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Effects of tobacco control policies on smoking prevalence and tobacco-attributable deaths in Mexico: the *SimSmoke* model

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ABSTRACT

Objective. *To examine how policies adopted in Mexico in response to the Framework Convention on Tobacco Control affected smoking prevalence and smoking-attributable deaths.*

Methods. *The* SimSmoke *simulation model of tobacco control policy is applied to Mexico. This discrete time, first-order Markov model uses data on population size, smoking rates and tobacco control policy for Mexico. It assesses, individually and jointly, the effects of seven types of policies: cigarette taxes, smoke-free air laws, mass media campaigns, advertising bans, warning labels, cessation treatment, and youth tobacco access policies.*

Results. *The Mexico* SimSmoke *model estimates that smoking rates have been reduced by about 30% as a result of policies implemented since 2002, and that the number of smoking-attributable deaths will have been reduced by about 826 000 by 2053. Increases in cigarette prices are responsible for over 60% of the reductions, but health warnings, smoke-free air laws, marketing restrictions and cessation treatments also play important roles.*

Conclusions. *Mexico has shown steady progress towards reducing smoking prevalence in a short period of time, as have other Latin American countries, such as Brazil, Panama and Uruguay. Tobacco control policies play an important role in continued efforts to reduce tobacco use and associated deaths in Mexico.*

Key words Tobacco use; smoking; attributable risk; premature mortality; public policy; Mexico.

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It is estimated that, globally, about 6 million deaths each year are attributable to smoking, a figure projected to increase to 8.3 million by the 2030s (1). In response, the World Health Organization has established the Framework Convention on Tobacco Control (FCTC) (2), which recommends policies consistent with the MPOWER Report (3). The FCTC and MPOWER build upon substantial evidence that higher cigarette taxes, smoke-free air laws, advertising bans, health warnings, media campaigns and cessation treatment policies can reduce adult smoking rates, especially when combined in a comprehensive strategy (4, 5). Mexico ratified the FCTC in June 2004, and since then has increased cigarette taxes, placed graphic warnings labels on cigarette packs, and adopted restrictions on product advertising and smoking in indoor public places.

The effects of policies implemented in Mexico have not been previously considered. Mathematical models can be applied to distinguish the effects of different policies. One such model, *SimSmoke*, has been validated and previously used to estimate the impact of a broad array of tobacco control policies in different countries (6–11).

This paper uses the *SimSmoke* tobacco control policy simulation model to estimate the effects of such policies on smoking prevalence and health outcomes in Mexico. The objective is to predict overall smoking rates and annual smoking-attributable deaths through the year 2053, while estimating the effects of policies implemented in Mexico since 2002. The model is first validated for smoking prevalence by age and gender.

MATERIALS AND METHODS

Basic model

SimSmoke estimates the impact of major tobacco control policies on smoking behaviors and health outcomes. The model uses parameters derived from epidemiologic and demographic analyses and is validated with respect to repeated cross-sectional survey data. The Mexico *SimSmoke* model takes the large-scale Encuesta Nacional de Adicciones (ENA) Survey, conducted in 2002, as a starting point (12). This preceded FCTC ratification in 2004 and the subsequent implementation of most major tobacco control policies (see Figure 1). Smoking prevalence had been relatively stable prior to that year (12). *SimSmoke* characterizes the population by age, gender and smoking status (never, current and former, with former smokers distinguished by number of years since quitting).

A discrete time, first-order Markov process is employed to project future population as a function of birth and death rates, and future smoking prevalence as a function of rates of smoking initiation, cessation, and relapse. Shifts in prevalence are assumed to occur through changes in tobacco control policies. Smoking-attributable deaths are estimated using smoking rates and mortality risks of smokers and former smokers relative to never smokers, as in standard measures of attributable risk (13). The Mexico implementation of *SimSmoke* is further described in a technical report, available as supplementary material. (14)

Population counts and fertility and mortality rates by gender and age were obtained from the Consejo Nacional de Población (CONAPO) (15). International immigration was negligible, less than 1% (16), and is therefore not included in the model. Model population projections for 2011 were found to be within 2% of the actual population (15).

Smoking status

Data were obtained from four nationally representative surveys (see Figure 1). The surveys asked different questions regarding smoking, but measures were standardized where possible. Current, former and never smoking prevalence for the baseline year were obtained from the 2002 ENA (12, 17, 18), a nationally representative survey of the population between 12 and 65 years old (N = 5 051 males and 6 021 females). A current smoker was defined as having smoked at least 100 cigarettes in his/her lifetime and having smoked during the last 30 days. Former smokers were distinguished by the number of years since they quit smoking (1–2, 3–5, 6–10, 11–15, or greater than 15 years). The 2011 ENA (N = 16 249) was used to validate model-projected smoking rates (19).

