	15.4	14.9
50-54	-	-	-	11.2	14.3	13.9
55-59	-	-	-	9.3	19.4	11.9
60-64	-	-	-	9.8	20.3	12.5
65-69	-	-	-	10.3	21.3	13.0
70-74	-	-	-	10.3	21.1	12.9
75-79	-	-	-	8.7	16.8	11.1
80-84	-	-	-	8.3	16.1	10.6
85+	-	-	-	8.0	15.5	10.2

Maciosek MV, *et al. Tob Control* 2021;0:1–7. doi: 10.1136/tobaccocontrol-2019-055482

Incident cases per 100,000 by disease, age, sex and smoking status (Continued)

Cancer of the Urinary Bladder (Invasive and In Situ)*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	1.5	2.6	2.1	0.7	0.9	0.9
40-44	3.4	5.9	4.6	1.6	2.0	1.9
45-49	7.4	12.8	10.0	2.8	3.6	3.5
50-54	15.2	26.5	20.7	5.8	7.4	7.2
55-59	29.9	55.7	39.2	8.7	18.0	11.1
60-64	54.2	100.9	71.1	15.3	31.8	19.6
65-69	86.7	203.6	129.1	26.5	54.6	33.4
70-74	125.6	295.0	187.1	36.6	75.3	46.1
75-79	184.9	403.0	269.9	51.2	98.7	65.0
80-84	237.2	517.0	346.3	61.3	118.3	77.8
85+	268.7	585.8	392.3	66.2	127.8	84.1

Cancer of the Kidney and Renal Pelvis*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	5.0	8.8	6.8	3.8	4.8	4.7
40-44	9.8	17.0	13.3	6.2	7.9	7.6
45-49	15.8	27.4	21.4	9.2	11.8	11.4
50-54	23.7	41.3	32.3	13.5	17.3	16.8
55-59	34.7	64.5	45.4	16.6	34.5	21.3
60-64	47.9	89.1	62.7	22.6	46.9	28.9
65-69	58.7	138.0	87.5	34.5	71.1	43.5
70-74	67.0	157.4	99.8	39.6	81.6	49.9
75-79	72.5	158.0	105.8	43.4	83.8	55.1
80-84	71.6	156.1	104.6	41.1	79.4	52.2
85+	59.4	129.5	86.7	34.5	66.5	43.8

Acute Myeloid Leukemia*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	1.4	2.4	1.8	1.4	1.8	1.7
40-44	1.6	2.8	2.2	1.7	2.2	2.2
45-49	1.9	3.3	2.6	2.3	2.9	2.8
50-54	2.9	5.1	4.0	2.9	3.7	3.6
55-59	4.2	7.8	5.5	3.2	6.7	4.1
60-64	7.3	13.6	9.6	5.2	10.7	6.6
65-69	10.2	24.0	15.2	8.3	17.2	10.5
70-74	15.0	35.2	22.3	11.8	24.3	14.9
75-79	21.4	46.7	31.3	14.3	27.6	18.2
80-84	27.0	58.9	39.5	17.6	33.9	22.3
85+	26.9	58.7	39.3	16.7	32.2	21.2

Incident cases per 100,000 by disease, age, sex and smoking status (Continued)

Ischemic Heart Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	79.8	309.7	146.1	41.9	208.5	93.4
40-44	81.1	314.6	148.4	42.4	211.4	94.7
45-49	364.3	1,413.4	666.6	113.8	567.0	253.9
50-54	369.7	1,434.4	676.6	114.4	569.7	255.1
55-59	757.9	2,266.2	1,152.1	394.2	1,281.3	477.0
60-64	767.0	2,293.2	1,165.8	400.6	1,302.0	484.7
65-69	1,404.2	3,875.5	2,218.6	738.6	2,430.0	1,152.2
70-74	1,412.0	3,897.1	2,231.0	738.2	2,428.7	1,151.6
75-79	2,228.0	4,411.5	2,941.0	1,464.2	3,294.6	2,079.2
80-84	2,233.0	4,421.3	2,947.5	1,457.7	3,279.9	2,070.0
85+	2,547.2	5,043.4	3,362.3	2,054.1	4,621.7	2,916.8

