RESEARCH

The potential effects of tobacco control in China: projections from the China SimSmoke simulation model

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Abstract

Objective To use a computer simulation model to project the potential impact in China of tobacco control measures on smoking, as recommended by the World Health Organization Framework Convention on Tobacco Control (FCTC), being fully implemented.

Design Modelling study.

Setting China.

Population Males and females aged 15-74 years.

Intervention Incremental impact of more complete implementation of WHO FCTC policies simulated using SimSmoke, a Markov computer simulation model of tobacco smoking prevalence, smoking attributable deaths, and the impact of tobacco control policies. Data on China's adult population, current and former smoking prevalence, initiation and cessation rates, and past policy levels were entered into SimSmoke in order to predict past smoking rates and to project future status quo rates. The model was validated by comparing predicted smoking prevalence with smoking prevalence measured in tobacco surveys from 1996-2010.

Main outcome measures Projected future smoking prevalence and smoking attributable deaths from 2013-50.

Results Status quo tobacco policy simulations projected a decline in smoking prevalence from 51.3% in 2015 to 46.5% by 2050 in males and from 2.1% to 1.3% in females. Of the individual FCTC recommended tobacco control policies, increasing the tobacco excise tax to 75% of the retail price was projected to be the most effective, incrementally reducing current smoking compared with the status quo by 12.9% by 2050. Complete and simultaneous implementation of all FCTC policies was projected to incrementally reduce smoking by about 40% relative to the 2050 status quo levels and to prevent approximately 12.8 million smoking attributable deaths and 154 million life years lost by 2050.

Conclusions Complete implementation of WHO FCTC recommended policies would prevent more than 12.8 million smoking attributable deaths in China by 2050. Implementation of FCTC policies would alleviate a substantial portion of the tobacco related health burden that threatens to slow China's extraordinary gains in life expectancy and prosperity.

Introduction

China is the most populous nation in the world, and with over 50% of Chinese men smoking¹ accounts for about a third of the world's smokers.² China is also the world's largest tobacco producer, predominantly by government owned tobacco companies.³ Reducing smoking in China would have an enormous public health impact, even on a global scale.

In 2003 China joined the World Health Organization Framework Convention on Tobacco Control (FCTC). The FCTC mandates a comprehensive set of tobacco control policies: surveillance and monitoring of the prevalence of tobacco use, creation of smoke-free environments, treatment of tobacco dependence, taxation on tobacco consumption and other price controls, and enforcement of health warnings on tobacco packages and marketing bans. China increased the tax on tobacco products at the producer and wholesale price level, with an average 11.7% increase in 2009. The tax increase did not, however, translate to higher retail prices experienced by consumers.⁴ Of smoke-free environment regulations, only a smoking ban on public transportation has been legislated. China implemented treatment programs for tobacco dependence and to some extent bans on advertising, but these are weakly enforced. Overall, the country profile for China in the WHO 2011 report on the global tobacco

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Supplementary information

epidemic identified multiple opportunities to improve implementation of the FCTC.⁵

Studies have estimated the health and economic burden of tobacco related diseases in China,⁶⁻¹⁰ but none have estimated the potential health benefits of complete implementation of the FCTC. Using a version of the SimSmoke tobacco control policy model¹¹⁻¹⁸ populated with Chinese national demographic and tobacco exposure data, we projected the potential health impact of a comprehensive tobacco control program in China from 2015-50.

Methods

The China SimSmoke tobacco policy model

SimSmoke is a discrete-time first-order Markov process (state-transition) model of the prevalence of tobacco smoking and smoking related mortality that simulates the impact of tobacco control policies. The model begins in a baseline year, with the population divided into current, never, and former smokers by age and sex. The projected population is estimated using fertility and mortality data from the United Nations Population Division, Department of Economic and Social Affairs.¹⁹ Smoking prevalence evolves with age and sex specific smoking initiation, cessation, and relapse rates. SimSmoke is programmed in Microsoft Excel (Office 2007 version; Microsoft, Redmond, WA, USA).