Because the 2002 ENA did not contain information on smokers above age 65, estimates for that population were obtained from the 2000 Encuesta Nacional de Salud y Nutrición, (ENSANut), a nationally representative survey of the adult Mexican population 20 years of age and older (N = 18 400 males and 35 700 females) (20). Data from the United States 1993 Tobacco Use Supplement to the Current Population Survey (TUS-CPS) were used to estimate the proportion of former smokers above the age of 65 in each of the years-quit categories (21). The 2006 (N = 56 600) (22) and the 2012 (N = 56 300) (23) ENSANut were used for model validation.

Nationally representative data for model validation were also obtained from the 2009 Global Adult Tobacco Survey (GATS, N = 13 627) (24), in which individuals were asked if they currently smoked every day or some days.

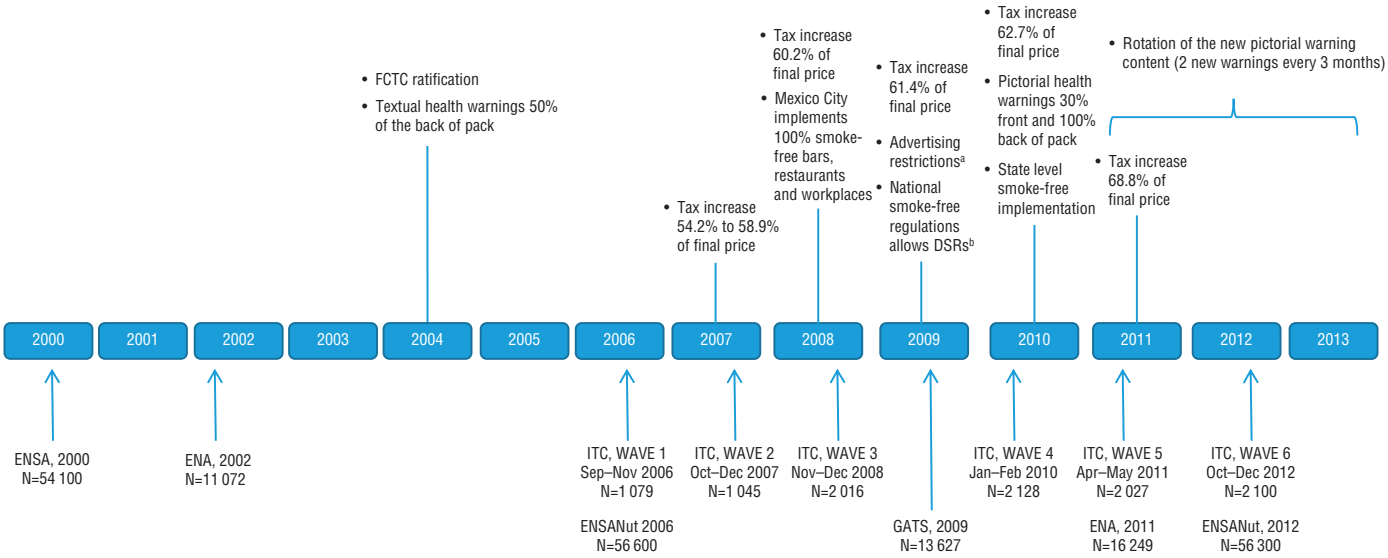
Data on policy implementation and cessation rates were derived from the version of the International Tobacco Control Policy Evaluation Survey administered in Mexico (ITC Mexico) (25). ITC Mexico is a population-based representative cohort study of adult smokers (i.e., adults who have smoked at least 1 cigarette in the prior month and 100 cigarettes in their lifetime), comprising six surveys (waves 1-6) between 2006 and 2012. Waves 1-2 covered 4 cities (Mexico City, Tijuana, Guadalajara and Juarez; N = ~1 000); waves 3-6 covered 7 cities (Mexico City, Monterrey, Guadalajara, Tijuana, Leon, Merida and Puebla) (N = ~2 000).

Initiation rates at each age were measured as the difference between the baseline smoking rate at that age and the baseline rate at the previous age. Based on smoking prevalence and stated age of initiation from the 2002 ENA, initiation was allowed through age 24. The past-year cessation rate was calculated from the 2002 ENA as the ratio of former smokers who quit during the previous year to all those smoking during the last year (i.e., current smokers plus those who quit during the last year). Allowing for the effect of policies since 2002, the 2002 ENA yielded similar cessation rates to those estimated by the ITC (25). Because ITC relapse rates were close to those observed in the United States (26), the latter were used in this analysis, which covers a period without confounding policy changes.

Smoking-attributable deaths

Smoking-attributable deaths were estimated by applying the difference between the mortality rate of current or former smokers and that of never smokers to the number of current and former smokers. Death rates were calculated by age, gender and smoking category (never, current and former) using 2002 smoking and death rates and relative mortality risks. Because risks for Mexico (27) are likely lower than those observed in the United States due to the lower quantity of cigarettes smoked, relative risks of 1.6 for males and 1.5 for females were used here, consistent with risks from other middle-income countries earlier in the tobacco epidemic (28, 29). A sensitivity analysis was conducted using relative risks of 2.2 for males and 2.0 for females, as observed in the United States (30).

