Background: This study examines the interrelationship between tobacco control policies and cigarette and smokeless tobacco (SLT) use by applying the *SimSmoke* tobacco control policy simulation model. We extend the previous Minnesota SimSmoke simulation model of cigarette use to more recent years and to include SLT use, which has increased in Minnesota since at least 2007.

Methods: Using data from large-scale Tobacco Use Supplement surveys and information on federal and state policies, the Minnesota *SimSmoke* model was updated and extended to incorporate SLT use. SimSmoke considers the effect of implementing individual and combined tobacco control policies on smoking and SLT use (both exclusive use and dual use), and on deaths attributable to their use. The model was validated against survey data through 2018, and was then used to estimate the impact of policies implemented between 1993 and 2018. The model was then used to estimate the impact of stronger future policies.

Results: The model validated well for cigarette use, but under-predicted the prevalence of SLT use in recent years. The model also projected that smoking prevalence was 35% (36%) lower in relative terms for males (females) by 2018 and 43% (44%) lower by 2040. Reductions were also projected for male SLT use. In addition, tobacco-attributable deaths were reduced by 7,808 by 2018 and 46,933 by 2040 due to policies. Prices increases, primarily through taxes, were projected to have had the greatest effect on cigarette use followed by smoke-free air laws, cessation treatment policies, tobacco control expenditures and youth access enforcement. For SLT use, prices increases have a more dominant influence, but smoke-free air laws have less effect compared with cigarette use and there was a slight effect of health warnings. Future policy changes, including tax increases and raising the minimum purchase age from 18 to 21, were

shown to have substantial effects, but the effects could be largely negated by reducing tobacco control funding and cessation treatment programs.

Conclusions: With the landscape for nicotine delivery products dramatically changed in the last 10 years, it becomes increasingly important to monitor the use of all nicotine delivery products. Since cigarettes are still the dominant form of nicotine delivery product, cigarette-oriented policies may be an effective means, perhaps the most effective means, of reducing the use of all nicotine delivery products. However, policies directed at other products, particularly smokeless tobacco and e-cigarettes, may also play an important role.

INTRODUCTION

In 1985, Minnesota became one of the first states to launch a state-funded tobacco control program, and using funds from the settled lawsuit against cigarette manufactures in 1998,[1] the state has had a sustained focus on reducing tobacco use. Minnesota has funded tobacco control in the top 20% of states since 2000,[2] increased taxes on cigarette and other tobacco products, implemented comprehensive smoke-free indoor air laws, and established comprehensive cessation services, including a telephone quit line. A previous study[3] found that taken together these policies had reduced smoking prevalence by almost 30% and averted almost 50,000 deaths by 2011.

As Minnesota enacted additional local and state-wide policies against smoking cigarettes, the tobacco market has seen growth in alternative nicotine delivery products, such as smokeless tobacco (SLT). In particular, cigarette manufacturers entered the U.S. SLT market beginning in 2006, mostly through the purchase of existing companies, but also introducing new versions of SLT co-branded with cigarettes (e.g., Camel and Marlboro snus). These products were marketed as alternative to cigarettes where smoking is not permitted.[4] After a period of relatively constant use from 2000 through 2007, Minnesota SLT prevalence increased from 3.1% in 2007 to 4.3% in 2010, with SLT use by smokers increasing from 4.4% in to 9.6% in 2010.[5] Recently Minnesota updated the definition of tobacco products to reflect changing products,[6] implemented a large tax increase[7] and expanded coverage of cigarette policies to include other tobacco products.

The increase in SLT use may have discouraged smokers who would have otherwise quit from actually quitting or encourage youth to take up tobacco use, and thus have a harmful public

health impact. On the other hand, increased smokeless use could have been a substitute for smoking, and thus improve public health. A better understanding of the effect of policies on SLT use may help in developing strategies to not only to help minimize the harm associated with SLT, but also alternative nicotine delivery products, such as e-cigarettes.

This report examines the relationship of tobacco policies to cigarette as well as SLT use in Minnesota using the previously developed *Minnesota SimSmoke* tobacco control policy simulation model.[3] That model had been previously validated for Minnesota, and others have been validated for the U.S. and over 25 other nations.[3,8–17] *Minnesota SimSmoke* estimated the effect of past and future tobacco control policies on smoking prevalence, as well as the impact of smoking rates on deaths attributable to smoking. Using the structure of a *SimSmoke* model for the U.S.,[18] the *Minnesota SimSmoke* has been extended to consider the impact of tobacco control on both Minnesota's cigarette smoking and SLT prevalence rates. The model considers the effect of tobacco control policies on exclusive cigarette, exclusive SLT and dual use and tobacco-attributable deaths in Minnesota. In addition, *Minnesota SimSmoke* has been updated and validated through 2018. The model is used to project the effect on smoking and SLT prevalence and tobacco-attributable deaths from past policies, as well as projecting the effect of implementing a new set of tobacco control policies in future years.

METHODS

The model begins with the 1993 population distinguished by age and gender and further distinguished by the number of never tobacco users, current and former exclusive smokers, current and former exclusive SLT users, and current and former dual users. The year 1993 was

chosen as the baseline year, because of the availability of sufficiently detailed data on smoking and SLT use, and because it was before major policies were implemented, thereby allowing for model calibration. Over time, cigarette and SLT use at each age change through modules for population, tobacco use, tobacco-attributable deaths and separate modules for each policy.

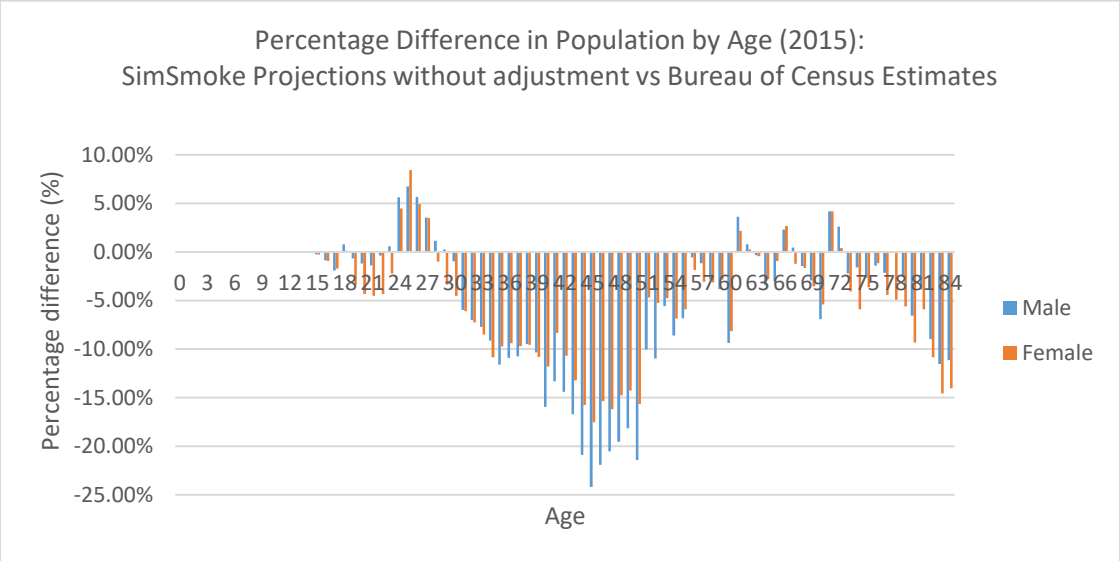
Population

Minnesota had a population of 5.6 million by 2017. Population data were obtained from the Census Bureau's Population Estimates Program for 1993–2015[19–21] and from the Minnesota State Demographic Center for 2016–2067.[22] Population data were obtained for males and females by single ages, 0 through 84, and the 85-and-older age group.

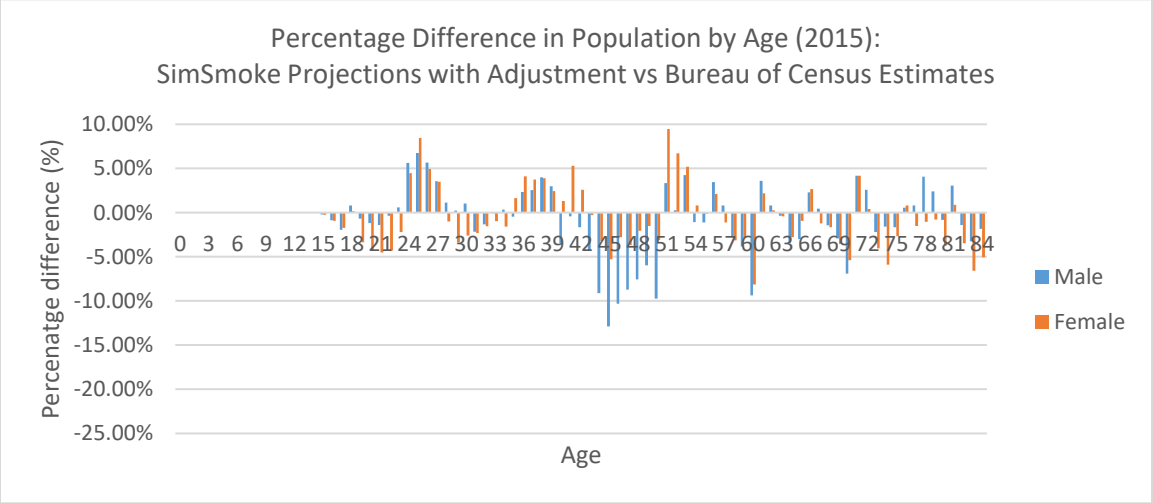
Over time, the population normally evolves through births and deaths and to a lesser extent net migration. Since initiation into cigarette or SLT use takes place after age 14 in the model, before that age, we replaced the number of never tobacco users through age 14 with population data from Census Bureau, thus implicitly incorporating the evolution of never tobacco users through deaths and fertility. For later ages, we allowed for differential death rates for current and former cigarette and SLT users and never tobacco users as described below. While mortality rates change over time, our estimates of smoking-attributable deaths are based on mortality rates for a representative year. To obtain reliable mortality rates by age and gender, we averaged rates by age group[23] over the years 1999 through 2013. The age-group mortality rates for ages 3 and above were then smoothed using a 3-year Moving Average (MA) for age 3, 5-year MA for ages 4 to 24, 10-year MA for ages 25–80, and linear interpolated age 79–80 to older ages. In Minnesota, only age group 45–54 (6.6% relative increase) for females and age group 20–24 (18.0%) and 25–34 (9.6%) for males had an upward mortality trend from 1999 to 2013. All other

age groups showed decreasing mortality rates over this period (relative decrease >10.0%, up to 57.8%). The combined 1999–2013 mortality rates were utilized as an average to reflect declining mortality rates. Minnesota had little in-migration or out-migration during 1993–2015.

Using the mortality data for ages 14 and above, *Minnesota SimSmoke* projections for 2015 over all ages were 5.0% less for male and 4.1% less for female than 2015 Census Bureau population estimates. By age group, the variations were 0% for male and 1.7% less for female for age group 15–24, 3.2% less for male and 2.9% less for female for age group 25–34, 13.1% less for male and 10.4% less for female for age group 35–44, 8.9% less for male and 6.4% less for female for age group 45–64, and 4.1% less for male and 3.0% less for female for age group 65–84. As shown below, the fluctuations within younger groups (0–14, 15–24, 25–34, and 35–44) are relatively smaller but relatively larger in senior groups (45–64 and 65–84).



Since population predictions were systematically lower than Census Bureau estimates for most ages, but especially over age 25, an adjustment was made to enlarge the mortality-adjusted population ages 25 and above. With the population adjustments, the estimated total populations in 2015 were 0.8% less for males and 0.3% more for females. By age group, SimSmoke projections were 0.0% less for males and 1.7% less for females for age group 15–24, 1.7% more for males and 2.0% more for females for age group 25–34, 4.0% less for males and 1.0% less for females for age group 35–44, 2.0% less for males and 0.7% more for females for age group 45–64, and 0.0% for males and 1.1% more for females for age group 65–84.



Tobacco Use

The model divides the 1993 baseline population into never tobacco users; current exclusive cigarette, exclusive SLT, and dual users; and former exclusive cigarette, exclusive SLT, and dual users. Individuals evolve from never tobacco users to current exclusive cigarette, exclusive SLT, or dual users through cigarette, SLT, and dual initiation. Current exclusive cigarette, exclusive SLT, or dual users may quit and thereby become former users. Former exclusive smokers

through cessation may return to smoking through relapse, and similarly for former exclusive SLT users and former dual users. A discrete time, first-order Markov process is employed to project smoking and SLT rates through initiation, cessation, and relapse.

Baseline estimates of cigarette, SLT, and dual use prevalence by age and gender were obtained from the 1992/3 Tobacco Use Supplement (TUS) of the Current Population Survey (CPS),[24] which provide state-representative estimates. Current s[mokers are defined as] those [who have smoked more than 100 cigarettes in their lifetime and currently] smoke either daily or on some days. The 1992/3 TUS asked about regular SLT use. We distinguished dual (SLT with cigarette use). Former cigarette users are defined as those who meet the definitions for use, but report that they are not current users. Former smokers are asked the number of years ago that they quit, and are distinguished by years quit.

The CPS-TUS data were aggregated into the three cigarette use categories (never smokers, all current smokers, all former smokers) by nine age groups (age 15–17, 18–21, 22–24, every 10 years for age 25–74, and age $\geq$75) and two SLT use categories (all current SLT users and current dual users) by six age groups (18–24, 25–34, 35–44, 45–54, 55–64, $\geq$65). The distribution of all former smokers was derived for the same age groups by years quit (<1, 1–2, 3–4, 5–9, 10–15, $\geq$16 years). The ratio of former to current smoking increased steeply with age.

As described below, we assume that all switching between product categories occurs at earlier ages. Based on that framework, we assume that individuals quit over time entirely from their respective exclusive cigarette, exclusive cigarette categories i.e., dual users quit both cigarettes

and SLT, and SLT do not quit and move to the other product. Since the data did not distinguish former exclusive smokers and former dual users, these groups were split from all former smokers by the percent of exclusive cigarette and dual users in total current smokers at the same age. Since data was not provided in the CPS-TUS for former exclusive SLT users and SLT rates did not decline at the same steep rates as smoking rates, we simply assumed that the baseline prevalence rate for former exclusive SLT users was 1% at age 35–44, 2% at age 45–54, 3% at age 54–64, and 6% at age ≥65 for males. Since SLT use was minimal and there was no dual use for females, we simply assumed 0% baseline prevalence for all age groups.

To obtain the prevalence for single ages, we assumed the same cigarette/SLT use rate within each age group and applied a 3-year moving average (MA) for age 15–17, 5-year MA for age 18–21, 7-year MA for age 22–24, and 9-year MA for age 25–79, and assumed constant rates after age 79 for all types of cigarette/SLT users. Current dual users were subtracted from all current smokers and all current SLT users separately to obtain the respective exclusive smokers and exclusive SLT users at each age. After summing current and former exclusive cigarette, exclusive SLT and dual rates at each single age, the rest of the population was treated as never tobacco users.

Due to the lack of sufficient observations to distinguish, we assumed that the quit-year distribution of former exclusive cigarette, exclusive smokeless and dual use rate were the same as the corresponding age category and gender distribution for all former smokers. The former prevalence for the three former smoker and SLT user groups within were further divided into single quit-years. The same smoothing strategy as above was used for all quit year groups.

Due to empirical challenges in measuring initiation and quitting, and to ensure stability and internal consistency of the model, *SimSmoke* has traditionally measured smoking initiation using net smoking prevalence, i.e., net initiation is measured as the difference between exclusive smoking prevalence at a given age and the previous age. The ability to obtain stable initiation and cessation rates is further compounded in a multiproduct setting, because individuals who experiment with tobacco use at young ages often switch products as well as initiate and quit from each of the different products. The evidence on SLT initiation and transitions to regular exclusive and dual use at early ages is contentious,[25–29] and sufficient information was not available to distinguish initiation patterns in the TUS. Consequently, the same method as in previous *SimSmoke* smoking models was employed using net initiation for each of the three user groups, but now represents initiation net of switching and cessation. Based on the smoothed Minnesota prevalence data for 1993, exclusive smoking prevalence continued to increase until age 23 for males and age 30 for females, which is slightly greater than for the U.S. as a whole.[30] Exclusive SLT prevalence continued to increase until age 29 for males and was minimal for females. Dual use prevalence continued to rise until age 29 for males, but was minimal for females and assumed to be zero for all years. In order to incorporate switching between products as well as initiation and cessation, net initiation was applied to dual and exclusive cigarette and SLT prevalence through age 30 for males and age 27 for females.