Tobacco smoking prevalence in China

We searched the WHO Global InfoBase for studies reporting sex and age specific prevalence of current smoking and ever smoking in China, inclusive of at least ages 15-74 years (see appendix and appendix table 1).²⁰ The 1996 national prevalence survey provided estimates of current smoking prevalence for the simulation base year.²¹ We estimated current smoking prevalence for specific ages by linear interpolation between midpoint ages for each 10 year age category.

In the 1996 survey, ever smokers were asked if they had quit. We estimated the prevalence of former smokers in 1996 as the difference between the prevalence of ever smokers and that of current smokers. Those who quit were further asked if they quit for less than six months, six months to one year, one to two years, and two years or more. We used these data to apportion the former smokers to groups representing less than one year, one to two years, and two years or more since quitting. Owing to lack of data for two years or more since quitting, we used US survey percentages (for 3-5 years, 6-10 years, 11-15 years, and ≥ 15 years) to apportion the former smokers who had quit for two years or more.²²

Smoking rates evolve through age and sex specific initiation, cessation, and relapse rates. We assumed that cessation, initiation, and relapse rates depend only on current rates and not past behaviors (Markov assumption); that cessation and initiation rates are assumed constant over time, except when changes in policy occur; and that relapse rates are constant over time and unaffected by policies.

Owing to empirical challenges in measuring initiation and cessation among younger smokers and to ensure stability of the model, we measured initiation rates at each age as the difference between the smoking rate at that age year and the rate at the previous age year, determined by year at which smoking rates begin to level off. Because no similar data were provided in the global adult tobacco survey, we relied on the 1996 survey data for initiation and cessation rates. Based on an examination of prevalence data for 1996 and ensuing years, and 1996 data in

the 1997 report showing stated ages of initiation,² prevalence rates increased until a specific age. Initiation in the model occurred until age 30 years for men and age 35 years for women. Cessation rates were based on published data in the 1997 report. Based on an examination of 1996 data on smokers who quit in the past year,² we set annual cessation rates in males equal to 2% for smokers aged 30-65 years and 3% for those ages 65 years or more. We set the cessation rates in females to 2%. We tracked cessation from age 30 years for males and age 35 years for females. Relapse rates were based on US rates, but the limited information provided on rates in China indicated that similar relapse rates applied. We adjusted first year relapse rates based on model calibration.

To calibrate and validate China SimSmoke predictions from 1996-2010, we used two surveys of tobacco use in China since 1996. The global adult tobacco survey, a cross sectional survey of tobacco use among adults in 16 low and middle income countries sponsored by the US Centers for Disease Control and Prevention and WHO, was used for age and sex specific current tobacco smoking prevalence in 2010 (see appendix).²³ We used six household survey waves from the multiprovincial China health and nutrition survey (repeated samples of the same households) to estimate the secular trend in active smoking prevalence from 1991 to 2006 (see appendix), with the first nine years used to calibrate the model.²⁴

Relative risk of all cause mortality in current and former smokers

For all cause mortality we use relative risks of 1.35 for male smokers and 1.50 for female smokers aged 35-54 years, 1.35 for both sexes aged 55-64 years, and 1.30 for both sexes aged 65 years or more. Chinese studies that reported relative risks for all cause mortality in smokers compared with never smokers were in the range 1.19-1.40,^{10 25-28} with most in the 1.30-1.40 range.²⁹ For former smokers, we assumed relative risks to decline over time at the rate observed in US studies.³⁰

Tobacco control policies simulated

We applied simulated policy effects to current smoking prevalence in the year in which the policy was or could be implemented, and, unless otherwise specified, applied to initiation and cessation rates in future years if the policy was sustained (table 1). Unless synergies were specified, we reduced the effect of a second policy by [1 minus the effect of the first policy]. Except for the effects of cigarette prices and marketing bans, the model relies on studies of policy effects from high income countries, owing to the lack of studies for low and middle income countries. However, we considered two types of factors that may affect the impact of policies in low and middle income countries relative to high income countries; firstly, the degree of urbanization, which increases the potential reach and therefore effectiveness of policies. During the past 20 years, China's urban population increased from 18% to 46% of the total population.³¹ A second factor is a population's baseline level of awareness of tobacco related harms. In countries with lower levels of income and general health awareness and no previous serious tobacco control campaigns, a lower base level of the knowledge of the dangers of smoking and of antismoking attitudes is expected to provide increased potential for the effectiveness of policies.

