Section IV
Societal Level Influences on Tobacco Use

Chapter 12
Simulation Modeling of Tobacco-Related Health Disparities: *SimSmoke*

Contents

Tables

Introduction

Racial/ethnic disparities and socioeconomic status (SES), at both the individual and the community levels, are generally related to poorer health outcomes such as higher risks of heart disease and cancer.[1,2] Smoking is an important risk factor for these and other chronic diseases, and as discussed in chapter 2, smoking rates remain high among people with low education levels and income.[3–10] Low education and income have also been linked to a lower rate of quit attempts and quit success.[11–13] Additional information on relationships between race/ethnicity, SES, and tobacco-related health disparities (TRHD) is presented in chapters 2 through 9. Chapters 8 and 9 discuss the relationship between SES and TRHD in detail.

Extensive research has demonstrated that tobacco control policies are an important tool in reducing smoking rates. Since 1997, smoking rates in the United States have declined substantially, with much of this reduction attributable to public policies such as tobacco product price increases, mass media anti-tobacco campaigns, and smoke-free laws.[4,8,14–16] States with strong tobacco control policies, such as California, Massachusetts, Minnesota, Hawaii, and Arizona, have seen particularly large reductions in smoking rates.[17–20] There is evidence that most traditional policies are effective in reducing smoking rates among low-SES groups, but smoking rates are still high among low-SES groups and certain racial/ethnic groups (see chapter 9).[4,5,8,9] Increasingly, national and state programs have focused on reducing smoking among particular sociodemographic groups.[5,21,22]

To examine the effects of tobacco control policies on tobacco use, many investigators have used simulation models. Statistical evaluations have limited ability to distinguish the effects of policies on smoking rates, thus most statistical evaluation studies have examined the effect of only one or, at most, two policies (e.g., studies by Hu and colleagues,[23,24] and Farrelly and colleagues 2003[25]). Simulation models combine information from different sources, such as various policy evaluation studies, and information on policy levels to examine how the effects of public policies unfold over time in complex social systems.[26,27] Simulation models examining the effects of tobacco control policies have been developed by Mendez and Warner,[28,29] Tengs and colleagues,[30–32] Ahmad,[33] Ahmad and Billimek,[34,35] and Levy and colleagues.[15,27,36,37] Levy and colleagues' *SimSmoke* model simultaneously considers a broad array of public policies[38] and has been applied in many countries[15,16,39–48] and U.S. states.[18–20,49–51]

This chapter discusses a modified version of the *SimSmoke* tobacco control simulation model that was developed to examine trends in smoking rates related to SES disparities and the potential effect of tobacco control policies on smoking trends in the United States. *SimSmoke* is easily programmed to project outcomes for the total population and for subpopulations (by age and gender), thereby identifying target groups that may need special policy attention. *SimSmoke* shows likely trends in rates of smoking and rates of smoking-attributable deaths in the absence of policies, and how specific policies or groups of policies may alter these rates.[15,37,52–58] The modified version of *SimSmoke* discussed in this chapter examines policies in seven areas: cigarette taxes, smoke-free laws, mass media anti-tobacco campaigns, marketing restrictions, health warnings, cessation treatment policies, and enforcement of youth access laws. This chapter also examines the effect of a combination of these policies.

As this monograph describes, many sociodemographic, psychosocial, environmental, and biological factors may help explain TRHD. As discussed in prior chapters, disparities may be related to SES or race/ethnicity, among other factors. As reviewed in chapter 9, there is an inverse relationship between smoking status and the two primary measures of SES: education and income. The relationship of smoking to race/ethnicity is more complex; Hispanics, African Americans, Native Hawaiians and Other

Pacific Islanders, and American Indian and Alaska Natives are disproportionately represented in lower SES strata compared to whites and Asian aggregate groups. Consequently, this chapter focuses on SES; the potential for variation by race/ethnicity is considered in the Conclusions section.

The Modified *SimSmoke* Model: Methods

The *SimSmoke* model is designed to project smoking rates and deaths attributable to smoking.[36,38] This section first describes the income quintiles used in the development of the models, and particularly the income quintiles developed for the two lower income quintiles. This section then describes the populations of interest: smokers, never-smokers, and former smokers by age and gender. Next is a discussion of the two *SimSmoke* models, a population model and a smoking model. In the following section, policy modules for the input of policy parameters are described. A discrete-time, first-order Markov process is employed to project future population growth and changes in smoking rates over time that could be caused by tobacco control policies and prior smoking patterns.

Income Quintiles

SES is often categorized by income quintiles or levels of education (e.g., less than high school, high school, some college, undergraduate degree, some graduate training, graduate degree). The models used in this chapter are defined in terms of income quintiles because education levels are generally increasing, whereas income quintiles are a relative measure and thus a more stable measure over time. Further, for youth and young adults, family income can be expected to more closely reflect SES than education.

Two income disparities models, pertaining to the two lower income quintiles in the United States, were created. The policies used in the models are the same since both were applied at the national level during the same time span. However, although the same procedures are used to derive smoking prevalence and rates of initiation and cessation, these rates differ because the models pertain to different income groups with different rates. Both models begin in 2006, using the 2006-2007 Tobacco Use Supplement to the Current Population Survey (TUS-CPS).[59–61] This survey had a sufficiently large sample size to distinguish smoking rates by age and gender as well as SES classifications. The 2010-2011 TUS-CPS was used to calibrate the model.[60]

The basic *SimSmoke* model of population, smoking, and policies was programmed using Excel software.

Population Model

U.S. population data for 2006 were obtained from the Census Bureau for both males and females for each age from 0 through 84, and in the 85-and-older age group. The data were not modified for use in the models. Given that the models pertain to income quintiles, the population estimate for the second-lowest income quintile was first estimated by simply dividing the U.S. population by 5. This method may impart a bias, since age distributions may vary by income quintile. Accordingly, the 2006-2007 TUS-CPS populations by income quintile were used to adjust the age groups 15 and above,[59] and Census income-specific population data on children per household were used to adjust the age group 0–14.[62] After categorizing the data by quintile, the percentage difference by age group in the lowest and second-lowest income quintiles (also referred to as the first and second quintiles relative to the total population) was obtained. Compared to other income quintiles, the first and second quintiles generally had larger proportions below age 24 and at or above age 55.

Fertility and mortality rates were obtained from the Centers for Disease Control and Prevention (CDC).[63] To reflect an average value over time, the 2010 fertility and mortality rates were used for all years. Average fertility rates, calculated by income quintile relative to the average fertility rates for all quintiles, were 1.4 for the lowest quintile and 1.07 for the second-lowest quintile.[64] (Similar variations have been found using education groups.[65]) Fertility rates differentiated by age groups (e.g., 14, 15–17, 18–19, 20–24, 25–29, etc.) were adjusted to reflect the overall higher fertility rates in these two income quintiles. Mortality rates were distinguished by age and gender. Studies generally find that people at lower income and education levels, particularly those of working age, have higher mortality rates,[66,67] with the differential from higher levels of income and education increasing over time. Canadian studies conducted in 2012 and 2013 on data collected between 1991 and 2006 found that mortality rates in the lowest income quintile were 31% higher for males and 26% higher for females than average mortality rates in the general population; and mortality rates in the second-lowest income quintile were 6% higher for males and 4% higher for females than population rates.[68–70] Similar results were obtained by a 2008 U.S. study (NHANES data collected 1988–1994 and 2001)[71] and in a study examining 2002 mortality rates of people younger than age 65 (i.e., premature mortality).[72]

For the modified version of *SimSmoke*, mortality rates by age and gender for ages 25 through 75 were adjusted upward, using the relative difference in the Canadian mortality rates to reflect the higher rates for the first and second income quintiles compared with the average death rates of the population.

Smoking Model

SimSmoke divided the population into the number of smokers, former smokers, and never-smokers in the 2006 baseline year. Smokers were defined as individuals who have smoked more than 100 cigarettes in their lifetime and are currently smoking either daily or on some days. Former smokers were defined as individuals who meet the 100 lifetime cigarettes threshold but are not currently smoking, and never-smokers are those who have not smoked 100 cigarettes in their lifetimes. Former smokers were further categorized by years since quitting (<1, 1, 2,…, 15, >15 years). Baseline estimates of smoking status were obtained from the 2006-2007 TUS-CPS.[59] These data using self-response weights were aggregated by smoking status (never, current, former smokers, and former smokers by years quit), gender, age group (15–17, 18–20, 21–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75–84, and 85 and older), wave of the survey, and income category ($19,999 or less, $20,000–$39,999, $40,000–$59,999, $60,000–$99,999, and $100,000 or more). For former smokers, the years-quit categories in the data before converting to single years quit were: less than 1 year, 1 year to less than 3 years, 3 years to less than 5 years, 5 years to less than 10 years, 10 years to less than 15 years, and 15 years or more.

Next, the data for each wave were broken into income quintiles based on the 2006 Census Bureau figures. For 2006, the upper limits for the first four income quintiles (in 2006 dollars) were $20,035, $37,774, $60,000, and $97,032. The highest income quintile for each year did not have an upper cutoff (i.e., the highest quintile included any household earning above the upper limit for the fourth quintile). For 2007, the upper limits for the income quintiles increased to $20,291, $39,100, $62,000, and $100,000. Since the TUS-CPS was conducted in May and August 2006 and in January 2007, the 2006 and 2007 data were weighted to arrive at an estimated income distribution such that TUS-CPS income categories would be the closest match to the 2006 Census income quintiles. This resulted in an upper limit of $20,078 for the first quintile, $37,995 for the second quintile, $60,333 for the third quintile, $97,527 for the fourth quintile.

Separate data sets for each year were then created by age group and smoking status counts, including former smokers by years quit, for the 10 gender/income quintile categories. Because the income categories outlined in the TUS-CPS do not coincide with these income quintiles, linear interpolation was used to estimate the number of cases in the different income quintiles. Since the lowest TUS-CPS income response category was $0–$19,999, the lowest income quintile for 2006-2007 was estimated as $0–$20,078. To correct for the difference in brackets between the income quintile and the TUS-CPS classifications, the number of smokers in the lowest income quintile was estimated using the formula:

$$N_{Q1,2006/07} = N_{[\$0,\ \$19,999]} + [(\$20,078–\$20,000)/(\$39,999–\$20,000)] * N_{[\$20,000,\ \$39,999]}$$

where N represents the count for the respective age group/smoking status category in the income category denoted by the given subscript. Since the second-lowest TUS-CPS income category was $20,000–$39,999 and the second-lowest income quintile was $20,079–$37,995, the following formula was used for the second-lowest quintile:

$$N_{Q2,2006/07} = N_{[\$20,000,\ \$39,999]} * [1 – (\$20,079–\$20,000)/(\$39,999–\$20,000) – (\$39,999–\$37,995)/(\$39,999–\$20,000)]$$

The data from the lowest and second-lowest income quintiles were distributed into the three smoking status categories (never, current, and former smokers) by the age groups above, and the former smokers were distributed into the six years-quit categories mentioned above. Interpolation (moving average [MA] smoothing) was then used to distribute the age group smoking rates to single ages within each smoking status category as follows: 3-year MA for ages 15 to 26 and 5-year MA for ages 27 and older. Individuals younger than 15 years were considered never-smokers. The age group rates for current smokers, former smokers, and former smokers by years-quit were distributed to each single age within the respective age group. Cessation was tracked from age 24, since the relative mortality risks from smoking are not discernible for those quitting before that age.[73,74] Therefore, former smokers under age 25 were reclassified as never-smokers. With the above procedure, the age group estimate became the estimate for the mid-point age of each age group. To ensure that the prevalence rates of all smoking categories combined was 100%, the never-smoking rate was recalculated as 100% minus the sum of the current- and former-smoking rates.

Within the smoking model, individuals may evolve from never-smokers to smokers through smoking initiation. People are classified as never-smokers from birth until and unless they initiate smoking. Individuals may evolve from smoker to former smoker through cessation and may return to smoking through relapse. Relapse rates are proportional to the cessation rate (although independent of it), but are specific to age and the number of years since quitting.

Because estimating initiation and cessation rates at young ages is difficult, and to ensure stability and internal consistency of the model, initiation is measured net of quitting (i.e., as new smokers minus those who quit at each age) by computing initiation as the smoking prevalence at a particular age in the base year minus the smoking prevalence at the previous age in the base year. Initiation into the lowest and second-lowest income quintile model occurs until age 24.

Data on quit rates for individuals age 26 and older were obtained from the TUS-CPS. The measure of annual quit rates was based on the number of smokers who quit in the last year. The 2006 age group cessation data were initially interpolated by using 5-year MA smoothing from age 27. Data aggregated over all SES quintiles from the *SimSmoke* model were used to measure relapse rates for the lowest and

second-lowest income quintiles by duration of cessation for each of the years' quit groups.[73,75–77] However, in calibrating the model, relapse rates were checked by SES group.

Predicting Smoking-Attributable Deaths

Smoking-attributable deaths in *SimSmoke* were predicted using smoking prevalence rates and the relative risks of smokers and former smokers relative to nonsmokers, similar to standard attribution measures.[78,79] Specifically, the relative risks and prevalence rate of smokers and former smokers and the death rate in a particular age group were used to distinguish the death rates of never, current, and former smokers. The number of smokers at each age was 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 using the former smoker death rate, and the results were summed over smoking groups for all ages to obtain the number of smoking-attributable deaths.