FIGURE 1. Timeline of Tobacco Control Policy Implementation and Surveys in Mexico, 2000–2013



Sources of information: ENSA: Encuesta Nacional de Salud (20); ENA: Encuesta Nacional de Adicciones (17–19); ENSANut: Encuesta Nacional de salud (22, 23); ITC: International Tobacco Control Policy Evaluation Survey (25); GATS: Global Adult Tobacco Survey (24).
[a] Ads banned on TV, radio, billboards, and non-adult print media.
[b] Designated smoking rooms, physically separated by walls and with separated ventilation system.

Policy effects

The policy parameters in *SimSmoke* are based on literature reviews (4) and the advice of expert panels. Tobacco control policies and effect sizes are summarized in Table 1. Since estimated effects are based primarily on studies conducted in high-income countries, policy impacts have been adjusted to reflect Mexico's urban/rural mix and level of income. Reductions are applied to smoking prevalence for the year in which the policy is implemented and, unless otherwise specified, to initiation and cessation rates in future years.

Policy implementation levels in Mexico were tracked from 2002 to 2013, as shown in Figure 1. Policy level definitions are based on MPOWER reports (3, 31), the 2013 Tobacco Control Report for the Americas (32), and descriptions from publications (33).

Cigarette excise taxes. Changes in price were translated into changes in smoking prevalence through an equation dependent on price elasticities. Since demand studies for Mexico (34, 35) were consistent with those for the United States, the age-specific prevalence elasticities (i.e., the percentage change in prevalence for a percentage increase in price) used in the United States *SimSmoke* implementation were adopted here. For the years 2002–2009, price data were obtained from Waters et al. (34). For 2008 through 2012, data from the ITC (36), which included national and international cigarette brands, were used. Prices were adjusted for inflation using the consumer price index, yielding a 58% cigarette price increase over the study period.

Smoke-free air laws. Until 2008, Mexico had minimal smoke-free air laws, limited to a ban on smoking in health care facilities, educational facilities, and theaters and cinemas; a "weak" policy, in the *SimSmoke* parameterization. A national law in 2008 restricted smoking to designated areas in worksites, restaurants and other public places. Also in 2008, Mexico City and Tabasco (comprising about 10% of the national population) adopted comprehensive smoke-free policies, including for bars, restaurants and workplaces; similar bans were implemented by additional states in 2011, 2012, and 2013, increasing comprehensive smoke-free policy coverage to 40% of the total population by 2013. For each year, the level of enforcement of smoke-free laws was also rated according to criteria from MPOWER and was used to modify the effect magnitudes of these policies; based on GATS (24) and ITC (37–39) compliance data, enforcement level was set to 5 on a 10-point scale for all years.

Marketing restrictions. Mexico banned tobacco advertising on television (except for during certain restricted hours) and radio in 2004. In 2009, such advertising was banned on all television, radio, and billboards, but continued to be allowed in magazines that primarily target adults, in adult-only venues and points of sale, and through the mail (40). Promotional discounts, branding and advertising at sponsored events were also banned. In the model, Mexico is denoted as having no ban in 2002, a minimal ban in 2004, and a near-moderate ban (categorized as 75% moderate and 25% minimal) in 2009, to reflect the implementation of a nearly complete direct advertising ban without a ban on indirect advertising. As for smoke-free policies, level of enforcement was estimated for marketing restrictions and was used to modify effect magnitudes; based on GATS (24) and the ITC (40), enforcement was set at 5 out of 10.

Health warnings. As of 2002, Mexican law required minimal health warnings on cigarette packaging; a "weak" policy. In 2004, warning requirements were increased to 50% coverage of the back of

TABLE 1. Policy actions and levels of implementation, descriptions and effect sizes of *SimSmoke* policies