In the model, all product initiation and switching is assumed to occur up until the final age of net initiation, and only cessation from the exclusive cigarette, exclusive SLT and dual categories occurs after that age. Since data were not available from the CPS-TUS to obtain cessation rates for exclusive SLT and dual users, we considered previous literature. Although most exclusive

cigarette smokers remained exclusive cigarette smokers, the proportion of exclusive cigarette smokers who quit cigarettes at follow-up was 11.3% for males and 12.3% for females after a year in Zhu et al.[31] and 15.7% after 4 years in Wetter et al.[32] (half of which transitioned to exclusive SLT use). Both studies also found that few adults (<5%) switched from exclusive SLT use to exclusive cigarette use or dual use, and a large percentage of SLT users (35% and 20%) transitioned to no use. An analysis of the 2010/2011 CPS-TUS follow-up indicated that quit rates among smokers doubled and 6% of dual users transitioned to SLT use only, but the results were otherwise similar.[33] Using 2010/11 CPS-TUS, Schauer et al.[34] found similar rates of quit attempts among dual users and exclusive smokers, while Messer et al.[35] found dual users more likely than exclusive smokers to have made a quit attempt, but no differences in staying quit on the most recent quit attempt. However, Frost-Pineda[36] found dual users more likely than exclusive smokers to quit smoking, and Rodu and Phillips[37] found SLT users had quit rates at least as high as those using nicotine replacement treatment. Thus, past studies were mixed, but indicate quit rates for dual users at least comparable to those of smokers.

Based on the lack of contrary evidence and absence of sufficient data from the TUS, we assumed the same 1 year quit rates for dual and exclusive SLT users as for exclusive smokers. Cessation is incorporated from the last age of net initiation, since relative mortality risks from smoking are not discernable for those quitting before age 35.[38,39] Data on quit rates were obtained from the TUS, measured as those who quit in the last year, but not the last 3 months.[40] Thereby, quitters in the last 3 months who may remain quit are assumed to be offset former smokers who quit in the previous 3–12 months who may relapse. Since Minnesota data were not available in sufficient detail to distinguish quit rates by age, U.S. age-specific quit rates from the TUS were scaled to

the Minnesota average (i.e., 11.0% male and 6.3% female of smokers quit compared to 8.1% and 8.0% for the U.S.). Cessation rates were further adjusted downward, because quit rates were temporarily high in 1993 due to the introduction of the patch in late 1992.[41] Quit rates were then smoothed using a 7-year MA.

Relapse rates were assumed proportional to (although independent of) cessation rates, but vary by age, gender, and the number of years since quitting. Data from U.S. *SimSmoke*[38,42–44] were used to measure relapse rates for Minnesota, assuming rates similar to those of the U.S.

Tobacco-Attributable Deaths

Since studies of smoker mortality risk have not generally distinguished SLT users, we developed death rates for all current and former smokers/users and never tobacco users using relative risks, current and former smoking prevalence and mortality rates, similar to standard attribution measures.[46,47] Relative risk estimates for current and former exclusive smokers are those used in previous U.S. SimSmoke models, based on the Cancer Prevention Study II,[48–50] Relative smoking risks vary by age, and average 2.2 for males and 2.0 for females. However, we also consider risks of 2.8 based on recent studies.[51,52] Relative risks for dual users may be less than for exclusive smokers, due to reduced quantity smoked.[41,53,54] However, studies have found similar risks for dual compared to exclusive smokers,[53,55] except with large quantity reductions.[56] We assign the same risks to exclusive and dual cigarette users. Relative risks are assumed to decline with years quit[48–50] at the same rate for exclusive and dual smokers.

Estimates of SLT mortality risks vary with the years studied and the choice of product (e.g., snus vs other SLT).[57–60] A large-scale study using the CPS-I and CPS-II[61] obtained total mortality

risks of 1.17 (1.1–1.23) and 1.18 (1.08–1.29), respectively. Another large-scale study[62] did not obtain significant risks (hazard ratio=1.1, 95% CI=0.6, 1.9). Relative to cigarettes, SLT risks are generally lower for heart, COPD and lung and oral cancer. Studies for snus find substantially lower total mortality risks.[63–65] For the overall mortality risks of SLT, we estimate an exclusive SLT mortality risk of 1.15, with a range of 1.05 to 1.25. We would expect lower risks, if smokers in the U.S. switch to lower risk snus. We also consider those who switch from smoking to SLT and attribute a risk of 1.08 based on a large scale study.[66]

Using standard attribution formulas,[45–48] the relative risks and prevalence estimates for all tobacco use groups are used to estimate each group's mortality rate. The excess mortality risks are then estimated as the difference between the mortality rate of a smoker or SLT group and the mortality rate of never tobacco users at each age. To obtain smoking-attributable deaths, the number of exclusive smokers at each age is multiplied by the excess mortality risks, and the same procedure is applied to former exclusive smokers. Both are summed over all ages to obtain cigarette-attributable deaths. The same procedure is applied to exclusive SLT and dual users to obtain SLT- and dual-attributable deaths (SLT-AD and Dual-AD). Cigarette- and dual-attributable deaths are combined to obtain all-smoking-attributable death (ASAD).

Policy Modules

SimSmoke includes separate modules for tobacco prices (taxes), smoke-free air laws, tobacco control campaign expenditures, advertising restrictions, health warnings, cessation treatment policies including quit lines, and youth access policies. The model is initialized with 1993 policy levels, and incorporates the effect of U.S. or state policies that have changed between 1993 and 2018.

The effects of policies are estimated in terms of the percentage change (PC) relative to the initial rates [PC= (post-policy rate - initial rate)/initial rate], PC<0. Their immediate effect is directly on smoking prevalence, i.e., $Smokers_{t,a}$ * $(1+PC_a)$, which may vary by age. During each year in which the policy continues in effect after the first, the percentage reduction is applied to the initiation rate as $(1+PC_b)$ and as a percentage increase $(1-PC_b)$ to the cessation rate, where PC_b may differ from PC_a. Policy descriptions and effect sizes are shown in Appendix Table 1. When more than one policy is in effect, the effects are multiplicatively applied, i.e., $(1+PC_i)*(1+PC_j)$ 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 in effect.

The effect sizes for each policy are in Appendix Table 1 and the policy levels are in Appendix Table 2.

1. Cigarette Taxes/Price

In the tax module,[49] prices are modeled as having constant proportional effects (i.e., constant price elasticities) with respect to price, as derived from demand studies. Based on previous reviews,[49–53] the model assigns a prevalence elasticity for both cigarettes and dual users of –0.4 for both males and females below age 18; –0.3 for individuals ages 18 to 24; –0.2 for ages 25 to 34; –0.1 for ages 35 to 64; and –0.2 for age 65 and older.

Studies, using a variety of data sources, time periods, and statistical methodologies, have obtained tax elasticities for adult SLT use that mostly ranged from –0.04 to –0.2,[54,55,56] with higher elasticities found in two studies.[54,57] Implied price elasticities ranged from –0.3 to –1.0, indicating price elasticities similar to those for cigarettes.[51,58] Consistent with studies of cigarette

price elasticities,[51] SLT studies[59–61] generally indicate greater effects on youth and young adults than older adults, including higher frequency of use. Based on a recent review and two recent studies,[62,63] the price prevalence elasticity for SLT is estimated at –0.4 for those through age 17, –0.3 for those ages 18–24, and –0.2 for ages 25 and above. Since studies of cross-price effects (the effect of SLT price on cigarette use and vice versa) have obtained mixed results,[64] cross price elasticities were not incorporated and elasticities for exclusive cigarette and dual use were assumed to be the same.

Minnesota SimSmoke incorporates the effect of past tax changes through actual price changes. Minnesota cigarette prices (1993–2016) for November are measured by a retail price index weighted by brand sales that includes generic cigarettes.[65] Results from the 2014 MATS[66] indicated that the average price paid by smokers in Minnesota to be $7.16, close to those from the Tax Burden Report.[65] Prices rose slowly from 1993 to 1998, with larger increases in 1999 following the national tobacco settlement, and in 2005 with a state tax ($0.75) increases in 2009 with a federal tax increase in 2009 ($0.63).[65] The state tax reached $1.50 in 2009, and was then increased by $1.60 in 2013, $0.07 in 2015, $0.10 in 2016, and $0.04 in 2017, with the price reaching $8.66 by November 2017.[67] With the excise tax rate annually adjusted for inflation (under 2013 legislation and repealed in 2017), price was estimated at $8.70 in 2017 to allow for the adjustment with no further change in 2018. Prices were then adjusted in previous years for general price inflation using the Bureau of Labor Statistics Consumer Price Index.[68]

Because Minnesota-specific data were not available over time for SLT prices, both chew and snuff, we developed price data based on the manufacturer price, state and federal taxes, and

wholesale and retail mark-ups.[69] Manufacturer level data on the dollar value of sales and quantity shipped in pounds for the years 1993 to 2018 were converted to average manufacturer price (sales/quantity) per average size snuff and chew product. Taxes at a state and federal level were then added assuming that these costs were directly passed on to consumers subject to a wholesale and retail markup. U.S. prices were checked against prices found on the Internet for various years, as well as Neilsen data found in a recent paper[70] and price data found in a Wells Fargo Report.[71] Prices were deflated using the Consumer Price Index.[68] The federal tax (per pound) increased from $0.30 for snuff and $0.12 in 1993 to $1.51 for snuff and $0.503 for chew in 2009 and the state tax increased from 35% (since 1993) to 70% in 2005. As of January 1, 2014, a minimum tax was applied to all containers of "moist snuff," either 95% of the wholesale price or $2.83 per container (whichever is greater).[72]

The price of both cigarettes and SLT are relevant to dual use. However, because we had limited information on the interactive effects of these different prices, we did not attempt to model their individual effects. Prices for dual users were instead calculated at 75% of the cigarette price and 25% of the SLT price to reflect the greater use of cigarettes.

2. Smoke-Free Air Laws

The smoke-free air policy module considers laws for four types of places: worksites, restaurants, pubs and bars, and other public places.[73] The effect also depends on the level of enforcement. Compared to no smoke-free air laws, the module predicts a 10% reduction in cigarette prevalence rates with complete smoking bans and with complete enforcement. Worksite laws are estimated to have the largest overall effect in reducing smoking prevalence, a 6% effect (relative reduction) in the first year, with the relative reductions from restaurant laws at 2%, pubs and bar

laws at 1%, and other public places at 1%.[53,73] The effects increase by 25% over the long-term through the effects on cessation and initiation. The estimated effects for work site bans are reduced by one-third when smoking is not allowed in ventilated areas and by two-thirds when only not allowed in common areas. The effects are also reduced by half proportional with no enforcement, with effects increasing proportionally to the level of enforcement. The U.S. employment rate and rate of workforce in agriculture in 1993–2017, obtained from the Bureau of Labor Statistics,[68] were used to adjust the effect size of worksite smoke-free air laws.

Studies have found that SLT use is lower within states with smoke-free air laws, although all studies used data prior to 2006.[64] We estimated that these laws have 25% of the effect on exclusive SLT use and on dual use as for exclusive smokers overall years. We note, however, that the effects of smoke-free air laws may have changed to encourage SLT use after 2005, when cigarette manufacturers began to promote the use of smokeless in places where smoking was not permitted.[4,74,75]

In terms of policies in effect, Minnesota had limited smoke-free regulations in worksites, restaurants, and bars between 1993 and 2000.[76] Starting in 2000, Moose Lake enacted 100% smoke-free air policies that applied to worksites. By the end of 2001, Duluth had implemented strong smoke-free air laws, covering 2% of the state population. Bloomington, Golden Valley, Mankato, Minneapolis, and Ramsey County implemented smoke-free air laws in 2005, increasing the percentage of the population covered to about 18%. By the end of 2006, five counties and ten towns/cities had enacted SFA laws representing about 38% of the state population.[76] On October 1, 2007 a comprehensive smoke-free air policy for the state was

enacted, with 100% bans in all workplaces, restaurants, pubs and bars, and other places.

Enforcement is rated on a 10-point scale, where a level of 10 represents complete (100%) enforcement. Because data is not available to directly measure enforcement, we use compliance as a proxy. While one study found that exposure in bars was reduced[77] and another found that perceptions of the opportunities to smoke were reduced,[78] the 2010 MATS[79] indicated that 10% of all Minnesotans were exposed to smoke in the workplace in the past 7 days. While exposure overall was reduced, the 2014[66] MATS reported that over 30% of nonsmokers were exposed in the community at large and 13% of those were exposed at a restaurant or bar. Based on data on workplace exposure, we estimate that compliance increased from 8 out of 10 in 200 and prior years, and to 9 in 2008 and later.

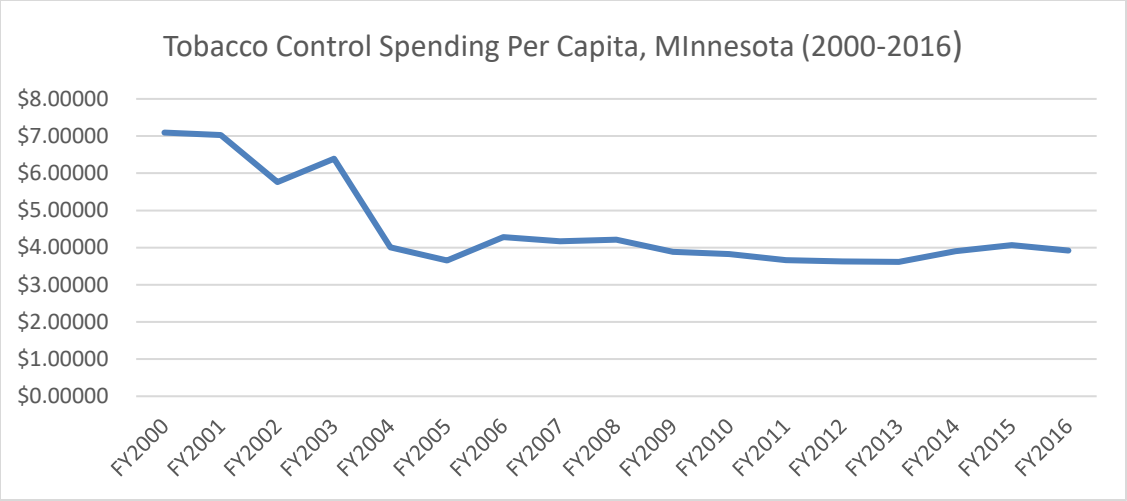
3. Tobacco Control Expenditures

Tobacco control campaigns include expenditures for media campaigns, school education programs, and community interventions as well as cessation treatments. The educational components may provide information about the harms of tobacco use, cessation techniques and availability, and adverse industry behaviors such as advertising.[80] This policy module module[81] as applied to cigarettes is based largely on experiences in California, Massachusetts, and several European nations, where the media campaigns are part of a more comprehensive policy (including local initiatives and other policies). The model distinguishes a high level campaign (over $2.00 per capita), a moderately funded campaign (at least $0.50 per capita), and a low level campaign (at least some expenditures). Since 2000, SimSmoke also uses CDC recommended minimums of tobacco control expenditures (low <25%, 25%$\leq$medium<75%, $\geq$75% high). Tobacco control campaigns are estimated to yield up to a 6.5% reduction in cigarette prevalence

rates (relative to the initial level). Compared to a high publicity campaign, a moderately publicized campaign is assigned 50% of the effect, and a low publicity campaign is assigned 25% of the effect.[53,81]

Several studies have examined educational policies that provide information about the relative harms of SLT and cigarettes or about cessation. Studies have generally found educational campaigns effective for youth[82–84] and adults.[85,86] With limited information on the effectiveness of expenditures on SLT-oriented campaigns and the extent of expenditures on SLT-oriented campaigns, we impute 50% of the effect of cigarettes in reducing SLT use, due to the potential role in educating individuals about the harms of any tobacco use and the role of changing tobacco norms. We assume the same effect size for exclusive cigarette and dual users.