Other Heart Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	156.9	376.6	167.9	131.4	320.7	131.4
40-44	159.6	382.9	170.7	133.3	325.3	133.3
45-49	471.9	1,132.6	505.0	297.4	725.6	297.4
50-54	480.5	1,153.3	514.2	301.1	734.8	301.1
55-59	810.3	2,033.8	1,223.5	703.4	1,392.8	773.8
60-64	815.8	2,047.7	1,231.9	709.2	1,404.2	780.1
65-69	1,888.5	4,192.4	2,492.8	1,727.4	3,195.7	2,228.3
70-74	1,901.3	4,220.9	2,509.7	1,723.3	3,188.1	2,223.1
75-79	4,428.8	7,351.8	5,093.1	3,772.2	6,601.4	4,979.3
80-84	4,446.0	7,380.4	5,112.9	3,754.7	6,570.7	4,956.1
85+	7,949.3	13,195.8	9,141.7	6,158.6	10,777.6	8,129.4

Cerebrovascular Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	84.3	202.3	90.2	46.4	113.1	46.4
40-44	85.7	205.7	91.7	47.0	114.7	47.0
45-49	200.2	480.6	214.3	181.2	442.1	181.2
50-54	203.9	489.3	218.2	183.5	447.7	183.5
55-59	425.1	1,067.1	641.9	341.0	675.3	375.2
60-64	428.0	1,074.4	646.3	343.8	680.8	378.2
65-69	949.4	2,060.2	1,167.8	850.1	1,929.7	1,054.1
70-74	958.0	2,078.8	1,178.3	851.3	1,932.5	1,055.7
75-79	1,949.9	2,885.9	2,183.9	1,650.9	2,806.6	1,816.0
80-84	1,954.9	2,893.2	2,189.5	1,652.8	2,809.7	1,818.0
85+	2,273.7	3,365.1	2,546.5	3,160.3	5,372.5	3,476.3

Incident cases per 100,000 by disease, age, sex and smoking status (Continued)

Other Vascular Diseases*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	20.5	49.2	21.9	25.0	61.1	25.0
40-44	20.8	50.0	22.3	25.4	62.0	25.4
45-49	40.8	98.0	43.7	30.7	74.9	30.7
50-54	41.6	99.8	44.5	31.1	75.9	31.1
55-59	129.5	325.1	195.6	109.2	216.2	120.1
60-64	130.4	327.3	196.9	110.1	218.0	121.1
65-69	240.9	1,746.7	530.0	113.4	772.3	256.3
70-74	247.1	1,791.4	543.6	113.6	773.6	256.7
75-79	397.9	1,961.7	684.4	257.1	1,483.6	519.4
80-84	405.3	1,997.9	697.0	256.7	1,481.3	518.6
85+	540.1	2,662.9	929.0	352.9	2,036.1	712.8

Diabetes*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	92.0	220.8	98.4	103.4	252.3	103.4
40-44	93.5	224.5	100.1	104.9	255.9	104.9
45-49	240.6	577.4	257.4	222.3	542.4	222.3
50-54	245.0	588.0	262.1	225.1	549.3	225.1
55-59	280.6	704.4	423.7	288.6	571.4	317.4
60-64	282.5	709.2	426.6	290.9	576.0	320.0
65-69	335.5	503.3	513.3	315.4	485.8	406.9
70-74	332.6	498.9	508.9	314.1	483.7	405.2
75-79	677.4	677.4	718.0	478.0	525.8	506.7
80-84	675.8	675.8	716.4	477.4	525.1	506.0
85+	558.6	558.6	592.1	655.3	720.9	694.7

Influenza, Pneumonia*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	37.9	169.3	84.1	48.5	311.7	89.7
40-44	38.4	171.7	85.3	49.7	319.3	91.9
45-49	129.7	579.8	288.0	111.5	717.2	206.3
50-54	131.3	587.1	291.6	113.4	729.3	209.8
55-59	89.6	1,359.4	356.7	126.5	1,138.9	612.5
60-64	92.7	1,405.9	368.9	126.0	1,134.4	610.1
65-69	596.9	1,540.1	967.0	677.3	1,185.2	866.9
70-74	598.5	1,544.1	969.5	675.4	1,182.0	864.6
75-79	1,454.1	2,355.7	2,064.9	1,528.7	3,149.1	1,849.7
80-84	1,446.6	2,343.4	2,054.1	1,528.7	3,149.1	1,849.7
85+	3,747.9	6,071.6	5,322.0	2,828.5	5,826.8	3,422.5

Maciosek MV, *et al. Tob Control* 2021;0:1–7. doi: 10.1136/tobaccocontrol-2019-055482