Policy and level	Description	Effect size[a]
Tax Policy		
Actual prices from 2002–2012; tax changes after 2010	Cigarette price index adjusted for inflation; taxes measured in absolute terms	For each 10.0% price increase: 4.0% reduction ages 15–17 3.0% reduction ages 18–24 2.0% reduction ages 25–34 1.0% reduction ages 35 and above
Smoke-free Air Policies (policies additive)		
Worksite total ban	Ban in all worksite areas with full enforcement and publicity	9.0% reduction[b]
Restaurant total ban	Ban in all indoor restaurant areas with full enforcement and publicity	3.0% reduction[b]
Bar and pubs ban	Ban in all indoor areas of bars and pubs with full enforcement and publicity	1.5% reduction[b]
Other places total ban	Ban in 3 of 4 (malls, retail stores, public transportation and elevators) with full enforcement and publicity	1.0% reduction[b]
Mass Media Campaigns (policies mutually exclusive)		
Highly publicized	Campaign publicized heavily on TV (at least two months of the year) and at least some other media	6.5% reduction
Moderately publicized	Campaign publicized sporadically on TV and at least some other media, and a local program	3.5% reduction
Low publicity	Campaign publicized only sporadically in newspaper, billboards or some other media.	1.0% reduction
Marketing bans (policies mutually exclusive)		
Comprehensive	Ban applied to television, radio, print, billboards, in-store displays, sponsorships and free samples with full enforcement	10.0% reduction in prevalence[c] 12.0% reduction in initiation[c] 6.0% increase in cessation[c]
Moderate	Ban applied to all media, television, radio, print, billboards with full enforcement	6.0% reduction in prevalence[c] 8.0% reduction in initiation[c] 4.0% increase in cessation[c]
Weak	Ban applied to some of television, radio, print, billboards with full enforcement	2.0% reduction in prevalence[c] 2.0% reduction in initiation[c] 1.0% increase in cessation[c]
Warning Labels (policies mutually exclusive)		
Strong	Labels large, bold and graphic	4.0% reduction in prevalence 4.0% reduction in initiation 10.0% increase in cessation
Weak	Labels cover less than 1/3 of package, not bold or graphic	1.0% reduction in prevalence 1.0% reduction in initiation 2.0% increase in cessation
Cessation Treatment Policy		
Complete availability and reimbursement of pharmaco- and behavioral treatments, quit lines, and brief interventions	Nicotine replacement therapy provided in stores without prescription; Bupropion provided by prescription; provision of treatments in all health facilities; telephone quit line; 100% smoker brief interventions with follow-up	6.8% reduction in prevalence 55.0% increase in cessation
Youth Access Restrictions (policies mutually exclusive)		
Strongly enforced & publicized	Compliance checks conducted regularly; penalties are heavy; publicity is strong; vending machine and self-service bans	30.0% reduction in prevalence ages < 16 30.0% reduction in initiation ages < 16 20.0% reduction in prevalence ages 16–17 20.0% reduction in initiation ages 16–17
Moderately enforced	Compliance checks conducted sporadically; penalties are potent; little publicity	21.0% reduction in prevalence ages < 16 21.0% reduction in initiation ages < 16 14.0% reduction in prevalence ages 16–17 14.0% reduction in initiation ages 16–17
Low enforcement	Compliance checks absent; penalties are weak; no publicity	3.0% reduction in prevalence ages < 16 3.0% reduction in initiation ages < 16 2.0% reduction in prevalence ages 16–17 2.0% reduction in initiation ages 16–17

[a] Unless otherwise specified, the same percentage effect is applied as a percentage reduction in the prevalence in the initial year and as a percentage reduction in the initiation rate and a percentage increase in the cessation rate in future years. Effect sizes are shown relative to the absence of any policy, and are based on literature reviews, advice of an expert panel and model validation.

[b] The magnitudes of effects are reduced in proportion with less-than-full levels of enforcement and publicity; in the situation with no enforcement or publicity, they equal 50% of the full effect size.

[c] The magnitudes of effects are reduced in proportion with less-than-full levels of enforcement; in the situation with no enforcement, they equal 50% of the full effect size.

the cigarette package ("moderate"). By early 2011 (41), pictorial and textual warnings were required on 30% of the package front and textual warnings on 100% of the back (a "strong" policy).

Tobacco control/media campaigns. Prior to 2005, campaigns were limited to a few school-based educational programs. National media campaigns were mounted in 2005 and 2013, and a later campaign targeted Mexico City (42), Tabasco and Guadalajara (41). The MPOWER 2013 report (31) indicated tobacco control expenditures totaling US$ 200,000 during the 2013 campaign.

Since tobacco control/media campaigns in Mexico have been sporadic and minimally funded, they are classified as "low level" from 2002 onwards in the model.

Cessation treatment policy. Since 2002, nicotine replacement therapy (NRT) has been available over the counter in pharmacies in Mexico; Bupropion is available with a prescription. From 2006–2012, a national program to support health care units for addiction treatment provided cognitive behavioral therapy to individuals and groups, but few patients were referred to the program and pharmacotherapy was not included in the basic list of essential medications. According to MPOWER reports (31), addiction treatment is available in some clinics, hospitals, community and other health care facilities, with few changes since 2006 (32). A telephone intervention hotline was established in 2010 and promoted through new pictorial warnings (41, 43). Based on data from ITC (44) and GATS (24), the brief intervention index was set to a level of 2 out of 10, indicating that brief interventions are provided to about 20% of smokers.

Youth access policy. According to Global Youth Tobacco Surveys (GYTS) in 2003 and 2011 (45, 46), less than 40% of youth attempting to purchase cigarettes in stores were refused. The 2011 GYTS found that 20% of students aged 13–15 had purchased single cigarettes (46). In the model, youth access enforcement is classified as "low" from 2002 onwards.

Calibration, validation and projection

Given variance in the cessation rates, the model was first calibrated by adjusting these rates to insure smooth, slightly declining smoking rates in the absence of policy change. *SimSmoke* was then validated by comparing predicted smoking rates to those observed in the 2011 ENA, the 2006 and 2012 ENSANut and the 2009 GATS.