Deaths rates were distinguished by age, gender, and smoking type (never, current, and the six former smoker groups based on years quit, as above) using the data on mortality rates and smoking rates (as described above) and relative risk estimates for current and former smokers from the Cancer Prevention Study II.[77,80,81] While the mortality rates by smoking status used in this study are not adjusted for demographic and behavioral factors, such as diet and physical activity, other studies have found that the estimates are robust after controlling for these factors.[82,83] The relative risks may, however, vary for those groups; for example, relative risks may be higher if poor diet and other behavioral factors create greater risk from smoking (as has been found for lung cancer), or may be reduced to the extent that background risk is higher. Although no studies were found that specifically distinguish relative risks by income, Thun and colleagues[84] found that "the relative-risk estimates associated with current and former smoking among smokers with only a high school education are generally similar to or larger than those among smokers who are college graduates."[84,p.363] As a conservative measure, the relative risks for the two lowest income quintiles were assumed to be the same as the average relative risk for the entire population, but note that the estimates of smoking-attributable deaths from the two low-income groups reflect the higher mortality rates, especially in the lowest income group.

Policy Modules Methods

The model begins with policies in effect in 2006. Using the policy modules, the model then incorporated the effects of policies that changed between 2006 and 2014 by taking into account the changes in policies that were newly implemented and the effects of those changes. Seven policies were considered: cigarette taxes, smoke-free laws, mass media anti-tobacco campaigns, marketing restrictions, health warnings, cessation treatment policies, and youth access policies.

The effects of policies were estimated in terms of the percentage change (PC) in the smoking, initiation, and cessation rates relative to the initial rates:

$$[PC = (\text{post-policy rate} - \text{initial rate})/\text{initial rate}]$$

with $PC < 0$. Policies have their most immediate effect on smoking prevalence directly through cessation—that is,

$$Smokers_{t,a} * (1 + PC)$$

which may vary by age **a** and is assumed to occur in year **t** of the policy change. During each year after the first year in which the policy was in effect, the percentage reduction was also applied to the initiation rate as (1 + PC) and as a percentage increase (1 – PC) to the cessation rate. First-year quit rates continued to be elevated for each of the policies, because they reduce quantity smoked, which tends to increase cessation.[85] When more than one policy is in effect, the effects are multiplicatively applied—that is, $(1 + PC_i)*(1 + PC_j)$ for policies **i** and **j**—implying that the relative effect is independent of other policies, but the absolute effect is smaller when another policy is also implemented.

Policy descriptions and effect sizes are shown in Table 12.1. The effect sizes by income group were modified from those in the previous United States *SimSmoke* model[15,16] informed by the studies presented in chapter 11.

Table 12.1 Policy Inputs and Effect Size for *SimSmoke* Projection

Policy	Description	Effect Size*
Cigarette taxes		
Cigarette taxes	The state-level average price for a pack of cigarettes was computed as the weighted average of single pack, carton, and vending machine cigarette prices, including state excise taxes. Prices of both branded and generic cigarettes were used in the average.	Elasticity: ages 10–17: –0.60 ages 18–24: –0.45 ages 25–34: –0.30 ages 35–64: –0.15 ages 65 and above: –0.25
Smoke-free policies		
Worksite ban, well enforced	Cigarette use banned in all indoor worksites in all areas, with strong public acceptance and enforcement	4.5% reduction
Restaurant and bar ban, well enforced	Ban in all indoor restaurants in all areas	2.25% reduction
Bans in other places	Ban in 3 out of 4 of the following: government buildings, retail stores, public transportation, and elevators	0.75% reduction
Mass media anti-tobacco campaigns		
Highly publicized media campaign	Campaign publicized heavily on TV (for at least 2 months of a year) and on at least some other media, with a social marketing approach	6.5% reduction
Moderately publicized media campaign	Campaign publicized sporadically on TV and in at least some other media, and a local program	3.75% reduction
Low-publicity media campaign	Campaign publicized only sporadically in newspaper, on billboards, or some other medium	1.65% reduction
Marketing restrictions		
Comprehensive marketing ban	Advertising banned on television, radio, billboards, and in print; in-store displays, sponsorships, and free samples also banned	Prevalence: 5% reduction Initiation: 6% reduction Cessation: 3% increase
Total advertising ban	Advertising banned on television, radio, billboards, and in print	Prevalence: 3% reduction Initiation: 4% reduction Cessation: 2% increase

Table 12.1 continued

Policy	Description	Effect Size*
Enforcement	A government agency is designated to enforce the laws.	Effect size is reduced 50% if no enforcement
Health warnings		
Strong health warnings	Warning is bold and graphic, and covers at least 50% of the package	Prevalence: 4% reduction Initiation: 4% reduction Cessation: 8% increase
Weak health warnings	Warning does not include graphics, and covers less than one-third of the package	Prevalence: 1% reduction Cessation: 4% increase
Quitlines	A proactive quitline with nicotine replacement therapy and a campaign of publicity through the media	~1% reduction in prevalence, but a greater effect on cessation rates depending on level of publicity through the media
Youth access enforcement		
Youth access restrictions, strongly enforced and publicized	Regular compliance checks, heavy penalties, high visibility; vending machine and self-service bans	Prevalence and initiation only: ages <16: 30% reduction ages 16–17: 20% reduction
Youth access restriction, moderate enforcement	Compliance checks are conducted at least once per year per outlet, penalties are moderate, and the program receives some publicity	Prevalence and initiation only: ages <16: 15% reduction ages 16–17: 10% reduction

*Unless otherwise indicated, the effects are on prevalence in the first year, and on initiation and first-year quit rates during the ensuing years that the policy is in effect. The effect sizes are based on previous *SimSmoke* models, with modifications informed by the studies presented in chapter 11.

The effect of changes in U.S. policies was tracked from 2006 through 2014. Data pertaining to tobacco control policies were simulated at the state level for smoke-free laws, tobacco control campaigns, cessation treatment programs, and youth access enforcement. Since the 2006-2007 TUS-CPS data are from May, August, and January, smoking rates that represented the midpoint month, August, were used. To be consistent, policy data were set to their August levels of the particular year.

Cigarette Tax Module

In the tax module, prices were modeled as having constant proportional effects, derived from studies of demand elasticities.[55] The studies reviewed consistently obtained higher elasticities among people of low SES compared with high SES, in terms of both income and education; elasticities were generally between 50% and 100% higher for low- than for middle- and high-income individuals. Based on these studies, the model for the lowest and second-lowest income quintiles assigns a prevalence elasticity of –0.60 for both males and females younger than age 18; –0.45 for individuals ages 18 to 24; –0.30 for individuals ages 25 to 34; –0.15 for those ages 35 to 64; and –0.25 for those 65 and older.

U.S. prices (2006–2014) were measured by a retail price index weighted by brand sales, which includes generic cigarettes.[86] The prices were deflated using the Bureau of Labor Statistics' Consumer Price Index,[87] and the deflated prices were adjusted to the first quarter of 2006. From the average state price of a pack of cigarettes of $3.92 in 2006 prices, pack price rose slightly in 2007 and 2008, reaching $4.33, but with the federal tax increase in 2009, the average price increased sharply, to $5.15. Prices continued to rise in 2010 and 2011 but not as sharply as in 2009, reaching $5.60. In 2014, prices were at $6.03.

After adjusting for inflation (with base year 2014), prices increased from $4.60 to $6.03 between 2006 and 2014—a 26% increase. From 2006 to 2014, the average state and federal tax increased from $1.98 to $2.55 per pack, with the largest increases ($0.70 and $0.15) in 2008 and 2009. The model assumes that prices increase in absolute terms with the amount of the cigarette tax after the year 2014, and the non-taxed price increases over time with general price inflation.

Smoke-Free Laws Module

The smoke-free policy module examines the effect of smoking restrictions in three locations: worksites, restaurants, and other public places.[56] The module incorporated an interaction with publicity through the mass media anti-tobacco campaign module. The module takes into account the effect of enforcement, which is measured on a scale of 0–10, where 10 represents complete enforcement. The review in chapter 11 found that most studies obtained larger effects for whites than other racial groups, and Farrelly and colleagues[25] found much smaller effects for people with less education.

Based on the review in chapter 11 and the lower likelihood that low-SES smokers participate in the workforce or frequent restaurants, the effects for low-SES individuals were reduced by 25% compared to the population as a whole. The module predicted that prevalence rates would be 7.5% lower in locations with complete smoking bans that are strongly enforced and publicized through the media than in locations without smoke-free laws. Worksite laws were assumed to have the largest effect, reducing prevalence 4.5%; smoke-free laws in restaurants, pubs, and bars were assumed to produce a 2.25% effect, and laws covering other places each were assumed to have about a 0.75% effect. Partial worksite and restaurant bans were assumed to have one-third the effect of total bans.

Information on smoking bans that distinguish between venues in which they are imposed (private worksites, restaurants, and free-standing bars) was obtained for the years 2006 through 2009.[88] Each location was given a value of 3 if covered by smoke-free restrictions, a value of 2 if separate ventilated areas were required for smokers, 1 if only separate areas were required, or 0 if no smoke-free restrictions were in place. Locations with a value of 3 were given full weight, those with a value of 2 were given 0.5 weight, and those with a value of 1 were give 0.25 weight. The state data were aggregated to the U.S. level weighted by adult population. These data were updated using information from the Americans for Nonsmokers' Rights website: By 2014, smoke-free policies covered 65% of the U.S. population in the workplace, 77.3% of restaurant patrons, and 65.1% of customers in bars.[89]

Mass Media Anti-Tobacco Campaigns Module

The mass media anti-tobacco campaigns policy module[52] was based largely on experiences in California, Massachusetts, and several European nations, where media campaigns are part of a comprehensive policy (including local initiatives and other policies). Mass media campaigns were categorized based on campaign expenditures, a large part of which in most states is devoted to mass media campaigns publicized on TV and radio, and to local grassroots educational efforts. State per capita expenditures include revenues distributed to state health departments from state and federal government agencies such as the CDC, through its National Tobacco Control Program, as well as funding through nongovernmental organizations such as the Truth Initiative (formerly known as the American Legacy Foundation) and the Robert Wood Johnson Foundation, through its SmokeLess States Program. These data were updated with state expenditures data obtained from the Campaign for Tobacco-Free Kids.[90] The expenditure data were divided by yearly population from the Census and by the annual Bureau of Labor Statistics Consumer Price Index[87] so that they would represent inflation-

adjusted per capita measures and thus be comparable over time. States were categorized based on CDC-recommended levels, with <25% being low intensity, 25% to <75% medium intensity, and ≥75% high intensity.

Studies such as those by Al-Delaimy and colleagues[91] and Friedan and colleagues[92] found that these campaigns had greater effects with high-income smokers, but Levy and colleagues[93] found greater effects among females with less than a high school education. Estimates from the previous U.S. *SimSmoke* model were used.[16] Mass media policies directed at all smokers are assumed to yield up to a 6.5% reduction in smoking rates (relative to the initial level) for low-SES smokers, the same as for the entire population.[16]

Marketing Bans Module

The marketing bans policy module in *SimSmoke* corresponds to the bans on advertising, promotion, and sponsorship discussed in the World Health Organization's *Report on the Global Tobacco Epidemic: The MPOWER Package*.[94] This report distinguished four levels of marketing bans: (1) no policy, (2) minimal policy (banning some direct advertising), (3) moderate policy (banning direct advertising and some indirect promotions), and (4) complete policy (a total ban on direct and indirect marketing). The basis for policy effect estimates is described in studies by Levy and colleagues[95] and Blecher.[96] Where a complete policy is in effect (total ban), it is assumed that prevalence is reduced by 6%, cessation is increased by 3%, and initiation is reduced by 8%. With a moderate policy (direct advertising and some indirect promotions are banned), it is assumed that prevalence is reduced by 4%, cessation is increased by 2%, and initiation is reduced by 6%. With a minimal policy, it is assumed that prevalence is reduced by 1%, cessation is not affected, and initiation is reduced by 1%. The *SimSmoke* module also incorporates the effect of enforcement, which is measured on a scale of 0–100%, where 100% represents complete enforcement. The effects are reduced by up to 50% if the enforcement level is zero.

Marketing may be particularly effective among people of low SES, as indicated by evidence presented in National Cancer Institute (NCI) Tobacco Control Monograph 21, *The Economics of Tobacco and Tobacco Control*,[97] that advertising and marketing are targeted to minority groups, and that advertising bans are particularly effective in low- and middle-income countries.

In the United States, cigarette advertising on radio and television has been banned since 1971, but tobacco advertising is still allowed at the point of sale and in newspapers and magazines. Other forms of marketing, such as sponsorships, branding, and mail giveaways, are also still allowed. For the purposes of the marketing module, marketing restrictions are considered moderate, and enforcement is set at level 8.

Health Warnings Module

In the United States, health warnings were first placed on cigarette packs in 1966 as "Caution: Cigarette Smoking May Be Hazardous to Your Health." The current four rotating health warnings on cigarette packages and advertisements were mandated by the Comprehensive Smoking Education Act, enacted in 1984. In this module, health warnings are considered minimal.