Incident cases per 100,000 by disease, age, sex and smoking status (Continued)

Chronic Obstructive Pulmonary Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	16.4	73.3	36.4	23.2	149.0	42.9
40-44	16.6	74.3	36.9	23.7	152.7	43.9
45-49	60.9	272.3	135.2	103.1	663.2	190.8
50-54	61.7	275.7	136.9	104.9	674.4	194.0
55-59	77.8	1,180.7	309.8	130.5	1,174.3	631.5
60-64	80.5	1,221.0	320.4	130.0	1,169.6	629.0
65-69	558.0	1,439.6	903.9	907.7	1,588.4	1,161.8
70-74	559.4	1,443.3	906.3	905.2	1,584.1	1,158.6
75-79	1,186.5	1,922.1	1,684.8	996.7	2,053.2	1,206.0
80-84	1,180.3	1,912.1	1,676.0	996.7	2,053.2	1,206.0
85+	1,367.5	2,215.3	1,941.8	1,152.9	2,375.0	1,395.1

*IMPORTANT: The granular age strata and disease categories shown in this table are used in the model to obtain more precise estimates of life years and quality adjusted life years. However, the rates for an individual age group or disease category may be inaccurate by themselves because the underlying relative risks by smoking status are based on broader age groups and combined disease categories. Some of the estimates shown in this table are obtained by applying a relative risk for broader age groups and combined disease categories to each granular age group and detailed disease category covered by that relative risk. For this reason, model results are reported only for broader categories and the estimates shown in this table should not be used or reported by themselves. For the age strata and disease groups on which the relative risks are estimated, please see U.S. Department of Health and Human Services. The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General, 2014. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014.

Probability of disease-specific mortality by age, sex, and smoking status, conditional on having a disease event

Cancer of the Oral Cavity and Pharynx*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.14	0.14	0.14	0.08	0.08	0.08
40-44	0.12	0.12	0.12	0.12	0.12	0.12
45-49	0.15	0.15	0.15	0.13	0.13	0.13
50-54	0.17	0.17	0.17	0.15	0.15	0.15
55-59	0.19	0.19	0.19	0.17	0.17	0.17
60-64	0.21	0.21	0.21	0.18	0.18	0.18
65-69	0.22	0.22	0.22	0.20	0.20	0.20
70-74	0.25	0.25	0.25	0.22	0.22	0.22
75-79	0.29	0.29	0.29	0.26	0.26	0.26
80-84	0.33	0.33	0.33	0.35	0.35	0.35
85+	0.41	0.41	0.41	0.46	0.46	0.46

Cancer of the Esophagus*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	1.00	1.00	1.00	0.50	0.50	0.50
40-44	0.93	0.93	0.93	0.75	0.75	0.75
45-49	0.88	0.88	0.88	0.86	0.86	0.86
50-54	0.97	0.97	0.97	0.78	0.78	0.78
55-59	0.96	0.96	0.96	0.77	0.77	0.77
60-64	0.89	0.89	0.89	0.80	0.80	0.80
65-69	0.90	0.90	0.90	0.80	0.80	0.80
70-74	0.98	0.98	0.98	0.86	0.86	0.86
75-79	1.00	1.00	1.00	0.91	0.91	0.91
80-84	1.00	1.00	1.00	0.98	0.98	0.98
85+	1.00	1.00	1.00	1.00	1.00	1.00

Cancer of the Stomach*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.44	0.44	0.44	0.39	0.39	0.39
40-44	0.41	0.41	0.41	0.38	0.38	0.38
45-49	0.39	0.39	0.39	0.38	0.38	0.38
50-54	0.41	0.41	0.41	0.37	0.37	0.37
55-59	0.39	0.39	0.39	0.39	0.39	0.39
60-64	0.39	0.39	0.39	0.40	0.40	0.40
65-69	0.38	0.38	0.38	0.39	0.39	0.39
70-74	0.40	0.40	0.40	0.39	0.39	0.39
75-79	0.45	0.45	0.45	0.45	0.45	0.45
80-84	0.50	0.50	0.50	0.52	0.52	0.52
85+	0.62	0.62	0.62	0.70	0.70	0.70

Probability of disease-specific mortality by age, sex, and smoking status, conditional on having a disease event (Continued)