The SimSmoke China base case (1996-2011) incorporated Chinese policies over the time period on tax policy, legislation on smoke-free environments, mass media anti-tobacco campaigns, bans on tobacco marketing, health warnings,

cessation of treatment for tobacco dependence, and restrictions on access for youth. China SimSmoke simulated Monitor, Protect, Offer, Warn, Enforce, and Raise (MPOWER) measures,³² a package of practical steps toward implementation of the FCTC, starting in 2012 and continuing through to 2050 (the last year projected by the model).

Model outcomes

The two primary outcomes are annual smoking prevalence (percentage), and smoking attributable deaths by age and sex and all causes. From mortality rates, smoking prevalence, and relative risks we calculated the numbers of deaths by age, sex, and smoking status. We multiplied the number of current and former smokers at each age by their respective excess risk and summed the result to obtain total smoking attributable deaths. We compared the effect of implementing WHO FCTC/MPOWER measures in China starting in 2012, individually and in combination, with the status quo scenario in which tobacco control policies were maintained at 2010 levels. We then calculated the results for smoking prevalence in relative terms (percentage change in smoking prevalence compared with the status quo). The number of deaths averted was calculated as the difference between the number of smoking attributable deaths under the status quo and the number of smoking attributable deaths with policies implemented. Using 2005-10 China specific life expectancies estimated by the United Nations Population Division,³³ we tabulated life years lost at each age attributed to tobacco from life expectancies for the age at tobacco related death.

Results

China SimSmoke validation

Between 1996 and 2010, based on demographic projections, smoking initiation and cessation rates, and tobacco control policy effects, SimSmoke predicted that for ages 15 years or more, the prevalence of age standardized active smoking in males declined from 59.8% to 52.1% (see appendix figure 1). The prevalence of active smoking in females declined from 3.5% to 2.4%. SimSmoke estimates of smoking prevalence in 2010 for ages 15 years or more were similar to the China global adult tobacco survey point estimate (52.9% for males; 2.7% for females) and within the survey's confidence interval boundaries (51.7% to 54.0% for males; 2.3% to 3.1% for females). In addition, SimSmoke projections fit well with active smoking trends in the China health and nutrition survey during 1991-2006. For younger ages (15-34 years), SimSmoke projections followed closely both the global adult tobacco survey 2010 estimate and the China health and nutrition survey trend. For older men and women (35-74 years), SimSmoke predictions mirrored the China health and nutrition survey trend but fell short of prevalence levels from the global adult tobacco survey. However, analyses of more specific age ranges (15-24, 25-44, 45-64, and ≥65 years) showed that all SimSmoke estimates for prevalence in 2010 fell within the 95% confidence intervals obtained by the China global adult tobacco survey, except for males aged 45-64 years (SimSmoke 59.1%; global adult tobacco survey range 60.0-65.8%, see appendix table 2).

Projected active smoking prevalence, China, 2015-50

Projecting the status quo scenario forward, active smoking in males was expected to decrease from 51.3% in 2015 to 46.5% by 2050 (table 2⇓). The prevalence of active smoking in females was projected to decline slightly, from 2.1% in 2015 to 1.3%

in 2050 (see appendix table 3). In 2015, the estimated number of smoking attributable deaths alone was about one million (932 000 for males and 79 000 for females; totals, table 3⇓) and the estimated life years lost was about 14 562 000 (13 751 000 for males and 811 000 for females). In the status quo scenario, annual smoking attributable deaths in males were projected to increase through 2040 to about 1 459 000 but then decline to slightly less than 1.4 million by 2050. Projected annual life years lost reached about 17 029 000 by 2030 and then declined to 15 250 000 by 2050. Annual smoking attributable deaths in females were projected to be 49 000 in 2040 and 42 000 per year in 2050. Under current policies, a total of over 50 million smoking attributable deaths and 626 709 000 life years lost due to smoking were projected from 2012 to 2050 (table 3).