Minnesota has had active tobacco control campaigns since 1985. Data from CDC[87] indicating per capita expenditures of less than $1.00 from 1993 to 1999, and then generally in the range of about $4.00 per capita from 2000 to the present. There was a focus on youth in the early years from 2000–2003,[88] which was found to be effective.[89] A statewide media campaign has been active since 2001 initially to encourage smokers to stop smoking and to increase awareness among smokers and nonsmokers of the dangers of secondhand smoke. Recent evidence also indicates high levels of youth exposure to advertisements.[90] Media campaigns have not been directed at SLT use or other alternatives to cigarette smoking in Minnesota. Minnesota campaigns are designated as low-level in 1993–1995, mid-level in 1996–1999, and high-level in 2000. Because campaign expenditures have remained above $2.00 per capita, tobacco control campaigns are maintained at a high level from 2000 through 2018.



4. Marketing Restrictions

Marketing restrictions are imposed on the industry and are considered at four levels (none, minimal, moderate, and complete policy) and their effect depends on enforcement levels. With a complete ban on direct and indirect marketing, *SimSmoke* reduces the prevalence of exclusive cigarette use by 5%, increases cessation by 4% and reduces initiation by 8%, but, as with smoke-free air laws, the effects are halved with no enforcement.

Evidence on the effectiveness of SLT marketing restrictions is mixed. The odds of youth experimenting with snus was found to increase with the number of different types (Internet, newspapers/ magazines, and retail store) of tobacco advertisements viewed by youth.[91] In-store, magazine, and mail promotions predicted awareness, and magazine ads and online promotions predicted the trial of dissolvable tobacco products by adults.[92] Teens who had ever tried flavored tobacco products were found to be 3 times more likely to be current smokers than those who never tried flavored tobacco products.[93] An online experiment[94] found that packaging and corporate branding encouraged SLT use, especially among youth and young adults. Like

cigarette marketing,[84,95,96] SLT advertising, new product introductions and packaging are associated with greater product use, particularly among youth. SLT and dual use marketing restrictions are assigned the same effect as those directed at cigarettes.

Federal law prohibits advertising of cigarettes (*Public Health Cigarette Smoking Act of 1969*) and SLT (1986) on any electronic communication medium, including television and radio. The 2009 Family Smoking Prevention and Tobacco Control Act mandates some new restrictions on the marketing and advertising of cigarettes and smokeless tobacco: (1) outdoor advertising within 1,000 feet of schools and playgrounds, (2) brand sponsorships of sports and entertainment events, (3) free giveaways of any non-tobacco items with the purchase of a product or in exchange for coupons or proof of purchase, (4) free samples and the sale of cigarettes in packages that contain fewer than 20 cigarettes, (5) advertising in publications with significant teen readership, except to black text on white background only, and (6) most audio-visual advertising. However, two important sources of advertising remain, at retail point-of-sale and in newspapers and magazines, as well as social media.[97,98] In 2014, 8.5 billion was spent on advertising and promoting cigarettes in the U.S., with approximately 85% of these expenditures for discounts, price promotions, coupons, and other activities that lower prices, and 3% was spent on point-of-sale display advertising.[99] In the same year, $1.2 billion was spent on advertising and promoting SLT products, with more than 50% for activities that lower SLT prices and 3% for point-of-sale advertising.[100] While federal law prohibits SLT advertising on television and radio, SLT advertising in U.S. magazines increased substantially between 1998–1999 and 2005–2006, with more recent ads displaying flavored products, using messages portraying SLT products as alternatives to cigarettes, and depicting their use in indoor settings.[101]

Using information from the U.S. SimSmoke,[18] restrictions on advertising are categorized as minimal through 2018 for SLT and cigarette use. The 2007 MATS Report notes that marketing still takes place in the form of being approached at bars and price discounts. Enforcement is set at level 8 out of 10 in all years, based on exposure to ads.

5. Health Warnings

The health warnings module includes four levels: none, minimal (<30% of the principal pack display area), moderate (a warning that covers at least 30% of the principal display area), and strong (a warning that covers at least 30% of the principal display area and is graphic). Evidence on the effects of health warnings on cessation behaviors is provided in Levy et al.[50] and has been strengthened based on a more recent article.[102] Two recent studies obtain prevalence reductions in Canada near 12%.[103,104] With strong health warnings, prevalence of exclusive cigarette use is reduced by 4%, cessation is increased by 10% and initiation is reduced by 6%.

Similar to cigarettes,[105,106] evidence indicates limited effectiveness of text-only warnings on SLT packages,[107,108] but pictorial warnings have been associated with less susceptibility to SLT use among youth and greater interest in cessation among adults.[94,109,110,111] We estimate the same effect of health warnings on exclusive and dual SLT use as on cigarette users.

Health warnings are set at the national level, and have covered less than 10% of cigarette packages since they were first implemented in 1966. They are considered to be at a low level in all years. However, since 2010, SLT packaging is required to display text warnings covering two principal sides of the package and covering at least 30% of each side. SLT warnings are assigned a low level until 2009, and are considered at a moderate warning since 2010.

6. Cessation Treatment

The cessation treatment policy module has four sub-policies: pharmacotherapy availability, financial coverage of treatments, quit lines, and brief interventions. These policies have initial effects through prevalence and future effects on cessation, but no effect on initiation.

The pharmacotherapy availability sub-policy option is based on whether NRT and/or non-nicotine replacement therapy, such as Bupropion and Varenicline, are available and where they may be obtained. If all three PT are available and NRT is available without prescription, prevalence is reduced by 1.0% in the first year and the pre-policy cessation rate is increased by 4% in all years after the first. The financial coverage of treatment sub-policy option is in terms of the percent of the population that is completely covered for pharmacotherapy and behavioral therapy. This reduces prevalence by 2.25% and increases cessation by 8% when well publicized.[53,112,113] The quit line sub-policy option indicates that quit lines, when active and publicized, reduce prevalence by 1% and increase cessation by 6% in all years after the first.[50] The brief intervention sub-policy option indicates that when fully implemented, brief interventions reduce prevalence by 1.0% and increase the cessation rate by 6%.[50] The above effects are also subject to interactions, as described in more detail in Levy et al.[113] With all policies implemented, smoking prevalence is initially reduced by 5%, but the effects grow over time due to the higher cessation rates (20% higher) to more than 8% within 10 years.[53,112,113]

Evidence of cessation treatment policy effectiveness toward SLTs is less strong. Reviews[114–116] of randomized trials have found Varenicline effective at increasing cessation. While studies find limited or no effects for nicotine replacement therapy,[114–116] an 8-week trial of 4-mg nicotine lozenge and tobacco-free snuff for 81 SLT users with no immediate intention to quit found 12%

biochemically-confirmed abstinence at week 26.[117] Reviews[114–116] have also found behavioral interventions, particularly telephone counseling or healthcare provider interventions, to promote quitting among SLT users. However, SLT users currently use these resources at low rates.[118] Cessation treatment policies were assigned 50% the effect on SLT users while dual users are assigned 75% of the effects compared to the effect on smokers.

Pharmacotherapy Availability Sub-Policy Option

In 1993, the patch was available only by prescription. The prescription requirement for patch and gum was removed in 1996. In the model, Minnesota smokers were assigned the ability to obtain the patch and gum with a prescription since 1993, changing to the ability to buy the patch and gum from a pharmacy without prescription since 1997. The nicotine lozenge has been available since 2002 without prescription. Bupropion has been available since 1998 and Varenicline (Champix) has been available since 2007, both with prescription.

Financial Coverage of Treatment Sub-Policy Option

The majority of Minnesotans have health insurance. A Minnesota Health Access Survey indicates that 52% of those with health insurance have private insurance coverage, 36.5% have public insurance coverage (e.g., Medicare, Medicaid, VA), and 4.4% purchase insurance coverage on the individual market. A survey also shows that rates of uninsurance have varied over time (2001=6.1%; 2007=7.7%; 2009=9%; 2011=9%; 2013=8.2%; 2015=4.3%; 2017=6.3%).[119]

The Affordable Care Act, as well as other federal laws and rules, require almost all health insurance plans in the U.S. to cover some level of tobacco cessation treatments. Coverage varies

by category of insurance (e.g., Medicare, Medicaid, insurance purchased on the market, as well as group or employer-sponsored plans), and may vary depending on the specific insurance product sold.[120] While these requirements exist and have helped close coverage gaps, understanding of and compliance with these requirements still varies widely across private insurance markets (including self-insured).

According to the MMWR,[121,122] Minnesota Medicaid began covering the following tobacco dependence treatments: Nicotine gum in 1996, Nicotine patch in 1996, Individual counseling in 1996, Group counseling in 1996, Nicotine nasal spray in 1996, Nicotine Inhaler in 1997, Bupropion in 1997, and Champix/Varenicline in 2007. Co-payments were removed for cessation medications for Medicaid enrollees in January 2016; there were already no co-payments for individual and group counseling at that time. Under the Affordable Care Act, Minnesota expanded its Medicaid program to cover more low-income individuals. Minnesota also has the MinnesotaCare program, which covers additional low-income individuals (those at 200%–400% of the federal poverty level). All Medicaid and MinnesotaCare enrollees, totaling about 1,000,000 Minnesotans, have access to all seven FDA-approved cessation medications, as well as individual and group counseling through their health insurance.

Medicare now covers some, but not all, cessation treatments (no OTC products are covered). State employees in Minnesota had full coverage for all FDA-approved cessation medications and all forms of counseling as of January 2016, but prior to that date had limited coverage which varied under different state plans. QUITPLAN Services, Minnesota's quit line program, provides

cessation treatments, including nicotine replacement therapy (see Quit line sub-policy section below).

Since specific information on levels in tobacco cessation coverage was not available for the private insurance market or on grandfathered plans, this limited our ability to provide a precise estimate of coverage for tobacco dependence treatment. We estimate that levels of coverage are the same for pharmacotherapy and behavioral therapy. We estimate that coverage for both types of therapy was effectively available to 40% of smokers in 1993, increasing to 60% in 2003 and increasing to 70% by 2007 due to the changes in coverage described above and services provided by QUITPLAN Services (see Quit line sub-policy section below). With the increases in the number of insured as well as the Affordable Care Act preventive services requirement that addresses cessation treatment, the levels of coverage were increased to 85% in 2011 and 90% in 2016.

Quit Line Sub-Policy Option

Minnesota began an active cessation program soon after the settlement. ClearWay Minnesota began its telephone counseling program (QUITPLAN Helpline) in 2001. ClearWay Minnesota was directed not to duplicate or supplant benefits available through health insurance, and thus has limited eligibility for the QUITPLAN Helpline to the uninsured and underinsured (i.e., those who do not have coverage for quit line counseling and nicotine replacement therapy (NRT) through their health insurance). Five of the seven major health plans in Minnesota provide quit line services to their members. NRT coverage varies for insured populations. Information was not available about the percentage of health plan members that have an NRT benefit through their health insurance. An et al.[123] found that about 2% of Minnesota smokers used the quit line.

A study[124] found that, in the first year, almost 3.8% of the approximately 720,000 Minnesota smokers contacted the quit line, of which about 1.1% were referred to private plans. The rates of callers dropped to about 1% of smokers in the following years, with progressively more being referred to private plans. ClearWay Minnesota has funded additional QUITPLAN Services over time. These programs are not described because they are not directly incorporated in the model.

In March 2014, ClearWay Minnesota redesigned its cessation services. The QUITPLAN Helpline, providing telephone counseling and 4 weeks of NRT to the uninsured and underinsured was maintained (those with insurance who wish to enroll in a telephone counseling program are connected to their health plan quit line). A new suite of services, called Individual QUITPLAN Services, was added. These services are provided to all adult tobacco users in Minnesota, regardless of insurance status, and consist of a 2-week starter kit of NRT, text message support, e-mail support, and a quit guide. Tobacco users can sign up for any of the Individual QUITPLAN Services alone or in combination. Additionally, tobacco users can sign up for the Helpline and Individual QUITPLAN Services either online or by phone.

Studies have generally found increased usage of these services in recent years,[125–127] and especially following the cigarette tax increase of 2013[128] and the redesign of QUITPLAN in in 2014[106] as well as increased usage by those reporting any SLT use starting in 2014.[129] The 2014 MATS[66] report that pharmacotherapy and behavioral therapy both show large initially increases between 2003 and 2007, but settled to lower rates by 2014.

Quit line studies for Minnesota found rates of quit success comparable or even at the high end of state quit line studies,[53,112,113] with more recent studies finding higher rates with the provision of pharmacotherapies to callers.[125,130] Since ClearWay Minnesota has actively and consistently funded and promoted QUITPLAN Services, Minnesota is categorized as having an active, well publicized quit line since 2001.

Brief Interventions

ClearWay Minnesota has periodically undertaken efforts to inform clinicians about the PHS Guideline and the Minnesota Quit Line Network (Minnesota's quit line fax referral program), as well as funding health systems change projects. For example, ClearWay Minnesota sponsored access to an online CME program on its website, and inserted an informational card for providers in an issue of Minnesota Medicine (monthly journal of the Minnesota Medical Association). In 2014, ClearWay Minnesota began funding efforts to improve how clinics and health systems assessed and addressed tobacco use. Data from the 2014 MATS[66] indicate that about 70% of smokers visit a healthcare provider, of which over 90% were asked about smoking, about 75% receive advice and 50% receive a referral, which has changed little since 2007.[131] We estimate that 50% of physicians have effectively provided brief advice since 2004, increasing from 40% in previous years.

7. Youth Access Laws

The youth access module considers the effect of restrictions on self-service and vending machines, and retail compliance. The model considers three levels of retail compliance: strongly enforced and publicized (retailer violation rate less than 5%); well enforced, but with little community support (retailer violation rate between 5% and 16%); weak enforcement (retailer

violation rate more than 16% and below 30%); and no enforcement (retailer violation rate more than 30%).[132,133] As retail sales to youth are reduced, youth may switch to non-retail sources such as theft, older peers and parents, which limits the effect of youth access policies to a maximum estimated 16% reduction in youth smoking initiation for 16 and 17-year-olds and 24% on 10–15 year-olds.[132,133] These effects are enhanced by 8% in relative terms with a vending machine ban, by 4% with a self-service ban, and by 10% with publicity.

Two studies of youth SLT use[59,60] found evidence that youth access policies affect SLT use, although the effect was weak. A study for the U.S.[134] and one for Minnesota[135] found lower rates of compliance for SLT than for cigarettes. Youth access policies are assigned 50% the effect on exclusive SLT use compared to the effect on cigarette use, while the effects on dual use are assumed the same as for exclusive cigarette use. The youth access data on enforcement were based on Synar enforcement.[76] In 2010, the Tobacco Modernization Act[136] required all tobacco products to be behind the counter and extended enforcement to all tobacco products, thereby increasing the ability to avoid theft by underage youth and underage purchase of SLT. The data indicate compliance rates above 20% through the year 2000 classified as low, then 5%–16% through 2010 classified as medium, and below 5% since 2011 classified as high. The same classifications were applied to exclusive and dual SLT use. A national ban was implemented in 2009 and vending machines were banned in 1996.

Several local areas in Minnesota, including Minneapolis in May 2018 and Bloomington in November 2017, have recently implemented laws raising the minimum legal purchase age to 21.[136] These laws are not expected to have affected smoking prevalence through 2018, but can be

expected to play a role in future rates. The effects will be modelled using the parameters in the recent IOM Report on raising the legal age to 21.[137]

Calibration

To calibrate the model we employed methods that have been used in previous SimSmoke models. The CPS-TUS data used to populate and calibrate our model was only available every three years (i.e., 1992/3, 1996/7, 1998/9). Since we did not have sufficient time series data to conduct a grid search, we focused on the time period 1993–1996, in order to consider a time period before new policies were implemented and to allow sufficient time to validate the model. We compared predicted rates to rates from the CPS-TUS survey for 1996, and checked whether the resulting time trends were reasonable, i.e., showed a smooth slow downward trend. We further considered the year 1998, where the 1996 data were not sufficient to detect trends (e.g., due to large SEs) or appeared subject to error.