Cancer of the Colon and Rectum*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.27	0.27	0.27	0.21	0.21	0.21
40-44	0.26	0.26	0.26	0.23	0.23	0.23
45-49	0.27	0.27	0.27	0.24	0.24	0.24
50-54	0.25	0.25	0.25	0.23	0.23	0.23
55-59	0.31	0.31	0.31	0.28	0.28	0.28
60-64	0.33	0.33	0.33	0.31	0.31	0.31
65-69	0.33	0.33	0.33	0.30	0.30	0.30
70-74	0.37	0.37	0.37	0.33	0.33	0.33
75-79	0.42	0.42	0.42	0.37	0.37	0.37
80-84	0.48	0.48	0.48	0.43	0.43	0.43
85+	0.65	0.65	0.65	0.64	0.64	0.64

Cancer of the Liver and Intrahepatic Bile Duct*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.58	0.58	0.58	0.50	0.50	0.50
40-44	0.58	0.58	0.58	0.64	0.64	0.64
45-49	0.55	0.55	0.55	0.70	0.70	0.70
50-54	0.56	0.56	0.56	0.65	0.65	0.65
55-59	0.59	0.59	0.59	0.62	0.62	0.62
60-64	0.60	0.60	0.60	0.68	0.68	0.68
65-69	0.66	0.66	0.66	0.75	0.75	0.75
70-74	0.74	0.74	0.74	0.82	0.82	0.82
75-79	0.85	0.85	0.85	0.94	0.94	0.94
80-84	0.94	0.94	0.94	1.00	1.00	1.00
85+	1.00	1.00	1.00	1.00	1.00	1.00

Cancer of the Pancreas*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.54	0.54	0.54	0.50	0.50	0.50
40-44	0.71	0.71	0.71	0.50	0.50	0.50
45-49	0.75	0.75	0.75	0.69	0.69	0.69
50-54	0.79	0.79	0.79	0.75	0.75	0.75
55-59	0.83	0.83	0.83	0.78	0.78	0.78
60-64	0.83	0.83	0.83	0.81	0.81	0.81
65-69	0.85	0.85	0.85	0.81	0.81	0.81
70-74	0.86	0.86	0.86	0.87	0.87	0.87
75-79	0.93	0.93	0.93	0.89	0.89	0.89
80-84	0.95	0.95	0.95	0.95	0.95	0.95
85+	1.00	1.00	1.00	1.00	1.00	1.00

Probability of disease-specific mortality by age, sex, and smoking status, conditional on having a disease event (Continued)

Cancer of the Larynx*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.20	0.20	0.20	-	-	-
40-44	0.15	0.15	0.15	-	-	-
45-49	0.24	0.24	0.24	0.18	0.18	0.18
50-54	0.27	0.27	0.27	0.22	0.22	0.22
55-59	0.30	0.30	0.30	0.27	0.27	0.27
60-64	0.29	0.29	0.29	0.31	0.31	0.31
65-69	0.31	0.31	0.31	0.35	0.35	0.35
70-74	0.31	0.31	0.31	0.38	0.38	0.38
75-79	0.37	0.37	0.37	0.45	0.45	0.45
80-84	0.46	0.46	0.46	0.65	0.65	0.65
85+	0.60	0.60	0.60	0.71	0.71	0.71

Cancer of the Lung and Bronchus*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.54	0.54	0.54	0.50	0.50	0.50
40-44	0.71	0.71	0.71	0.62	0.62	0.62
45-49	0.82	0.82	0.82	0.69	0.69	0.69
50-54	0.84	0.84	0.84	0.71	0.71	0.71
55-59	0.83	0.83	0.83	0.70	0.70	0.70
60-64	0.80	0.80	0.80	0.70	0.70	0.70
65-69	0.79	0.79	0.79	0.69	0.69	0.69
70-74	0.81	0.81	0.81	0.72	0.72	0.72
75-79	0.83	0.83	0.83	0.75	0.75	0.75
80-84	0.91	0.91	0.91	0.83	0.83	0.83
85+	1.00	1.00	1.00	1.00	1.00	1.00

Cancer of the Cervix Uteri*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	-	-	-	0.17	0.17	0.17
40-44	-	-	-	0.21	0.21	0.21
45-49	-	-	-	0.31	0.31	0.31
50-54	-	-	-	0.36	0.36	0.36
55-59	-	-	-	0.41	0.41	0.41
60-64	-	-	-	0.43	0.43	0.43
65-69	-	-	-	0.44	0.44	0.44
70-74	-	-	-	0.47	0.47	0.47
75-79	-	-	-	0.57	0.57	0.57
80-84	-	-	-	0.66	0.66	0.66
85+	-	-	-	0.72	0.72	0.72