A counterfactual scenario of *no tobacco control policies implemented* was examined by setting all policies to their 2002 levels for the entire study period. The effects onsmoking rates of various policies implemented individually and in combination between 2002 and 2013 were then estimated, and deaths averted as a result of those policies were calculated. The difference between the actual and counterfactual smoking rates yielded the net effect of all policies implemented since 2002. To compare the effects of individual or combined policies, the relative change in smoking prevalence for a particular year was calculated, i.e., the difference between the smoking rate with the policy and the smoking rate in the counterfactual scenario, divided by the latter. For smoking-attributable deaths, deaths averted were calculated as the difference between the actual and counterfactual numbers of smoking-attributable deaths for a particular year. These deaths are summed over the period 2002–2053 to approximate cumulative smoking deaths among those who were current or former smokers in 2002.

RESULTS

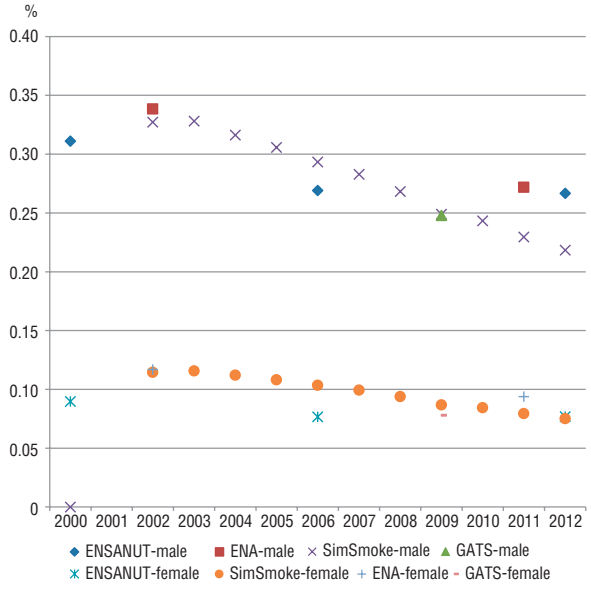
Validation

To test the predictive validity of the *SimSmoke* estimates, smoking rates predicted by the model were compared to rates estimated by surveys conducted between 2006 and 2012. Figure 2 shows male and female smoking prevalence for those 15 years and older from 2002–2012. Taking tobacco control policies into account, *SimSmoke* predicted that smoking rates would fall ~33% for males over this period. *SimSmoke* estimates are higher than the 2006 ENSANut estimates (29.4% vs 26.9%) and nearly equal to the 2009 GATS (25.0% vs 24.8%) for their respective years, but lower than the 2011 ENA (23.1% vs 27.3%) and 2012 ENSANut (22.0% vs. 26.7%) estimates. For females, *SimSmoke* projections exceed estimates from the 2006 ENSANut (11.2% vs. 7.7%) and 2009 GATS (9.7% vs 7.8%), but are close to the 2011 ENA (9.0% vs 9.4%) and 2012 ENSANut (8.7% vs. 7.7%). Thus, the predictive validity of the model depends on the comparison survey used, but estimates from the different surveys vary in a non-linear fashion across time that appears unrelated to policy changes.

Figure 3 shows *SimSmoke* and survey estimates of smoking prevalence by gender and age group. Between 2002 and 2012, estimates for 15–24 year-olds decline from 28.2% to 22.0% for males, and from 11.9% to 8.4% for females. For those between 25 and 44, estimates of smoking prevalence decline from 36.5% to 22.2% for males and from 11.6% to 7.2% for females. Similar magnitudes of decline are seen for ages 45 to 64 years and 65 years and older among males, but smaller declines are estimated among females.