The predicted levels of exclusive cigarette prevalence for males ages 18–24 from the model were initially considerably lower and to a lesser extent also lower for ages 35 and above compared to the 1996 and 1998–1999 estimated male exclusive cigarette prevalence rates from the CPS-TUS. Consequently, we calibrated the model by increasing the initiation rates for ages 18–30 by 15%, and reduced the cessation rate for ages 35 and above by 10%, thereby improving predictions for exclusive cigarette use. For females, the prevalence rates for current exclusive smokers for those ages 18–24 and those ages 25–44 were much higher than the rates from the 1996 TUS. Consequently, we reduced the initiation rate (through age 27) for female smokers by 20%. For male SLT and dual use, there was no further calibration due to small sample sizes. Due to the

sample size limitation, we do not consider the female exclusive SLT users or female dual users, and most of their prevalence by age group and year reported in CPS-TUS is 0.0%.

Validation

To validate the model, we compared predictions from our model that incorporate policies implemented between 1993 and 2015 to rates of cigarette and SLT use. We use 1998/9 2001/2, 2002/3, 2006/7, 2010/11, 2014/15 CPS-TUS surveys and the 1999, 2003, 2007, 2010, and 2014 Minnesota Adult Tobacco Survey. CPS-TUS is a national survey that is constructed to be state representative. MATS 2014 was a telephone survey of more than 9,000 adult Minnesotans, conducted between February and July 2014, similar in size to previous surveys, with similar sample sizes and methodology in earlier years.

For the CPS-TUS and MATS, we use the same definitions for cigarette use as used in the model (100 cigarettes lifetime and having smoked in the last 30 days). However, screening questions on SLT use in the TUS changed from "regular use" prior to 1998 to "at least one time in the last month" in the last month. Current SLT users from 1998 onward are defined as individuals who are currently using SLT at least 10 days in the last month, based on previous analysis,[138] but also consider 20 of the last 30 days use.

We applied two data sources for MATS, distinguished as MATS 1 and 2 in the validation Appendix Figure 1. MATS 1 is the prevalence for overall smokers and SLT users collected from MATS reports. It provided valid estimations for smoking prevalence by age and gender separately in 1999, 2003, 2007, 2010, 2014, and 2018, and provided valid estimations for SLT use rates by gender in 2007, 2010, 2014, and 2018. MATS 1 used the same measure as the CPS-TUS for current smokers. However, the current SLT users were defined as those who used SLT

products at least 20 times in lifetime and at least one time in past 30 days. MATS 2 was the data for exclusive smokers, exclusive SLT users, and dual users by age and gender collected from MATS surveys in 1999, 2003, 2007, 2010, 2014, and 2018. It defined current smokers as those having smoked 100 cigarettes lifetime and smoked at least 1 day in past 30 days, and defined current SLT users the same as in CPS-TUS.

Since the survey estimates may reflect differences in how the surveys are conducted, we consider percentage change in the rates over time. We conduct comparisons by gender for all adults (ages 18 years and above) and for the 18–24, 25–44, 45–64, and 65 and older age groups.

Assessing the Impact of Past Tobacco Control Policies

Upon validating the model, we estimate the effect of policies implemented between 1993 and 2018. First, we programmed the model so that all policies remain at their 1993 levels. Comparing the predictions of this model with the estimates with all policies implemented provides an estimate of the net reductions in smoking prevalence due to the policies implemented since 1993. We next consider the contribution of individual policies and their contribution to the overall predicted decline in smoking during this period, by reprogramming the model to only allow for the change in that policy while holding other policies constant.

We examine the relative reduction in a policy relative to the sum of the effect of all policies, since the effect of the individual policies do not add up to the contribution when all policies are simultaneously implemented due to assumption of multiplistic effects between policies and the assumption of synergism between policies. We focus on the impact of policies through 2018. We separately consider the effects of policies on (dual and exclusive) cigarette use and (dual and

exclusive) SLT use for both genders as weighted by their respective prevalence rates. The charts are presented as a weighted average of the male and female effects.

The Effect of Stronger Future Tobacco Control Policies

We consider the effect of strengthening current policies individually and in combination to levels that are similar to those recommended in the Healthy People 2010 objectives, as well as comprehensive marketing restrictions and strong health warnings. Their incremental effect will depend on the level of policies in effect in 2018. The effects of policies are presented relative to the *status quo* level in the same year, i.e., (Policy $rate_t$- *status quo* $rate_t$)/ *status quo* $rate_t$, for the smoking prevalence, and in terms of lives saved for attributable deaths. We consider changes in the following policies, individually and in combination:

- Tax are increased by $1.50 beginning in 2021 and maintained over time. We consider the effect of a $1.50 increase for cigarette tax alone. We also consider the effect of a $1.50 increase for both cigarettes and SLT tax, with the SLT tax based on current laws that require a tax on SLT equivalent to that on cigarettes. We assume that these taxes are indexed to inflation, so that their value is maintained over time.
- Raising the minimum purchase age from 18 to 21 for both cigarettes and SLT implemented in 2020.
- Reducing the level of funding in 2020 from a high to medium level and simultaneously terminating the quit line service (although maintaining other cessation programs).

RESULTS

Validation Against TUS and MATS 1 for Overall Smokers/Users

We first validated the model against overall smoking prevalence (including exclusive smokers and dual users) and overall SLT users (including exclusive SLT and dual users). In the TUS, overall smokers are those who smoked at least 100 cigarettes lifetime and now use cigarettes every day/some days; overall SLT users are people who used SLT products at least 10 times in past 30 days. MATS data were collected from MATS reports during 1999–2018. MATS had two data sources distinguished as MATS 1 and 2 in validation Appendix Figure 1. MATS 1 was the prevalence data for overall smokers and SLT users collected from MATS reports since 1999. It used the same measure with CPS-TUS for current smokers, however, the current SLT users were defined as people who used SLT products at least 20 times in lifetime and at least one time in past 30 days. MATS 2 included data for exclusive smokers, SLT users, and dual users collected from MATS surveys. It defined the current smokers as having smoked 100 cigarettes in their lifetime and smoked at least 1 day in past 30 days, and defined the current SLT users with the same measure in CPS-TUS.

As shown in Appendix Figure 1a and 1b, *SimSmoke* predicted that male (female) smoking prevalence (ages 18 and above including exclusive and dual use) fell from 25.3% (23.5%) in 1993 to 15.0% (13.3%) in 2015, while the CPS-TUS was 25.6% with 95% CI=23.2%, 28.1% (24.0% with 95%CI=21.9%, 26.1%) in 1993 and 14.4% with 95% CI=12.5%, 16.2% (12.4% with 95% CI=10.9%, 14.0%) in 2015. By 2018, smoking prevalence had fallen to 14.1 (12.5%) in SimSmoke estimations, compared to 15.0% with 95% CI=13.2%, 16.8% (12.6% with 95% CI=10.9%, 14.3%) in MATS. For both 2015 and 2018 as well as for all years, except the

overestimation for male smokers in 1998 (24.5% compared with TUS 95% CI=15.2%, 22.1%) and female smokers in 1999 (21.6% compared with TUS 95% CI=16.2%, 21.4%) and 2003 (19.3% compared with TUS 95% CI=14.9%, 18.3% and MATS 95% CI=14.9%, 18.9%), *SimSmoke* predictions were well within the 95% CIs of the respective surveys. Similar analysis by age group yielded predictions within the CPS-TUS CIs for each gender.

Validation for male SLT prevalence was less clear. As shown in Appendix Figure 1c *SimSmoke* predicted that male SLT prevalence (ages 18 and above including exclusive and dual use) fell from 3.9% in 1993 to 2.6% in 2015 and 2.5% in 2018, compared to 3.9% with 95% CI=2.8%, 4.9% in 1993 TUS, 1.7% with 95% CI=1.2%, 22% in 2015 TUS, and 6.4% with 95% CI=5.2%, 7.6% in 2018 MATS. In both 2015 and 2018, *SimSmoke* projections were outside the CI of respective survey. For earlier years, projections were generally within the CPS-TUS CIs but below the MATS 1 CIs.

Validation of Exclusive and Dual Smoking and SLT Prevalence

SimSmoke predictions incorporating policy changes were also validated against the estimates from the TUS and MATS data distinguishing exclusive smokers, exclusive SLT users and dual users.

Validation Against the CPS-TUS

In Appendix Table 3a, the model was validated for the period 1993–2002, 2002–2007, 2007–2010/2011, and the 2010/2011–2014/2015 using the CPS-TUS, and finally considered the change from 1993–2015. Since the 2010/2011 data was mainly collected in 2010 (May 2010, August 2010, and January 2011), and 2014/2015 data was mainly collected in 2015 (July 2014,

Jan 2015, and May 2015), we compared model projections in 2010 and 2015 with those years. As shown in Appendix Table 3 for the adult population (ages 18 and above), *SimSmoke* predicted that exclusive male (female) cigarette prevalence fell from 24.1% (23.5%) in 1993 to 20.4% (20.0%) in 2002, and to 14.0% (13.3%) in 2015, and similarly the TUS showed a decline from 24.4% with 95% CI=22.0%, 26.9% (24.0% with 95% CI=21.9%, 26.1%) in 1993, to 21.0% with 95% CI=19.0%, 22.9% (19.2% with 95% CI=17.5%, 21.0%) in 2002, and to 14.0% with 95% CI=12.3%, 15.9% (12.2% with 95% CI=10.7%, 13.9%) in 2015. All projections of male and female exclusive smoker prevalence were within the 95% CI of CPS-TUS from 1993–2015. Adult male (female) exclusive smokers from the TUS showed a 43% (49%) relative reduction between 1993 and 2015 compared to 42% (44%) relative reduction predicted by *SimSmoke*. The model also does well for adult smokers during the two sub-periods (1993–2002 and 2002–2015), and the relative reductions over each time period differed by less than 5% of TUS estimates for both genders, and well within the CIs.

In examining the reductions by age groups for male exclusive smokers, the model generally predicted well, but under-estimated the increase for ages 18–24 during 1993–2002, under-estimated the reduction for ages 18–24 during 2002–2015, over-estimated the reduction for age 65 and above during 2002–2015. For female exclusive smokers, the model over-estimated the decrease for ages 18–24 during 1993–2002 and under-estimated the decrease for age 18–24 during 2002–2015, but otherwise predicted well.

SimSmoke predicted that male dual use prevalence stayed the same from 1.2% in 1993 and 2002 to 0.9% in 2015, and similarly the TUS showed a decline from 1.2% with 95% CI=0.6%, 0.8%

in 1993, to 0.8% with 95% CI=0.4%, 1.2% in 2002and 0.8% with 95% CI=0.4%, 1.4% in 2015. Adult male dual use from the TUS showed a 36% relative reduction between 1993 and 2015 compared to a 21% relative reduction predicted by *SimSmoke*. The predictions in all years were within the 95% CI for adult male users. However, *SimSmoke* predicted a stable prevalence when the prevalence was measured to have drop during 1993–2002 and predicted a decrease when the prevalence was measured to be stable during 2002–2015 in TUS. By age groups, the model predictions were all within in the 95% CI measured by TUS except for age 24–44 in 2002 where model predicted 1.8% and TUS measured 0.8% with 95% CI=0.2%, 1.5%. Due to small sample size and large variation within age groups, the model had a weak performance in predicting the prevalence fluctuation for sub-age groups in sub-periods. Due to the small number of female dual users observed in the TUS, we did not validate for this group.

SimSmoke predicted that male exclusive SLT use prevalence slightly fell from 2.7% in 1993 to 2.1% in 2002, and to 1.7% in 2015, while the TUS showed an increase from 2.8% in 1993 to 3.4% with 95% CI=2.5%, 4.3% in 2002, and decreased to 2.6% with 95% CI=1.9%, 3.5% in 2015. Male use in the TUS showed an 8% relative reduction between 1993 and 2015 compared to a 40% relative reduction predicted by *SimSmoke*. The predicted male prevalence was lower than the TUS 95% CI in 2002 and 2015. By age group, *SimSmoke* predicted the reduction in ages 18–24 during 1993–2002 but failed to detect the increase in ages 18–24 during 2002–2015. *SimSmoke* failed to detect the increase for ages 25–44 during 1993–2002 but predicted the decrease during 2010–2015. The model predicted decreases during 1993–2002 and 2002–2015 but TUS measured stable rate during 1993–2002 and slight increase during 2002–2015. The discrepancy is small for age 65 and above and the model predicted the continues reduction in

1993–2002 and 2002–2015. Due to the small number of female SLT users observed in the TUS, we did not validate for these users.

Validation Against MATS

As shown in Appendix Table 3b, the model was validated for exclusive cigarette, exclusive SLT and dual users against the MATS over 1999–2007 and 2007–2014. For the adult population (ages 18 and above), *SimSmoke* predicted that exclusive male (female) smoking prevalence fell from 22.4% (21.6%) in 1999 to 17.3% (16.4%) in 2007, to 13.2% (12.5%) in 2018, and similarly the MATS showed a decline from 18.7% with 95% CI=16.3%, 21.1% (17.9% with 95% CI=16.0%, 19.9%) in 1999, to 18.3% with 95% CI=16.2%, 20.4% (15.7% with 95% CI=13.8%, 17.5%) in 2007, to 14.0% with 95% CI=12.2%, 15.8% (12.6% with 95% CI=11.0%, 14.3%) in 2018. Most estimated prevalence for male and female exclusive smokers aged over 18 were within the 95% CI of MATS, except overestimating the male smokers in 1999 and female smokers in 1999 and 2003. Adult male (female) smokers from the MATS showed a 1.8% (12.6%) relative reduction between 1999 and 2007 and a 23.8% (19.5%) relative reduction between 2007–2018, compared to 22.9% (24.1%) and 23.5% (23.6%) relative reductions predicted by *SimSmoke*. The model does well for the decreasing pattern of adult smoking rates during the years, however, *Simsmoke* model overestimated the reduction from 1999 to 2018 for both genders (41.0% vs 25.2% relative reduction for male smoking rates in *Simsmoke* and MATS; 42.0% vs 29.6% female relative reduction for female smoking rates).

In examining the reductions by age groups for male exclusive smokers, the model failed to predict the slight increase for males aged 18–24 and 45–64 during 1999–2007, underestimated the reduction for males aged 18–24 during 2007–2018, and overestimated the decrease for ages

45–64 during 2007–2018. The model also overestimated male smokers aged over 65 during all years. For female exclusive smokers the model had a better prediction, but it overestimated the reduction for ages 45–64 during 1999–2007 and ages 25–44 during 2007–2018 and underestimated the decrease for ages 18–24 during 2007–2018.

For the adult males by different periods, *SimSmoke* predicted that dual use rate fell from 1.2% in 1999 to 1.1% in 2007, to 1.0% in 2010, and to 0.9% in 2018, however, MATS showed a decline from 1.5% with 95% CI=0.7%, 2.3% in 1999 to 0.9% with 95% CI=0.5%, 1.4% in 2007, but increased to 1.5% with 95% CI=0.9%, 2.1% in 2010, then decreased to 1.3% with 95% CI=0.7%, 1.8% in 2018. All estimated prevalence for overall male dual use were within the 95% CI of MATS. Adult male dual use from the MATS showed a 38.4% relative reduction compared to 12.5% predicted by *SimSmoke* between 1999 and 2007, but showed a 35.1% relative increase compared to 17.6% reduction predicted by *SimSmoke* between 2007 and 2018. Over years, the model overestimated the reduction for male dual use (29.9% relative reduction in *SimSmoke* vs. 16.7% relative reduction in MATS). In examining the changes by age groups for male dual users, the model failed to predict the increase for ages 18–24 during 2007–2018 and ages 25–44 during 1999–2010, failed to predict the decrease for ages 45–64 during 1999–2003 and 2007–2010 and ages over 65 during 2003–2010. Due to the small number of female dual users observed in the MATS, we did not validate for this group.