Impact of implementing FCTC/MPOWER measures

Relative to the status quo scenario, increasing cigarette taxes to 75% of the package price was projected to reduce smoking prevalence in relative terms by almost 10% for both sexes by 2015 (table 2 and appendix table 3). By 2050, smoking prevalence showed a relative reduction of 13% for males and of 12% for females in the taxation simulation. With a 75% tax, about 134 000 lives and 1 644 000 life years would be gained annually by the year 2050 (table 3). Summing over the years 2015 to 2050, approximately 3.5 million deaths would be averted (3 333 000 for males and 143 000 for females) and 44 315 000 life years gained (42 882 000 for males and 1 433 000 for females) by the tax policy with the benefits continuing to grow in subsequent years.

Though increasing taxes had the largest impact on smoking prevalence, comprehensive smoke-free air laws and a well enforced marketing ban also showed potent and immediate effects. Comprehensive smoke-free air laws were projected to yield an almost 9% relative reduction in smoking rates by 2015, increasing to about a 10% reduction in 2050, and potentially averting about 3 437 000 deaths through 2050. A comprehensive marketing ban would reduce smoking prevalence by about 4.0% and avert 2.15 million deaths by 2050. A high intensity tobacco control campaign would lead to a 2.5% relative decline in smoking rates by 2015 and prevent about 1 080 000 smoking attributable deaths by 2050. Cessation treatment policies had smaller effects, with cessation policies growing over time to a 4% relative reduction. Stronger health warnings were projected to yield a relative 2.3% reduction in smoking rates by 2050.

When all MPOWER measures were combined, smoking prevalence was initially projected to decrease by about 30% relative to the status quo in 2015, and by about 40% by 2050. The model projected 494 000 (480 000 for males and 14 000 for females) fewer smoking attributable deaths by 2050 alone. By 2050, a total of approximately 12.8 million tobacco related deaths (12 274 000 for males and 491 000 for females) could be averted and 154 248 000 life years gained (149 303 000 for males and 4 945 000 for females) by implementing the complete set of policies.

Discussion

Using the SimSmoke model calibrated to track with national estimates of smoking prevalence and repeated measures from a multiprovincial survey, we projected that complete implementation of the World Health Organization Framework Convention on Tobacco Control (FCTC)/Monitor, Protect, Offer, Warn, Enforce, and Raise (MPOWER) measures would lead to as much as a 34% relative reduction in male smoking prevalence

by 2020, and a 41.0% reduction by 2050 (40 years after implementation). Despite the lag time expected between reductions in current smoking and declines in smoking attributable deaths, nearly half a million annual tobacco related deaths could be averted yearly by 2050. Without complete implementation of WHO FCTC/MPOWER policies, and with other public health factors remaining unchanged, we projected that China will experience an additional 12.8 million preventable smoking related deaths and 154 million life years lost by 2050. Our projections suggest that the Chinese government's goal of less than 25% prevalence of active smoking in adults by 2015³⁴ is only achievable by adding to current tobacco control measures. The year 2025 goal of a relative 30% reduction in smoking prevalence in people aged 15 years and older targeted by WHO is achievable³⁵ but only with complete implementation of the WHO FCTC/MPOWER measures.

For many tobacco associated diseases (particularly chronic obstructive pulmonary disease and cancers) the risk related to tobacco use will not usually manifest until 20 years or more. Though we forecast decades into the future, given the "long shadow" cast by tobacco use, a 35 year simulation underestimates the impact of policies. Decreases in deaths related to second hand smoke from the direct impact of smoke-free air regulations and indirect impact of current smoking was not projected, leading to underestimation of the effects on smoking attributable deaths.