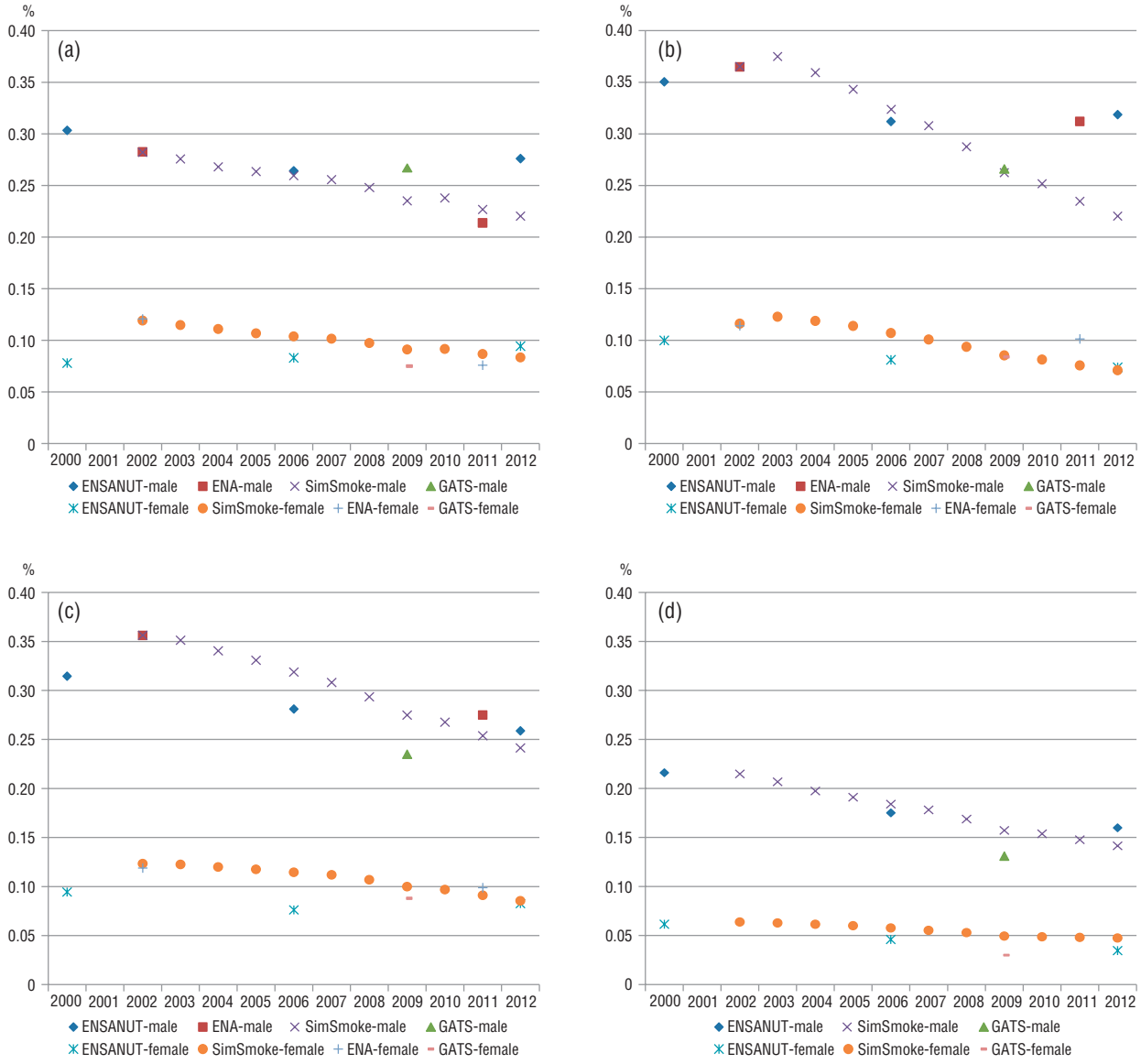
Except for males aged 25–44 years and females aged 65 years and older, the model fits survey estimates relatively well, considering the variability in prevalence estimates across different surveys.

FIGURE 2. Smoking prevalence (%) in Mexico for males and females aged 15 and above, comparing *SimSmoke* results versus results from nationally representative smoking surveys, 2000–2012



Data source: Encuesta Nacional de Adicciones (ENA) (17–19). Encuesta Nacional de Salud y Nutrición (ENSANut) (20, 22, 23). 2009 Global Adult Tobacco Survey (GATS) (24).

FIGURE 3. Smoking prevalence (%) in Mexico for males and females, by age, comparing *SimSmoke* results with results from nationally representative surveys, 2000–2012. (a) age 15–24 years, (b) age 25–44 years, (c) age 45–64 years, (d) age ≥65 years



Data source(s): Encuesta Nacional de Adicciones (ENA) (17–19); Encuesta Nacional de Salud y Nutrición (ENSANut) (20, 22, 23); 2009 Global Adult Tobacco Survey (GATS) (24).

SimSmoke estimates are above GATS estimates in all cases, except for males aged 15–24 years, but are close to or slightly below the 2011 ENA and 2012 ENSANut estimates.

The effects of policies implemented through 2013

Table 2 shows estimated impacts on smoking prevalence and smoking-attributable deaths of tobacco control policies implemented in Mexico between 2002 and 2013; the latter increased from 47 800 to 56 800 over this period. In a sensitivity analysis applying relative risks from studies in the United States rather than those for a middle-income nation, smoking-attributable deaths were estimated to reach 84 700 in 2013.

SimSmoke estimates that smoking rates given existing policies were reduced by 31% from 2002–2013 relative to the counterfactual rate, averaged over males and females. These policies are estimated to have reduced smoking-attributable deaths by about 3 000 in the year 2013, with a cumulative reduction of about 10 800 (9 300 males and 1 500 females) since 2002. By 2053, the reduction in smoking prevalence reaches about 45% as the policies continue to reduce smoking through increased cessation and reduced initiation, resulting in 826 000 fewer deaths (673 000 male and 153 000 female). When relative risks from the United States are applied, the estimate for deaths averted increases to about 1.2 million.