For the adult males by different periods, *SimSmoke* predicted that exclusive SLT use rate fell from 2.3% in 1999 to 1.9% in 2007, to 1.8% in 2010, and to 1.6% in 2018, however, MATS showed a decline from 4.2% with 95% CI=3.1%, 5.4% in 1999 to 3.4% with 95% CI=2.5%,

4.2% in 2007, but increased to 4.7% with 95% CI=3.7%, 5.7% in 2010, then decreased to 3.8% with 95% CI=2.8%, 4.7% in 2018. All estimated prevalence for overall male SLT use were smaller than the lower bounds of 95% CIs in MATS. Adult male SLT use in MATS showed a 20.6% relative reduction compared to 17.7% predicted by *SimSmoke* between 1999 and 2007, but showed a 12.9% relative increase compared to 15.8% reduction predicted by *SimSmoke* between 2007 and 2018. Over years, the model overestimated the reduction for male dual use (30.7% relative reduction in *SimSmoke* vs 10.3% relative reduction in MATS). In examining the changes by age groups for male SLT users, the model failed to predict the increase for ages 18–24 during 2007–2010 and 2014–2018, ages 25–44 during 2007–2014, ages 45–64 during 1999–2010, and ages over 65 during 2003–2007 and 2014–2018, and underestimated the decrease for ages 18–24 during 1999–2007. Due to the small number of female dual users observed in the MATS, we did not validate for this group.

The Effect of Tobacco Control Policies Implemented Through 2018

Comparisons of the effect of policies implemented between 1993 and 2018 to a counterfactual with policies set to their 1993 levels (i.e., the absence of policy change) are shown in Appendix Table 4. Results for tobacco-attributable deaths and lives saved are shown in Appendix Tables 5, with the last column summed over the years 1993–2040 to obtain the lives saved over that period.

In 1993, total tobacco-attributable deaths in Minnesota were 5,367 (3,411 males), including 5,279 (3,323 male) exclusive smokers, 17 male (0 female) dual users and 71 male (0 female) exclusive SLT users. In 2018 with actual policies, *SimSmoke* projected 6,281 (4,062 male) deaths, including 6,117 (3,898 male) exclusive smokers, 102 male dual users and 62 male

exclusive SLT users. In future years, premature deaths for males were projected to increase to 3,942 in 2022 then decline to 3,335 in 2040 among exclusive smokers, continuously increasing to 178 in 2040 among male dual users, and increasing to 79 in 2000–2003 then decreasing to 61 in 2021–2029 and increasing to 65 in 2040 among exclusive SLT users. Premature female deaths among exclusive smokers were projected to increase gradually to 2,529 in 2036 and 2037 and then slightly decline to 2,513 in 2040.

Compared to the no policy change scenario (counterfactual with no new policies had been implemented since 1993), *SimSmoke* projected that exclusive cigarette, dual, and exclusive SLT use rates in relative terms would have been 35% (36%), 32% (not available) and 16% (not available) higher in status quo, respectively by 2018 for males (females). As a result of policies, annual tobacco-attributable deaths were reduced by 1,058 (662 males) in 2018 alone with a cumulative impact from 1993 to 2018 of 7,808 (4,916 male) fewer tobacco-attributable deaths. By 2040, the impact for males (females) increases to a reduction of 43% (44%) for exclusive cigarette, 42% (not available) for dual and 15% (not available) for exclusive SLT use, as policies continue to reduce tobacco use through increased cessation and reduced initiation. Due to policies implemented by 2018, 46,933 (28,662 male) premature deaths are averted by 2040.

Comparing the counterfactual for each individual policy to that of no policies, much of the gain for exclusive cigarette use is due to price increases. Price increases alone are predicted to have reduced the exclusive cigarette use rates in relative terms by 19% for both genders in 2018 increasing to 25% and 24% for males and females by 2040, and would have reduced premature deaths by 21,264 (13,130 males) by 2040. Smoke-free air laws yielded an 8% relative reduction

in exclusive cigarette use for both genders in 2018 increasing to 9% reduction by 2040, and would have reduced premature deaths by 11,340 (6,806 males) by 2040. Cessation treatments showed a 4.6% (5.2%) relative reduction in 2018 increasing to 5.0% (6.1%) by 2040 for males (females), and would have reduced premature deaths by 10,649 (6,395 males) by 2040. Tobacco control expenditures and youth access enforcement showed 2.9% (3.1%) and 2.6% (2.7%) reductions in 2018 increasing to 3.1% (3.4%) and 6.5% (6.6%) by 2040 for males (females), and would have reduced premature deaths by 5,693 and 487 by 2040. For male (female) exclusive cigarettes users, taxes represented 52% (50%) of the total policy effects, followed by smoke-free air laws at 21% (22%), and cessation treatment at 12% (14%) by 2018.

Different results are observed for dual and exclusive SLT use. For male dual use, the largest reductions by 2018 are again for taxes (59% effect), and followed by youth access enforcement (13%), followed by cessation treatment (10%), and smoke-free air law (9%) and tobacco control expenditures (9%). For exclusive SLT use, the largest reduction by 2018 is again for taxes (65% effect), and followed by cessation treatment (18%), then followed by health warnings (9%) and tobacco control campaigns (9%). Some categories show a small amount of increased use in future years, due to the larger pool of potential initiates from those who would have smoked cigarettes.

The relative effects for each policy are shown in Appendix Figures 2 and 3. For cigarette use, the figures show that 53% is due to taxes, 18% is due to smoke-free air laws, 12% is due to cessation treatment policies, 9% is due to youth access enforcements, 8% is due to tobacco control spending. For smokeless tobacco use, the figures shown that 60% is due to taxes, 13% is due to

cessation treatment policies, 10% is due to youth access policies, 9% is due to tobacco control spending, 5% is due to smoke-free air laws, 3% is due to stronger SLT health warnings.

The Effects of Stronger Future Policies

New, stricter policies are modeled as implemented and maintained from 2020/2021 through 2040. The effect on male and female exclusive cigarette, SLT, and dual prevalence and the effects on smoking-attributable deaths are shown in Appendix Tables 6a and 6b. Their effect on prevalence is presented relative to the status quo, in which tobacco control policies remain unchanged from their 2018 levels.

In the status quo scenario, adult male smoking prevalence is projected to decline from 13.2% in 2018 to 10.2% in 2040, while the female smoking prevalence is projected to decline from 12.6% in 2018 to 9.7% in 2040. The adult male dual use rate is projected to decline from 0.9% in 2018 to 0.7% in 2040, and the adult male SLT use rate is projected to decline from 1.6% in 2018 to 1.4% in 2040. Much of the reduction in smoking prevalence is explained by stricter public policies implemented prior to 2018, including the increase in prices since 1993, more stringent smoking restrictions in work and public places, cessation treatment policies and better information about the effects of smoking.

Of the tobacco control policies, *SimSmoke* attributes the most pronounced effect on smoking prevalence trends between 1993 and 2003 to taxes. However, the same absolute increase in taxes has a smaller percentage effect at the higher prices found in 2018 than in earlier years, since the tax change yields a smaller relative price increase. However, the largest effect of the price increases is on those at younger ages, particularly those below age 18. Consequently, the growth

in policy effects over time is primarily because youth are more responsive to price increases than adults.

A $1.50 increase (indexed to inflation) in the 2021 tax rate on cigarettes alone is projected to result in a relative decline of 6% exclusive smoking prevalence for both genders, compared to the status quo by 2025. This relative reduction is projected to grow to an 8% decline compared to the status quo by the year 2040. For male dual use, a relative decline of 3% is predicted by 2025 and 4% by 2040. For male SLT use, a relative decline of 0.1% is predicted by 2025 and 0.4% by 2040. In terms of lives saved by both exclusive and dual smokers, the tax increase of $1.50 is projected to avert 191 (110 males and 81 females) smoking-attributable deaths in 2040. By 2040, a cumulative total of 2,108 (1,245 males and 863 females) smoking-attributable deaths are projected to be averted.

A $1.50 increase (indexed to inflation) in the 2021 tax rate on both cigarettes and smokeless tobacco is projected to reduce smoking prevalence by 6% for both genders compared to the status quo by 2025. This relative reduction is projected to increase to an 8% decline compared to the status quo by the year 2040. For male dual use, a relative decline of 4% is predicted by 2025 and 5% by 2040. For male exclusive SLT use, a relative decline of 5% is predicted by 2025 and 7% by 2040. In terms of lives saved, the tax increase of $1.50 is projected to avert 191 (110 males and 81 females) smoking-attributable deaths in 2040. By 2040, a cumulative total of 2,114 (1,251 males and 863 females) smoking-attributable deaths are projected to be averted. Combining smokers and SLT users, the model projects a total of 2,137 deaths are cumulatively averted by 2040.

Raising the Minimum Purchase Age to 21

A policy of increasing the minimum purchase to 21 will be implemented in 2020 for the whole state. Including the effects of localities that increased the age before that date, the model projects that the change in minimum purchase age alone yields a relative decline of 2% (3%) in the male (female) smoking prevalence, compared to the status quo, by 2025. This reduction is projected to grow to an 8% (8%) decline compared to the status quo by the year 2040. For male dual use, a relative decline of 5% is predicted by 2025 and 19% by 2040. The larger effects for dual use reflect that much of the transition to dual use occurs between the ages of 18 and 21 years of age. For male exclusive SLT use, a relative decline of 3% is predicted by 2025, 9% by 2040. In terms of lives saved, raising the minimum purchase age to 21 is projected to avert 13 (10 males and 3 females) smoking-attributable deaths in 2040 alone. By 2040, a cumulative total of 42 (34 males and 8 females) smoking-attributable deaths are projected to be averted. The policy has no effects on increasing the lives saved from SLT users compared with the status quo.

Tobacco Control Spending

The effect of reducing the level of funding in 2020 from a high to medium level and simultaneously terminating the quit line (while maintaining other cessation treatment sub policies such as pharmacotherapy) was considered in the model. Compared to the status quo, *SimSmoke* projected a relative increase of 2% in smoking prevalence for both genders by 2025. This relative increase is projected to grow to a 5% and 6% increase for males and females compared to the status quo by the year 2040. For male dual use, a relative increase of 3% is predicted by 2025 and 5% by 2040. For exclusive SLT use, a relative increase of 1% is predicted by 2025 and 3% by 2040. In terms of lives lost, decreasing the tobacco control spending from

high to medium and terminating the quit line since 2020 is projected to increase 140 (82 males and 58 females) smoking-attributable deaths in 2040. By 2040, a cumulative total of 1,160 (702 males and 459 females) additional smoking-attributable deaths are projected. Combining smokers and SLT users, a total of 1,166 cumulative additional deaths are projected by 2040.

Combined Policies

The final cases consider a combination of policies representing a cigarette tax increase of $1.50, with raising the minimum purchase age to 21. We consider the cases where high-intensity tobacco control campaigns and quit line are maintained and with those programs reduce as described above.

With a policy of increasing the minimum purchase to 21 and the $1.50 tax increase for both cigarette and SLT tax with no change in funding, the model projects a relative decline of 8% in smoking prevalence for both genders, compared to the status quo by 2025. This reduction is projected to grow to a 15% decline compared to the status quo by the year 2040. For male dual use, a relative decline of 8% is predicted by 2025 and 22% by 2040. For male exclusive SLT use, a relative decline of 3% is predicted by 2025 and 8% by 2040. In terms of lives saved, the combined policy change is projected to avert 203 (119 males and 83 females) smoking-attributable deaths in 2040. By 2040, a cumulative total of 2,147 (1,276 males and 871 females) smoking-attributable deaths are projected to be averted. Combining smokers and SLT users, a total of 2,147 deaths are cumulatively averted by 2040, so the policies have no effects on increasing the lives saved from SLT users compared with status quo.

With a policy of increasing the minimum purchase to 21 and the $1.50 for both cigarette and SLT tax with a reduction in funding from high to medium level and quit line services, the model projects a relative decline of 4% in smoking prevalence for both genders, compared to the status quo by 2025. This reduction is projected to grow to an 8% decline compared to the status quo by the year 2040. For male dual use, a relative decline of 6% is predicted by 2025 and 18% by 2040. For male exclusive SLT use, a relative decline of 7% is predicted by 2025 and 12% by 2040. By 2040, a cumulative total of 423 (249 males and 174 females) lives saved are projected among overall smokers. Combining smokers and SLT users, a total of 440 lives saved are projected by 2040. We can observe both lives saved and lost from smokers and SLT users in some years due to the combined policy change.

DISCUSSION

Our estimates of the trends in cigarette use from the *Minnesota SimSmoke* cigarette and SLT model reflected well the trends observed in the large scale, state representative TUS survey and those of the MATS. However, due to the smaller number of dual users, the results are less clear, and the model under-predicted the reductions during 1993–2002 and 2007–2010, and predicted continued decreases over time, whereas the surveys indicate relatively increases since 2010. Similar and clearer results are seen for exclusive SLT users, where *SimSmoke* under-estimates the relative reductions during 2002–2007 and 2010–2015 and shows continued declines through 2015, whereas surveys indicate the increases during 1993–2002 and 2007–2010.

Like previous literature[7,8] our analysis indicates overall SLT rates fell at least up through 2002, especially for those below the age of 45. These reductions may reflect the impact of tobacco

control policies. While there were some policies directed at SLT use, the strong cigarette-oriented policies implemented between 1993 and 2007, including price increases, and tobacco control campaigns, may have also reduced SLT use. These results suggest the importance of strong cigarette policies in reducing overall tobacco use. The estimated effect sizes of cigarette-oriented policies on SLT use that we applied in the model, however, are tentative, which reflects studies of use patterns prior to 2007.[15] Better information is needed on the effects of policies, especially for recent years, and the extent to which policies, such as media and other tobacco control campaigns, are directed at other forms of tobacco use besides cigarettes.

Even for the policies where we have better information, such as SLT tax increases, the relationships may have changed in recent years with the domination of the SLT market by cigarette manufacturers. The model failed to predict that SLT use increased in recent years relative to the TUS young group (18–24) and under estimated the prevalence compared with MATS estimates, which are consistent with recent studies.[6,9–12] These increases among young adults and higher use rates than expectation may reflect marketing directed by cigarette manufacturers, who took ownership of major SLT firms. Consequently, the role of cigarette manufacturers needs to be carefully monitored.

Minnesota *SimSmoke* also provides estimates of the health effects of tobacco use in terms of attributable deaths from their use. *SimSmok*e estimated 62 male exclusive SLT-attributable deaths in 2018 up from 71 in 1993. The number of male SLT-attributable deaths pale in comparison to male cigarette-attributable deaths, which are estimated as 3,323 exclusive and 17 dual deaths in 1993 and 3,898 exclusive and 102 dual deaths in 2018. We do not distinguish the

risk of SLT use to dual users compared to exclusive smokers. Dual use may reduce the number of cigarettes smoked over the lifetime, thereby, reducing mortality risks, but may also influence the likelihood of quitting cigarette use.

The model was used to update and extend the effect of tobacco control policies implemented in Minnesota since 1993. *SimSmoke* projected that smoking prevalence was 35% (36%) lower in relative terms for males (females) in 2018 and 43% (44%) in 2040. Substantial reductions were also projected for male dual use and SLT use for both genders. In addition, tobacco-attributable deaths were reduced by 7,808 by 2018 and 46,933 by 2040. Price increases, primarily through taxes, were project to have had the greatest effect for cigarette use followed by smoke-free air laws, cessation treatment policies, tobacco control campaigns, and youth access enforcement. Price increases had a more dominated influence on SLT use, but Smoke-free air law has much less effect compared with its effect on cigarette use.

Finally, the model was used to show the impact of future policies. Tax increases and raising the minimum purchase age from 18 to 21 were shown to have substantial effects, but the effects could be largely negated by reducing tobacco control funding and cessation treatment.

Like all models, our results are only as strong as the assumptions and underlying data. In particular, we assumed that projections of cigarette use are based on initiation and cessation rates derived in 1993, but subject to policy changes over time. Thus, the initiation and cessation rate estimates in 1993 and the policy levels and effect sizes play important roles. As discussed above, more information for the effect of cigarette and SLT-oriented policies on both SLT and cigarette

use is needed. Also as mentioned above, we do not explicitly incorporate the role of the industry, especially after major SLT producing firms being acquired by the cigarette manufacturers.