The effect of implementing a strong warning that covers at least 50% of the principal display area of the pack and contains graphic images was considered. Evidence on the effects of health warnings on cessation behaviors is provided by Levy and colleagues[95] and has been strengthened by findings from

studies conducted since 2004[98–100] and two studies of Canadian health warnings completed in 2013 and 2014.[101,102] Evidence presented in chapter 11 indicates that health warnings can be as effective for low-income groups as for the rest of the population. With strong health warnings, prevalence is reduced by 4%, cessation is increased by 8%, and initiation is reduced by 4%. When the level is set to moderate, prevalence is reduced by 2%, cessation is increased by 4%, and initiation is reduced by 2%. When the level is minimal, prevalence is reduced by 0.5%, cessation is increased by 1%, and initiation is reduced by 0.5%.

Cessation Treatment Module

The cessation treatment policy module considered the effect of increased access to pharmacotherapies and behavioral therapies through quitlines that are well publicized (e.g., through a media campaign), including those that encourage follow-up with multiple sessions.[103,104] The module allowed for a direct prevalence effect, as well as a continuous effect on future 1-year quit rates. The effect on future 1-year quit rates was halved to reflect the greater use of treatments and effectiveness of interventions in the first year of the program. It was estimated that use of either behavioral therapy or pharmacotherapies alone doubles quit rates, and that their combined use quadruples quit rates. Proactive quitlines with follow-up can double the quit success rate of those making a quit attempt.

A study by Abrams and colleagues[103] indicates that quitlines that are highly publicized and provide free nicotine replacement therapy (NRT) to the qualified smoker attract 4% of smokers in the first year (range: 2% to 6%). Of those who used these quitlines and the free NRT, 30% were new quit attempts. The authors estimated that 50% of those who use treatments as a result of cessation-based policies would not otherwise have made a quit attempt.[103]

Quitline data for 2006 to 2014 obtained from the North American Quitline Consortium's Annual Survey of Quitlines indicated that all states had proactive quitlines with follow-up by 2006. By 2006, 24 states provided free NRT; 40 states were offering free NRT by 2009.[105] The number of states offering quitlines and free NRT has stayed relatively constant since 2009. This module did not consider other aspects of cessation treatment policies, such as financial access outside of quitlines and the role of brief health care provider interventions. Health care provider interventions are surveyed in the TUS-CPS, and information on Medicaid coverage for these interventions is provided in the American Lung Association's 2010 report on cessation coverage in the states.[106]

Youth Access Policies Module

For the minimum legal purchase age of 18, the model considered three levels of enforcement: (1) strongly enforced and publicized, (2) medium enforcement, and (3) weak enforcement. The module also incorporated the role of self-service and vending machine bans. When all policies are in full force, it was estimated a 20% reduction in prevalence and initiation for 16- and 17-year-olds and a 30% reduction for ages 10–15.[107] The review in chapter 11 did not find obvious differences in purchase rates and compliance by race or education. Enforcement and compliance estimates from previous models were used. Based on average compliance rates of about 90%, it was estimated that there has been a medium level of enforcement since 2006. Vending machine and self-service bans are both considered at 90% compliance since 2006.

Calibration Methods

To calibrate the model, predictions of smoking prevalence by age and gender from the model for 2010 and 2011 were compared to corresponding estimates from the 2010-2011 TUS-CPS.[60] Based on this comparison, the first-year cessation rate was adjusted. For those age 55 and older, relapse rates were generally lowered, leading to higher cessation rates and lower smoking prevalence over time. For those under age 55, relapse rates generally increased, yielding higher smoking rates.

Predicted Results of the Recommended Policies Compared With the Status Quo

This section presents estimates of smoking prevalence by income quintile from the TUS-CPS, then estimates the status quo scenario for the two lower income quintiles, and then discusses the differential effects of varying levels of tobacco control policies, in isolation and in combination, as a comprehensive tobacco control strategy.

Smoking Prevalence by Income Quintile

Smoking prevalence rates from the TUS-CPS are shown in Table 12.2 (for 2006-2007) and Table 12.3 (for 2010-2011), by income quintile. Except for the age category 75 to 84, smoking prevalence declined as income increased. For ages 18 and above in 2006-2007, smoking prevalence among males fell from 30.2% for the first income quintile to 10.6% for fifth quintile, and among females, from 22.7% for the first quintile to 8.3% for fifth quintile. For ages 18 and above in 2010-2011, smoking prevalence for males fell from 28.0% for the first income quintile to 8.8% for fifth quintile, and for females, from 20.8% for the first quintile to 6.7% for fifth quintile. The smoking rate declined for all income quintiles between 2006-2007 and 2010-2011—for example, the prevalence rates for males fell from 30.2% to 28.0% in quintile 1, and the rates fell from 10.6% to 8.8% in quintile 5.

Table 12.2 Smoking Prevalence by Age and Income Quintile, TUS-CPS, 2006-2007 (Percentages)

	Income Quintiles – Male					Income Quintiles – Female				
Age Group	1	2	3	4	5	1	2	3	4	5
18–20	24.3	28.0	20.7	13.0	8.8	21.4	13.6	18.6	10.5	5.7
21–24	29.3	23.1	27.5	22.0	11.1	26.2	19.3	16.5	21.6	11.7
25–34	30.7	31.2	24.2	19.0	13.6	28.9	23.7	16.5	13.4	6.9
35–44	41.8	30.6	25.4	15.2	11.5	31.8	22.6	21.8	14.5	8.9
45–54	43.1	31.4	24.8	19.7	11.1	33.5	26.7	22.3	15.8	9.5
55–64	31.4	26.4	21.4	15.8	8.0	24.9	16.9	14.9	12.9	7.6
65–74	23.3	12.5	10.6	7.9	5.0	14.7	10.5	9.0	6.3	2.9
75–84	11.5	7.8	6.9	3.9	10.7	5.2	3.3	4.5	1.7	5.4
85+	2.3	0.1	0.0	0.0	0.0	2.5	3.8	3.1	0.0	0.0
18+	30.2	25.3	22.3	16.7	10.6	22.7	18.4	17.2	13.8	8.3

Note: Quintile 1 is the lowest income group; quintile 5 is the highest.
Source: U.S. Department of Commerce 2008.[59]

Table 12.3 Smoking Prevalence by Age and Income Quintile, TUS-CPS, 2010-2011 (Percentages)

	Male Income Quintile					Female Income Quintile				
Age Group	1	2	3	4	5	1	2	3	4	5
18–20	22.3	15.7	15.6	12.1	9.5	16.5	11.8	10.8	9.5	3.3
21–24	26.1	24.6	22.0	16.0	14.0	21.9	19.4	14.5	10.0	7.7
25–34	32.2	26.1	19.5	17.3	12.0	26.1	21.2	15.2	10.4	6.8
35–44	32.9	25.2	20.4	13.9	7.5	27.0	21.2	15.0	11.1	6.1
45–54	38.1	27.7	22.5	15.1	9.0	31.3	24.0	19.2	13.7	8.5
55–64	30.7	24.1	18.6	13.0	8.5	22.6	19.1	13.3	9.3	6.2
65–74	19.3	12.3	10.2	10.0	5.0	14.8	10.1	7.5	7.0	4.5
75–84	7.4	6.6	4.9	2.6	4.5	6.0	4.4	4.0	2.4	4.2
85+	3.3	2.3	1.7	0.0	1.1	1.7	2.6	1.9	1.6	0.6
18+	28.0	21.8	18.1	14.0	8.8	20.8	17.1	13.7	10.5	6.7

Note: Quintile 1 is the lowest income group; quintile 5 is the highest.
Source: U.S. Department of Commerce 2012.[60]

The Status Quo Scenario

The model begins with the policy levels in effect in 2006 as the baseline. Changes in policy through 2014 were entered into the model. The status quo scenario maintains policies at the 2014 level through 2064. Data presented for years after 2006 are predictions. Table 12.4 shows results for the status quo scenario by gender, income quintile, and age group.

Table 12.4 Smoking Prevalence by Income Quintile (Lowest and Second-Lowest) and by Age, Sex, and Year, as Predicted by *SimSmoke's* Status Quo Scenario (Percentages)

	Lowest Income Quintile					2nd Lowest Income Quintile				
Age Group	2006	2011*	2015*	2045*	2064*	2006	2011*	2015*	2045*	2064*
Males										
18–24	26.4	22.7	22.3	22.1	22.0	23.2	19.7	19.7	19.6	19.6
25–44	36.7	28.2	24.4	20.9	20.8	30.9	24.6	22.0	18.1	18.1
45–64	36.8	32.2	30.9	14.5	14.4	28.5	24.1	21.8	10.6	9.9
65+	17.6	15.9	15.4	8.5	5.3	10.4	10.9	11.5	5.8	3.5
18+	30.5	25.7	23.6	16.9	15.9	24.6	20.7	19.1	13.2	11.7
Females										
18–24	21.7	18.8	18.5	18.3	18.2	18.4	15.7	15.6	15.5	15.5
25–44	30.5	23.6	20.8	18.0	17.8	23.2	19.3	17.5	14.2	14.2
45–64	28.6	25.6	24.4	12.0	11.8	21.2	20.6	20.8	12.0	11.5
65+	9.8	9.7	10.2	6.9	4.7	7.0	8.0	9.%	8.9	6.0
18+	22.5	19.5	18.3	14.1	13.3	17.6	16.2	15.8	12.5	11.2

*Predicted smoking prevalence using the *SimSmoke* model.

For the lowest income quintile in 2006, smoking prevalence for males age 18 and over was 30.5%. Predicted prevalence declined slowly in subsequent years: to 25.7% in 2011, 23.6% in 2015, 16.9% in 2045, and 15.9% in 2064. For the second-lowest income quintile model, adult male smoking prevalence was at 24.6% in 2006, with predictions falling to 20.7% in 2011, 19.1% in 2015, 13.2% in 2045, and 11.7% in 2064. Smoking prevalence among women age 18 and over in the lowest quintile model also decreased gradually over these years: 22.5% in 2006 and predicted to be 19.5% in 2011, 18.3% in 2015, 14.1% in 2045, and 13.3% in 2064. Smoking prevalence for women in the second-lowest quintile model was 17.6% in 2006, then predicted to be 16.2% in 2011, 15.8% in 2015, 12.5% in 2045, and 11.2% in 2064. The model predicted a slow downward trend in the absence of policy change, as reflected in 2006 prevalence, initiation, and cessation rates. Fluctuations from that trend are due to policy changes, primarily explained by increases in cigarette prices between 2006 and 2014 and the implementation of additional smoke-free laws.

Table 12.4 shows that by 2011, smoking prevalence rates also declined for most age groups, except for women in the 65-and-older age group in both income quintiles, and men ages 65 and older in the second-lowest income quintiles. The 45–64 age group showed the largest declines, followed by the 25–44 group and the 18–24 group. Among adults ages 45–64, the 2006 prevalence for males was 36.8% for the first income quintile and 28.5% for the second, and for females, 28.6% for the first income quintile and 21.2% for the second. The larger declines in the 25–44 and 45–64 age groups may reflect a need to further calibrate the model once data are available for later years. This calibration will allow for initiation in later age groups and lower cessation rates at the younger ages.

Smoking-attributable deaths predicted for age 18 and older according to *SimSmoke's* status quo scenario are shown in Table 12.5. With the policies implemented and maintained in future years, smoking-attributable deaths predicted for the lowest income quintile in 2006 were 74,778 among men and 38,916 among women, or 113,694 combined. In 2011, estimated smoking-attributable deaths in this income quintile increased to 78,190 for men and 40,233 for women, or 118,423 combined. In 2015 these estimates rose again, to 78,181 deaths among men and 40,970 deaths among women (119,151 combined); the number of deaths declined by 2064 to 38,492 deaths (men), 23,716 (women), and 62,208 (combined). For the years 2015 through 2064, a total of 4,382,226 premature deaths were predicted.

For the second-lowest quintile, the status quo model predicted 54,400 smoking-attributable deaths among males and 33,159 smoking-attributable deaths among females (87,559 combined) in 2006, and predictions increased in 2011 to 59,119 deaths among males and 33,802 deaths among females (92,921 combined). The number of deaths was predicted to increase again in 2015, to 60,867 among males and 35,499 among females (96,366 combined), then decline in 2064 to 29,573 deaths among males and 24,822 deaths among females (54,395 combined). For the years 2015 through 2064, a total of 3,842,548 premature deaths were predicted. The lower number of deaths in the second income quintile reflects lower smoking rates at that income level. The increase in smoking-attributable deaths over time reflects the aging of the large number of former smokers as well as general population growth.

Table 12.5 Smoking-Attributable Deaths by Income Quintile (Lowest and Second-Lowest) and by Sex and Year, as Estimated by *SimSmoke's* Status Quo Scenario

Quintile and Sex	2006	2011*	2015*	2025*	2045*	2064*	2015–2064*
Lowest income quintile							
Men	74,778	78,190	78,181	70,661	45,867	38,492	2,746,847
Women	38,916	40,233	40,970	40,619	28,804	23,716	1,635,379
Total	113,694	118,423	119,151	111,280	74,671	62,208	4,382,226
Second-lowest income quintile							
Men	54,400	59,119	60,867	57,500	37,065	29,573	2,215,841
Women	33,159	33,802	35,499	38,129	30,658	24,822	1,626,707
Total	87,559	92,921	96,366	95,629	67,723	54,395	3,842,548

*Predicted smoking prevalence using the *SimSmoke* model.