About 63% of the total reduction in smoking prevalence is due to price increases, which alone are estimated to

have reduced smoking rates by about 21% in 2013. By 2053, this reduction is predicted to reach 32%, along with 445 700 deaths averted. The strength of the effect of price increases is followed by that of smoke-free air laws, which reduced smoking rates by 5% in 2013, a figure which will have increased to 6.5% in 2053 (13% of the total effect of policies on smoking prevalence). Health warnings are estimated to reduce smoking rates by about 4% by 2053 (8% of the total effect) and cessation treatment by nearly 4.5% (9% of the total effect). Advertising restrictions generated only modest reductions in smoking rates (3%) in 2013, increasing to 4% by 2053 (7% of the total effect), due to lingering legal loopholes. No effects were observed for media campaigns and youth access policies due to the lack of change in these policies at the national level between 2002 and 2013.

DISCUSSION

SimSmoke was used to examine the effect of tobacco control policies implemented between 2002 and 2012 in Mexico. Cigarette excise taxes increased from 40.2% in 2002 to 55.3% of the total price by 2011, national and local smoke-free air laws were implemented, restrictions on tobacco product marketing were strengthened, prominent pictorial health warnings were required on cigarette packs, and access to cessation services was increased by the creation and promotion of a national telephone helpline in 2010. *SimSmoke* estimates that these policies contributed to a 31% reduction in smoking prevalence by 2013. *SimSmoke* also projected that these policies will reduce smoking rates by 44% and avert about 826 000 smoking-related deaths by 2053.

Mexico has shown steady progress in reducing smoking over a short period of time, consistent with other Latin American countries (47). Levy et al. (7) showed the dramatic effect of implementing FCTC policies in Brazil. Abascal et al. (48) have described successes in Uruguay, and Panama has lowered smoking prevalence to near 6% after having implementing most MPOWER policies (49).

These projections should be interpreted in a conservative manner. *SimSmoke* results depend on the reliability of the data, estimated parameters and assumptions. The validation was based on surveys that used different methodologies and data definitions, which may have affected their estimates. In particular, Mexico has an unusually high rate of non-daily smokers. Some of the reduction in smoking may reflect non-daily smokers that consider themselves non-smokers, which may explain low observed smoking rates among the elderly,

TABLE 2. Projected smoking prevalences and smoking attributable deaths from *SimSmoke*, based on the implementation of tobacco control policies, Mexico, 2002–2053

	2002	2007	2013	(Through 2013)	2033	2053	(Through 2053)
Smoking prevalence (males, %)				Change[a]			Change[a]
No policies	32.7	32.3	30.8	-	26.2	23.2	-
All policies	32.7	28.4	21.4	-30.4	15.7	13.0	-44.2
Price only	32.7	29.3	24.5	-20.2	19.0	15.9	-31.4
Smoke-free air only	32.7	32.3	29.3	-4.8	24.7	21.8	-6.2
Advertising restrictions only	32.7	32.1	29.8	-3.0	25.3	22.4	-3.7
Health warnings only	32.7	32.1	30.2	-1.7	25.4	22.3	-3.9
Cessation treatment only	32.7	31.7	29.9	-2.9	25.2	22.3	-4.1
Smoking attributable deaths (males, No.)				Deaths averted[b]			Deaths averted[b]
No policies	41 756	44 779	49 912	-	70 643	79 359	-
All policies	41 756	44 434	47 319	9 286	53 165	52 339	673 340
Price only	41 756	44 578	48 521	5 052	61 472	62 705	372 267
Smoke-free air only	41 756	44 779	49 562	1 083	67 576	75 145	112 890
Advertising restrictions only	41 756	44 723	49 597	1 213	68 787	76 845	69 883
Health warnings only	41 756	44 734	49 727	782	68 640	76 197	76 423
Cessation treatment only	41 756	44 732	49 438	1 544	67 570	75 283	113 191
Smoking prevalence (females, %)				Change[a]			Change[a]
No policies	11.4	11.4	10.6	-	8.6	7.2	-
All policies	11.4	10.0	7.3	-31.1	5.0	3.9	-46.2
Price only	11.4	10.3	8.4	-20.5	6.2	4.9	-32.4
Smoke-free air only	11.4	11.4	10.1	-4.9	8.1	6.8	-6.6
Advertising restrictions only	11.4	11.3	10.3	-3.1	8.3	7.0	-3.9
Health warnings only	11.4	11.3	10.4	-1.8	8.2	6.9	-4.6
Cessation treatment only	11.4	11.2	10.3	-3.3	8.2	6.9	-5.0
Smoking attributable deaths (females, No.)				Deaths averted[b]			Deaths averted[b]
No policies	6 018	7 976	9 885	-	18 653	23 153	-
All policies	6 018	7 926	9 444	1 508	14 689	16 824	152 918
Price only	6 018	7 947	9 656	796	16 839	19 787	73 527
Smoke-free air only	6 018	7 976	9 825	180	17 931	22 082	26 991
Advertising restrictions only	6 018	7 968	9 832	196	18 224	22 525	16 284
Health warnings only	6 018	7 969	9 851	133	18 105	22 211	21 519
Cessation treatment only	6 018	7 969	9 800	265	17 798	21 884	32 257

Data source: author's calculations.

