

## The Minnesota SimSmoke Tobacco Control Policy Model of Smokeless Tobacco and Cigarette Use



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**Introduction:** A previous Minnesota SimSmoke tobacco control policy model is extended to more recent years and to include smokeless tobacco use.

**Methods:** Using data from the 1993 Tobacco Use Supplement and information on state policies, the Minnesota SimSmoke model was updated and extended to incorporate smokeless tobacco (both exclusive and dual use) and smokeless tobacco-attributable deaths. The model was then validated against the 2002, 2006/2007, and 2014/2015 Tobacco Use Supplement and the 1999, 2007, 2014, and 2018 Minnesota Adult Tobacco Survey and used to estimate the impact of policies implemented between 1993 and 2018. Analysis was conducted in April 2019.

**Results:** The model validated well for cigarette and earlier smokeless tobacco use, but it predicted smokeless tobacco use less well in recent years. The model projected that male (female) smoking prevalence was 35% (36%) lower in relative terms by 2018 and 43% (44%) lower by 2040 owing to policies, with lesser reductions projected for male smokeless tobacco use. Tobacco-attributable deaths were reduced by 7,800 by 2018 and 46,900 by 2040. Price increases, primarily through taxes, were projected to have had the greatest impact on cigarette use followed by smoke-free air laws, cessation treatment policies, tobacco control campaign expenditures, and youth access enforcement. Similar effects were projected for smokeless tobacco use, except that smoke-free air laws had smaller effects.

**Conclusions:** As cigarettes remain the dominant form of nicotine delivery product, cigarette-oriented policies may be an effective means of reducing the use of all nicotine delivery products. However, noncigarette-oriented policies may also play an important role.

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### INTRODUCTION

Since the 1964 Surgeon General's Report, U.S. smoking prevalence has declined by more than 50%. Much of that decline has been attributed to tobacco control policies,<sup>1–3</sup> including smoke-free air laws, media campaigns, and tax increases. Whereas early policies were implemented at the federal level, recent policies have mostly been implemented by states.<sup>3</sup> Simulation models have been used to show the effect of state-level policies.<sup>4–11</sup> As one of the more active tobacco control states, a previous SimSmoke<sup>7</sup> policy simulation model for Minnesota attributed a 25% reduction in smoking prevalence to policies implemented between 1993 and 2011.

Although cigarette use has fallen rapidly in Minnesota, smokeless tobacco (SLT) use has increased. After a period of relatively constant prevalence from 2000 to 2007, SLT use increased from 3.1% in 2007 to 4.3% in 2010, with SLT use by smokers increasing from 4.4% in

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2007 to 9.6% in 2010.<sup>12</sup> Since 2010, Minnesota passed policies that updated tobacco product definitions,<sup>13</sup> implemented a large SLT tax increase,<sup>14</sup> and expanded SLT treatment coverage. A better understanding of how policies affect SLT use is needed to develop effective strategies to minimize harm because of cigarette and SLT use.

In this paper, Minnesota SimSmoke is extended and further validated to 2018, and, based on a U.S. model,<sup>15</sup> expanded to consider SLT use. The effect of policies implemented between 1993 and 2018 on cigarette and SLT use and deaths attributable to their use is estimated. Methods and Results sections are summarized below and discussed in greater detail in the [Appendix](#) (available online).

## METHODS

The model begins with the 1993 population distinguished by never tobacco users and current and former exclusive cigarette, exclusive SLT, and dual users. Changes over time in tobacco use occur from changes in the population, previous use patterns, and new policies.

### Study Population

Population data by single age and gender were obtained from the Census Bureau's Population Estimates Program for 1993–2015<sup>16–18</sup> and the Minnesota State Demographic Center for 2016–2067.<sup>19</sup> The population evolves using birth, mortality, and immigration rates.<sup>20</sup>

### Measures

Individuals evolve from never tobacco users to current tobacco users through smoking and SLT initiation, become former users through quit rates, and may return to their previous tobacco use state through relapse. These transitions follow a discrete time, first-order Markov process.

Baseline estimates of exclusive smoking, exclusive SLT, and dual use status by age and gender were obtained from the state-representative 1992/1993 Tobacco Use Supplement of the Current Population Survey (CPS-TUS).<sup>21</sup> Current smokers included those who smoked  $\geq 100$  cigarettes and currently smoke either daily or nondaily. A question on "regular" SLT use was used to distinguish dual and exclusive SLT users. Former users were defined as those who met the respective definitions for use, but reported no current use, and were distinguished by years quit. Former exclusive smokers and dual users were split from all former smokers using age-specific percentages of exclusive smokers and dual users. As former SLT use was not available, former exclusive SLT prevalence was estimated using the ratio of former to current smokers, assuming the same initial profile by years quit as smokers. Female exclusive and dual SLT use was  $<0.2\%$  for all years and thus not considered.

Because evidence on initiation and early transitions to SLT use is mixed,<sup>22–26</sup> and the CPS-TUS does not provide sufficient information to distinguish information on early initiation, cessation, and product switching, transitions at young ages are modeled using net initiation rates. Measured as the difference between the 1993 prevalence at the current age and previous age for each category of tobacco user, this method incorporates initiation, cessation, and

switching between tobacco products, and helps ensure model stability and internal consistency. Net initiation occurs through the age of 30 years for males and the age of 27 years for females, the respective ages when net initiation for all 3 user groups began to decline.