Taxation of tobacco products has been an effective means of tobacco control in many nations and was projected to be the most effective policy for China. Our results were broadly consistent with previous reports by one of the authors.^{4 36 37} We assumed more sensitivity to price changes in younger smokers for several reasons. Teenage and young adult smokers generally earn lower wages, on average smoke less frequently (many less than daily), and are less dependent on tobacco than older smokers, all of which would lead to greater sensitivity to price increases. We also assumed fixed price elasticities over time. We considered an affordability index (price relative to income), but the model fit changes in trend better using a price (adjusted for inflation) index. However, in an economically rapidly developing nation where individual and household incomes have been rising rapidly, price increases may be increasingly more easily tolerated by smokers. In addition, we have assumed that tax increases will be passed along to consumers, leading to an increase in package price from 5.5 CNY (\$0.90; £0.55; €0.66) to 13 CNY. A recent tax increase in China was absorbed at the producer (wholesale) level and resulted in no change on cigarette prices for consumers at the point of purchase.^{4 38} However, if accompanied with other strong tobacco control policies, which reduce future demand for cigarettes and hence increase the incentive to increase current prices, large tax increases are more likely to lead to substantial if not commensurate increases in price. Our results show that multiple policy tools will be needed to substantially reduce the prevalence of smoking.

We projected that smoke-free air laws would be the second best policy, with all other policies simulated leading to more moderate projected effectiveness. As was the case years ago in other nations that evolved through the phases of the tobacco epidemic,³⁹ cigarette smoking is currently ingrained in Chinese cultural practices. The 2010 global adult tobacco survey found that many Chinese are largely unaware of the adverse health effects of smoking.⁴⁰ For this reason we modified our policy effectiveness assumptions for laws on a smoke-free environment, bans on marketing, and warnings on packaging to account for low awareness of the harms of tobacco in the adult population of China. In particular, the benefits of increasing awareness

through health promotion are likely to play an increasingly important role in a country such as China where educational levels are increasing rapidly. Media campaigns can facilitate increased health awareness. The low rates for usage of cessation treatment and advice by health providers on the dangers of smoking also suggest an important role for the health sector, especially if cessation policies are combined with other policies.^{41 42} Evidence indicates that many physicians in China smoke, and, given that physicians may be important role models, this practice should be strongly discouraged.^{43 44} We allowed for synergies between media campaigns and other policies but may have underestimated policy effectiveness in assuming that the effect of adding a second policy is reduced if another policy is simultaneously implemented.

Strengths and limitations of this study

Though it is difficult to directly test the assumptions of China SimSmoke, we did incorporate nationally representative data on smoking prevalence and recent and historical tobacco taxation policies through price. Model validation showed that projections from 1996 to 2010 were consistent with the best available evidence on smoking prevalence levels (from the national surveys) and temporal trends (from the China health and nutrition survey). Inclusion of trend data from the China health and nutrition survey was particularly important for mitigating small variations in the different national surveys that may be due more to differences in survey design and sampling error than to temporal trends. In addition, SimSmoke has performed well in predicting smoking prevalence in over 20 countries, including comparison of model projections with historical effects of past implemented policies in other East Asian and middle income nations with widely different policies.^{11-18 45-48} In particular, the Thailand and Korea models closely followed prevalence trends in nations with active tobacco control policies.^{15 18} A SimSmoke analysis of tobacco control policies in Vietnam yielded results similar to those produced by a simulation modeling analysis of tobacco policies in Vietnam by Higashi and colleagues using a different approach.^{48 49}

The model validated well, but our China projections should be interpreted with caution because to date evidence on policy intervention for the policies studied in the Chinese context is limited. Of all the policies, taxation has the best evidence base for low and middle income countries.⁵⁰ Evidence on the effectiveness of smoke-free laws on active smoking and media comes almost exclusively from high income countries.^{51 52} In our analysis we incorporated China specific inputs wherever possible, including adjustments for a low population awareness of the harms of tobacco and the degree of urbanization. In other work, we have suggested that the percentage changes in smoking prevalence could vary by as much as 25% from our best estimate of the effect of changes in tax rates and by as much as 50% for the effects of other policies.^{11 53}

Finally, data on cessation and initiation rates were generally not available over time and could not be validated over time. We conducted sensitivity analysis allowing cessation rates and initiation rates to vary by 10% from the levels used in the model. The resulting changes in smoking prevalence in males projected to 2050 were relatively robust, with ranges of 45.8% to 47.3% from variations in initiation rates and of 43.7% to 49.1% from variations in cessation rates. Given the low levels of cessation in 1996 and the low rates of advice to quit by healthcare providers and use of cessation treatment,¹ it will be important to monitor treatment use and cessation and initiation rates in the Chinese population.