Stronger Policy Scenarios

Next, the effect of strengthening current policies, both individually and in combination, was considered. These stronger policies—which might be viewed as the desired set of policies, similar to those recommended in the Healthy People 2010 objectives[37]—included:

- Tax increases of $1.00, $2.00, and $3.00 per pack, with the assumption that these taxes are indexed to inflation so that their value is maintained over time
- Extending coverage of smoke-free laws to cover worksites, restaurants, and bars in all 50 states, with high compliance
- Increasing mass media anti-tobacco campaign expenditures to a high intensity level in all states from their average current medium-high intensity level
- Increasing restrictions from current advertising on TV and radio, to include newspapers, point of sale, sponsorship, branding, and mail giveaways, with stronger enforcement; and implementing strong graphic health warnings
- Implementing a well-publicized cessation policy involving multi-session quitlines and free NRT
- Strengthening youth access policies to a high level of enforcement.

The incremental effects of these stronger policies (referred to below as *SimSmoke*-Recommended Policies) depend on the level of policies in effect in 2014. The effects of policies are presented relative to the status quo level for smoking prevalence in the same year (**t**), that is:

$$[\text{Policy rate}_t - \text{status quo rate}_t]/\text{status quo rate}_t$$

and in terms of lives saved:

$$[\text{Deaths in status quo}_t - \text{Deaths with policies in place}_t]$$

for smoking-attributable deaths.

The comprehensive best-case strategy includes the predicted simultaneous implementation (in the year 2015) of each of the above policies together with a tax increase of $1.00, $2.00, or $3.00 per pack.

New, more rigorous policies were modeled as if implemented and maintained from 2015 through 2064. The predicted effects on male and female smoking prevalence are shown in Tables 12.6 and 12.7 for the lowest quintile, and in Tables 12.8 and 12.9 for the second-lowest quintile. The effects of these policies on smoking-attributable deaths among both genders are shown in Table 12.10 for the first income quintile and Table 12.11 for the second income quintile. These tables reveal the effects of tax increases, universal adoption of smoke-free laws, enhanced mass media anti-tobacco campaigns, marketing restrictions, health warnings, cessation treatment policies, and youth access policies. Each tobacco control policy and data from Tables 12.6 to 12.11 are discussed in the subsections below.

Cigarette Taxes

Of the tobacco control policies, *SimSmoke* attributes the most pronounced effect on smoking prevalence trends between 1993 and 2003 to tax increases.[95] NCI Tobacco Control Monograph 21 concluded that "significantly increasing the excise tax and price of tobacco products is the single most consistently effective tool for reducing tobacco use."[97,p.151] However, the same absolute increase in taxes or price had a smaller effect in 2009 than in earlier years because prices were higher in 2009, and the same increases were smaller in relative terms. In both the lowest and second-lowest income quintile models, a $1.00/pack increase in the 2015 average tax rate was projected to result in a relative decline of about 3.5% in smoking prevalence for both men and women compared to the status quo tax rate in that year. By 2064, the tax rate increase is projected to lead to a much larger decline, about 8.2% in both income quintiles, compared to the status quo rate. In both the lowest and second-lowest income quintile models, an increase of $2.00 in the average tax rate is projected to result in a relative reduction of about 6.5% in both men's and women's smoking prevalence in 2015 compared to the status quo. By 2064, this increased rate is projected to lead to a reduction in prevalence of between 14.4% and 14.8% in males and females relative to the status quo. In 2015 in both the lowest and second-lowest income quintile models, an increase of $3.00 in the average tax rate was projected to result in about a 9.0% relative reduction in smoking prevalence for both men and women compared to the status quo. By 2064, smoking prevalence under the recommended policy scenario is projected to decrease to about 19.6% of the status quo smoking prevalence.

The largest effect of the price increases is seen among young people, particularly those younger than 18 years old. Price increases have a greater effect over time primarily because young people are more responsive to price increases than adults, and as those young people grow older, fewer of them smoke. As noted, the *SimSmoke* model assumes that taxes increase with the rate of inflation over time, but some of the effect of tax increases on smoking prevalence dissipates over time if the per-unit taxes are not indexed to inflation.[55]

Table 12.6 Comparison of Status Quo Policies With *SimSmoke*-Recommended Policies: Smoking Prevalence and Percentage Change Among Men Ages 18 to 85, Lowest Income Quintile (Percentages)

Policies and Effects	2014	2015*	2025*	2045*	2064*
Status quo policies – smoking prevalence	24.0	23.6	20.1	16.9	15.9
Recommended policies – independent effects on smoking prevalence					
1. Tax increases (per pack)					
By $1.00	24.0	22.8	19.1	15.7	14.6
By $2.00	24.0	22.1	18.3	14.7	13.6
By $3.00	24.0	21.5	17.7	13.9	12.8
2. Comprehensive, well-enforced smoke-free laws	24.0	23.1	19.6	16.5	15.5
3. High-intensity mass media anti-tobacco campaigns	24.0	23.0	19.3	16.0	15.0
4. Comprehensive, well-enforced marketing bans	24.0	22.8	19.3	16.1	15.1
5. Strong health warnings	24.0	22.8	19.1	16.0	15.0
6. Cessation treatment policies	24.0	23.3	19.4	16.2	15.3
7. Strong youth access enforcement	24.0	23.6	19.9	16.3	15.2
Combined policy effects on prevalence					
2–7 above, plus $1.00 tax increase	24.0	19.3	14.8	11.4	10.4
2–7 above, plus $2.00 tax increase	24.0	18.8	14.2	10.7	9.7
2–7 above, plus $3.00 tax increase	24.0	18.3	13.7	10.1	9.1
% Change in smoking prevalence with recommended policies vs. status quo					
Independent policy effects					
1. Tax increases					
By $1.00	0.0	–3.5	–4.9	–7.3	–8.2
By $2.00	0.0	–6.5	–8.9	–13.0	–14.5
By $3.00	0.0	–8.9	–12.1	–17.7	–19.6
2. Comprehensive, well-enforced smoke-free laws	0.0	–1.9	–2.3	–2.6	–2.6
3. High-intensity mass media anti-tobacco campaigns	0.0	–2.5	–3.9	–4.4	–4.4
4. Comprehensive, well-enforced marketing bans	0.0	–3.4	–3.9	–4.8	–5.1
5. Strong health warnings	0.0	–3.5	–4.8	–5.5	–5.7
6. Cessation treatment policies	0.0	–1.1	–3.5	–4.0	–3.9
7. Strong youth access enforcement	0.0	0.0	–1.1	–3.4	–4.7
% Change – combined policy effects					
2–7 above, plus $1.00 tax increase	0.0	–18.0	–26.3	–32.6	–34.4
2–7 above, plus $2.00 tax increase	0.0	–20.5	–29.5	–36.9	–39.0
2–7 above, plus $3.00 tax increase	0.0	–22.6	–32.1	–40.4	–42.8

*Predicted smoking prevalence or percentage change using the *SimSmoke* model.

Table 12.7 Comparison of Status Quo Policies With *SimSmoke*-Recommended Policies: Smoking Prevalence and Percentage Change Among Women Ages 18 to 85, Lowest Income Quintile (Percentages)

Policies and Effects	2014	2015*	2025*	2045*	2064*
Status quo policies – smoking prevalence	18.5	18.3	16.0	14.1	13.3
Recommended policies – independent effects on smoking prevalence					
1. Tax increases (per pack)					
By $1.00	18.5	17.6	15.2	13.1	12.2
By $2.00	18.5	17.1	14.5	12.3	11.4
By $3.00	18.5	16.6	14.0	11.6	10.7
2. Comprehensive, well-enforced smoke-free laws	18.5	17.9	15.6	13.7	12.9
3. High-intensity mass media anti-tobacco campaigns	18.5	17.8	15.3	13.4	12.7
4. Comprehensive, well-enforced marketing bans	18.5	17.6	15.3	13.4	12.6
5. Strong health warnings	18.5	17.6	15.2	13.3	12.5
6. Cessation treatment policies	18.5	18.1	15.3	13.4	12.7
7. Strong youth access enforcement	18.5	18.3	15.8	13.7	12.8
Combined policy effects on prevalence					
2–7 above, plus $1.00 tax increase	18.5	15.0	11.6	9.4	8.6
2–7 above, plus $2.00 tax increase	18.5	14.5	11.1	8.8	8.0
2–7 above, plus $3.00 tax increase	18.5	14.1	10.7	8.3	7.5
% Change in smoking prevalence with recommended policies vs. status quo					
Independent policy effects					
1. Tax increases (per pack)					
By $1.00	0.0	–3.6	–5.0	–7.3	–8.1
By $2.00	0.0	–6.5	–9.1	–13.0	–14.4
By $3.00	0.0	–9.0	–12.4	–17.6	–19.5
2. Comprehensive, well-enforced smoke-free laws	0.0	–1.9	–2.3	–2.6	–2.8
3. High-intensity mass media anti-tobacco campaigns	0.0	–2.5	–4.1	–4.8	–4.9
4. Comprehensive, well-enforced marketing bans	0.0	–3.4	–4.0	–4.9	–5.2
5. Strong health warnings	0.0	–3.5	–5.0	–5.8	–6.1
6. Cessation treatment policies	0.9	–1.1	–3.9	–4.7	–4.8
7. Strong youth access enforcement	0.0	0.0	–1.1	–3.1	–4.1
% Change – combined policy effects					
2–7 above, plus $1.00 tax increase	0.0	–18.0	–27.4	–33.4	–35.5
2–7 above, plus $2.00 tax increase	0.0	–20.5	–30.6	–37.7	–40.1
2–7 above, plus $3.00 tax increase	0.0	–22.6	–33.3	–41.1	–43.7

*Predicted smoking prevalence or percentage change using the *SimSmoke* model.

Table 12.8 Comparison of Status Quo Policies With *SimSmoke*-Recommended Policies: Smoking Prevalence and Percentage Change Among Men Ages 18 to 85, Second-Lowest Income Quintile (Percentages)

Policies and Effects	2014	2015*	2025*	2045*	2064*
Status quo policies – smoking prevalence	19.4	19.1	16.3	13.2	11.7
Recommended policies – independent effects on smoking prevalence					
1. Tax increases (per pack)					
By $1.00	19.4	18.4	15.5	12.2	10.8
By $2.00	19.4	17.8	14.8	11.4	10.0
By $3.00	19.4	17.4	14.2	10.8	9.4
2. Comprehensive, well-enforced smoke-free laws	19.4	18.7	15.9	12.8	11.4
3. High-intensity mass media anti-tobacco campaigns	19.4	18.6	15.7	12.6	11.2
4. Comprehensive, well-enforced marketing bans	19.4	18.5	15.7	12.5	11.1
5. Strong health warnings	19.4	18.5	15.5	12.4	11.0
6. Cessation treatment policies	19.4	19.0	15.9	12.7	11.3
7. Strong youth access enforcement	19.4	19.1	16.2	12.9	11.4
Combined policy effects on prevalence					
2–7 above, plus $1.00 tax increase	19.4	15.7	12.1	8.9	7.7
2–7 above, plus $2.00 tax increase	19.4	15.2	11.6	8.4	7.1
2–7 above, plus $3.00 tax increase	19.4	14.8	11.1	7.9	6.7
% Change in smoking prevalence with recommended policies vs. status quo					
Independent policy effects					
1. Tax increases (per pack)					
By $1.00	0.0	–3.6	–5.3	–7.4	–8.3
By $2.00	0.0	–6.7	–9.5	–13.2	–14.8
By $3.00	0.0	–9.2	–12.9	–17.9	–20.0
2. Comprehensive, well-enforced smoke-free laws	0.0	–1.9	–2.3	–2.8	–2.9
3. High-intensity mass media anti-tobacco campaigns	0.0	–2.6	–3.8	–4.5	–4.7
4. Comprehensive, well-enforced marketing bans	0.0	–3.4	–4.0	–5.0	–5.4
5. Strong health warnings	0.0	–3.5	–5.1	–6.2	–6.6
6. Cessation treatment policies	0.0	–0.7	–2.7	–3.7	–3.9
7. Strong youth access enforcement	0.0	0.0	–1.0	–2.3	–3.1
% Change – combined policy effects					
2–7 above, plus $1.00 tax increase	0.0	–17.7	–25.8	–32.3	–34.6
2–7 above, plus $2.00 tax increase	0.0	–20.3	–29.2	–36.7	–39.3
2–7 above, plus $3.00 tax increase	0.0	–22.5	–32.0	–40.2	–43.1

*Predicted smoking prevalence and percentage change using the *SimSmoke* model.