Probability of disease-specific mortality by age, sex, and smoking status, conditional on having a disease event (Continued)

Cancer of the Urinary Bladder (Invasive and In Situ)*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.05	0.05	0.05	0.13	0.13	0.13
40-44	0.07	0.07	0.07	0.12	0.12	0.12
45-49	0.11	0.11	0.11	0.16	0.16	0.16
50-54	0.13	0.13	0.13	0.14	0.14	0.14
55-59	0.14	0.14	0.14	0.15	0.15	0.15
60-64	0.14	0.14	0.14	0.15	0.15	0.15
65-69	0.14	0.14	0.14	0.16	0.16	0.16
70-74	0.17	0.17	0.17	0.20	0.20	0.20
75-79	0.19	0.19	0.19	0.24	0.24	0.24
80-84	0.26	0.26	0.26	0.32	0.32	0.32
85+	0.41	0.41	0.41	0.52	0.52	0.52

Cancer of the Kidney and Renal Pelvis*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.08	0.08	0.08	0.07	0.07	0.07
40-44	0.09	0.09	0.09	0.06	0.06	0.06
45-49	0.14	0.14	0.14	0.10	0.10	0.10
50-54	0.18	0.18	0.18	0.13	0.13	0.13
55-59	0.21	0.21	0.21	0.16	0.16	0.16
60-64	0.23	0.23	0.23	0.19	0.19	0.19
65-69	0.23	0.23	0.23	0.20	0.20	0.20
70-74	0.28	0.28	0.28	0.25	0.25	0.25
75-79	0.34	0.34	0.34	0.31	0.31	0.31
80-84	0.42	0.42	0.42	0.43	0.43	0.43
85+	0.68	0.68	0.68	0.68	0.68	0.68

Acute Myeloid Leukemia*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.41	0.41	0.41	0.47	0.47	0.47
40-44	0.45	0.45	0.45	0.47	0.47	0.47
45-49	0.54	0.54	0.54	0.52	0.52	0.52
50-54	0.59	0.59	0.59	0.56	0.56	0.56
55-59	0.70	0.70	0.70	0.65	0.65	0.65
60-64	0.73	0.73	0.73	0.67	0.67	0.67
65-69	0.77	0.77	0.77	0.69	0.69	0.69
70-74	0.83	0.83	0.83	0.71	0.71	0.71
75-79	0.84	0.84	0.84	0.80	0.80	0.80
80-84	0.84	0.84	0.84	0.78	0.78	0.78
85+	0.83	0.83	0.83	0.82	0.82	0.82

Probability of disease-specific mortality by age, sex, and smoking status, conditional on having a disease event (Continued)

Ischemic Heart Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.12	0.12	0.12	0.08	0.08	0.08
40-44	0.12	0.12	0.12	0.08	0.08	0.08
45-49	0.11	0.11	0.11	0.11	0.11	0.11
50-54	0.11	0.11	0.11	0.11	0.11	0.11
55-59	0.16	0.16	0.16	0.11	0.11	0.11
60-64	0.16	0.16	0.16	0.11	0.11	0.11
65-69	0.17	0.17	0.17	0.17	0.17	0.17
70-74	0.17	0.17	0.17	0.17	0.17	0.17
75-79	0.32	0.32	0.32	0.29	0.29	0.29
80-84	0.32	0.32	0.32	0.29	0.29	0.29
85+	0.86	0.86	0.86	0.80	0.80	0.80

Other Heart Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.05	0.05	0.05	0.04	0.04	0.04
40-44	0.05	0.05	0.05	0.04	0.04	0.04
45-49	0.04	0.04	0.04	0.04	0.04	0.04
50-54	0.04	0.04	0.04	0.04	0.04	0.04
55-59	0.05	0.05	0.05	0.04	0.04	0.04
60-64	0.05	0.05	0.05	0.04	0.04	0.04
65-69	0.05	0.05	0.05	0.04	0.04	0.04
70-74	0.05	0.05	0.05	0.04	0.04	0.04
75-79	0.08	0.08	0.08	0.07	0.07	0.07
80-84	0.08	0.08	0.08	0.07	0.07	0.07
85+	0.17	0.17	0.17	0.20	0.20	0.20