In addition to the policies explicitly considered in the model, other policies have been recently implemented that go beyond the traditional policies implemented in most states. In particular, several cities, including Minneapolis and St. Paul, implemented flavor bans, including bans on menthol. Previous modeling suggests that these policies may have important effects on cigarette use.[139]

Another limitation is that the model is limited to cigarette and SLT use. It does not incorporate the use of other nicotine delivery products, including cigars, water pipes and e-cigarettes. These products may substitute for or encourage the continued use of cigarettes and SLT. Since 2010, there has been a greater focus on other tobacco products in additional to smokeless tobacco, such as cigars and e-cigarettes. The definition of a "cigarette" for excise tax purposes was amended in 2013 to include "little cigars."[72] As a result, products that bear a close resemblance to standard cigarettes were taxed as cigarettes, even if they are labeled as cigars, small cigars, cigarillos or mini-cigarillos. These products are particularly likely to act as a substitute for cigarettes.[140,141] The increased taxes on these products in recent years appear to have reduced their use in Minnesota. E-cigarettes may play a key role in future years. These products may serve as a gateway into cigarette smoking or encourage continued smoking, or instead may serve as a replacement for smoking.[142] In addition, we treated SLT as a homogeneous category in terms of risks and their ability to substitute for cigarettes, with new forms, such as snus and dissolvables, having come onto the market.

In conclusion, with the landscape for tobacco use dramatically changed in the last 10 years, it becomes increasingly important to monitor the role of all nicotine delivery products. Since cigarette is still the dominant form of nicotine delivery product, a strong focus on cigarette-oriented policies may be an effective means, perhaps the most effective means, of reducing the use of all nicotine delivery products. Nevertheless, policies directed at other products, particularly smokeless tobacco and e-cigarettes, may also play an important role.

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Appendix Table 1. Policy Inputs for Cigarette and Smokeless Tobacco in *SimSmoke* Simulation Model

Policy	Description	Cigarette effect size[a]	Smokeless tobacco effect size[b]
Tax policy			
Cigarette prices	The effect of taxes is directly incorporated through average price (including generics), with separate prices for cigarette and SLT. The price elasticity is used to convert the % price changes into effect sizes. The dual price is computed as 3/4 of the cigarette price +1/4 SLT price	Elasticities[c] –0.4 ages 10–17 –0.3 ages 18–24 –0.2 ages 25–34 –0.1 ages 35–64 –0.2 ages ≥65	 same same same –0.2 same
Smoke-free air policies			
Worksite smoking ban, well-enforced	Ban in all indoor worksites, with strong public acceptance and enforcement of laws (reduced by 1/3 if allowed in ventilated areas and by 2/3 if allowed in common areas)	–6%[d]	One-fourth
Restaurant smoking ban	Ban in all indoor restaurants (reduced by half if partial)	–2%[d]	One-fourth
Bars smoking ban	Ban in all indoor (reduced by half if partial)	–1%[d]	One-fourth
Other places bans	Ban in 3 out of 4 government buildings, retail stores, public transportation, and elevators	–1%[d]	One-fourth
Enforcement	Government agency enforces the laws	Effects reduced 50% absent enforcement	same
Tobacco control expenditures			
High level tobacco control campaign	Campaign heavily publicized, with per capita expenditures of at least $2.00	–6.5%	Half
Mid-level tobacco control campaign	Campaign publicized, with per capita expenditures of at least $0.50	–3.25%	Half
Low level tobacco control campaign	Campaign sporadically publicized with per capita expenditures of at least $0.05	–1.63%	Half

Marketing restrictions			
Comprehensive marketing ban	Ban is applied to television, radio, print, billboard, in-store displays, sponsorships and free samples (all indirect marketing)	–5% prevalence, –8% initiation, +4% cessation	Same
Total advertising ban	Ban is applied to all media (television, radio, print, billboard) plus one indirect marketing medium	–3% prevalence, –4% initiation, +2% cessation	Same
Weak advertising ban	Ban is applied to some television, radio, print, and billboard	–1% in prevalence and initiation only	Same
Enforcement	Government agency enforces the laws	Effects reduced 50% absent enforcement	Same
Health warnings			
Strong	Labels are large, bold and graphic, and cover at least 30% of pack	–4% prevalence, –6% initiation, +10% cessation	Same
Moderate	Laws cover 1/3 of package, not bold or graphic	–2% in prevalence and initiation, +4% cessation	Same
Weak	Laws cover less than 1/3 of package, not bold or graphic	–1% prevalence and initiation, +2% cessation	Same
Cessation treatment policy			
Availability of pharmacotherapies	Legality of NRT, Bupropion and Varenicline	–1% prevalence, +4% cessation[e]	Half
Proactive quitline	A proactive quitline with publicity throughout the media campaign with no cost NRT	–1% prevalence, +6% cessation[e]	Half
Treatment coverage	Payments to cover pharmacotherapy and behavioral therapy	–2.25% prevalence, +8% cessation[e]	Half
Brief healthcare provider interventions	Advice by healthcare provider to quit and methods provided	–1% prevalence, +4% cessation[e]	Half
All of the above	Complete availability and reimbursement of pharmaco- and behavioral treatments, quitlines, and brief interventions	–5.7% prevalence, +27.4% cessation[e]	Half

Youth access restrictions			
Strongly enforced and publicized	Compliance rates of ≤5%, penalties are potent, enforced with heavy publicity	–16% initiation and prevalence for ages 16–17 and –24% ages <16	Half
Well enforced	Compliance rates of ≤20% (and >5%), penalties are potent, and publicity and merchant training are included	–8% initiation and prevalence for ages 16–17 and –12% ages <16	Half
Low enforcement	Compliance rates >20%, penalties are weak	–2% initiation and prevalence for ages 16–17 and –3% ages <16	Half
Vending machine restrictions	Total ban	Enforcement effects increase by 8%	Half
Self-service restrictions	Total ban	Enforcement effects increase by 4%	Half
Publicity	Media campaigns directed at youth use	Enforcement effects increase by 10%	Half

[a]Unless otherwise indicated, the effects are in terms of the reduction in prevalence during the first year, the reduction in initiation, and increase in first year quit rates during the years that the policy is in effect.
[b]Effect sizes are relative to cigarette effect sizes and applied to exclusive use only unless otherwise indicated.
[c]Elasticities translate into effect sizes through percentage change in price.
[d]Effect size differs for exclusive SLT and dual use.
[e]Effect size for dual use is assumed 3/4 that of exclusive cigarette.

SLT, smokeless tobacco; NRT, nicotine replacement therapy.

Appendix Table 2. Tobacco Control Policy Levels, Minnesota, 1993–2018

Policies	1993	1997	2000	2004	2007	2011	2014	2018
Tax policy								
Cigarette price	$2.04	$2.19	$3.12	$3.48	$4.60	$5.86	$7.73	$8.68
Cigarette tax	$4.05	$0.72	$0.82	$0.87	$1.88	$2.60	$3.84	$4.05
SLT price	$2.55	$3.07	$3.32	$3.92	$4.74	$4.62	$5.71	$5.72
SLT tax	$0.70	$0.84	$0.89	$1.05	$1.97	$1.97	$2.84	$2.84
Smoke-free air laws								
Worksite, %	0.0	0.0	0.0	0.9	100.0	100.0	100.0	100.0
Restaurant, %	0.0	0.0	0.0	0.2	100.0	100.0	100.0	100.0
Pubs and bars, %	0.0	0.0	0.0	0.2	100.0	100.0	100.0	100.0
Enforcement (out of 10 point)	8	8	8	8	8	9	9	9
Mass media campaigns	low	medium	high	high	high	high	high	high
Marketing restrictions								
Advertising and marketing	low	low	low	low	low	low	low	low
Health warning								
Cigarettes	low	low	low	low	low	low	low	low
Smokeless tobacco	low	low	low	low	low	medium	medium	medium
Cessation treatment policy								
Availability of NRT	with Rx	without Rx	without Rx	without Rx	without Rx	without Rx	without Rx	without Rx
Availability of Bupropion			with Rx	with Rx	with Rx	with Rx	with Rx	with Rx
Availability of Chantix					with Rx	with Rx	with Rx	with Rx
Coverage of behavioral interventions, %	40	40	40	60	70	85	85	90
Coverage of pharmacotherapies, %	40	40	40	60	70	85	85	90
Active quitline	0	0	0	1	1	1	1	1
Healthcare provider involvement, %	40	40	40	50	50	50	50	50
Youth access restrictions								
Vending machine ban, %	0	100	100	100	100	100	100	100
Self-service ban, %	0	0	0	0	0	100	100	100
Enforcement	low	low	low	medium	medium	high	high	high
Publicity, %	60	100	100	100	100	100	100	100

SLT, smokeless tobacco; NRT, nicotine replacement therapy.

Appendix Table 3a. Validation of Exclusive and Dual Cigarette and Smokeless Tobacco Users: SimSmoke Projections vs CPS-TUS, by Age and Gender, 1993–2015

Variable	1993, %	2002, %	% change 1993–2002[a]	2010, %	2015, %	% change 2002–2015[a]	% change 1993–2015[a]
Exclusive cigarette prevalence							
Male							
≥18							
SimSmoke	24.1	20.4	–15.4	16.1	14.0	–31.3	–41.9
CPS–TUS	24.4	21.0	–14.2	16.2	14.0	–33.4	–42.9
95% CI	(22.0, 26.9)	(19.0, 22.9)		(14.6, 17.9)	(12.3, 15.9)		
18–24							
SimSmoke	21.3	22.2	4.4	18.1	16.3	–26.7	–23.5
CPS–TUS	23.6	29.3	24.2	16.9	16.9	–42.2	–28.2
95% CI	(16.6, 30.5)	(22.2, 36.4)		(11.8, 23.6)	(9.7, 27.8)		
25–44							
SimSmoke	29.9	23.5	–21.6	20.0	18.5	–21.2	–38.3
CPS–TUS	29.8	24.2	–19.0	19.0	16.8	–30.5	–43.7
95% CI	(26.2, 33.5)	(21.0, 27.3)		(16.3, 22.1)	(13.8, 20.3)		
45–64							
SimSmoke	23.0	20.6	–10.4	14.5	11.5	–43.9	–49.7
CPS–TUS	23.6	19.2	–18.6	17.9	14.8	–23.0	–37.3
95% CI	(18.8, 28.4)	(15.9, 22.5)		(15.3, 20.8)	(12.0, 18.2)		
≥65							
SimSmoke	10.3	10.4	1.1	9.3	8.7	–16.9	–15.9
CPS–TUS	8.3	8.3	0.1	6.6	7.5	–9.4	–9.3
95% CI	(4.2, 12.4)	(4.6, 12.0)		(4.5, 9.8)	(5.1, 10.9)		
Female							
≥18							
SimSmoke	23.5	19.6	–16.5	15.3	13.3	–32.3	–43.5
CPS–TUS	24.0	19.2	–19.7	14.4	12.2	–36.4	–49.0
95% CI	(21.9, 26.1)	(17.5, 21.0)		(13.0, 15.8)	(10.7, 13.9)		
18–24							
SimSmoke	30.7	20.3	–34.0	16.2	14.3	–29.7	–53.6
CPS–TUS	32.0	28.2	–11.9	15.1	11.0	–61.0	–65.6
95% CI	(25.5, 38.5)	(21.6, 34.8)		(10.7, 20.9)	(6.4, 18.3)		
25–44							
SimSmoke	27.5	26.3	–4.6	20.6	17.6	–33.1	–36.2
CPS–TUS	27.6	23.5	–15.0	18.8	14.8	–36.8	–46.3
95% CI	(24.3, 30.9)	(20.4, 26.5)		(16.3, 21.6)	(12.1, 18.0)		
45–64							

SimSmoke	23.2	17.7	–23.7	13.8	12.5	–29.4	–46.1
CPS–TUS	23.5	17.4	–25.7	15.7	13.6	–22.2	–42.2
95% CI	(19.1, 27.8)	(14.5, 20.4)		(13.5, 18.3)	(11.0, 16.6)		
≥65							
SimSmoke	10.7	9.3	–13.0	8.2	7.6	–18.5	–29.1
CPS–TUS	10.6	7.9	–25.4	4.6	6.9	–13.3	–35.3
95% CI	(7.1, 14.1)	(4.9, 10.9)		(3.1, 6.8)	(4.8, 9.8)		
Exclusive SLT prevalence-male							
≥18							
SimSmoke	2.7	2.1	–22.7	1.8	1.6	–22.9	–40.4
CPS–TUS	2.8	3.4	22.8	3.0	2.6	–25.0	–7.9
95% CI	(1.9, 3.7)	(2.5, 4.3)		(2.3, 3.8)	(1.9, 3.5)		
18–24							
SimSmoke	2.8	2.1	–25.0	2.1	2.0	–3.3	–27.5
CPS–TUS	3.0	1.8	–40.7	2.6	6.2	250.0	107.6
95% CI	(0.2, 5.7)	(–0.3, 3.8)		(1.0, 6.5)	(2.4, 14.8)		
25–44							
SimSmoke	2.8	2.6	–9.4	2.2	2.1	–18.5	–26.2
CPS–TUS	2.9	5.2	81.9	3.8	3.2	–39.7	9.8
95% CI	(1.5, 4.2)	(3.6, 6.9)		(2.6, 5.5)	(2.0, 5.1)		
45–64							
SimSmoke	2.1	1.6	–26.2	1.4	1.3	–17.5	–39.2
CPS–TUS	2.1	2.1	1.9	2.7	2.3	10.3	12.4
95% CI	(0.5, 3.7)	(0.9, 3.3)		(1.8, 4.1)	(1.3, 4.0)		
≥65							
SimSmoke	3.4	2.0	–40.1	1.4	1.1	–46.3	–67.8
CPS–TUS	3.5	1.8	–47.6	2.0	1.3	–31.9	–64.3
95% CI	(0.8, 6.2)	(0.0, 3.6)		(1.0, 4.1)	(0.5, 3.2)		
Dual use prevalence-male							
≥18							
SimSmoke	1.2	1.2	0.1	1.0	0.9	–21.0	–20.9
CPS–TUS	1.2	0.8	–35.8	0.5	0.8	0.2	–35.6
95% CI	(0.6, 1.8)	(0.4, 1.2)		(0.3, 0.9)	(0.4, 1.4)		
18–24							
SimSmoke	3.2	2.4	–25.3	2.1	1.9	–21.4	–41.2
CPS–TUS	3.7	3.3	–10.2	1.3	4.6	38.9	24.7
95% CI	(0.5, 6.9)	(0.7, 6.0)		(0.4, 4.6)	(1.6, 12.7)		
25–44							
SimSmoke	1.5	1.8	20.4	1.5	1.3	–26.2	–11.2
CPS–TUS	1.4	0.8	–40.9	0.7	1.6	87.9	11.1

95% CI	(0.5, 2.4)	(0.2, 1.5)		(0.3, 1.7)	(0.8, 3.1)		
45–64							
SimSmoke	0.3	0.5	56.4	0.6	0.7	39.2	117.7
CPS–TUS	0.3	0.1	–55.0	0.1	0.0	–100.0	–100.0
95% CI	(–0.3, 1.0)	(–0.2, 0.5)		(0.0, 0.8)	(0.0, 0.7)		
≥65							
SimSmoke	0.0	0.0	0.0	0.1	0.1	803.6	0.0
CPS–TUS	0.0	0.3	0.0	0.3	0.0	–100.0	0.0
95% CI	(0.0, 0.0)	(0.0, 0.9)		(0.1, 1.6)	(0.0, 1.2)		

[a]Percent change is measured relative to the initial value (i.e., percent change 1993–2002=Prevalence2002-Prevalence1993)/Prevalence1993).

CPS–TUS, Current Population Survey-Tobacco Use Supplement.