Table 12.9 Comparison of Status Quo Policies With *SimSmoke*-Recommended Policies: Smoking Prevalence and Percentage Change Among Women Ages 18 to 85, Second-Lowest Income Quintile (Percentages)

Policies and Effects	2014	2015*	2025*	2045*	2064*
Status quo policies	15.8	15.8	14.7	12.5	11.2
Recommended policies – independent effects on smoking prevalence					
1. Tax increases (per pack)					
By $1.00	15.8	15.2	14.0	11.6	10.3
By $2.00	15.8	14.8	13.4	11.0	9.6
By $3.00	15.8	14.4	13.0	10.4	9.0
2. Comprehensive, well-enforced smoke-free laws	15.8	15.5	14.3	12.2	10.9
3. High-intensity mass media anti-tobacco campaigns	15.8	15.4	14.2	12.0	10.8
4. Comprehensive, well-enforced marketing bans	15.8	15.2	14.1	11.9	10.7
5. Strong health warnings	15.8	15.2	14.0	11.8	10.6
6. Cessation treatment policies	15.8	15.7	14.4	12.1	10.9
7. Strong youth access enforcement	15.8	15.8	14.5	12.1	10.8
Combined policy effects on prevalence					
2–7 above, plus $1.00 tax increase	15.8	13.0	11.3	8.8	7.5
2–7 above, plus $2.00 tax increase	15.8	12.6	10.8	8.3	7.0
2–7 above, plus $3.00 tax increase	15.8	12.3	10.4	7.9	6.6
% Change in smoking prevalence with recommended policies vs. status quo					
Independent policy effects					
1. Tax increases (per pack)					
By $1.00	0.0	–3.5	–4.6	–6.8	–8.1
By $2.00	0.0	–6.4	–8.4	–12.1	–14.4
By $3.00	0.0	–8.8	–11.5	–16.5	–19.4
2. Comprehensive, well-enforced smoke-free laws	0.0	–1.9	–2.2	–2.5	–2.7
3. High-intensity mass media anti-tobacco campaigns	0.0	–2.6	–3.3	–3.9	–4.1
4. Comprehensive, well-enforced marketing bans	0.0	–3.4	–3.8	–4.6	–5.1
5. Strong health warnings	0.0	–3.5	–4.5	–5.4	–5.8
6. Cessation treatment policies	0.0	–0.7	–2.1	–2.7	–3.0
7. Strong youth access enforcement	0.0	0.0	–1.4	–3.2	–3.6
% Change – combined policy effects					
2–7 above, plus $1.00 tax increase	0.0	–17.6	–23.2	–29.4	–32.8
2–7 above, plus $2.00 tax increase	0.0	–20.1	–26.2	–33.5	–37.5
2–7 above, plus $3.00 tax increase	0.0	–22.2	–28.8	–36.9	–41.3

*Predicted smoking prevalence and percentage change using the *SimSmoke* model.

Table 12.10 Smoking-Attributable Deaths, from *SimSmoke* Model, Lowest Income Quintile

Policies and Effects	2014	2015*	2025*	2045*	2064*	2015–2064*
Status quo policies	119,526	119,151	111,280	74,671	62,207	4,382,226
Independent policy effects						
1. Tax increases (per pack)						
By $1.00	119,526	119,151	110,115	72,235	58,411	4,270,483
By $2.00	119,526	119,151	109,161	70,273	55,421	4,180,505
By $3.00	119,526	119,151	108,366	68,657	53,066	4,106,466
2. Comprehensive, well-enforced smoke-free laws	119,526	119,151	110,512	73,220	60,674	4,320,096
3. High-intensity mass media anti-tobacco campaigns	119,526	119,151	109,881	71,678	59,040	4,261,227
4. Comprehensive, well-enforced marketing bans	119,526	119,151	110,037	72,366	59,613	4,281,115
5. Strong health warnings	119,526	119,151	109,620	71,281	58,579	4,241,867
6. Cessation treatment policies	119,526	119,151	109,878	71,193	58,523	4,250,476
7. Strong youth access enforcement	119,526	119,151	111,280	74,467	61,152	4,369,917
Combined policy effects						
2–7 above, plus $1.00 tax increase	119,526	119,151	102,837	57,572	42,793	3,663,201
2–7 above, plus $2.00 tax increase	119,526	119,151	102,055	56,066	40,662	3,593,766
2–7 above, plus $3.00 tax increase	119,526	119,151	101,405	54,831	38,950	3,536,825
Attributable deaths with the status quo policies minus attributable deaths with recommended policies						
Independent policy effects						
1. Tax increases (per pack)						
By $1.00	—	—	1,166	2,436	3,797	111,743
By $2.00	—	—	2,120	4,399	6,786	201,721
By $3.00	—	—	2,915	6,015	9,201	275,760
2. Comprehensive, well-enforced smoke-free laws	—	—	768	1,451	1,534	62,130
3. High-intensity mass media anti-tobacco campaigns	—	—	1,400	2,993	3,167	120,999
4. Comprehensive, well-enforced marketing bans	—	—	1,244	2,305	2,595	101,111
5. Strong health warnings	—	—	1,660	3,391	3,629	140,359
6. Cessation treatment policies	—	—	1,402	3,479	3,685	131,750
7. Strong youth access enforcement	—	—	—	204	1,055	12,310
Combined policy effects						
2–7 above, plus $1.00 tax increase	—	—	8,444	17,100	19,414	719,025
2–7 above, plus $2.00 tax increase	—	—	9,223	18,606	21,545	788,461
2–7 above, plus $3.00 tax increase	—	—	9,875	19,840	23,258	845,401

*Predicted smoking-attributable deaths using the *SimSmoke* model.

Table 12.11 Smoking-Attributable Deaths, from *SimSmoke* Model, Second-Lowest Quintile

Policies and Effects	2014	2015*	2025*	2045*	2064*	2015–2064*
Status quo policies	95,986	96,366	95,629	67,723	54,395	3,842,548
Independent policy effects						
1. Tax increases (per pack)						
By $1.00	95,986	96,366	94,694	65,560	51,124	3,745,356
By $2.00	95,986	96,366	93,929	63,817	48,551	3,667,859
By $3.00	95,986	96,366	93,291	62,381	46,473	3,603,789
2. Comprehensive, well-enforced smoke-free laws	95,986	96,366	95,008	66,466	53,064	3,789,373
3. High-intensity mass media anti-tobacco campaigns	95,986	96,366	94,607	65,498	52,018	3,751,328
4. Comprehensive, well-enforced marketing bans	95,986	96,366	94,621	65,707	52,152	3,755,695
5. Strong health warnings	95,986	96,366	94,294	64,832	51,243	3,723,103
6. Cessation treatment policies	95,986	96,366	94,882	65,787	52,204	3,767,696
7. Strong youth access enforcement	95,986	96,366	95,629	67,574	53,680	3,833,878
Combined policy effects						
2–7 above, plus $1.00 tax increase	95,986	96,366	89,353	54,284	39,023	3,277,993
2–7 above, plus $2.00 tax increase	95,986	96,366	88,715	52,900	37,120	3,216,322
2–7 above, plus $3.00 tax increase	95,986	96,366	88,184	51,765	35,588	3,165,727
Attributable deaths with the status quo policies minus attributable deaths with recommended policies						
Independent policy effects						
1. Tax increases (per pack)						
By $1.00	—	—	935	2,163	3,270	96,792
By $2.00	—	—	1,700	3,907	5,844	174,689
By $3.00	—	—	2,339	5,342	7,922	238,759
2. Comprehensive, well-enforced smoke-free laws	—	—	621	1,257	1,331	53,175
3. High-intensity mass media anti-tobacco campaigns	—	—	1,022	2,225	2,377	91,220
4. Comprehensive, well-enforced marketing bans	—	—	1,008	2,017	2,243	86,853
5. Strong health warnings	—	—	1,335	2,891	3,151	119,445
6. Cessation treatment policies	—	—	747	1,936	2,190	74,852
7. Strong youth access enforcement	—	—	—	150	714	8,670
Combined policy effects						
2–7 above, plus $1.00 tax increase	—	—	6,276	13,439	15,371	564,555
2–7 above, plus $2.00 tax increase	—	—	6,975	14,823	17,275	626,226
2–7 above, plus $3.00 tax increase	—	—	7,445	15,959	18,806	676,821

*Predicted smoking-attributable deaths using the *SimSmoke* model.

In terms of lives saved, it is projected that in 2064, a $1.00 tax increase would avert 3,797 smoking-attributable deaths of men and women in the lowest income quintile and 3,270 deaths in the second-lowest quintile. A $1.00 tax increase in effect until 2064 would have averted a cumulative total of 111,743 smoking-attributable deaths in the lowest income quintile, and 96,792 deaths in the second-lowest quintile. A $2.00 tax increase is projected to avert 6,786 smoking-attributable deaths in 2064 in the lowest income quintile, and 5,844 deaths in the second-lowest quintile. Cumulatively, it is projected that 201,721 smoking-attributable deaths would be averted between 2015 and 2064 in the lowest income quintile, and 174,689 deaths in the second-lowest quintile with a $2.00 tax increase. A $3.00 tax increase would avert 9,201 smoking-attributable deaths in 2064 in the lowest income quintile, and 7,922 deaths in the second-lowest quintile. Over the 50-year period from 2015 to 2064, the model predicts that a $3.00 tax would avert a total of 275,760 smoking-attributable deaths in the lowest income quintile, and 238,759 deaths in the second-lowest quintile. These effects grow over time because individuals tend to reap the benefits of quitting smoking 2–10 years after quitting. In addition, those who are prevented from beginning to smoke between the ages of 10 and 24 also avoid smoking-attributable deaths, which generally occur at ages 35 and older.

Smoke-Free Laws

SimSmoke data support the conclusion that public health would be considerably improved if all states enacted and strongly enforced comprehensive laws that ban smoking in worksites, bars, restaurants, and other public places. These recommended measures are predicted to reduce male and female smoking prevalence in both the lowest and second-lowest income quintiles by 1.9% in 2015 relative to the status quo scenario. By 2045, smoking prevalence declines for men and women in the lowest income quintiles by 2.6%; in the second-lowest quintile it declines by 2.8% for men and 2.5% for women. By 2064, in the lowest income quintile smoking prevalence decreases by 2.6% for men and 2.8% for women; in the second-lowest quintile smoking prevalence by 2.9% for men and 2.7% for women. By 2064, comprehensive smoke-free laws would avert 1,534 smoking-attributable deaths (male and female) in the lowest income quintile and 1,331 deaths in the second-lowest quintile. From 2015 to 2064, comprehensive smoke-free laws would avert a total of 62,130 smoking-attributable deaths in the lowest income quintile and a total of 53,175 deaths in the second-lowest quintile.

Mass Media Anti-Tobacco Campaigns

A high-intensity mass media anti-tobacco campaign implemented in 2015 was projected to lead to a decline of 2.5% in adult smoking prevalence in the lowest income quintile compared to the status quo, and a 2.6% decline in the second-lowest income quintile. By 2064 the relative effect would increase to 4.4% among men and 4.9% among women, both in the lowest quintile, and to 4.7% among men and 4.1% among women in the second-lowest quintile. The model projects that in 2064, a strong campaign directed at all smokers would avert 3,167 smoking-attributable deaths in the lowest income quintile and 2,377 deaths in the second-lowest quintile. Between 2015 and 2064, the enhanced anti-tobacco media campaign would avert a total of 120,999 smoking-attributable deaths in the lowest income quintile and 91,220 deaths in the second-lowest quintile.

Marketing Restrictions

Strongly enforced restriction of both direct and indirect marketing is predicted to lead male and female smoking prevalence to decline 3.4% in 2015 for the lowest and second-lowest income quintiles, compared to status quo policies. By 2064, prevalence would decline by around 5.2% (in the lowest

quintile, 5.1% for men and 5.2% for women; in the second-lowest quintile, 5.4% for men and 5.1% for women). Strong marketing restrictions are estimated to avert 2,595 smoking-attributable deaths in 2064 in the lowest quintile, and 2,243 deaths in the second-lowest quintile. Over the 50-year period from 2015 to 2064, a total of 101,111 smoking-attributable deaths would be averted in the lowest income quintile and 86,853 deaths would be averted in the second-lowest quintile with well-enforced marketing restrictions.

Health Warnings

In 2015, a stronger health warning policy was predicted to reduce smoking prevalence by 3.5% among men and women in the lowest and second-lowest income quintiles relative to the status quo. By 2064 the stronger policy is projected to reduce smoking by a higher percentage compared to the status quo policy: in the lowest quintile, by 5.7% among men and 6.1% among women; in the second-lowest quintile, by 6.6% among men and 5.8% among women. It is projected that in 2064, a strong health warning policy would avert a total of 3,629 smoking-attributable deaths in the lowest quintile, and 3,151 deaths in the second-lowest quintile. The cumulative total number of smoking-attributable deaths averted by a strong health warning policy in the years 2015 through 2064 would be 140,359 in the lowest income quintile and 119,445 in the second-lowest quintile.