Comparison with other studies

Our projections on status quo policy smoking attributable deaths for the years 2006 are similar to those estimated by Gu and colleagues.¹⁰ Our projections for 2050 are, however, more conservative than Liu and colleague's prediction²⁷ of "about three million" smoking attributable deaths annually by that time, perhaps because they assumed no tobacco policy changes, and our status quo case incorporated effects of China's current tobacco control policies.

Conclusions and policy implications

Our estimates of China's burden of mortality attributable to smoking using the China SimSmoke tobacco policy model suggest that substantial health gains could be made—a 40% relative reduction in smoking prevalence and almost 13 million smoking attributable deaths averted and more than 154 million life years gained by 2050—by extending effective public health and clinical interventions to reduce active smoking. Tax policies can play an especially important role, particularly if prices increase with taxes. Consistent with the WHO FCTC, smoke-free air policies, marketing restrictions, health warnings, media campaigns, and cessation treatment policies play an important role. Though smoke-free air laws and marketing bans require enforcement and some costs for implementation (including political capital), a recent report by WHO found that the policies suggested by the FCTC are clearly cost effective using traditional metrics,⁵⁴ a contention that has been reinforced by a study of tobacco control in Vietnam.⁴⁹ Studies of specific policies have also found that smoke-free air laws,⁵⁵ media campaigns,^{56 57} and cessation treatment⁵⁸ are cost effective. Tax policy and health warnings, which involve minimal cost, are particularly cost effective.

In the next four decades, China will face over 50 million smoking attributable deaths, the largest absolute burden of smoking related deaths of any nation. Despite that the prevalence of smoking has been decreasing in China for both males and females, the absolute number of smokers will continue to increase for decades. This pattern of prevalence has been predicted globally: the 23.7% world's overall smoking prevalence for adults in 2010 will continuously decline to 22.7% by 2020 and to 22.0% by 2030, but the number of smokers will increase.² The consequences of inaction are considerable; without the implementation of the complete set of stronger policies, the death and disability legacy of current smoking will endure for decades in China.

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Contributors: DL and AEM designed the study. DL designed and programmed the SimSmoke tobacco control model. DL and T-WH selected SimSmoke inputs for China. AEM and RLR-B designed the model calibration and validation method and reviewed and selected past Chinese tobacco surveys. AEM and RLR-B conducted original analyses of Global adult tobacco survey and China health and nutrition survey data. RLR-B ran all model simulations and prepared the results and produced the first draft of the manuscript. All authors contributed to writing and reviewing the manuscript. All authors had access to the SimSmoke model, original data, and approved of this manuscript. AEM and DL will act as guarantors.

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Ethical approval: Not required; all data analyses were secondary analyses of publicly available, de-identified data.

Data sharing: More details on the model data inputs and other assumptions are provided in a technical appendix. Researchers interested in using or exploring China SimSmoke software or development of a new national SimSmoke software version may contact the corresponding author at dl777@georgetown.edu.

Transparency: The senior author (DL) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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What is already known on this topic

- The prevalence of active smoking in Chinese men is among the highest in the world
- Studies have estimated the mortality and disability burden attributable to smoking in China
- They have not, however, estimated how much fully implementing measures recommended by the World Health Organization Framework Convention on Tobacco Control might change future smoking prevalence or prevent tobacco related deaths

What this study adds

- Complete implementation of recommended tobacco control measures in China could lead to a relative reduction of over 40% in smoking and prevent almost 13 million tobacco related deaths by 2050

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Tables

Table 1 | Policies, description, and effect sizes of SimSmoke model and policies in China

