SimSmokeFinn: How far can tobacco control policies move Finland toward tobacco-free 2040 goals?

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Abstract
Aims: Finland is the first country to stipulate in law that its aim is to end the use of tobacco products containing compounds that are toxic to humans and that create addiction. This paper describes the development of a simulation model examining the potential effect of tobacco control policies in Finland on smoking prevalence and associated future premature mortality.
Methods: The model is developed using the SimSmoke simulation model of tobacco control policy, previously developed for other nations. The model uses population, smoking rates, and tobacco control policy data for Finland. It assesses, individually, and in combination, the effect of seven types of policies: taxes, smoke-free air laws, mass media campaigns, advertising bans, warning labels, cessation treatment, and youth access policies. Results: With a comprehensive set of policies, smoking prevalence can be decreased by as much as 15% in the first few years, increasing to 29% by 20 years and 34% by 30 years. By 2040, 1300 deaths can be averted in that year alone with the stronger set of policies. Without effective tobacco control policies, 23,000 additional lives will be lost due to smoking over all years through 2040. Conclusions: The model shows that significant inroads to reducing smoking prevalence and premature mortality can be achieved through tax increases, a high-intensity media campaign complete with programmes to encourage cessation, a comprehensive cessation treatment programme, stronger health warnings, and enforcement of youth access laws. Other policies will be needed to further reduce tobacco use.
Key Words: Finland, simulation model, smoking prevalence, smoking-attributable deaths, tobacco control policy

Introduction
Finland has a long history of tobacco control and was one of the first countries to ratify the World Health Organization’s Framework Convention on Tobacco Control (FCTC) in 2005. In the 1950s 70% of Finnish men smoked cigarettes, yet Finland now has one of the lowest smoking prevalence rates in Europe [1]. While action to reduce tobacco use began in the 1960s, the first legislative action occurred in the 1970s [2].

In 1970, Finland banned tobacco advertising on television. In 1976, the Tobacco Act introduced prohibitions on smoking in most public places including public transport, required health warnings on packages, limited sales to people over age 16, further restricted advertising, and dedicated 0.5% of tobacco tax revenues to tobacco control programmes and other health-promotion initiatives [2,3]. Since 1994, Finland has increased cigarette taxes, conducted media campaigns, restricted marketing, and strengthened smoke-free air laws and health warnings. In October 2010, Finland ventured into new territory with a revised Tobacco Act that stipulated in law the aim to “end the use of tobacco products containing compounds that are toxic to humans and create addiction” [4]. The aim enables bold actions to reduce tobacco use and provides legal justification for these actions in anticipation of tobacco industry...
resistance. The spirit of the Tobacco Act has provided a shared vision for the tobacco control community of a “Tobacco-Free Finland by 2040”.

This study examines the effect of implementing stricter policies that would be fully consistent with the FCTC, including strict enforcement of youth access laws. We consider how far these policies might go towards the common goal of a tobacco-free Finland by 2040. A modified version of SimSmoke [5] has been developed — SimSmokeFinn — which uses population, smoking, and tobacco control policy data for Finland. The model predicts future smoking rates and the number of smoking-attributable deaths (SADs) by age and gender, and the effect of tobacco control policies on these outcomes.

Methods

We employ the SimSmoke tobacco control policy simulation model. Since the ability of purely statistical studies to distinguish the effects of different policies on smoking rates is limited, simulation models combine information from different sources to provide a useful tool for examining how the effects of public policies unfold over time [5]. SimSmoke simultaneously considers a broader array of public policies than other models and has been validated in several countries [6] and states within the USA [7]. SimSmokeFinn began in the year 1999 with the population divided into current, never, and former smokers by age and gender. The baseline year (1999) was chosen based on the availability of a large-scale survey for that year and lack of concurrent policy changes.

Population model

A discrete time, first-order Markov process was employed to project future population growth through fertility and deaths. Population (1999), mortality (2005), and fertility (2005) data by age and gender were taken from the Statistics Finland website. Projections from the model through 2010 were found to slightly underpredict population growth when compared to actual population data.

Smoking model

Within the smoking model, individuals are classified as never smokers from birth until they initiated smoking or die. Following a first-order Markov process, they could evolve from current to former smoker through cessation or could return to smoker through relapse. The extent of relapse depends on the number of years quit.