[a] For each policy or set of policies, prevalence reductions are measured according to the formula: [SP (with policy)-SP(CF)]/SP(CF), where SP is smoking prevalence and CF is the counterfactual with no policies implemented.

[b] For each policy or set of policies, deaths averted are calculated according to the formula: SAD (CF)-SAD(with policy), where SAD is smoking-attributable deaths and CF is the counterfactual with no policies implemented.

especially women, in surveys. Where non-daily smokers do consider themselves smokers, especially among youth, they may simply be experimenting and soon quit, which may explain the relatively high rates of smoking observed among youth and young adults.

The estimated relative risks for total mortality of smokers applied in this study are based on studies conducted in middle-income countries, because the lower observed daily smoking frequencies are closer to those in Mexico than are frequencies in high-income countries such as the United States. However, relative risks are likely to increase as those who began smoking at an earlier age reach age 50 and beyond (50–52). When applying relative risks from high-income countries, the estimated number of deaths increased by about 50%. These estimates also do not include additional deaths averted due to reductions in second-hand smoke exposure or the effects of maternal smoking on the fetus.

The overall effects of policies in *SimSmoke* depend on underlying assumptions about the value of parameters measuring the impact of specific actions on initiation and cessation rates, and assumptions about the interdependence of policies. Reliance on policy studies conducted in high-income countries could introduce bias into the estimates. For example, health warnings and higher cigarette prices may have higher impacts in low- and middle-income countries (53, 54). Furthermore, pictorial warning policy in Mexico differs from other countries in that new content is introduced every 3 to 6 months. This is the fastest rotation of any nation, and may lead to sustained impacts over time (55). Studies of tobacco control campaigns, advertising bans, cessation treatment and health warnings provide a broad range of estimates, and are mostly for high-income countries. Previous work (7, 9) estimated that effect sizes can vary by about 25% for taxes, and up to 50% for other policies (with an upper limit of 100% around cessation treatment and youth access policies). The effects of each policy on smoking rates are also conservatively assumed to be constant and independent of other policies. However, some evidence indicates that policies may be synergistic (4, 5) through their cumulative impact on social norms and their reinforcing effects on smokers' motivation to quit.

Despite these limitations, the results of this study support the overall conclusion that the implementation of stronger tobacco control policies between 2002 and 2013 have contributed to less smoking in Mexico. The *SimSmoke* model estimates that such policies have lowered the overall smoking prevalence by about one-third and that over 800 000 premature deaths from smoking will be averted over the next 40 years. Simulation models such as *SimSmoke* are useful tools for key stakeholders, such as policy-makers, academics and civil society, who want to show the success of past programs and implement new programs and public policies to improve population health at the local, regional or global levels.

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RESUMEN

Efectos de las políticas de control del tabaco sobre la prevalencia del tabaquismo y las defunciones atribuibles al tabaco en México: el modelo *SimSmoke*

Objetivo. Analizar cómo las políticas adoptadas en México en respuesta al Convenio Marco para el Control del Tabaco han tenido efecto en la prevalencia de tabaquismo y en la mortalidad atribuible al tabaco.

Métodos. Se aplicó en México el modelo de simulación *SimSmoke* de la política de control del tabaco. Este modelo de Markov de tiempo discreto y de primer orden utiliza datos sobre el tamaño de la población, las tasas de tabaquismo y la política de control del tabaco en México. También evalúa individual y conjuntamente los efectos de siete tipos de políticas: impuestos sobre el tabaco, legislaciones de ambientes libres de humo de tabaco, campañas en medios de comunicación, prohibiciones de publicidad, etiquetas de advertencias sanitarias, tratamientos de cesación y regulaciones del acceso al tabaco por parte de los jóvenes.

Resultados. Mediante el modelo *SimSmoke* aplicado en México, se calculó que las tasas de tabaquismo se han reducido aproximadamente en un 30% como resultado de las políticas implantadas desde el 2002, y que el número de defunciones atribuibles al tabaquismo podrían reducirse aproximadamente en 826 000 para el 2053. Los aumentos de precios de los cigarros son responsables de más del 60% de las reducciones, pero las advertencias sanitarias, las leyes de ambientes libres de humo de tabaco, las restricciones a la mercadotecnia y los tratamientos de cesación también desempeñan una función importante.

Conclusiones. En México, análogamente a lo ocurrido en otros países latinoamericanos, como Brasil, Panamá y Uruguay, se ha observado un constante progreso en la reducción de la prevalencia del tabaquismo en poco tiempo. Las políticas de control del tabaco desempeñan una importante función en las iniciativas continuadas para reducir el consumo de tabaco y las defunciones asociadas a este en México.

Palabras clave Uso de tabaco; hábito de fumar; riesgo atribuible; mortalidad prematura; política social; México.