Cessation Treatment Policies

A policy requiring well-publicized, multi-session quitlines with free NRT would have relatively small effects in the earlier years of the projection compared to other policies, but over time would lead to higher rates of cessation, which reflects the tendency of people older than 24 to quit smoking at higher rates than younger people.[54] In 2015, enhanced cessation policies were projected to reduce smoking prevalence by 1.1% for men and women in the lowest income quintile compared to the status quo scenario, and by 0.7% for men and women in the second-lowest quintile. In 2064 these policies are expected to result in the following changes: in the lowest income quintile, a 3.9% relative reduction in prevalence rates among men and a 4.8% relative reduction among women; in the second-lowest quintile, these policies are expected to lead to a 3.9% relative reduction in men and a 3.0% reduction in women. It is projected that in 2064, a stronger cessation policy would avert a total of 3,685 smoking-attributable deaths in the lowest income quintile and 2,190 deaths in the second-lowest quintile. During the years 2015 through 2064 the comprehensive cessation policy is expected to avert a cumulative total of 131,750 smoking-attributable deaths in the lowest income quintile and 74,852 in the second-lowest quintile compared to the status quo policy. These effects are relatively small because the model takes into account that about 80% of states already provide free NRT, and 100% have active quitlines with follow-up.[105]

Youth Access

Strong enforcement of youth access policies is estimated to have no immediate effect on reducing smoking prevalence for men and women in the lowest and second-lowest income quintiles in 2015, since it is directed at youth, who make up a small percentage of the population; however, a stronger effect is predicted in later years. In 2064, stricter enforcement of youth access policies is projected to reduce smoking prevalence in comparison with status quo policies as follows: in the lowest quintile, by 4.7% among men and 4.1% among women; in the second-lowest quintile, by 3.1% among men and 4.0% among women. In 2064, strong enforcement of youth access is projected to prevent a total of 1,055 smoking-attributable deaths in the lowest income quintile and 714 deaths in the second-lowest income

quintile. During the years 2015 through 2064, it is estimated that a total of 12,310 smoking-attributable deaths would be averted in the lowest quintile and 8,670 in the second-lowest quintile.

Best-Case Scenario: A Comprehensive Set of Policies

Lastly, the combination of the individual policies described in previous sections—comprehensive smoke-free laws, a high-intensity mass media anti-tobacco campaign, enhanced marketing restrictions, strong health warnings, and strengthened cessation and youth access policies—with varying increases in cigarette taxes were considered. For 2015, these policies, combined with a tax increase of $1.00 per pack, would lead smoking prevalence among both men and women to decline to about 18.0% below what status quo policies would produce for the lowest income quintile and to decline by about 17.7% among men and 17.6% among women for the second-lowest quintile. Maintaining this set of policies is estimated to reduce the smoking rate in 2064 by 34.4% among men and 35.5% among women in the lowest income quintile relative to the status quo, and by 34.6% among men and 32.8% among women in the second-lowest quintile.

Similarly, a tax increase of $2.00 per pack in combination with the other policies was projected to reduce the smoking rate in 2015 by about 20.5% in men and women in the lowest income quintile, and by 20.3% in men and 20.1% in women in the second-lowest quintile, compared to the status quo. In 2064 this combination is projected to reduce the smoking rate by 39.0% among men and 40.1% among women in the lowest income quintile compared to the status quo, and by 39.3% among men and 37.5% among women in the second-lowest quintile. Increasing taxes by $3.00 per pack in combination with the other policies was projected to reduce the smoking rate in 2015 by 22.6% for men and women in the lowest income quintile, and by 22.5% for men and 22.2% for women in the second-lowest quintile. In 2064 this policy is projected to reduce the smoking rate by 42.8% among men and 43.7% among women in the lowest income quintile relative to the status quo, and by 43.1% among men and 41.3% among women in the second-lowest quintile.

In terms of smoking-attributable deaths averted, a comprehensive policy with a $1.00 per pack tax increase is projected to avert 19,414 deaths in the lowest income quintile and 15,371 deaths in the second-lowest quintile in the year 2064. The model projects that these combined policies will avert 719,025 smoking-attributable deaths between 2015 and 2064 for the lowest quintile and 564,555 for the second-lowest quintile. In 2064, a $2.00 tax increase combined with the other policies would prevent an estimated 21,545 smoking-attributable deaths in the lowest quintile and 17,275 deaths in the second-lowest quintile. Over the years 2015 through 2064 these policies are projected to avert 788,461 deaths in the lowest income quintile and 626,226 lives in the second-lowest quintile. A comprehensive policy that includes a $3.00 tax increase is projected in 2064 to prevent 23,258 smoking-attributable deaths in the lowest quintile, 18,806 deaths in the second-lowest quintile, and a cumulative total between 2015 and 2064 of 845,401 deaths in the lowest quintile and 676,821 deaths in the second-lowest quintile.

Of the seven policies in the comprehensive package, tax increases have the greatest effects overall in reducing smoking prevalence and smoking-attributable deaths. Some policies, such as cessation treatment programs, have a larger impact on adult smoking than on youth smoking. Others, such as taxes, have a greater effect on youth smoking prevalence than on adult smoking prevalence (especially those ages 35–64).

Conclusions

In 2006, smoking prevalence in the lowest income quintile was 30.2% for men and 22.7% for women, with rates for people ages 25 to 64 averaging 36.8% for men and 29.8% for women. Rates in the second-lowest income quintile were also high—25.3% for men and 18.4% for women, while rates for people ages 25 to 64 averaged 29.9% for men and 22.5% for women. Smoking prevalence was thus considerably higher in these income quintiles than the average for the population as a whole in 2006 (20.1% for males and 15.5% for females, based on the 2006-2007 TUS-CPS).[108] Based on current policies, *SimSmoke* predicts declining rates for both the lowest and second-lowest income quintiles, but it also predicts that smoking rates for these quintiles will be high for many years to come.

Through stronger tobacco control policies, smoking prevalence rates can be considerably reduced for the lowest two income quintiles. Raising average taxes by $3.00 per pack would lower prevalence rates by more than 19% by the year 2064. Health warnings, anti-tobacco media campaigns, and comprehensive marketing restrictions can also play an important role. With a $3.00 tax increase, comprehensive marketing restrictions, smoke-free laws, strong graphic health warnings, a higher intensity media campaign, broader cessation treatment coverage, and greater youth access enforcement, the model predicts that smoking prevalence will fall by about 23% in the first few years. By 2064, the recommended policies would reduce smoking prevalence by more than 41% compared to status quo policies. While cessation treatments did not appear to produce large effects in this model, other studies have shown that fully integrating cessation treatment policies into the health care system has strong potential to influence smoking prevalence, specifically through rewarding health care providers for conducting interventions with follow-up and providing low- or no-cost therapies.[103,104] Additionally, the Affordable Care Act emphasizes prevention of disease and expands access to tobacco cessation services.[109]

SimSmoke also estimated that in 2014, 119,526 people in the lowest income quintile and 95,986 people in the second-lowest income quintile would die prematurely from smoking. A stronger set of policies and a $3.00 tax increase is predicted to result in 42,064 fewer deaths in 2064 (23,258 in the lowest income quintile and 18,806 in the second-lowest) than with the status quo policies, and a cumulative total for the years 2015 through 2064 of 1,522,222 lives saved (845,401 in the lowest income quintile and 676,821 in the second-lowest). These figures do not include lives lost due to secondhand smoke or fires caused by smoking, nor are the savings in excess medical costs associated with smoking-related conditions taken into account. These results show that tobacco control policies can have a major effect in reducing health disparities in low-income populations.

This analysis was conducted at the national level, but disparities are also seen at the state level. Many of the states with the lowest median household income,[110] such as Alabama, Arkansas, Kentucky, Louisiana, South Carolina, and Tennessee, also have weak tobacco control policies.[111] Significantly increasing tobacco taxes, implementing comprehensive smoke-free laws, and conducting strong mass media campaigns in these states can go a long way toward reducing income-related health disparities.

Although this analysis focused on income disparities, disparities by education and race/ethnicity merit consideration both individually and as they interact with income. For example, chapter 11 discusses the potential for higher cigarette taxes and more rigorous marketing restrictions to reduce smoking by African Americans. A *SimSmoke* model developed by Levy and colleagues[112] examines how a ban on menthol cigarettes could affect both smoking prevalence and smoking-attributable deaths, considering three possible scenarios. The model projects that in the continued absence of a ban on menthol

cigarettes, smoking prevalence will decline slowly and the percentage of people smoking menthol cigarettes will increase. In contrast, a ban on menthol cigarettes is projected to lead to greater reductions in smoking prevalence and fewer smoking-attributable deaths; the largest proportion of benefits would accrue to African Americans. As the authors note, "our results suggest that somewhere between 323,000 and 633,000 deaths could be avoided under a [menthol] ban, almost one-third of which would be among Blacks."[112,p.1238] Similarly, a model could be developed specifically focused on the Hispanic population, for example, to distinguish the effects of policies on more acculturated versus less acculturated Hispanic smokers.

The income disparities model presented above did not consider the use of other tobacco products, such as smokeless tobacco and cigars, which are increasingly used with cigarettes.[113,114] Smokeless tobacco use has increased since the 1990s, especially among young, low-income white males, and much of this use is in conjunction with cigarettes.[115–119] Cigar use among young adults has also increased[120–122]; some brands are very similar to cigarettes in size and content but are taxed at lower rates. Use of e-cigarettes, a relatively new product, will be important to monitor in low-income populations.[123] In general, further research is needed on the different types of tobacco used by people of low SES, especially by youth and young adults.

Another limitation of the model is traceable to its method of evaluating initiation to smoking. Initiation generally takes place until the age of 24 in all models, but income varies over the life of the individual, and income until age 24 may be a poor indicator of later income and likely SES. For example, an individual may be in college through age 24 and receiving very low income. In addition, living circumstances vary, with some individuals living with their family of origin and others living independently with their own children. Therefore, it may be important to consider initiation at later ages, when income may more closely reflect eventual future income. Initially it appeared that TUS-CPS income data were missing for a disproportionate number in the lower age groups (< 24 years old), possibly because many in these younger groups were full-time students. However, using family income and analyzing missing income revealed that the proportion of those with missing income appeared to be roughly uniform across age groups. The model also might be extended to consider the steps in the progression to smoking initiation and to smoking cessation, rather than just considering simple initiation and cessation.

The results from *SimSmoke* are subject to the limitations of the existing data, which indicate the importance of better surveillance to a better understanding of disparities in relation to public health. The model applied variations in mortality by income from Canada, which did not distinguish by age. The model also did not incorporate variations in mortality rates by income as they apply to smoking status. Information on mortality rates by income and smoking status is needed to better estimate the number of smoking-attributable deaths. To the extent that there are greater variations in the United States than in Canada, smoking-attributable deaths are likely to have been underestimated.

In addition, the relatively high exposure to secondhand smoke among some racial/ethnic and low-SES groups (see chapter 9) is likely to impact the mortality rates of people of low SES more than those of high SES. More information is also needed on exposure to particular policies by SES. For example, compared to smokers of higher SES, lower SES smokers may pay lower prices for tobacco products on average, may be less subject to smoke-free laws, may be less likely to use quitlines and low- or no-cost pharmacotherapies, and may have less exposure to anti-tobacco media campaigns.

The *SimSmoke* results depend on a set of assumptions on effect sizes derived from the literature. The impact that an array of tobacco control policies have on different sectors of the population can be exceedingly complex, where the effect of an individual policy may depend on the array of policies already implemented or any policies implemented at the same time as the policy of interest. The strength of the evidence for each of the policies varies.[18,19,42,95,124] The evidence for taxes and smoke-free policies is stronger than the evidence for mass media campaigns, and the evidence for cessation policies is weaker and less consistent. The model allowed for some variations in the effects of tobacco control policies by SES, but these effects could be subject to greater uncertainty as they affect low-SES groups. With smoking increasingly concentrated in low-SES groups, better information is needed on the effects of policies by SES. Knowledge of the synergistic effect of policies is also limited. Although a small number of empirical studies simultaneously consider the effect of two tobacco control policies,[23,25,125] most studies examine the effect of only one policy, making it difficult to determine how multiple policies interact with one another.

The direct effect of policies on cessation in *SimSmoke* can be seen in a decrease in prevalence in the first year of the model. In future years, the effects of policy are maintained or increased through effects on initiation and cessation rates. The effects may also depend on relapse, although data on relapse rates in general and specifically relapse among lower SES individuals are limited.

Another simplifying assumption is that policies are modeled as having a unidirectional effect on smoking rates. *SimSmoke* does not explicitly model potential feedbacks through tobacco industry practices, social norms and attitudes, and peer and family behaviors. As policies are implemented, the tobacco industry might strategically respond and counteract some policies by changing pricing or marketing practices or by introducing new products. In particular, tobacco companies may increasingly target low-SES groups. Projections of the strongest case assume that actions of tobacco companies do not negate a set of strong regulations and treatment progress.

In addition to the validation conducted for this study, previous applications of *SimSmoke* to the United States, Arizona, California, Kentucky, and Minnesota[17–20,48–51] as well as to other countries[15,39–46,48] have accurately projected trends and turning points in smoking rates, confirming the validity of the parameters and assumptions underlying the income models. However, the income disparities models chart new territories for the *SimSmoke* models. It will be important to validate those models over time in future work. Other classifications of SES, such as by education level, might be considered, along with racial/ethnic interactions. By assessing the impact of policies on different sociodemographic groups, problem areas might be identified and policies evaluated so that future policies could be targeted to those areas.[27]

To summarize, smoking rates among the lowest and second-lowest income quintiles are considerably above the national average, leading to over half of the smoking-attributable deaths in the United States. *SimSmoke* projects that a stronger set of tobacco control policies, especially price policies, may reduce smoking prevalence in the two lowest income quintiles by 25% in the near term, increasing to almost 45% by 2065. These stronger policies will avert 850,000 smoking-attributable deaths in the lowest income quintile and 675,000 deaths in the second-lowest quintile by 2064. Modeling not only makes it possible to examine the potential role of policies in reducing smoking rates in disadvantaged populations, but also provides a framework for more systematically determining data and research needs.