The 1999–2009 smoking prevalence data are from the Health Behaviour and Health among Finnish Adult Population surveys for those ages 15–64 and from the Health Behaviour and Health among the Finnish Elderly 1985–2009 for those ages 65 and above, both of which were conducted by the National Institute for Health and Welfare (THL) [8]. These surveys were carried out every year on representative samples of about 4000 individuals.

Smoking status was based on participant self-report as never, former, or current smoker. Individuals were first asked if they have smoked 100 cigarettes, and then if they currently smoke. Both occasional and daily smokers were included as current smokers. The data for those ages 65 and above included daily smokers only and were adjusted upwards based on the percentage of occasional smokers among those ages 55–64 from Finland’s Adult Population surveys. Former-smokers were not distinguished by years-quit after the first year, so we used data from the Netherlands to distinguish former smokers.

Due to empirical challenges in measuring initiation and cessation and in order to ensure internal consistency of the model, initiation rates at each age were measured as the difference between the smoking rate at that age year and the rate at the previous age year. We allowed initiation through age 24 for males and 30 for females.

The annual cessation rate was based on available data on those who quit in the last year. That rate does not fully allow for relapse of those who quit less than 1 year ago; therefore, we applied a 50% relapse rate to that measure. These rates were consistent with estimates suggested by West [9] for the UK and those found in studies of quitting behaviours in the Netherlands. Relapse data were not available for Finland, so we used US relapse rates [10].

Smoking-attributable deaths

Death rates by age, gender, and smoking status were calculated from death rates, smoking rates, and relative risks. The number of current and former smokers at each age was multiplied by their respective excess risk and summed to obtain total SADs.

Large-scale studies of smoking risk were not found for Finland. Finland is a high-income nation with a similar smoking history to the USA, so we used risk estimates from the US Cancer Prevention Study II [11]. Similar risks have been found for Great Britain [12]. For ex-smokers, relative risks were assumed to decline at rates observed in US studies [11].

Policies

Smoking rates, and thereby SADs, also change over time in response to changes in tobacco control
policies. Policy effect sizes are in terms of percentage reductions applied to smoking prevalence in the year when the policy was implemented and applied to initiation and cessation rates in future years, unless otherwise specified. The policies and their effect sizes are summarised in Table I.

The effect of implementing a policy depends on the prior level of that policy. Policy levels for each year from 1999 through 2010 were based on MPOWER reports [13] and information provided by staff in Finland.

Tax policy in SimSmokeFinn used inflation-adjusted cigarette prices as the policy input through 2010, and used the total cigarette excise tax (including ad valorem and specific) to adjust future prices. The model used a cigarette price index deflated by the CPI for the years 1999 to 2000 [14]. According to EU Excise Duty Tables [15], the excise duty was 60% by 2009 (52% specific and 8% ad valorem). Taxes and consequently price (after adjusting for general price inflation) stayed relatively stable from 1999−2009. The MPOWER target-specific tax rate...
was 70% of the retail price, upon adjusting for their reduced percentage in overall price due to value added taxes. Changes in price were translated into changes in smoking prevalence through elasticities. Price elasticity estimates obtained for Finland [16] were comparable to those in the USA. Price elasticities of −0.4 for those below age 18, −0.3 for ages 18−24, −0.2 for ages 25−34, and −0.1 for ages 35 and above are applied.

Smoke-free air policy considers smoking restrictions in: (1) worksites; (2) restaurants and bars; and (3) other places, with their effect dependent on enforcement and publicity based on the level of tobacco control campaigns. We primarily relied on US studies of the effect of smoke-free indoor air laws; but studies for Finland have yielded consistent results [3,17]. With strong enforcement and publicity, the effect of a ban in restaurants, pubs, and bars is estimated as 3%, in worksites 6%, and in other public places 1%, with the full effects dependent on enforcement and publicity. Smoking was banned in Finnish worksites and most other public places in 1995 [3,17]. In 2000, smoke-free air laws were extended to bars and restaurants, but only to restricted areas [3]. This loophole was closed in late 2007 [18,19]. In 2000, we categorised the restaurant and bar restrictions at 50%, increasing to 100% in 2008 [18,19]. Compliance rates were based on the percentage of the workforce exposed to smoke at work [14].