Cerebrovascular Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.04	0.04	0.04	0.06	0.06	0.06
40-44	0.04	0.04	0.04	0.06	0.06	0.06
45-49	0.05	0.05	0.05	0.05	0.05	0.05
50-54	0.05	0.05	0.05	0.05	0.05	0.05
55-59	0.06	0.06	0.06	0.06	0.06	0.06
60-64	0.06	0.06	0.06	0.06	0.06	0.06
65-69	0.07	0.07	0.07	0.07	0.07	0.07
70-74	0.07	0.07	0.07	0.07	0.07	0.07
75-79	0.13	0.13	0.13	0.15	0.15	0.15
80-84	0.13	0.13	0.13	0.15	0.15	0.15
85+	0.32	0.32	0.32	0.28	0.28	0.28

Probability of disease-specific mortality by age, sex, and smoking status, conditional on having a disease event (Continued)

Other Vascular Diseases*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.05	0.05	0.05	0.02	0.02	0.02
40-44	0.05	0.05	0.05	0.02	0.02	0.02
45-49	0.07	0.07	0.07	0.04	0.04	0.04
50-54	0.07	0.07	0.07	0.04	0.04	0.04
55-59	0.05	0.05	0.05	0.03	0.03	0.03
60-64	0.05	0.05	0.05	0.03	0.03	0.03
65-69	0.04	0.04	0.04	0.06	0.06	0.06
70-74	0.04	0.04	0.04	0.06	0.06	0.06
75-79	0.08	0.08	0.08	0.10	0.10	0.10
80-84	0.08	0.08	0.08	0.10	0.10	0.10
85+	0.18	0.18	0.18	0.28	0.28	0.28

Diabetes*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.05	0.05	0.05	0.03	0.03	0.03
40-44	0.05	0.05	0.05	0.03	0.03	0.03
45-49	0.05	0.05	0.05	0.04	0.04	0.04
50-54	0.05	0.05	0.05	0.04	0.04	0.04
55-59	0.10	0.10	0.10	0.07	0.07	0.07
60-64	0.10	0.10	0.10	0.07	0.07	0.07
65-69	0.19	0.19	0.19	0.16	0.16	0.16
70-74	0.19	0.19	0.19	0.16	0.16	0.16
75-79	0.25	0.25	0.25	0.26	0.26	0.26
80-84	0.25	0.25	0.25	0.26	0.26	0.26
85+	0.57	0.57	0.57	0.38	0.38	0.38

Influenza, Pneumonia*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.03	0.03	0.03	0.02	0.02	0.02
40-44	0.03	0.03	0.03	0.02	0.02	0.02
45-49	0.02	0.02	0.02	0.02	0.02	0.02
50-54	0.02	0.02	0.02	0.02	0.02	0.02
55-59	0.04	0.04	0.04	0.02	0.02	0.02
60-64	0.04	0.04	0.04	0.02	0.02	0.02
65-69	0.04	0.04	0.04	0.03	0.03	0.03
70-74	0.04	0.04	0.04	0.03	0.03	0.03
75-79	0.07	0.07	0.07	0.05	0.05	0.05
80-84	0.07	0.07	0.07	0.05	0.05	0.05
85+	0.11	0.11	0.11	0.13	0.13	0.13

Maciosek MV, *et al. Tob Control* 2021;0:1–7. doi: 10.1136/tobaccocontrol-2019-055482

Probability of disease-specific mortality by age, sex, and smoking status, conditional on having a disease event (Continued)

Chronic Obstructive Pulmonary Disease*

	Males			Females		
Age*	Never	Current	Former	Never	Current	Former
35-39	0.02	0.02	0.02	0.02	0.02	0.02
40-44	0.02	0.02	0.02	0.02	0.02	0.02
45-49	0.05	0.05	0.05	0.04	0.04	0.04
50-54	0.05	0.05	0.05	0.04	0.04	0.04
55-59	0.09	0.09	0.09	0.07	0.07	0.07
60-64	0.09	0.09	0.09	0.07	0.07	0.07
65-69	0.14	0.14	0.14	0.10	0.10	0.10
70-74	0.14	0.14	0.14	0.10	0.10	0.10
75-79	0.21	0.21	0.21	0.23	0.23	0.23
80-84	0.21	0.21	0.21	0.23	0.23	0.23
85+	0.37	0.37	0.37	0.37	0.37	0.37