To simplify the model, all product initiation and switching is assumed to occur until the final age of net initiation, and only cessation occurs after that age. Smoker quit rates were obtained from the 1993 CPS-TUS, measured as those who quit in the last year, but not the last 3 months.<sup>27</sup> Data to distinguish exclusive SLT and dual users quit rates were not available, but previous literature<sup>28–30</sup> suggests quit rates at least as high among SLT as cigarette users, and similar quit rates for dual users and exclusive smokers.<sup>30–32</sup> Consequently, smoker quit rates and relapse rates<sup>33–36</sup> were applied to dual and exclusive SLT users. Because studies suggest limited switching between SLT use and smoking except at younger ages,<sup>28–30</sup> switching only occurs at young ages via net initiation.

Relative mortality risk estimates by age and gender for current and former smokers from the Cancer Prevention Study II<sup>35,37,38</sup> were assigned to exclusive cigarette and dual users, with risks declining for former smokers by years quit.<sup>35,37,38</sup> Current exclusive SLT RR of 1.15 was based on a large-scale U.S. study.<sup>39</sup> Tobacco user mortality rates were differentiated using prevalence rates and RRs, with excess risks measured as the difference between mortality rates of tobacco users and never tobacco users. Tobacco-attributable deaths were estimated as the number of users in each of the current and former use categories multiplied by their excess mortality risks.

Policy descriptions and best estimates and credible ranges of effect sizes are shown in [Table 1](#). Policies have immediate effects on prevalence rates and ongoing effects on initiation and cessation rates. When more than 1 policy is implemented, their effects are applied multiplicatively. Beginning with 1993, the model incorporates policy changes occurring between 1993 and 2018. Policy levels are based on consultation with ClearWay Minnesota staff.

In the tax module,<sup>40</sup> tax effects are modeled through price assuming constant proportional effects. Demand studies,<sup>41</sup> including 2 recent studies,<sup>42,43</sup> suggest that effects of price on SLT use are similar to those found for cigarette demand.<sup>44</sup> Exclusive cigarette use depends on Minnesota's average cigarette retail prices (including generics).<sup>45</sup> Because SLT prices were unavailable, they were estimated using data on manufacturer prices, state and federal taxes, and wholesale and retail markups.<sup>46</sup> Weighted prices (75% cigarette, 25% SLT) were applied to dual users.<sup>47</sup> Prices were adjusted for inflation using the Consumer Price Index.<sup>48</sup> Minnesota taxes increased substantially in 2005, 2009, and 2013 for cigarettes, and in 2005 and 2013 for SLT.

The existence and enforcement as well as publicity surrounding worksite, restaurant, bar, and other public place smoke-free air laws are incorporated in SimSmoke.<sup>49</sup> Exclusive SLT and dual use effect sizes were set at 25% that of cigarette use.<sup>41</sup> Minnesota implemented a state comprehensive smoke-free air law in 2007 after earlier local ordinances.<sup>50</sup> Enforcement was set at 80% during 1993–2007 and 90% for 2008–2018.

SimSmoke distinguishes high, medium, and low levels of per capita tobacco control expenditures,<sup>51</sup> much of which are for media campaigns.<sup>52</sup> Based on SLT-oriented media campaign evaluations,<sup>41</sup> the exclusive SLT effect size was set at 50% that of smokers. Based on per capita expenditures,<sup>53</sup> Minnesota tobacco control expenditures were designated as low in 1993–1995, moderate in 1996–1999, and high since 2000.

**Table 1.** Policy Inputs for Cigarette and Smokeless Tobacco Use in *Minnesota SimSmoke*

Policy	Description	Cigarette effect size <sup>a</sup>	Relative SLT effect size <sup>b</sup>	Sensitivity ranges cigarettes (SLT), <sup>c</sup> %
Tax policy <sup>40-44</sup>				
Cigarette prices	The effect of taxes is directly incorporated through average price (including generics), with separate prices for cigarettes 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 plus 1/4 SLT price	Elasticities <sup>d</sup> -0.4 ages 10-17 years -0.3 ages 18-24 years -0.2 ages 25-34 years -0.1 ages 35-64 years -0.2 ages ≥65 years	Same Same Same -0.2 Same	-25, 25 (50, 50)
Smoke-free air policies <sup>41,44,49</sup>				
Work site 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% <sup>e</sup>	25% lower	-50, +50 (-75, +75)
Restaurant smoking ban	Ban in all indoor restaurants (reduced by half if partial)	-2% <sup>e</sup>	25% lower	
Bars smoking ban	Ban in all indoor bars (reduced by half if partial)	-1% <sup>e</sup>	25% lower	
Other places bans	Ban in 3 out of 4 government buildings, retail stores, public transportation, and elevators	-1% <sup>e</sup>	25% lower	
Enforcement	Government agency enforces the laws	Effects reduced 50% absent enforcement	25% lower	
Tobacco control expenditures <sup>41,44,51</sup>				
High-level tobacco control campaign	Campaign heavily publicized, with per capita expenditures of at least \$2.00	-6.5%	50% lower	-50, +50 (-75, +75)
Mid-level tobacco control campaign	Campaign publicized, with per capita expenditures of at least \$0.50	-3.25%	50% lower	
Low-level tobacco control campaign	Campaign sporadically publicized with per capita expenditures of at least \$0.05	-1.63%	50% lower	
Health warnings <sup>41,44</sup>				
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% prevalence and initiation, +4% cessation	Same	
Weak	Laws cover <1/3 of package, not bold or graphic	-1% prevalence and initiation, +2% cessation	Same	
Cessation treatment policy <sup>41,44,54</sup>				
Availability of pharmacotherapies	Legality of nicotine replacement therapy, bupropion and varenicline	-1% prevalence, +4% cessation <sup>f</sup>	50% lower	-50, +50 (-75, +75)
Proactive quitline	A proactive quitline with publicity and no cost NRT	-1% prevalence, +6% cessation <sup>f</sup>	50% lower	