Appendix Table 3b. Validation of Exclusive Cigarette/SLT Use: SimSmoke Projections vs MATS, by Age and Gender, 1999–2018

Variable	1999, %	2003, %	2007, %	% change 1999–2007	2010, %	2018, %	% change 2007–2018[a]	% change 1999–2018[a]
Exclusive cigarette prevalence[a] – male								
≥18								
SimSmoke	22.4	20.1	17.3	–22.9	16.1	13.2	–23.5	–41.0
MATS	18.7	19.1	18.3	–1.8	15.4	14.0	–23.8	–25.2
95% CI	(16.3, 21.1)	(17.0, 21.1)	(16.2, 20.4)		(13.5, 17.2)	(12.2, 15.8)		
18–24								
SimSmoke	23.3	22.2	19.2	–17.7	18.1	15.4	–20.0	–34.2
MATS	23.7	32.0	25.6	7.8	17.8	9.9	–61.4	–58.4
95% CI	(16.1, 31.3)	(26.0, 37.9)	(18.6, 32.6)		(12.2, 23.5)	(5.5, 14.2)		
25–44								
SimSmoke	26.0	23.2	20.6	–20.7	20.0	17.9	–13.0	–31.0
MATS	22.8	22.2	20.5	–10.0	19.3	17.3	–15.9	–24.3
95% CI	(18.9, 26.8)	(18.2, 26.3)	(16.5, 24.6)		(15.7, 22.8)	(13.8, 20.7)		
45–64								
SimSmoke	22.6	20.1	16.4	–27.1	14.5	10.3	–37.1	–54.2
MATS	16.8	15.7	18.2	8.5	14.3	16.7	–8.2	–0.4
95% CI	(12.8, 20.8)	(13.2, 18.2)	(15.4, 21.0)		(11.7, 17.0)	(13.4, 20.0)		
≥65								
SimSmoke	11.0	10.5	9.5	–13.4	9.3	8.3	–13.0	–24.7
MATS	5.5	6.7	5.4	–1.6	5.3	4.6	–14.3	–15.7
95% CI	(1.8, 9.2)	(4.2, 9.2)	(3.5, 7.3)		(3.5, 7.2)	(3.0, 6.3)		
Exclusive cigarette prevalence[a] – female								
≥18								
SimSmoke	21.6	19.3	16.4	–24.1	15.3	12.5	–23.6	–42.0
MATS	17.9	15.7	15.7	–12.6	13.8	12.6	–19.5	–29.6
95% CI	(16.0, 19.9)	(13.9, 17.6)	(13.8, 17.5)		(12.3, 15.4)	(11.0, 14.3)		
18–24								
SimSmoke	23.1	20.1	17.2	–25.7	16.2	13.4	–21.7	–41.9
MATS	26.0	28.5	19.4	–25.4	19.6	8.2	–57.9	–68.6
95% CI	(17.9, 34.1)	(23.4, 33.6)	(13.5, 25.3)		(13.8, 25.3)	(3.4, 12.9)		
25–44								
SimSmoke	28.2	26.0	22.2	–21.2	20.6	16.4	–26.0	–41.7
MATS	21.0	16.1	17.2	–18.0	16.0	16.8	–2.4	–20.0
95% CI	(17.9, 24.0)	(12.9, 19.2)	(13.6, 20.7)		(13.0, 19.0)	(13.3, 20.3)		
45–64								

SimSmoke	19.8	17.3	14.8	–25.2	13.8	12.1	–18.3	–38.8
MATS	17.4	15.5	17.1	–1.4	14.0	14.8	–13.7	–14.9
95% CI	(14.0, 20.8)	(12.0, 19.1)	(14.2, 20.1)		(11.6, 16.3)	(11.9, 17.7)		
≥65								
SimSmoke	10.0	9.3	8.4	–15.9	8.2	7.2	–14.5	–28.1
MATS	7.3	5.5	7.0	–4.6	5.1	4.8	–30.9	–34.1
95% CI	(4.2, 10.4)	(4.0, 7.1)	(5.1, 8.9)		(3.7, 6.6)	(3.3, 6.3)		
Exclusive SLT prevalence[b]–male								
≥18								
SimSmoke	2.3	2.1	1.9	–17.7	1.8	1.6	–15.8	–30.7
MATS	4.2	3.3	3.4	–20.6	4.7	3.8	12.9	–10.3
95% CI	(3.1, 5.4)	(2.3, 4.3)	(2.5, 4.2)		(3.7, 5.7)	(2.8, 4.7)		
18–24								
SimSmoke	2.2	2.1	2.1	–3.7	2.1	2.0	–2.3	–6.0
MATS	8.3	2.9	1.8	–78.2	7.5	7.3	302.1	–12.5
95% CI	(3.9, 12.8)	(1.1, 4.8)	(0.5, 3.1)		(3.8, 11.1)	(3.2, 11.4)		
25–44								
SimSmoke	2.7	2.5	2.3	–12.6	2.2	2.1	–12.1	–23.1
MATS	5.9	5.4	5.2	–12.5	6.6	5.1	–1.2	–13.5
95% CI	(3.7, 8.1)	(3.2, 7.6)	(3.4, 7.0)		(4.6, 8.6)	(3.3, 6.9)		
45–64								
SimSmoke	1.7	1.5	1.4	–14.7	1.4	1.3	–11.9	–24.8
MATS	1.5	2.1	2.2	43.4	3.0	2.3	7.4	54.1
95% CI	(0.6, 2.4)	(1.1, 3.2)	(1.1, 3.2)		(1.7, 4.3)	(1.2, 3.5)		
≥65								
SimSmoke	2.4	1.9	1.6	–34.8	1.4	1.0	–38.3	–59.8
MATS	1.0	0.8	2.4	134.7	1.6	1.7	–28.9	66.9
95% CI	(0.0, 2.1)	(0.1, 1.5)	(0.9, 4.0)		(0.4, 2.8)	(0.1, 3.4)		
Dual use prevalence[c]–male								
≥18								
SimSmoke	1.2	1.2	1.1	–12.5	1.0	0.9	–17.6	–27.9
MATS	1.5	1.3	0.9	–38.4	1.5	1.3	35.1	–16.7
95%CI	(0.7, 2.3)	(0.7, 1.9)	(0.5, 1.4)		(0.9, 2.1)	(0.7, 1.8)		
18–24								
SimSmoke	2.6	2.4	2.1	–17.6	2.1	1.8	–16.0	–30.8
MATS	6.6	4.2	1.7	–75.1	2.8	1.7	4.8	–73.9
95% CI	(1.1, 12.2)	(1.7, 6.8)	(0.2, 3.1)		(0.6, 5.0)	(0.1, 3.3)		
25–44								
SimSmoke	1.8	1.8	1.6	–10.5	1.5	1.2	–26.6	–34.4
MATS	0.5	1.4	1.3	150.8	2.7	1.9	53.2	284.3

95% CI	(0.1, 0.9)	(0.2, 2.6)	(0.4, 2.2)		(1.2, 4.1)	(0.7, 3.1)		
45–64								
SimSmoke	0.4	0.5	0.6	31.1	0.6	0.7	25.4	64.3
MATS	1.3	0.3	0.6	–54.4	0.4	0.8	35.5	–38.2
95% CI	(0.2, 2.5)	(0.0, 0.6)	(0.1, 1.1)		(0.0, 0.7)	(0.1, 1.5)		
≥65								
SimSmoke	0.0	0.0	0.1	5997.4	0.1	0.1	142.3	14675.5
MATS	0.4	0.4	0.1	–75.8	0.0	0.5	431.4	28.4
95% CI	(0.0, 0.8)	(0.0, 0.9)	(0.0, 0.3)		(0.0, 0.0)	(0.0, 1.0)		

[a]Exclusive smokers were measured by ≥100 life time cigarettes and now smokes at least 1 day in MATS 2 but now smoke every day/some days in SimSmoke model.

[b]Exclusive SLT users were measured by used at least 10 days in last 30 days among never smokers who smoked <100 life time cigarettes and former smokers who smoked ≥100 life time cigarettes and do not smoke now in MATS, but were measured by used at least 10 days in last 30 days and smoked <100 cigarettes in SimSmoke model.

[c]Dual users were measured by used SLT at least 10 days in last 30 days and smoked ≥100 life time cigarettes and now smoke every day or some days in both MATS and SimSmoke model.

SLT, smokeless tobacco; MATS, Minnesota Adult Tobacco Survey.

Appendix Table 4. Prevalence by Tobacco Use, Projected by *SimSmoke* Under Multiple Scenarios, 1993–2040[a]

Scenario/Use	1993, %	2018, %	2019, %	2040, %	Relative difference in 2018,[a] %	Transform to unit 100% for 2018,[b] %	Relative difference in 2040,[a] %	Transform to unit 100% for 2040,[b] %
Male								
Counterfactual								
Smokers	25.3	21.6	21.5	19.1	–		–	
SLT use	3.90	3.18	3.16	2.87	–		–	
Status quo								
Smokers	25.3	14.1	13.8	10.9	–35	–	–43	–
SLT use	3.9	2.5	2.4	2.1	–23	–	–27	–
Price alone								
Smokers	25.3	17.4	17.2	14.3	–19	52	–25	52
SLT use	3.9	2.8	2.7	2.5	–14	61	–14	54
Smoke free air laws alone								
Smokers	25.3	20.0	19.8	17.5	–8	21	–8	17
SLT use	3.9	3.2	3.1	2.8	–1	4	–1	3
Media campaign alone								
Smokers	25.3	21.0	20.8	18.5	–3	8	–3	6
SLT use	3.9	3.1	3.1	2.8	–2	9	–2	8
Cessation treatment alone								
Smokers	25.3	20.7	20.5	18.2	–5	12	–5	10
SLT use	3.9	3.1	3.1	2.8	–3	13	–3	13
Health warnings alone								
Smokers	25.3	21.6	21.5	19.1	0	0	0	0
SLT use	3.9	3.2	3.1	2.8	–1	4	–1	4
Advertising ban alone								
Smokers	25.3	21.6	21.5	19.1	0	0	0	0
SLT use	3.9	3.2	3.2	2.9	0	0	0	0
Youth access alone								
Smokers	25.3	21.1	20.8	17.8	–3	7	–7	14
SLT use	3.9	3.1	3.1	2.7	–2	9	–5	18
Female								
Counterfactual								
Smokers	23.5	19.5	19.4	17.3	–		–	
SLT use	0.00	0.00	0.00	0.00	–		–	
Status quo								
Smokers	23.5	12.6	12.4	9.7	–36	–	–44	–
SLT use	0.0	0.0	0.0	0.0	–	–	–	–
Price alone								

Smokers	23.5	15.8	15.7	13.1	–19	50	–24	49
SLT use	0.0	0.0	0.0	0.0	–	–	–	–
Smoke free air laws alone								
Smokers	23.5	17.9	17.8	15.7	–8	22	–9	18
SLT use	0.0	0.0	0.0	0.0	–	–	–	–
Media campaign alone								
Smokers	23.5	18.9	18.8	16.7	–3	8	–3	7
SLT use	0.0	0.0	0.0	0.0	–	–	–	–
Cessation treatment alone								
Smokers	23.5	18.5	18.4	16.2	–5	14	–6	12
SLT use	0.0	0.0	0.0	0.0	–	–	–	–
Health warnings alone								
Smokers	23.5	19.5	19.4	17.3	0	0	0	0
SLT use	0.0	0.0	0.0	0.0	–	–	–	–
Advertising ban alone								
Smokers	23.5	19.5	19.4	17.3	0	0	0	0
SLT use	0.0	0.0	0.0	0.0	–	–	–	–
Youth access alone								
Smokers	23.5	19.0	18.8	16.2	–3	7	–7	13
SLT use	0.0	0.0	0.0	0.0	–	–	–	–

[a]Relative changes are estimated for a particular policy or group of policies relative to Counterfactual , i.e., ($Policy_{p,t}$-$Counterfactual_{p,t}$/$Counterfactual_{p,t}$ for policy p and time period t.
[b]Percent of total is measured as the relative change of a policy relative to the summed effects of the total.

SLT, smokeless tobacco.

Appendix Table 5. Tobacco-Attributable Deaths and Deaths Averted Relative to Counterfactual, Projected by *Minnesota SimSmoke* Under Multiple Scenarios, 1993–2040[a]

Variable	1993	2018	2040	Summation by 2018[b]	Summation by 2040[b]
Tobacco attributable deaths					
Actual/status quo					
CIG	5,279	6,117	5,848	149,535	285,213
Dual	17	102	178	1,421	4,662
SLT	71	62	65	1,900	3,269
Total	5,367	6,281	6,090	152,855	293,144
No policy change					
CIG	5,279	7,152	7,965	157,176	330,846
Dual	17	119	242	1,523	5,688
SLT	71	69	77	1,964	3,543
Total	5,367	7,339	8,285	160,663	340,076
Price alone					
CIG	5,279	6,711	6,956	153,720	310,276
Dual	17	111	208	1,476	5,171
SLT	71	64	70	1,916	3,367
Total	5,367	6,886	7,234	157,112	318,813
Smoke-free air law alone					
CIG	5,279	6,884	7,436	155,780	319,614
Dual	17	117	236	1,514	5,579
SLT	71	69	77	1,964	3,544
Total	5,367	7,070	7,749	159,258	328,736
Campaign spending alone					
CIG	5,279	7,007	7,753	155,773	325,318
Dual	17	116	235	1,501	5,551
SLT	71	68	76	1,955	3,515
Total	5,367	7,190	8,064	159,230	334,384
Cessation treatment alone					
CIG	5,279	6,928	7,483	155,527	320,465
Dual	17	115	230	1,502	5,475
SLT	71	67	74	1,954	3,488
Total	5,367	7,111	7,787	158,983	329,427
Health warnings alone					
CIG	5,279	7,152	7,965	157,176	330,846

Dual	17	119	242	1,523	5,688
SLT	71	68	76	1,962	3,526
Total	5,367	7,339	8,284	160,662	340,060
Advertising ban alone					
CIG	5,279	7,152	7,965	157,176	330,846
Dual	17	119	242	1,523	5,688
SLT	71	69	77	1,964	3,543
Total	5,367	7,339	8,285	160,663	340,076
Youth access alone					
CIG	5,279	7,152	7,909	157,176	330,399
Dual	17	119	237	1,523	5,648
SLT	71	69	77	1,964	3,543
Total	5,367	7,339	8,223	160,663	339,589
Deaths averted[c]					
Actual/status quo					
CIG	0	1,035	2,118	7,641	45,633
Dual	0	17	65	102	1,025
SLT	0	6	12	64	275
Total	0	1,058	2,194	7,808	46,933
Price alone					
CIG	0	441	1,010	3,457	20,570
Dual	0	8	34	47	517
SLT	0	4	7	48	177
Total	0	453	1,051	3,551	21,264
Smoke-free air law alone					
CIG	0	267	529	1,396	11,232
SLT	0	0	0	0	0
Dual	0	2	7	9	109
Total	0	269	536	1,405	11,340
Campaign spending alone					
CIG	0	145	212	1,403	5,528
Dual	0	3	7	22	136
SLT	0	1	1	9	28
Total	0	149	220	1,434	5,693
Cessation treatment alone					
CIG	0	224	483	1,649	10,381

Dual	0	4	13	21	213
SLT	0	1	3	10	55
Total	0	228	498	1,680	10,649
Health warning alone					
CIG	0	0	0	0	0
Dual	0	0	0	0	0
SLT	0	0	1	2	17
Total	0	0	1	2	17
Advertising ban alone					
CIG	0	0	0	0	0
Dual	0	0	0	0	0
SLT	0	0	0	0	0
Total	0	0	0	0	0
Youth access alone					
CIG	0	0	56	0	447
Dual	0	0	5	0	40
SLT	0	0	0	0	0
Total	0	0	61	0	487

[a]Estimates are given in terms of the best estimate and the upper and lower bounds based on the policy evaluation literature.
[b]Summation is the summed deaths or deaths averted from 1993 through the current year.
[c]Deaths averted is measured as the difference in deaths with a policy or group of policies implemented and the deaths under the counterfactual.

CIG, cigarettes; SLT, smokeless tobacco.