*IMPORTANT: The granular age strata and disease categories shown in this table are used in the model to obtain more precise estimates of life years and quality adjusted life years. However, the rates for an individual age group or disease category may be inaccurate by themselves because the underlying relative risks by smoking status are based on broader age groups and combined disease categories. Some of the estimates shown in this table are obtained by applying a relative risk for broader age groups and combined disease categories to each granular age group and detailed disease category covered by that relative risk. For this reason, model results are reported only for broader categories and the estimates shown in this table should not be used or reported by themselves. For the age strata and disease groups on which the relative risks are estimated, please see U.S. Department of Health and Human Services. The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General, 2014. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014.

Supplement 2

Sensitivity analysis for 10-year cumulative impacts of a 10-year media campaign compared to no campaign

	Deaths prevented	Net medical costs* ($ millions)	Net direct costs** ($ millions)	All payer, direct cost, breakeven Year***	Productivity gains ($ millions)
Base case	**-23,500**	**-6,360**	**-5,080**	**5**	**5,320**
Baseline smoking initiation rates +25%	-23,500	-6,350	-5,070	5	5,330
Baseline smoking initiation rates -25%	-23,500	-6,370	-5,090	5	5,310
Baseline smoking cessation rates +25%	-27,700	-7,620	-6,340	4	5,550
Baseline smoking cessation rates -25%	-21,000	-4,920	-3,640	6	4,340
Relative risks of SA diseases +25%	-33,800	-6,250	-4,960	5	6,330
Relative risks of SA diseases -25%	-21,900	-6,420	-5,140	5	4,740
Media campaign effectiveness +50%	-36,900	-9,390	-8,110	4	7,800
Media campaign effectiveness -50%	-12,200	-3,260	-1,980	6	2,620
SA medical costs +35%	-23,500	-8,810	-7,530	4	5,320
SA medical costs -35%	-23,500	-3,830	-2,550	6	5,320
SA medical costs: alternative source	-23,500	-12,640	-11,360	3	5,320
Smoking cessation treatment costs +35%	-23,500	-6,040	-4,760	5	5,320
Smoking cessation treatment costs -35%	-23,500	-6,600	-5,320	4	5,320
Media campaign costs +50%	-23,500	-6,360	-4,439	6	5,320
Media campaign costs -50%	-23,500	-6,360	-5,720	4	5,320
Discount rate 3%	-19,500	-5,200	-4,070	5	4,380
Media campaign effectiveness - 50%; Media campaign costs +50%; and Discount rate 3%	-10,100	-2,660	-980	8	2,160

SA = smoking-attributable
*Includes costs of smoking cessation treatments and costs of smoking-attributable illness.
**Includes all direct costs: media campaign costs, cessation treatment costs and SA medical costs
***Year in which cumulative net direct costs become negative (cost savings occur)

In sensitivity analyses we:

Increased and decreased baseline initiation and cessation rates by a relative 25%. That is, we multiplied each simulated individuals baseline rate by 1.25 or 0.75 in the model. This tests the impact of systematic under or over estimation of these rates from survey data. Similarly, we increased and decreased the relative risks of each smoking-attributable disease for both current and former smokers by a relative 25% to test the impact of any systematic bias in estimating these risks by the original source. We tested the effect of large variation in Media campaign effectiveness (a relative 50%), given lack of direct data

Maciosek MV, *et al. Tob Control* 2021;0:1–7. doi: 10.1136/tobaccocontrol-2019-055482

on the impact of sustained media campaigns. Likewise, we tested large variation in Media campaign costs (a relative 50%) given uncertainty in the relationship between media campaign intensity and effectiveness. We tested the impact of 35% changes in smoking cessation treatment costs and smoking-attributable medical costs to assess plausible systematic bias in their estimation. We also tested the impact of using an alternate estimate of smoking-attributable medical costs by age and sex (Maciosek et al. 2015, Preventive Medicine); however the alternate estimates do not vary by insurance status except to the extent that insurance status is correlated with age and sex. Finally, we implemented a 3% annual discount rate to determine the impact of discounting future costs to their present value at the start of the sustained media campaign, and we conducted a multivariate sensitivity analysis combining the 3% discount rate with the extremes of low media campaign effectiveness and high media campaign costs.

Maciosek MV, *et al. Tob Control* 2021;0:1–7. doi: 10.1136/tobaccocontrol-2019-055482