(continued on next page)

**Table 1.** Policy Inputs for Cigarette and Smokeless Tobacco Use in *Minnesota SimSmoke* (continued)

Policy	Description	Cigarette effect size <sup>a</sup>	Relative SLT effect size <sup>b</sup>	Sensitivity ranges cigarettes (SLT), <sup>c</sup> %
Treatment coverage	Payments to cover pharmacotherapy and behavioral therapy	–2.25% prevalence, +8% cessation <sup>f</sup>	50% lower	
Brief healthcare provider interventions	Advice by a healthcare provider to quit and methods provided	–1% prevalence, +4% cessation <sup>f</sup>	50% lower	
All the above	Complete availability and reimbursement of pharmaco- and behavioral treatments, quitlines, and brief interventions	–5.7% prevalence, +27.4% cessation <sup>f</sup>	50% lower	
Youth access restrictions <sup>58–61</sup>				–50, +50 (–75, +75)
Strongly enforced and publicized	Compliance rates of ≤5%, penalties are potent, enforced with heavy publicity	–16% initiation and prevalence for ages 16–17 years and –24% for ages <16 years	50% lower	
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 years and –12% for ages <16 years	50% lower	
Low enforcement	Compliance rates >20%, penalties are weak	–2% initiation and prevalence for ages 16–17 years and –3% for ages <16 years	50% lower	
Vending machine restrictions	Total ban	Enforcement effects increase by 8%	50% lower	
Self-service restrictions	Total ban	Enforcement effects increase by 4%	50% lower	
Publicity	Media campaigns directed at youth use	Enforcement effects increase by 10%	50% lower	

<sup>a</sup>Unless otherwise indicated, the effects are in 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.

<sup>b</sup>Effect sizes are relative to cigarette effect sizes and applied to exclusive SLT use only unless otherwise indicated.

<sup>c</sup>Same sensitivity ranges used for SLT effect sizes, unless otherwise indicated.

<sup>d</sup>Elasticities translate into effect sizes through percentage change in price.

<sup>e</sup>Effect size differs for exclusive SLT and dual use.

<sup>f</sup>Effect size for dual use is assumed to be 3/4 that of exclusive cigarette.  
NRT, nicotine replacement therapy; SLT, smokeless tobacco.

Health warnings on packages are assumed to have similar effects on cigarette and SLT use.<sup>41</sup> They had been minimal since 1993, but text warnings covering  $\geq 30\%$  of 2 principal sides have been required on SLT packages since 2010 (moderate).

Cessation treatment policy includes availability of pharmacotherapy, financial coverage of treatments, quitlines, and brief interventions.<sup>54</sup> Reviews of randomized SLT trials report mixed effects for pharmacotherapies, but slightly stronger effects for behavioral interventions;<sup>41</sup> but use has been low.<sup>55</sup> Cessation treatment policies were assigned 50% the effect on SLT users and 75% the effect on dual users compared with exclusive smokers. The patch was available by prescription in 1993 and became available without prescription in 1997. Bupropion became available in 1998 and varenicline became available in 2007, both by prescription. Pharmacotherapy and behavioral therapy coverage were effectively available to 40% of smokers in 1993, increasing to 60% in 2003, 70% in 2007, 85% in 2011, and 90% in 2016. Minnesota was categorized as having an active, well-publicized quitline since 2001. The 2014 Minnesota Adult Tobacco Survey (MATS)<sup>56</sup> indicates that about 67% of smokers visited a healthcare provider, of whom about 79% received advice and 53% received a referral.<sup>57</sup> Brief interventions were estimated at 40% coverage of smokers in 1993, increasing to 50% in 2004.

The effect of minimum purchase age laws depends on enforcement levels, and on vending machines and self-service restrictions.<sup>58</sup> Based on findings that youth access policies weakly affect SLT use,<sup>43,59–61</sup> these policies were assigned 50% the effect for exclusive SLT compared with cigarette use. Based on Synar data,<sup>62</sup> compliance rates were used to classify enforcement as low through 2000, moderate until 2010, and high since 2011. Bans were implemented on vending machines in 1996 and on self-service in 2009.