Appendix Table 6a. Tobacco Use Prevalence, Projected by SimSmoke, Under Future Change in Policy Scenarios, 1993–2040

Scenario[a]/Users	Male						Female					
	1993, %	2018, %	2025, %	2040, %	Relative difference in 2025, %	Relative difference in 2040, %	1993, %	2018, %	2025, %	2040, %	Relative difference in 2025, %	Relative difference in 2040, %
Status quo												
CIG	24.1	13.2	11.8	10.2	–	–	23.5	12.6	11.3	9.7	–	–
Dual	1.2	0.9	0.8	0.7	–	–	–	–	–	–	–	–
SLT	2.7	1.6	1.5	1.4	–	–	–	–	–	–	–	–
(1a)												
CIG	24.1	13.2	11.1	9.4	–6	–8	23.5	12.6	10.6	8.9	–6	–8
Dual	1.2	0.9	0.8	0.7	–3	–4	–	–	–	–	–	–
SLT	2.7	1.6	1.5	1.4	0.1	0.4	–	–	–	–	–	–
(1b)												
CIG	24.1	13.2	11.1	9.4	–6	–8	23.5	12.6	10.6	8.9	–6	–8
Dual	1.2	0.9	0.8	0.7	–4	–5	–	–	–	–	–	–
SLT	2.7	1.6	1.4	1.3	–5	–7	–	–	–	–	–	–
(2)												
CIG	24.1	13.2	11.5	9.4	–2	–8	23.5	12.6	11.0	8.9	–3	–8
Dual	1.2	0.9	0.8	0.6	–5	–19	–	–	–	–	–	–
SLT	2.7	1.6	1.4	1.3	–3	–9	–	–	–	–	–	–
(3)												
CIG	24.1	13.2	12.1	10.7	2	5	23.5	12.6	11.6	10.2	2	6
Dual	1.2	0.9	0.8	0.7	3	5	–	–	–	–	–	–
SLT	2.7	1.6	1.5	1.4	1	3	–	–	–	–	–	–
(1a+2)												
CIG	24.1	13.2	10.8	8.7	–8	–15	23.5	12.6	10.3	8.2	–8	–15
Dual	1.2	0.9	0.7	0.5	–8	–22	–	–	–	–	–	–
SLT	2.7	1.6	1.5	1.3	–3	–8	–	–	–	–	–	–
(1b+2+3)												
CIG	24.1	13.2	11.3	9.3	–4	–8	23.5	12.6	10.8	8.9	–4	–8
Dual	1.2	0.9	0.8	0.6	–6	–18	–	–	–	–	–	–
SLT	2.7	1.6	1.4	1.2	–7	–12	–	–	–	–	–	–

[a](1a) increase $1.5 for cig tax in 2021; (1b) increase $1.5 for cig and SLT tax in 2021; (2) only increase the minimum age (21) for legal access to tobacco products in 2020; (1a+2) increase $1.5 for cig tax in 2021 and increase the minimum age (21) for legal access to tobacco products in 2020; (3) drop the level of mass media campaigns from high to medium and eliminate the quitline service in 2020; (1b+2+3) increase $1.5 for cig and SLT tax in 2021, increase the minimum age (21) for legal access to tobacco products in 2020, drop the level of mass media campaigns from high to medium and eliminate the quitline service in 2020.

CIG, cigarettes; SLT, smokeless tobacco.

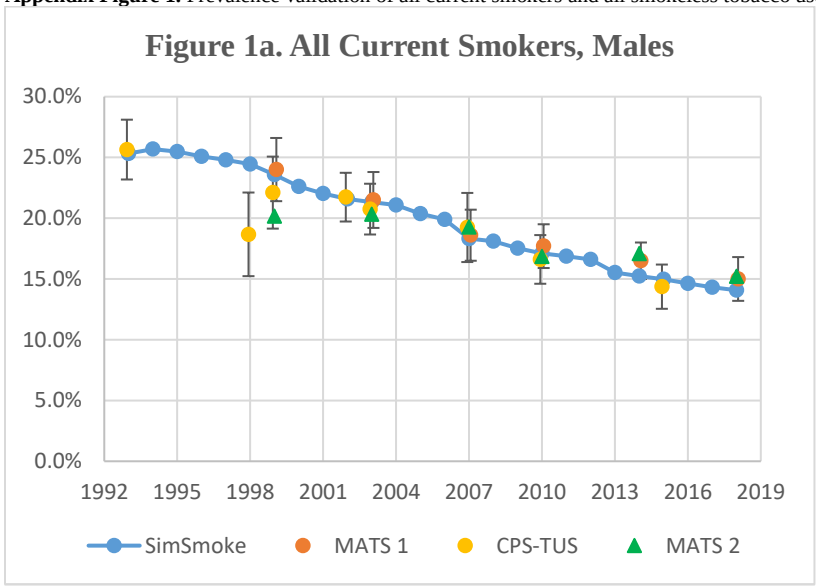
Appendix Table 6b. Tobacco Attributable Deaths, Projected by SimSmoke, Under Future Change in Policy Scenarios, 1993–2040

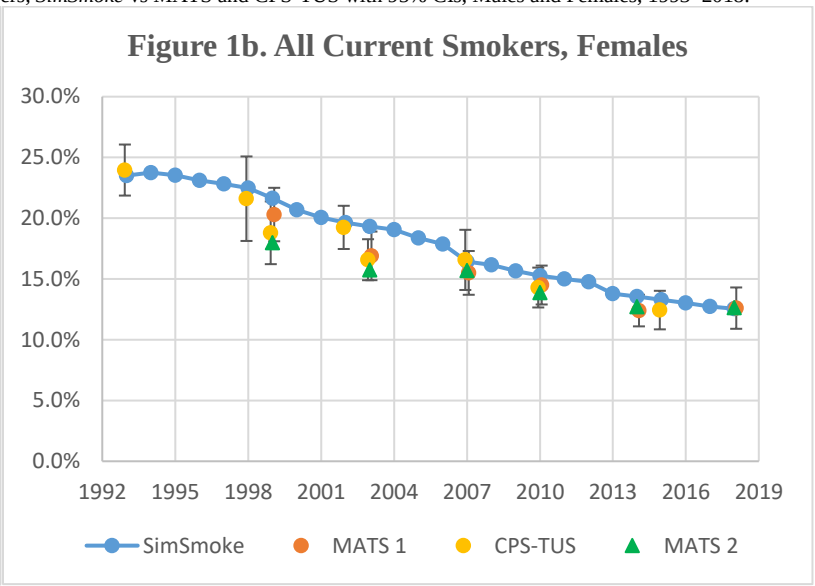
Scenario[a]	Male					Female					Overall
	1993	2018	2040	Cumulative sum by 2018	Cumulative sum by 2040	1993	2018	2040	Cumulative sum by 2018	Cumulative sum by 2040	Cumulative sum by 2040
Status quo											
Attributable deaths											
CIG	3,323	3,898	3,335	95,588	177,906	1,956	2,219	2,513	53,947	107,307	285,213
Dual	17	102	178	1,421	4,662	–	–	–	–	–	4,662
SLT	71	62	65	1,900	3,269	–	–	–	–	–	3,269
Total	3,411	4,062	3,578	98,908	185,837	1,956	2,219	2,513	53,947	107,307	293,144
(1a)											
Attributable deaths											
CIG	3,323	3,898	3,228	95,588	176,682	1,956	2,219	2,432	53,947	106,444	283,126
Dual	17	102	175	1,421	4,641	–	–	–	–	–	4,641
SLT	71	62	65	1,900	3,269	–	–	–	–	–	3,269
Total	3,411	4,062	3,468	98,908	184,592	1,956	2,219	2,432	53,947	106,444	291,036
Lives saved											
CIG	–	–	107	–	1,223	–	–	81	–	863	2,087
Dual	–	–	2	–	21	–	–	–	–	–	21
SLT	–	–	(0)	–	(0)	–	–	–	–	–	(0)
Total	–	–	110	–	1,245	–	–	81	–	863	2,108
(1b)											
Attributable deaths											
CIG	3,323	3,898	3,228	95,588	176,682	1,956	2,219	2,432	53,947	106,444	283,126
Dual	17	102	175	1,421	4,635	–	–	–	–	–	4,635
SLT	71	62	63	1,900	3,246	–	–	–	–	–	3,246
Total	3,411	4,062	3,465	98,908	184,563	1,956	2,219	2,432	53,947	106,444	291,007
Lives saved											
CIG	–	–	107	–	1,223	–	–	81	–	863	2,087
Dual	–	–	3	–	27	–	–	–	–	–	27
SLT	–	–	2	–	23	–	–	–	–	–	23
Total	–	–	113	–	1,273	–	–	81	–	863	2,137
(2)											
Attributable deaths											
CIG	3,323	3,898	3,326	95,588	177,877	1,956	2,219	2,510	53,947	107,299	285,176
Dual	17	102	176	1,421	4,658	–	–	–	–	–	4,658
SLT	71	62	65	1,900	3,268	–	–	–	–	–	3,268
Total	3,411	4,062	3,567	98,908	185,803	1,956	2,219	2,510	53,947	107,299	293,102
Lives saved											

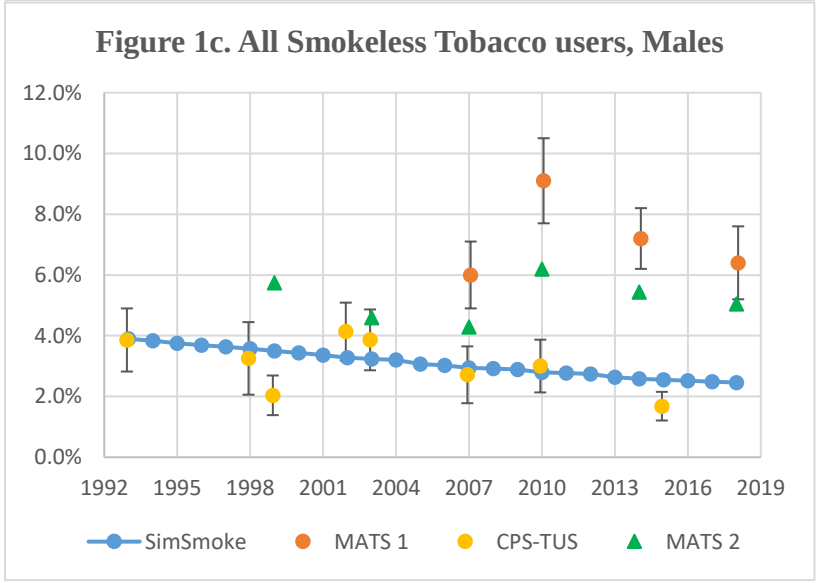
CIG	–	–	9	–	29	–	–	3	–	8	37
Dual	–	–	1	–	5	–	–	–	–	–	5
SLT	–	–	0	–	0	–	–	–	–	–	0
Total	–	–	10	–	34	–	–	3	–	8	42
(3)											
Attributable deaths											
CIG	3,323	3,898	3,412	95,588	178,573	1,956	2,219	2,571	53,947	107,766	286,338
Dual	17	102	182	1,421	4,697	–	–	–	–	–	4,697
SLT	71	62	66	1,900	3,275	–	–	–	–	–	3,275
Total	3,411	4,062	3,660	98,908	186,544	1,956	2,219	2,571	53,947	107,766	294,310
Lives saved											
CIG	–	–	(76)	–	(667)	–	–	(58)	–	(459)	(1,126)
Dual	–	–	(5)	–	(35)	–	–	–	–	–	(33)
SLT	–	–	(1)	–	(6)	–	–	–	–	–	(6)
Total	–	–	(82)	–	(708)	–	–	(58)	–	(459)	(1,166)
(1a+2)											
Attributable deaths											
CIG	3,323	3,898	3,219	95,588	176,655	1,956	2,219	2,429	53,947	106,436	283,092
Dual	17	102	174	1,421	4,637	–	–	–	–	–	4,637
SLT	71	62	65	1,900	3,268	–	–	–	–	–	3,268
Total	3,411	4,062	3,458	98,908	184,560	1,956	2,219	2,429	53,947	106,436	290,997
Lives saved											
CIG	–	–	116	–	1,250	–	–	83	–	871	2,121
Dual	–	–	4	–	26	–	–	–	–	–	26
SLT	–	–	0	–	0	–	–	–	–	–	0
Total	–	–	119	–	1,276	–	–	83	–	871	2,147
(1b+2+3)											
Attributable deaths											
CIG	3,323	3,898	3,325	95,588	177,655	1,956	2,219	2,510	53,947	107,133	284,788
Dual	17	102	178	1,421	4,664	–	–	–	–	–	4,664
SLT	71	62	63	1,900	3,252	–	–	–	–	–	3,252
Total	3,411	4,062	3,566	98,908	185,571	1,956	2,219	2,510	53,947	107,133	292,704
Lives saved											
CIG	–	–	10	–	251	–	–	2	–	174	425
Dual	–	–	(0)	–	(2)	–	–	–	–	–	(2)
SLT	–	–	1	–	17	–	–	–	–	–	17
Total	–	–	11	–	266	–	–	2	–	174	440

[a](1a) increase $1.5 for cig tax in 2021; (1b) increase $1.5 for cig and SLT tax in 2021; (2) only increase the minimum age (21) for legal access to tobacco products in 2020; (1a+2) increase $1.5 for cig tax in 2021 and increase the minimum age (21) for legal access to tobacco products in 2020; (3) drop the level of mass media campaigns from high to medium and eliminate the quiteline service in 2020; (1b+2+3) increase $1.5 for cig and SLT tax in 2021, increase the minimum age (21) for legal access to tobacco products in 2020, drop the level of mass media campaigns from high to medium and eliminate the quiteline service in 2020.
CIG, cigarettes; SLT, smokeless tobacco.

Appendix Figure 1. Prevalence validation of all current smokers and all smokeless tobacco users, *SimSmoke* vs MATS and CPS-TUS with 95% CIs, Males and Females, 1993–2018.



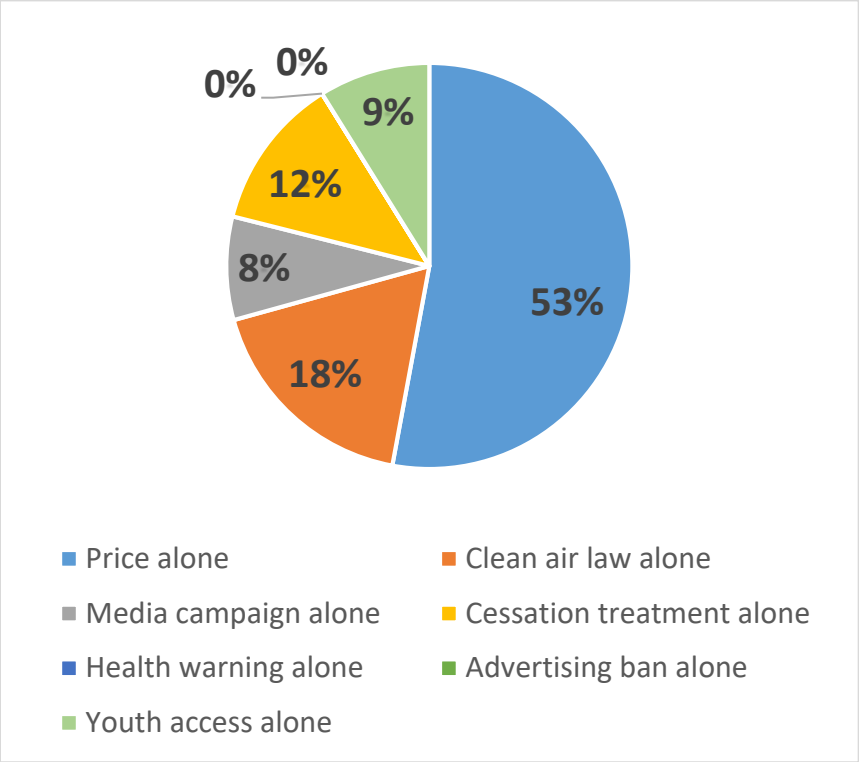




Notes: Smoking prevalence data and 95% CIs from CPS-TUS and MATS 1 (MATS 2) were measured by smoked at least 100 cigarettes in his/her lifetime and now smoking every day/some days (at least 1 day in past 30 days). Smokeless tobacco prevalence in CPS-TUS and MATS 2 was measured by used at least 10 of the last 30 days, but in MATS 1 it was measured by used at least 20 times lifetime and used at least 1 day in the last 30 days.

CPS-TUS, Current Population Survey-Tobacco Use Supplement; MATS, Minnesota Adult Tobacco Survey.

Appendix Figure 2. Reductions in 2018 cigarette smoker prevalence attributed to policies implemented between 1993 to 2018.



Appendix Figure 3. Reductions in 2018 smokeless tobacco prevalence attributed to policies implemented between 1993 to 2018.