Policy	MPOWER policy simulated	Potential % effect of MPOWER policy	Current policies in China
Tax policy	Cigarette price index adjusted for inflation for 1996 to 2010. Future prices increase with amount of cigarette tax in absolute terms of total taxes at 75% of retail price	Through price elasticity: −0.40 ages 15-17, −0.30 ages 18-24, −0.15 ages 25-34, −0.10 ages 35-64, and −0.15 ages ≥65	Tax rate of 40% was assumed at retail price. No tax change occurred from 2000-09. China specific price elasticities that vary by age are applied to the tracking period. Using these price elasticities, higher taxes are passed along to consumers, and applied to future active smoking prevalence
Smoke-free legislation:			
Worksite total ban	Ban in all areas	9.0% prevalence reduction effect	Smoke-free air laws are limited in China and determined at the municipal level, with no jurisdictions having a work ban (partial or limited) and relatively few private firms having their own bans (those few being international firms). No bans in restaurants, pubs, and bars; governmental facilities; educational facilities and universities; or healthcare facilities existed by 2010. Overall enforcement of regulation on smoke-free environments has been minimal
Restaurant and bar total ban	Ban in all indoor areas of restaurants	3.0% effect	
Other places total ban	Ban in 3 of 4 (malls, retail stores, public transportation, and elevators)	1.0% effect	
Enforcement and publicity	Government agency is designated to enforce and publicize laws. Publicity effect based on level of tobacco control funding	Effects weakened by as much as 50% if no enforcement and publicity	
Mass media campaigns:			
Highly publicized campaign (well funded media and tobacco control campaign)	Meet requirements for medium level campaign, plus have per capita expenditures over \$0.50 per capita from MPOWER, or evidence from other sources of strong, well focused media campaign and strong local campaigns	3.25% reduction (doubled when accompanied by other policies)	Low level media campaign, with no other policies in place
Low publicity campaign (low funded media and tobacco control campaign)	National agency and at least some level of funding and/or employees >0 from MPOWER, or evidence from other sources of intermittent media campaign	0.5% reduction (doubled when accompanied by other policies)	
Marketing bans:			
Comprehensive ban	MPOWER: score 4. Ban on direct and indirect marketing. Ban applied to television, radio, print, billboard, instore displays, sponsorships, and free samples	10.0% reduction in prevalence, 12.0% reduction in initiation, 6.0% increase in cessation	A “half way” policy between partial and complete advertising ban, with moderate enforcement (billboard and point of sale tobacco advertising is still allowed in China)
Weak ban	MPOWER: score 2. Partial ban on advertising. Ban applied to some of television, radio, print, and billboards	2.0% reduction in prevalence and initiation only	
Enforcement and publicity	Government agency designated to enforce laws	Effects weakened by as much as 50% if no enforcement	
Health warnings:			
Complete policy (strong health warnings)	MPOWER: score 4. Labels are large, bold, and graphic	1.0% reduction in prevalence, 1.0% reduction in initiation, and 5.0% increase in cessation rate	Weak health warnings enforced at same level over 1996 to 2010
Minimal policy (weak or minimal health warning)	MPOWER: score 2. Warning covers less than 30% of package, not bold or graphic	0.5% reduction in prevalence and initiation rates, 0.5% increase in cessation rate	
Cessation treatment policy	Complete availability and reimbursement of pharmaco and behavioral treatments, “quitlines,” and brief interventions	6.75% reduction in prevalence, 55% increase in cessation	No information found on how long ago cessation treatments became available in China. Model assumed availability started in 2004
Access restrictions for youth strongly enforced and publicized	Compliance checks conducted regularly and publicized, penalties heavy, and bans on vending machines and self-service	30.0% reduction for age <16 years in prevalence and initiation only, 20.0% reduction for ages 16 and 17 in prevalence and initiation only	No minimum legal purchase age

Table 1 (continued)

Policy	MPOWER policy simulated	Potential % effect of MPOWER policy	Current policies in China
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MPOWER=simulated Monitor, Protect, Offer, Warn, Enforce, and Raise measures.

*Unless otherwise specified, same percentage effect is applied as percentage reduction in prevalence and initiation rate and percentage increase in cessation rate, and is applied to all ages and both sexes. Effect sizes are shown relative to absence of any policy.