## Modeling

The model was calibrated by comparing predicted prevalence rates by gender and age with 1996 and 1998 CPS-TUS prevalence rates. Based on the deviations, male initiation rates were increased for ages 18–30 years, and cessation rates were reduced for ages  $\geq 35$  years. Because female exclusive smoker prevalence rates for ages 18–27 years were higher than CPS-TUS rates, their initiation rates were reduced by 20%. SLT and dual use were not calibrated owing to the limited reliability of CPS-TUS estimates.

The model was validated by comparing model predictions of prevalence rates with those of 2002, 2006/2007, and 2014/2015 CPS-TUS surveys and 1999, 2007, 2014, and 2018 MATS.<sup>57,63</sup> For the CPS-TUS, questions on SLT use changed in 1998 from asking about *regular use* to *at least one time in the last month*. Current SLT use was then defined to include those using  $\geq 10$  of the last 30 days in CPS-TUS.<sup>64</sup> Two definitions were used from MATS, both based on any last 30-day use with one requiring  $\geq 20$  times in lifetime.

To estimate the effect of policies implemented between 1993 and 2018 on all (exclusive and dual) cigarette and SLT use, the model was programmed with all policies remaining at their 1993 levels (the counterfactual). The net reduction as a result of all policies was estimated by the relative difference between the counterfactual projection and that with all policies implemented. The contribution of an individual policy is estimated by programming the model to allow for the change in that policy while holding other policies constant. Because policy effects are not additive, the effect of an individual policy is measured relative to the summed effects of all individual policies.

## RESULTS

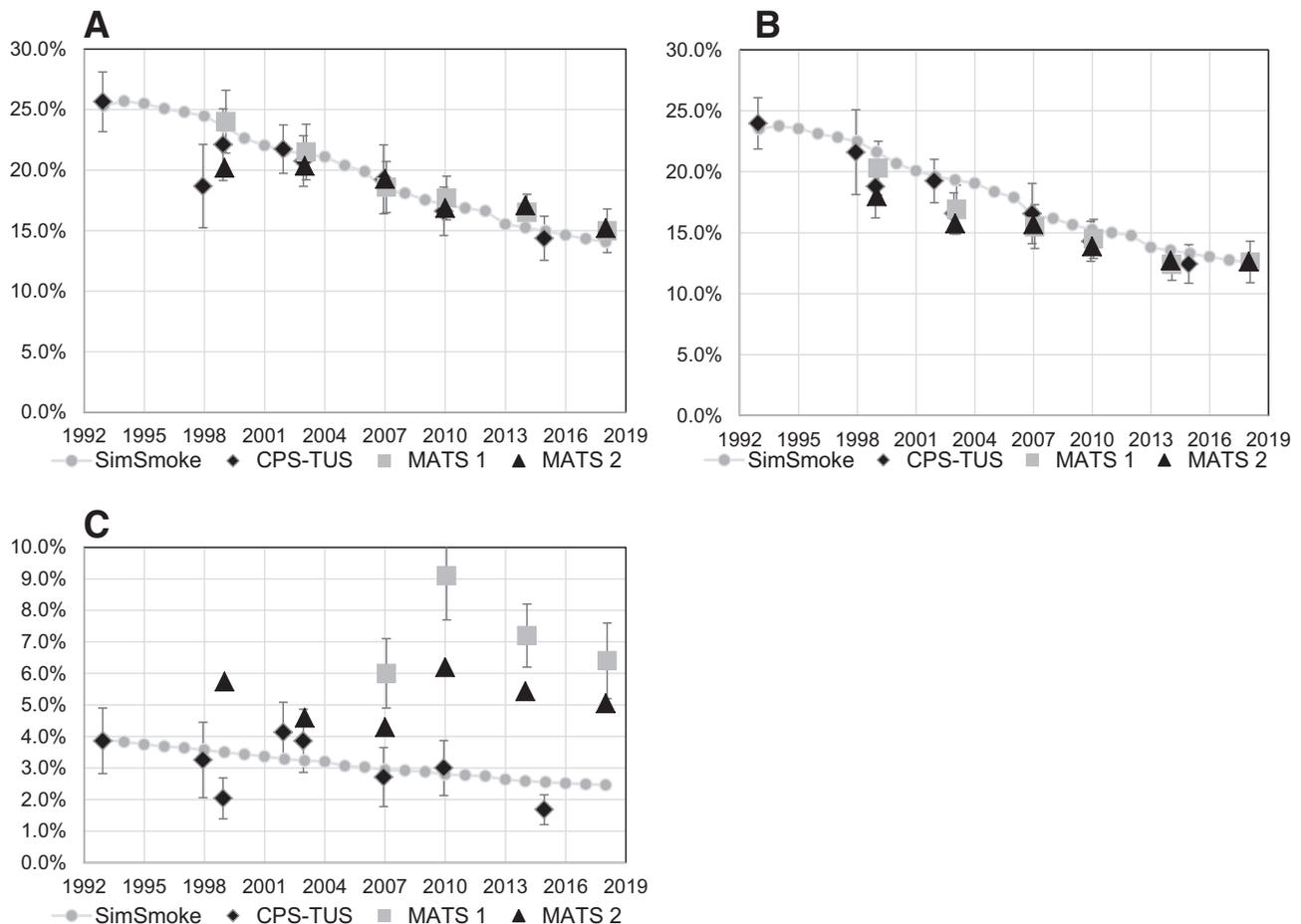
As shown in [Figure 1A](#) and [1B](#), SimSmoke predicted that prevalence of male (female) age  $\geq 18$  years cigarette use (exclusive plus dual) fell from 25.3% (23.5%) in 1993 to 15.0% (13.3%) in 2015, whereas the CPS-TUS was 14.4% (12.4%) in 2015. By 2018, smoking prevalence was projected to fall to 14.1% (12.5%) compared with 15.0% in MATS. For 2015 and 2018, and earlier years, SimSmoke predicted well within the 95% CIs of estimates from the respective surveys, except for overestimating male smoking in 1998 and female smoking in 1999 and 2003. Analysis by age group (not shown) also generally yielded predictions within CPS-TUS and MATS CIs for each gender.