References

1. Kawachi I, Daniels N, Robinson DE. Health disparities by race and class: why both matter. Health Aff (Millwood). 2005;24(2):343-52.
2. Williams DR, Jackson PB. Social sources of racial disparities in health. Health Aff (Millwood). 2005;24(2):325-34.
3. Flint AJ, Novotny TE. Poverty status and cigarette smoking prevalence and cessation in the United States, 1983-1993: the independent risk of being poor. Tob Control.1997;6(1):14-8.
4. Garrett BE, Dube SR, Trosclair A, Caraballo RS, Pechacek TF. Cigarette smoking—United States, 1965-2008. MMWR Surveill Summ. 2011;60(Suppl):109-13.
5. Garrett BE, Dube SR, Winder C, Caraballo RS; Centers for Disease Control and Prevention. Cigarette smoking – United States, 2006-2008 and 2009-2010. MMWR Surveill Summ. 2013;62(Suppl 3):81-4.
6. Gilman SE, Rende R, Boergers J, Abrams DB, Buka SL, Clark MA, et al. Parental smoking and adolescent smoking initiation: an intergenerational perspective on tobacco control. Pediatrics. 2009;123(2):e274-81.
7. Jarvandi S, Yan Y, Schootman M. Income disparity and risk of death: the importance of health behaviors and other mediating factors. PLoS One. 2012;7(11):e49929.
8. Koh HK. A 2020 vision for healthy people. N Engl J Med. 2010;362(18):1653-6.
9. Koh HK, Nowinski JM, Piotrowski JJ. A 2020 vision for educating the next generation of public health leaders. Am J Prev Med. 2011;40(2):199-202.
10. Scarinci IC, Robinson LA, Alfano CM, Zbikowski SM, Klesges RC. The relationship between socioeconomic status, ethnicity, and cigarette smoking in urban adolescents. Prev Med. 2002;34(2):171-8.
11. Burns D, Anderson C, Johnson M, Major JM, Biener L, Vaughn J, et al. Cessation and cessation measures among daily adult smokers: national and state-specific data. In: National Cancer Institute. Population-based smoking cessation: proceedings of a conference on what works to influence smoking in the general population. Smoking and tobacco control monograph no. 12. Bethesda, MD: U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, National Cancer Institute; 2000. p. 25-98.
12. Clare P, Bradford D, Courtney RJ, Martire K, Mattick RP. The relationship between socioeconomic status and 'hardcore' smoking over time—greater accumulation of hardened smokers in low-SES than high-SES smokers. Tob Control. 2014;23(e2):e133-8.
13. Levy D, Romano E, Mumford E. The relationship of smoking cessation to socio-demographic characteristics, smoking intensity and tobacco control policies. Nicotine Tob Res. 2005;7(3):387-96.
14. Holford TR, Meza R, Warner KE, Meernik C, Jeon J, Moolgavkar SH, et al. Tobacco control and the reduction in smoking-related premature deaths in the United States, 1964-2012. JAMA. 2014;311(2):164-71.
15. Levy DT, Nikolayev N, Mumford EA. Recent trends in smoking and the role of public policies: results from the SimSmoke tobacco control policy simulation model. Addiction. 2005;10(10):1526-37.
16. Levy DT, Meza R, Zhang Y, Holford T. Gauging the effect of U.S. tobacco control policies from 1965 through 2014 using SimSmoke. Am J Prev Med. 2016;50(4):535-42. doi: 10.1016/j.amepre.2015.10.001.
17. Koh H. An analysis of the successful 1992 Massachusetts tobacco tax initiative. Tob Control. 1996;5:220-5.
18. Levy DT, Hyland A, Higbee C, Remer L, Compton C. The role of public policies in reducing smoking prevalence in California: results from the California tobacco policy simulation model. Health Policy. 2007;82(2):153-66.
19. Levy DT, Ross H, Powell L, Bauer JE, Lee HR. The role of public policies in reducing smoking prevalence and deaths caused by smoking in Arizona: results from the Arizona tobacco policy simulation model. J Public Health Manag Pract. 2007;13(1):59-67.
20. Levy DT, Boyle RG, Abrams DB. The role of public policies in reducing smoking: the Minnesota SimSmoke tobacco policy model. Am J Prev Med. 2012;43(5 Suppl 3):S179-86.
21. U.S. Department of Health and Human Services. Healthy People 2010. Atlanta: Centers for Disease Control, Office of Disease Prevention and Health Promotion; 2000.
22. U.S. Department of Health and Human Services. Reducing tobacco use: a report of the Surgeon General. Atlanta: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2000.
23. Hu TW, Sung HY, Keeler TE. Reducing cigarette consumption in California: tobacco taxes vs an anti-smoking media campaign. Am J Public Health. 1995;85(9):1218-22.
24. Hu TW, Sung HY, Keeler TE. The state antismoking campaign and the industry response: the effects of advertising on cigarette consumption in California. Am Econ Rev. 1995;85(2):85-90.
25. Farrelly MC, Pechacek TF, Chaloupka FJ. The impact of tobacco control program expenditures on aggregate cigarette sales: 1981-2000. J Health Econ. 2003;22(5):843-59.

26. Homer JB, Hirsch GB. System dynamics modeling for public health: background and opportunities. Am J Public Health. 2006;96(3):452-8.
27. Levy DT, Bauer JE, Lee HR. Simulation modeling and tobacco control: creating more robust public health policies. Am J Public Health. 2006;96(3):494-8.
28. Mendez D, Warner KE, Courant PN. Has smoking cessation ceased? Expected trends in the prevalence of smoking in the United States. Am J Epidemiol. 1998;148(3):249-58.
29. Mendez D, Warner KE. Adult cigarette smoking prevalence: declining as expected (not as desired). Am J Public Health. 2004;94(2):251-2.
30. Tengs TO, Osgood ND, Chen LL. The cost-effectiveness of intensive national school-based anti-tobacco education: results from the tobacco policy model. Prev Med. 2001;33(6):558-70.
31. Tengs TO, Osgood ND, Lin TH. Public health impact of changes in smoking behavior: results from the Tobacco Policy Model. Med Care. 2001;39(10):1131-41.
32. Tengs TO, Ahmad S, Moore R, Gage E. Federal policy mandating safer cigarettes: a hypothetical simulation of the anticipated population health gains or losses. J Policy Anal Manage. 2004;23(4):857-72.
33. Ahmad S. Increasing excise taxes on cigarettes in California: a dynamic simulation of health and economic impacts. Prev Med. 2005;41(1):276-83.
34. Ahmad S, Billimek J. Estimating the health impacts of tobacco harm reduction policies: a simulation modeling approach. Risk Anal. 2005;25(4):801-12.
35. Ahmad S, Billimek J. Limiting youth access to tobacco: comparing the long-term health impacts of increasing cigarette excise taxes and raising the legal smoking age to 21 in the United States. Health Policy. 2007;80(3):378-91.
36. Levy DT, Cummings KM, Hyland A. A simulation of the effects of youth initiation policies on overall cigarette use. Am J Public Health. 2000;90(8):1311-4.
37. Levy DT, Nikolayev N, Mumford EA. The Healthy People 2010 smoking prevalence and tobacco control objectives: results from the SimSmoke tobacco control policy simulation model. Cancer Causes Control. 2005;16(4):359-71.
38. Levy DT, Chaloupka F, Gitchell J, Mendez D, Warner KE. The use of simulation models for the surveillance, justification and understanding of tobacco control policies. Health Care Manag Sci. 2002;5(2):113-20.
39. Currie LM, Blackman K, Clancy L, Levy DT. The effect of tobacco control policies on smoking prevalence and smoking-attributable deaths in Ireland using the IrelandSS simulation model. Tob Control. 2013;22(e1):e25-32.
40. Levy DT, Benjakul S, Ross H, Ritthiphakdee B. The role of tobacco control policies in reducing smoking and deaths in a middle income nation: results from the Thailand SimSmoke simulation model. Tob Control. 2008;17(1):53-9.
41. Levy DT, Cho SI, Kim YM, Park S, Suh MK, Kam S. SimSmoke model evaluation of the effect of tobacco control policies in Korea: the unknown success story. Am J Public Health. 2010;100(7):1267-73.
42. Levy D, de Almeida LM, Szklo A. The Brazil SimSmoke policy simulation model: the effect of strong tobacco control policies on smoking prevalence and smoking-attributable deaths in a middle income nation. PLoS Med. 2012;9(11):e1001336.
43. Levy DT, Blackman K, Currie LM, Mons U. Germany SimSmoke: the effect of tobacco control policies on future smoking prevalence and smoking-attributable deaths in Germany. Nicotine Tob Res. 2013;15(2):465-73.
44. Levy DT, Currie L, Clancy L. Tobacco control policy in the UK: blueprint for the rest of Europe? Eur J Public Health. 2013;23(2):201-6.
45. Levy DT, Huang AT, Currie LM, Clancy L. The benefits from complying with the Framework Convention on Tobacco Control: a SimSmoke analysis of 15 European nations. Health Policy Plan. 2014;29(8):1031-42.
46. Levy D, Rodriguez-Buno RL, Hu TW, Moran AE. The potential effects of tobacco control in China: projections from the China SimSmoke simulation model. BMJ. 2014;348:g1134.
47. Levy DT, Fouad H, Levy J, Dragomir A, El Awa F. Application of the Abridged SimSmoke model to four eastern Mediterranean countries. Tob Control. 2016;25(4):413-21.
48. Reynales-Shigematsu LM, Fleischer NL, Thrasher JF, Zhang Y, Meza R, Cummings KM, et al. Effects of tobacco control policies on smoking prevalence and tobacco-attributable deaths in Mexico: the SimSmoke model. Rev Panam Salud Publica. 2015;38(4):316-25.
49. Levy D, Tworek C, Hahn E, Davis R. The Kentucky SimSmoke tobacco policy simulation model: reaching Healthy People 2010 goals through policy change. South Med J. 2008;101(5):503-7.
50. Levy DT, Huang A, Havumaki JS, Meza R, The role of public policies in reducing smoking prevalence: results from the Michigan SimSmoke tobacco policy simulation model. Cancer Causes Control. 2016;27(5):615-25. doi: 10.1007/s10552-016-0735-4.
51. Levy DT, Fergus C, Rudov L, McCormick-Ricket I, Carton T. Tobacco policies in Louisiana: recommendations for future tobacco control investment from SimSmoke, a policy simulation model. Prev Sci. 2016;17(2):199-207. doi: 10.1007/s11121-015-0587-2.

52. Levy DT, Friend K. A computer simulation model of mass media interventions directed at tobacco use. Prev Med. 2001;32(3):284-94.
53. Levy DT, Friend K. A simulation model of policies directed at treating tobacco use and dependence. Med Decis Making. 2002;22(1):6-17.
54. Levy DT, Friend K. Examining the effects of tobacco treatment policies on smoking rates and smoking related deaths using the SimSmoke computer simulation model. Tob Control. 2002;11(1):47-54.
55. Levy DT, Cummings KM, Hyland A. Increasing taxes as a strategy to reduce cigarette use and deaths: results of a simulation model. Prev Med. 2000;31(3):279-86.
56. Levy DT, Friend K, Polishchuk E. Effect of clean indoor air laws on smokers: the clean air module of the SimSmoke computer simulation model. Tob Control. 2001;10(4):345-51.
57. Levy DT, Mumford E, Pesin B. Tobacco control policies, and reductions in smoking rates and smoking-related deaths: results from the SimSmoke Model. Expert Rev Pharmacoecon Outcomes Res. 2003;3(4):457-68.
58. Levy DT, Bales S, Nikolayev L. The role of public policies in reducing smoking and deaths caused by smoking in Vietnam: results from the Vietnam tobacco policy simulation model. Soc Sci Med. 2006;62(7):1819-30.
59. U.S. Department of Commerce, Census Bureau. National Cancer Institute and Centers for Disease Control and Prevention Co-sponsored Tobacco Use Supplement to the Current Population Survey (2006-07). 2008. Available from: https://cancercontrol.cancer.gov/brp/tcrb/tus-cps. Data files (AND/OR) technical documentation (technical documentation available from: http://www.census.gov/programs-surveys/cps/technical-documentation/complete.html.
60. U.S. Department of Commerce, Census Bureau. National Cancer Institute-sponsored Tobacco Use Supplement to the Current Population Survey (2010-11). 2012. Available from: https://cancercontrol.cancer.gov/brp/tcrb/tus-cps. Technical documentation available from: http://www.census.gov/programs-surveys/cps/technical-documentation/complete.html.
61. U.S. Department of Health and Human Services, National Cancer Institute, Division of Cancer Control and Population Sciences, Behavioral Research Program. Where can I get the TUS data, documentation, questionnaires? [no date]. Available from: https://cancercontrol.cancer.gov/brp/tcrb/tus-cps/info.html.
62. U.S. Census Bureau. Age of householder—households, by total money income in 2010, type of household, race, and Hispanic origin of householder. 2007 [cited 1 Aug 2014]. Available from: http://www.census.gov/hhes/www/cpstables/macro/032007/hhinc/new02_0001.htm.
63. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. Compressed mortality file (CMF) on CDC WONDER Online Database. Natality public-use data 2007-2015, on CDC WONDER Online Database. 2014 [cited 25 July 2014]. Available from: http://wonder.cdc.gov/natality-current.html.
64. U.S. Census Bureau. Current Population Survey data on fertility. Fertility rates by age, education and income. 2010 [cited 25 July 2014]. Available from: https://www.census.gov/hhes/fertility/data/cps.
65. Monte LM, Ellis RR. Fertility of women in the United States: 2012. Washington, DC: U.S. Department of Commerce, Economics and Statistics Administration, U.S. Census Bureau; 2014.
66. Wilkinson RG, Pickett KE. Income inequality and population health: a review and explanation of the evidence. Soc Sci Med. 2006;62(7):1768-84.
67. Wilkinson RG, Pickett KE. Income inequality and socioeconomic gradients in mortality. Am J Public Health. 2008;98(4):699-704.
68. Tjepkema M, Wilkins R, Long A. Cause-specific mortality by education in Canada: a 16-year follow-up study. Health Rep. 2012;23(3):23-31.
69. Tjepkema M, Wilkins R, Long A. Cause-specific mortality by income adequacy in Canada: a 16-year follow-up study. Health Rep. 2013;24(7):14-22.
70. Tjepkema M, Wilkins R, Long A. Socio-economic inequalities in cause-specific mortality: a 16-year follow-up study. Can J Public Health. 2013;104(7):e472-8.
71. Rehkopf DH, Berkman LF, Coull B, Krieger N. The non-linear risk of mortality by income level in a healthy population: US National Health and Nutrition Examination Survey mortality follow-up cohort, 1988-2001. BMC Public Health. 2008;8:383.
72. Krieger N, Rehkopf DH, Chen JT, Waterman PD, Marcelli E, Kennedy M. The fall and rise of US inequities in premature mortality: 1960-2002. PLoS Med. 2008;5(2):e46.
73. U.S. Department of Health and Human Services. The health benefits of smoking cessation: a report of the Surgeon General. Atlanta: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Office on Smoking and Health; 1990.
74. U.S. Department of Health and Human Services. The health consequences of smoking. A report of the Surgeon General. Atlanta: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2004.