Table 2| Smoking prevalence for males aged 15 to 85 years in China, 1996-2050, projected by the China SimSmoke model (see appendix table 3 for results in females)

Projected smoking prevalence	1996	2010	2015	2020	2030	2040	2050
Smoking prevalence (%)							
Status quo policies	59.8	52.3	51.3	50.4	49.0	47.5	46.5
Independent policy effects:							
Tax at 75% of retail price	—	—	46.2	45.1	43.4	41.7	40.5
Comprehensive smoke-free air laws	—	—	46.7	45.7	44.3	42.7	41.7
Comprehensive marketing ban	—	—	49.7	48.7	47.2	45.6	44.6
High intensity tobacco control campaign	—	—	50.0	48.9	47.5	46.0	45.0
Strong health warnings	—	—	50.6	49.6	48.1	46.4	45.5
Youth access enforcement	—	—	51.0	49.9	48.3	46.6	45.5
Cessation treatment policies	—	—	49.9	48.8	47.1	45.5	44.6
Combined policy effects	—	—	35.4	33.6	31.4	29.4	28.2
% change in smoking prevalence from status quo							
Independent policy effects:							
Tax at 75% of retail price	—	—	-10.0	-10.5	-11.3	-12.2	-12.9
Comprehensive smoke-free air laws	—	—	-8.8	-9.2	-9.7	-10.1	-10.3
Comprehensive marketing ban	—	—	-3.0	-3.2	-3.6	-3.8	-4.1
High intensity tobacco control campaign	—	—	-2.6	-2.8	-3.0	-3.2	-3.3
Strong health warnings	—	—	-1.3	-1.5	-1.9	-2.2	-2.3
Youth access enforcement	—	—	-0.5	-0.9	-1.3	-1.8	-2.3
Cessation treatment policies	—	—	-2.7	-3.1	-3.8	-4.1	-4.0
Combined policy effects	—	—	-31.3	-33.8	-37.0	-39.6	-41.2

Status quo=scenario in which tobacco control policies were maintained at 2010 levels.

Table 3| Smoking attributable deaths and life years lost in males and females aged 15 to 85 years in China, 2015-50, projected by the China SimSmoke model

Policy/years	1996	2012	2015	2020	2030	2040	2050	2012-50
Status quo smoking attributable deaths	584 775	956 371	1 011 725	1 115 006	1 351 154	1 459 165	1 399 000	50 343 758
Premature deaths averted (change in smoking attributable deaths from status quo to policy implemented):								
Tax at 75% of retail price	—	—	20 525	43 945	110 905	123 413	133 815	3 476 341
Comprehensive smoke free air laws	—	—	17 698	40 032	110 954	126 329	127 803	3 437 409
Comprehensive marketing ban	—	—	11 314	25 307	69 539	78 523	80 421	2 149 873
High intensity tobacco control campaign	—	—	5120	11 751	34 147	40 536	41 647	1 080 457
Strong health warnings	—	—	2304	6500	21 390	30 218	33 638	59 055
Youth access enforcement	—	—	—	—	63	1150	2977	27 186
Cessation treatment policies	—	—	5221	15 346	51 416	73 327	79 800	1 825 782
Combined policy effects	—	—	62 059	142 725	400 924	475 113	494 191	12 765 972
Status quo life years lost	9 737 332	14 044 270	14 561 986	15 522 481	17 028 826	16 738 797	15 250 065	626 709 126
Life years gained (change in life years lost from status quo to policy implemented):								
Tax at 75% of retail price	—	—	281 268	597 457	1 424 838	1 547 173	1 643 770	44 315 184
Comprehensive smoke free air laws	—	—	263 877	579 045	1 415 029	1 470 649	1 422 007	42 103 017
Comprehensive marketing ban	—	—	168 961	368 444	900 977	948 680	948 726	27 138 822
High intensity tobacco control campaign	—	—	76 346	170 000	434 418	466 159	453 706	13 076 991
Strong health warnings	—	—	33 816	89 147	250 022	310 712	322 030	8 205 264
Youth access enforcement	—	—	0	0	2559	43 226	92 598	949 533
Cessation treatment policies	—	—	76 130	206 643	580 247	705 141	686 079	18 582 968
Combined policy effects	—	—	903 791	2 015 417	5 040 733	5 490 093	5 479 588	154 247 987

Status quo=scenario in which tobacco control policies were maintained at 2010 levels.