As shown in [Figure 1C](#), SimSmoke projected adult male SLT (exclusive and dual use) prevalence falling from 3.9% in 1993 to 2.6% in 2015, above the 1.7% estimate and CI from 2015 CPS-TUS. SimSmoke projected male SLT use at 2.5% in 2018, and in that year, as well as in 2007, 2010, and 2014, SimSmoke projections were below the CIs from MATS estimates. The deviations from MATS since 2007 were especially large for young adults.

The effects of policies implemented between 1993 and 2018 are shown separately for male and female prevalence in [Table 2](#), and the total male and female tobacco-attributable deaths in [Table 3](#).

Compared with no new policies implemented after 1993, SimSmoke projected that male cigarette and SLT prevalence was reduced by 35% (23%–45%) and 23% (12%–32%), respectively, in 2018, and will be reduced by 43% (29%–55%) and 27% (15%–38%), respectively, in 2040. Similar results were obtained for female users. In 1993, total tobacco-attributable deaths were 5,367 (5,279 exclusive cigarette, 17 dual, and 71 exclusive SLT users). With policies implemented, the number of deaths increased to 6,281 deaths (6,117 exclusive cigarette, 102 dual, and 62 exclusive SLT users) with a range of 6,681 to 5,920 in 2018. With policies implemented, SimSmoke projected that 7,808 (4,880–10,519) cumulative tobacco-attributable deaths would be averted by 2018, with 46,933 (29,867–61,764) premature deaths averted by 2040.

Among individual policies, price increases alone were estimated to have reduced male smoking rates by 19% (15%–24%) in 2018, increasing to 25% (20%–30%) by 2040, and reduced premature deaths by 21,264 (16,289–26,006) by 2040. Smoke-free air laws yielded a 7.7% (3.9%–11.5%) relative reduction in male smoking rate by 2018, increasing to 8.4% (4.2%–12.4%) by 2040, with 11,340 (5,758–16,754) fewer deaths by 2040. The relative reductions were 4.6% (2.3%–6.7%) in 2018,



**Figure 1.** Prevalence validation of all current smokers and all smokeless tobacco users, *SimSmoke* versus MATS and CPS-TUS with 95% CIs, 1993–2018. (A) All male current smokers; (B) all female current smokers; (C) all male smokeless tobacco users. CPS-TUS, Current Population Survey-Tobacco Use Supplement; MATS, Minnesota Adult Tobacco Survey.

increasing to 4.9% (3.0%–7.2%) in 2040 for cessation treatments, 2.9% (1.5%–4.3%) increasing to 3.1% (1.6%–4.7%) for tobacco control expenditures, and 2.7% (1.2%–4.5%) increasing to 6.8% (3.0%–11.4%) for youth access enforcements. For male smokers in 2040, price increases represented 52% of total policy effects, followed by smoke-free air laws (17%), youth access enforcements (14%), cessation treatments (10%), and tobacco control expenditures (6%). For male SLT use in 2040, taxes represented 54% of total policy effects, followed by youth access enforcements (18%), cessation treatments (13%), tobacco control expenditures (5%), and health warnings (4%).

## DISCUSSION

Minnesota *SimSmoke* predicted cigarette use close to that in the CPS-TUS and MATS surveys. As in the previous U.S. literature,<sup>7,8</sup> the present analyses suggest that overall Minnesota SLT rates fell, at least through 2007,

especially for those aged <45 years. Indeed, the CPS-TUS SLT prevalence fell more rapidly than model predictions through 2007, suggesting that strong anti-cigarette policies may have had a major impact on SLT use.