75. Gilpin EA, Pierce JP, Farkas AJ. Duration of smoking abstinence and success in quitting. J Natl Cancer Inst. 1997;89(8):572-6.
76. McWhorter WP, Boyd GM, Mattson ME. Predictors of quitting smoking: the NHANES I followup experience. J Clin Epidemiol. 1990;43(12):1399-1405.
77. U.S. Department of Health and Human Services. Reducing the health consequences of smoking: 25 years of progress: a report of the Surgeon General. DHHS publication no. 89-8411. Atlanta: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 1989.
78. Centers for Disease Control and Prevention. Cigarette smoking among adults – United States, 2004. MMWR Morb Mortal Wkly Rep. 2005;54(44):1121-4.
79. Shultz JM, Novotny TE, Rice DP. Quantifying the disease impact of cigarette smoking with SAMMEC II software. Public Health Rep. 1991;106(3):326-33.
80. Burns D, Garfinkel L, Samet J, editors. Changes in cigarette-related disease risks and their implications for prevention and control. Smoking and tobacco control monograph no. 8. Bethesda, MD: National Institutes of Health, National Cancer Institute; 1997.
81. Thun MJ, Myers DG, Day-Lally C, Namboodiri MM, Calle EE, Flanders WD, et al. Age and the exposure-response relationships between cigarette smoking and premature death in Cancer Prevention Study II. In: Burns D, Garfinkel L, Samet J, eds. Changes in cigarette-related disease risks and their implications for prevention and control. Smoking and tobacco control monograph no. 8. Bethesda, MD: National Institutes of Health, National Cancer Institute; 1997. p. 383-413.
82. Malarcher AM, Schulman J, Epstein LA, Thun MJ, Mowery P, Pierce B, et al. Methodological issues in estimating smoking-attributable mortality in the United States. Am J Epidemiol. 2000;152(6):573-84.
83. Peto R, Lopez AD, Boreham J, Thun M. Mortality from smoking in developed countries, 1950-2000. Geneva: 2nd International Union Against Cancer; 2006.
84. Thun MJ, Carter BD, Feskanich D, Freedman ND, Prentice R, Lopez AD, et al. 50-year trends in smoking-related mortality in the United States. N Engl J Med. 2013;368(4):351-64.
85. Hughes JR. Reduced smoking: an introduction and review of the evidence. Addiction. 2000;95(Suppl 1):S3-7.
86. Orzechowski W, Walker RC. The tax burden on tobacco. Historical compilation, vol. 49. Arlington, VA: Orzechowski and Walker; 2014. Available from: http://www.taxadmin.org/assets/docs/Tobacco/papers/tax_burden_2014.pdf.
87. U.S. Department of Labor, Bureau of Labor Statistics. TED: The Economics Daily: Consumer price index up 1.7 percent over the year again. 21 Nov 2014. Available from: http://www.bls.gov/opub/ted/2014/ted_20141121.htm.
88. ImpacTeen. Tobacco control policy and prevalence data: 1991-2008. [Archived website]. Chicago: University of Illinois at Chicago, Institute for Health Research and Policy. Available from: http://www.impacteen.org/tobaccodata.htm.
89. Americans for Nonsmokers' Rights [Website]. [cited 2013]. Available from: http://www.no-smoke.org/goingsmokefree.php?id=519.
90. Campaign for Tobacco-Free Kids. Fact sheets: prevention programs: key elements and funding sources [no date]. Available from: http://www.tobaccofreekids.org/facts_issues/fact_sheets/policies/prevention_us_state/key_elements.
91. Al-Delaimy WK, Pierce JP, Messer K, White MM, Trinidad DR, Gilpin EA. The California Tobacco Control Program's effect on adult smokers: (2) Daily cigarette consumption levels. Tob Control. 2007;16(2):91-5.
92. Frieden TR, Mostashari F, Kerker BD, Miller N, Hajat A, Frankel M. Adult tobacco use levels after intensive tobacco control measures: New York City, 2002-2003. Am J Public Health. 2005;95(6):1016-23.
93. Levy DT, Mumford E, Compton C. Tobacco control policies and smoking in a population of low education females, 1992-2002. J Epidemiol Community Health. 2006;60(Suppl 2):ii20-6.
94. World Health Organization. WHO report on the global tobacco epidemic, 2008: the MPOWER package. Geneva: World Health Organization; 2008. Available from: http://whqlibdoc.who.int/publications/2008/9789241596282_eng.pdf.
95. Levy DT, Gitchell JG, Chaloupka F. The effects of tobacco control policies on smoking rates: a tobacco control scorecard. J Public Health Manag Pract. 2004;10:338-51.
96. Blecher E. The impact of tobacco advertising bans on consumption in developing countries. J Health Econ. 2008;27(4):930-42.
97. National Cancer Institute and World Health Organization. The economics of tobacco and tobacco control. NCI tobacco control monograph no. 21. NIH publication no. 16-CA-8029A. Bethesda, MD; U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; and Geneva: World Health Organization; 2016. Available from: https://cancercontrol.cancer.gov/brp/tcrb/monographs/21/docs/m21_complete.pdf.
98. Hammond D, Fong GT, Borland R, Cummings KM, McNeill A, Driezen P. Text and graphic warnings on cigarette packages: findings from the International Tobacco Control Four Country Study. Am J Prev Med. 2007;32(3):202-9.
99. Thrasher JF, Hammond D, Fong GT, Arillo-Santillan E. Smokers' reactions to cigarette package warnings with graphic imagery and with only text: a comparison between Mexico and Canada. Salud Publica Mex. 2007;49(Suppl 2):S233-40.

100. Willemsen MC. The new EU cigarette health warnings benefit smokers who want to quit the habit: results from the Dutch Continuous Survey of Smoking Habits. Eur J Public Health. 2005;15(4):389-92.
101. Azagba S, Sharaf MF. The effect of graphic cigarette warning labels on smoking behavior: evidence from the Canadian experience. Nicotine Tob Res. 2013;15(3):708-17.
102. Huang J, Chaloupka FJ, Fong GT. Cigarette graphic warning labels and smoking prevalence in Canada: a critical examination and reformulation of the FDA regulatory impact analysis. Tob Control. 2014;23(Suppl 1):i7-12.
103. Abrams D, Graham A, Levy D, Mabry P, Orleans CT. Boosting population quits through evidence-based cessation treatment and policy. Am J Prev Med. 2010;38(38):S351-63.
104. Levy D, Graham A, Mabry P, Abrams D, Orleans CT. Modeling the impact of smoking cessation treatment policies on quit rates. Am J Prev Med. 2010;38(38):S364-72.
105. North American Quitline Consortium. Survey of quitlines. [cited February 2017]. Available from: http://www.naquitline.org/?page=2013Survey.
106. American Lung Association. Helping smokers quit: state cessation coverage 2010. Available from: http://www.lung.org/assets/documents/tobacco/helping-smokers-quit2010.pdf.
107. Levy DT, Friend K, Holder H, Carmona M. Effect of policies directed at youth access to smoking: results from the SimSmoke computer simulation model. Tob Control. 2001;10(2):108-16.
108. U.S. Department of Health and Human Services, National Cancer Institute, Division of Cancer Control and Population Sciences, Behavioral Research Program. 2006-07 TUS-CPS data, table 1. Accessed April 1, 2014. Available from: https://cancercontrol.cancer.gov/brp/tcrb/tus-cps/results/data0607/table1.html.
109. American Lung Association. Tobacco cessation as a preventive service: new guidance clarifies Affordable Care Act provision. 2015. Available from: http://www.lung.org/assets/documents/tobacco/tobacco-cessation-preventive-service.pdf.
110. U.S. Bureau of the Census. State median income. 2013. Available from: https://www.census.gov/hhes/www/income/data/statemedian.
111. American Lung Association. State of tobacco control: state grades. 2017. Available from: http://www.lung.org/our-initiatives/tobacco/reports-resources/sotc/state-grades.
112. Levy DT, Pearson JL, Villanti AC, Blackman K, Vallone DM, Niaura RS, et al. Modeling the future effects of a menthol ban on smoking prevalence and smoking-attributable deaths in the United States. Am J Public Health. 2011;101(7):1236-40.
113. Fix BV, O'Connor RJ, Vogl L, Smith D, Bansal-Travers M, Conway K, et al. Patterns and correlates of polytobacco use in the United States over a decade: NSDUH 2002-2011. Addict Behav. 2014;39(4):768-81.
114. Richardson A, Williams V, Rath J, Villanti AC, Vallone D. The next generation of users: prevalence and longitudinal patterns of tobacco use among US young adults. Am J Public Health. 2014;104(8):1429-36.
115. Mumford EA, Levy DT, Gitchell JG, Blackman KO. Tobacco control policies and the concurrent use of smokeless tobacco and cigarettes among men, 1992-2002. Nicotine Tob Res. 2005;7(6):891-900.
116. Mumford EA, Levy DT, Gitchell JG, Blackman KO. Smokeless tobacco use 1992-2002: trends and measurement in the Current Population Survey-Tobacco Use Supplements. Tob Control. 2006;15(3):166-71.
117. Rodu B. Dual use. Nicotine Tob Res. 2011;13(3):221.
118. Rodu B, Cole P. Smokeless tobacco use among men in the United States, 2000 and 2005. J Oral Pathol Med. 2009;38(7):545-50.
119. Vijayaraghavan M, Pierce JP, White M, Messer K. Differential use of other tobacco products among current and former cigarette smokers by income level. Addict Behav. 2014;39(10):1452-8.
120. Cullen J, Mowery P, Delnevo C, Allen J, Sokol N, Byron MJ, et al. Seven-year patterns in US cigar use epidemiology among young adults aged 18-25 years: a focus on race/ethnicity and brand. Am J Public Health. 2011;101(10):1955-62.
121. Rath JM, Villanti AC, Abrams DB, Vallone DM. Patterns of tobacco use and dual use in US young adults: the missing link between youth prevention and adult cessation. J Environ Public Health. 2012;2012:679134.
122. Richardson A, Rath J, Ganz O, Xiao H, Vallone D. Primary and dual users of little cigars/cigarillos and large cigars: demographic and tobacco use profiles. Nicotine Tob Res. 2013;15(10):1729-36.
123. Arrazola RA, Singh T, Corey CG, Husten CG, Neff LJ, Apelberg BJ, et al. Tobacco use among middle and high school students – United States, 2011-2014. MMWR Morb Mortal Wkly Rep. 2015;64(14):381-5.
124. Hopkins DP, Briss PA, Ricard CJ, Husten CG, Carande-Kulis VG, Fielding JK, et al. Reviews of evidence regarding interventions to reduce tobacco use and exposure to environmental tobacco smoke. Am J Prev Med. 2001;20(2 Suppl):16-66.
125. Chaloupka FJ, Wechsler H. Price, tobacco control policies and smoking among young adults. J Health Econ.1997;16(3):359-73.