The model failed to predict the increased SLT use seen in MATS since 2007. Such increases occurred primarily at younger ages and are consistent with recent studies for the U.S.<sup>6,9–12</sup> These increases among young adults may reflect marketing by cigarette manufacturers.<sup>43,65</sup> In particular, cigarette manufacturers acquired major SLT firms and soon dominated the industry.<sup>66</sup> They also began promoting SLT as a way for smokers to satisfy nicotine cravings in places where smoking is banned,<sup>67,68</sup> increased the use of price promotions,<sup>69</sup> and marketed flavored products.<sup>18,45</sup>

The model was also used to update the estimated effects of tobacco-control policies implemented in Minnesota since 1993. *SimSmoke* projected that smoking prevalence was about 35% lower in relative terms by 2018, and 43% lower by 2040. The increased impact

**Table 2.** Prevalence by Tobacco Use, Projected by *Minnesota SimSmoke* Under Multiple Scenarios, 1993–2040

Scenario/use	1993, %	2018 best (lower, upper), <sup>a</sup> %	2040 best (lower, upper), <sup>a</sup> %	Relative change 2018, <sup>b</sup> %	Relative change 2040, <sup>b</sup> %	Percent of total 2040 <sup>c</sup>
<b>Males</b>						
Counterfactual						
Smokers	25.3	21.6 (21.6, 21.6)	19.1 (19.1, 19.1)	—	—	—
SLT use	3.9	3.2 (3.2, 3.2)	2.9 (2.9, 2.9)	—	—	—
All policies						
Smokers	25.3	14.1 (16.6, 11.8)	10.9 (13.5, 8.6)	-35 (-23, -45)	-43 (-29, -55)	100
SLT use	3.9	2.5 (2.8, 2.2)	2.1 (2.4, 1.8)	-23 (-12, -32)	-27 (-15, -38)	100
Price alone						
Smokers	25.3	17.4 (18.4, 16.5)	14.3 (15.4, 13.3)	-19 (-15, -24)	-25 (-20, -30)	52
SLT use	3.9	2.8 (2.9, 2.6)	2.5 (2.6, 2.3)	-14 (-9, -18)	-14 (-10, -19)	54
Smoke-free air laws alone						
Smokers	25.3	20.0 (20.8, 19.2)	17.5 (18.3, 16.8)	-8 (-4, -11)	-8 (-4, -12)	17
SLT use	3.9	3.2 (3.2, 3.1)	2.8 (2.9, 2.8)	-1 (0, -1)	-1 (0, -1)	3
Tobacco control expenditures alone						
Smokers	25.3	21.0 (21.3, 20.7)	18.5 (18.8, 18.2)	-3 (-1, -4)	-3 (-2, -5)	6
SLT use	3.9	3.1 (3.2, 3.1)	2.8 (2.8, 2.8)	-2 (-1, -3)	-2 (-1, -3)	8
Cessation treatment alone						
Smokers	25.3	20.7 (21.1, 20.2)	18.2 (18.7, 17.8)	-5 (-2, -7)	-5 (-3, -7)	10
SLT use	3.9	3.1 (3.1, 3.0)	2.8 (2.8, 2.7)	-3 (-1, -5)	-3 (-1, -5)	13
Health warnings alone <sup>d</sup>						
Smokers	25.3	21.6 (21.6, 21.6)	19.1 (19.1, 19.1)	—	—	—
SLT use	3.9	3.2 (3.2, 3.1)	2.8 (2.9, 2.8)	-1 (0, -1)	-1 (0, -1)	4
Youth access alone						
Smokers	25.3	21.1 (21.4, 20.7)	17.8 (18.6, 17.0)	-3 (-1, -5)	-7 (-3, -11)	14
SLT use	3.9	3.1 (3.2, 3.1)	2.7 (2.8, 2.6)	-2 (-1, -4)	-5 (-2, -9)	18
<b>Females</b>						
Counterfactual						
Smokers	23.5	19.5 (19.5, 19.5)	17.3 (17.3, 17.3)	—	—	—
SLT use	—	—	—	—	—	—
All policies						
Smokers	23.5	12.6 (14.9, 10.5)	9.7 (12.2, 7.6)	-36 (-23, -46)	-44 (-30, -56)	100
SLT use	—	—	—	—	—	—
Price alone						
Smokers	23.5	15.8 (16.7, 15.0)	13.1 (14.0, 12.2)	-19 (-15, -23)	-24 (-19, -29)	49
SLT use	—	—	—	—	—	—

(continued on next page)

**Table 2.** Prevalence by Tobacco Use, Projected by *Minnesota SimSmoke* Under Multiple Scenarios, 1993–2040 (continued)

Scenario/use	1993, %	2018 best (lower, upper), <sup>a</sup> %	2040 best (lower, upper), <sup>a</sup> %	Relative change 2018, <sup>b</sup> %	Relative change 2040, <sup>b</sup> %	Percent of total 2040 <sup>c</sup>
Smoke-free air laws alone						
Smokers	23.5	17.9 (18.7, 17.1)	15.7 (16.5, 15.0)	-8 (-4, -12)	-9 (-5, -14)	18
SLT use	—	—	—	—	—	—
Tobacco control expenditures alone						
Smokers	23.5	18.9 (19.2, 18.6)	16.7 (17.0, 16.4)	-3 (-2, -5)	-3 (-2, -5)	7
SLT use	—	—	—	—	—	—
Cessation treatment alone						
Smokers	23.5	18.5 (19.0, 18.0)	16.2 (16.8, 15.8)	-5 (-3, -8)	-6 (-3, -9)	12
SLT use	—	—	—	—	—	—
Health warnings alone						
Smokers	23.5	19.5 (19.5, 19.5)	17.3 (17.3, 17.3)	—	—	—
SLT use	—	—	—	—	—	—
Youth access alone						
Smokers	23.5	19.0 (19.3, 18.6)	16.2 (16.8, 15.4)	-3 (-1, -4)	-7 (-3, -11)	13
SLT use	—	—	—	—	—	—

<sup>a</sup>Estimates are given in the best estimate and the upper and lower bounds based on the policy evaluation literature.

<sup>b</sup>Relative changes are estimated for a particular policy or group of policies relative to the Counterfactual, i.e.,  $(Policy_{p,t} - Counterfactual_{p,t}) / Counterfactual_{p,t}$  for policy p and time period t.

<sup>c</sup>Percent of total is measured as the relative change from the policy relative to the summed relative change effects of all policies.

<sup>d</sup>Health warnings were changed for SLT, but not cigarettes.

SLT, smokeless tobacco.

**Table 3.** Tobacco-Attributable Deaths and Deaths Averted, Projected by *Minnesota SimSmoke* Under Multiple Scenarios, 1993–2040

Variable	1993	2018 best estimate (lower, upper) <sup>a</sup>	2040 best estimate (lower, upper) <sup>a</sup>	Summation by 2018 projected best (lower, upper) <sup>b</sup>	Summation by 2040 projected best (lower, upper) <sup>b</sup>
<b>Tobacco-attributable deaths</b>					
Counterfactual					
Cigarette	5,279	7,152 (7,152, 7,152)	7,965 (7,965, 7,965)	157,176 (157,176, 157,176)	330,846 (330,846, 330,846)
Dual	17	119 (119, 119)	242 (242, 242)	1,523 (1,523, 1,523)	5,688 (5,688, 5,688)
SLT	71	69 (69, 69)	77 (77, 77)	1,964 (1,964, 1,964)	3,543 (3,543, 3,543)
Total	5,367	7,339 (7,339, 7,339)	8,285 (8,285, 8,285)	160,663 (160,663, 160,663)	340,076 (340,076, 340,076)
Actual/status quo					
Cigarette	5,279	6,117 (6,507, 5,764)	5,848 (6,581, 5,239)	149,535 (152,389, 146,894)	285,213 (301,765, 270,841)
Dual	17	102 (108, 96)	178 (199, 159)	1,421 (1,459, 1,385)	4,662 (5,021, 4,342)
SLT	71	62 (66, 59)	65 (72, 59)	1,900 (1,935, 1,866)	3,269 (3,423, 3,130)
Total	5,367	6,281 (6,681, 5,920)	6,090 (6,852, 5,457)	152,855 (155,783, 150,145)	293,144 (310,209, 278,313)
<b>Tobacco-attributable deaths averted<sup>c</sup></b>					
Actual/status quo					
Cigarette	—	1,035 (644, 1,387)	2,118 (1,385, 2,726)	7,641 (4,787, 10,283)	45,633 (29,080, 60,004)
Dual	—	17 (11, 23)	65 (43, 84)	102 (64, 138)	1,025 (667, 1,346)
SLT	—	6 (3, 9)	12 (5, 18)	64 (29, 98)	275 (120, 413)
Total	—	1,058 (658, 1,419)	2,194 (1,433, 2,828)	7,808 (4,880, 10,519)	46,933 (29,867, 61,764)
Price alone					
Cigarette	—	441 (336, 542)	1,010 (781, 1,225)	3,457 (2,628, 4,264)	20,570 (15,802, 25,117)
Dual	—	8 (6, 10)	34 (27, 42)	47 (35, 58)	517 (397, 631)
SLT	—	4 (2, 6)	7 (4, 10)	48 (25, 71)	177 (91, 258)
Total	—	453 (345, 558)	1,051 (811, 1,276)	3,551 (2,688, 4,392)	21,264 (16,289, 26,006)
Smoke-free air laws alone					
Cigarette	—	267 (135, 397)	529 (270, 778)	1,396 (704, 2,079)	11,232 (5,703, 16,592)
Dual	—	2 (1, 3)	7 (3, 10)	9 (4, 13)	109 (55, 163)
SLT	—	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Total	—	269 (136, 400)	536 (273, 788)	1,405 (708, 2,092)	11,340 (5,758, 16,754)
Media campaigns alone					
Cigarette	—	145 (73, 216)	212 (107, 316)	1,403 (705, 2,095)	5,528 (2,783, 8,237)
Dual	—	3 (1, 4)	7 (4, 11)	22 (11, 33)	136 (69, 203)
SLT	—	1 (0, 1)	1 (0, 2)	9 (2, 15)	28 (7, 50)
Total	—	149 (75, 222)	220 (111, 328)	1,434 (718, 2,143)	5,693 (2,858, 8,490)
Cessation treatment alone					
Cigarette	—	224 (114, 330)	483 (250, 699)	1,649 (835, 2,443)	10,381 (5,324, 15,187)
Dual	—	4 (2, 5)	13 (7, 19)	21 (11, 32)	213 (109, 312)

(continued on next page)

**Table 3.** Tobacco-Attributable Deaths and Deaths Averted, Projected by Minnesota SimSmoke Under Multiple Scenarios, 1993–2040 (continued)

Variable	1993	2018 best estimate (lower, upper) <sup>a</sup>	2040 best estimate (lower, upper) <sup>a</sup>	Summation by 2018 projected best (lower, upper) <sup>b</sup>	Summation by 2040 projected best (lower, upper) <sup>b</sup>
SLT	—	1 (0, 2)	3 (1, 5)	10 (2, 17)	55 (14, 95)
Total	—	228 (116, 337)	498 (257, 723)	1,680 (848, 2,492)	10,649 (5,447, 15,595)
Health warnings alone <sup>d</sup>					
Cigarette	—	—	—	—	—
Dual	—	—	—	—	—
SLT	—	0 (0, 0)	1 (1, 2)	2 (1, 3)	17 (9, 26)
Total	—	0 (0, 0)	1 (0, 1)	2 (1, 3)	17 (8, 25)
Youth access alone					
Cigarette	—	0 (0, 0)	56 (25, 94)	0 (0, 1)	447 (201, 743)
Dual	—	0 (0, 0)	5 (2, 8)	0 (0, 0)	40 (18, 68)
SLT	—	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 1)
Total	—	0 (0, 0)	61 (27, 102)	0 (0, 1)	487 (219, 811)

<sup>a</sup>Estimates are given in the best estimate and the upper and lower bounds based on the policy evaluation literature.

<sup>b</sup>Summation is the summed deaths or deaths averted from 1993 through the current year.

<sup>c</sup>Deaths averted is measured as the difference in deaths with a policy or group of policies implemented and deaths under the counterfactual.

<sup>d</sup>Health warnings were changed for SLT, but not cigarettes. SLT, smokeless tobacco.

compared with an earlier Minnesota SimSmoke analysis<sup>7</sup> is primarily because of the growing effect of policies over time, and to a more limited extent to the implementation of additional policies. Price increases, primarily through taxes, were still projected to have had the greatest effect on cigarette use, followed by smoke-free air laws, cessation treatment policies, and tobacco-control expenditures. Substantial reductions were also projected for male dual use and SLT use, although the failure of the model to predict recent increases in SLT use warrants caution. These results are similar to those from SimSmoke models for other states<sup>4–11</sup> and suggest the importance of tax increases subject to their limitations.<sup>70–72</sup> However, other policies also play an important role, in and of themselves, and also through the synergistic effects of the different policies (e.g., taxes and cessation treatment policies).<sup>73</sup>

In 2018, Minnesota SimSmoke estimated 62 SLT and 102 dual premature deaths, which paled in comparison with 6,117 exclusive cigarette deaths. However, the model also estimated that policies implemented between 1993 and 2018 reduced tobacco-attributable deaths by 7,808 by 2018, estimating tobacco-attributable deaths to reduce by 46,933 by 2040.

**Limitations**

Similar to all models, the current results depend on the underlying assumptions and data. In particular, cigarette prevalence projections were based on cessation rates from the 1993 CPS-TUS for Minnesota, but these are subject to policy changes over time. Information on SLT cessation and product switching were not directly available. SLT prices had to be derived. The model also does not explicitly incorporate the role of the industry, which annually spends more than \$100 million in Minnesota promoting their products.<sup>74</sup> In addition, the model did not distinguish the risks to dual users compared with exclusive smokers, and treated SLT risks as a homogeneous category. Finally, several cities, including Minneapolis, St. Paul, and Duluth, recently implemented flavor restrictions, including menthol restrictions. Although not considered in this study, previous analysis suggests that these policies may have additional effects on cigarette use.<sup>75</sup>

The estimated effect sizes of policies for SLT use in the model largely reflect studies conducted before 2007.<sup>15</sup> The effect sizes may have changed in recent years, with cigarette manufacturers coming to dominate the SLT firm industry.<sup>66</sup> In addition, the model does not specifically consider interactive effects of cigarette policies on SLT use and SLT policies on smoking. In particular, cigarettes and SLT policy effects may have changed in recent years with increased multiproduct use<sup>76</sup> and the increased potential for substituting other products.

The model is limited to cigarette and SLT use and does not incorporate the use of cigars, water pipes, and e-cigarettes. Since 2010, there has been a greater focus in Minnesota on regulating other tobacco products, such as cigars and e-cigarettes, in addition to SLT. The definition of a “cigarette” for excise tax purposes was amended in 2013 to include “little cigars”<sup>13</sup> and appears to have reduced their use to 2%–3% in Minnesota.<sup>57</sup> E-cigarettes may have played a role in recent years to either increase or reduce cigarette smoking, and the analysis of SLT use herein may provide guidance.<sup>77</sup>

## CONCLUSIONS

Although the landscape for nicotine delivery products has dramatically changed in the last 10 years, some lessons can be gleaned from the present modeling. With cigarettes still being the dominant form of nicotine delivery, cigarette-oriented policies may be an effective means, perhaps the most effective means, for reducing the use of all nicotine delivery products. Nevertheless, policies directed at other products, such as SLT and e-cigarettes, may also play a role.

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## SUPPLEMENTAL MATERIAL

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