MPOWER distinguishes enforcement and three levels of direct (advertising and point of sale) and indirect (sponsorships, branding, or promotional discounts) marketing bans: minimal, moderate, and complete [13]. With a complete ban, prevalence is reduced by 5% and initiation by 6%, and cessation is increased by 3% [20,21]. The total prohibition on tobacco advertising outlined in the 1976 Act on measures to reduce smoking came into force in 1978. Since 1995, this advertising ban was expanded to cover most indirect advertising, and the level was thus set to complete from 1999 (the initial model year) to 2010. Enforcement was set to 10 [13].

MPOWER provides three levels for health warnings: minimal (<30% of the principal display area), moderate (>30% of display area and rotating), and strong (>50% of the display area, rotating bold, graphic, and a ban on deceitful terms). Strong health warnings reduce prevalence by 2% and initiation by 1%, and increase cessation by 5%. When moderate (low), prevalence is reduced by 0.75% (0.5%), cessation is increased by 2.5% (1.0%) and initiation is reduced by 0.5% (0.5%) [21,22]. Finland had minimal health warnings until 2003, when they were improved to a moderate level.

SimSmokeFinn specifies three levels for tobacco control campaigns: low (a national agency and minimal funding or employees), medium (per capita expenditures over US$0.10 per capita), and high (expenditures over US$0.50 per capita, and incorporated synergies from publicity surrounding other policies. A well-funded tobacco control campaign in conjunction with other policies yields an effect size of 6.5% compared to 1% for a low-intensity campaign [21,23]. MPOWER indicates health expenditures of less than US$0.50 per person [13]. We assigned a low-intensity media campaign to Finland for 1999−2004, increasing to a mid-level campaign in 2005−2010, when funds were earmarked for tobacco control.

A strongly enforced policy restricting cigarette purchases by youth reduces smoking prevalence by those under age 16 by 30% and those ages 16 and 17 by 20% [24]. Since 1995, retailers have had a duty to ensure tobacco products are not sold to those under the age of 18. Compliance rates were low as of 2003 [25], and no indication was found of increased efforts since then. Enforcement was set to a low level since 1999, with no bans on vending machines or self-service displays. While the law has been strengthened in 2010, we analysed its effects as a newly implemented policy.

Cessation treatment includes four subpolicies. Treatment coverage, based on the places providing and publicising cessation treatments, decreases prevalence by 2.25% and increases cessation by 12% [26]. A well-publicised quitline reduces prevalence by 0.5% and increases cessation by 5% [26]. With bupropion available by prescription and nicotine replacement therapy (NRT) available over-the-counter, prevalence is reduced by 1.0% and cessation is increased by 6% [27]. Brief interventions involve advice and assistance by healthcare providers, which reduce prevalence by 0.5%, and increase cessation by 10% [26]. With all subpolicies, prevalence is reduced by 4.75% and cessation is increased by 39%.

According to the MPOWER Report [13], NRT has been available in general stores since 2006. Prior to 2006, NRT was only sold by prescription in pharmacies [28]. Bupropion has been provided by prescription since 1999. Treatments are provided in most places for primary care facilities, hospitals, and offices of health professionals and in some community centres. A national quitline was introduced in 2002, and internet treatments were introduced in 2004 [29]. Only 50% of smokers reported having received advice to quit by their general practitioners in 1999, which has stayed constant through 2009.
Since the advice is generally minimal, brief intervention was set at 25% for all years.

**Model outcomes**

The model projected two primary outcomes over time: smoking prevalence and SADs. We calibrated the model based on comparing actual to predicted smoking prevalence from 1999 to 2002. The model was validated through 2008, because the smoking prevalence appeared to increase in 2009, due to high unemployment [30], and thus deviated from trends.

The effect of implementing MPOWER policies in 2011 and maintaining those policies was gauged relative to the status quo, for policies being maintained at their 2010 level. Smoking prevalence was gauged in terms of relative changes, i.e., the difference in smoking prevalence from the status quo divided by status quo smoking prevalence. Lives saved were calculated as the difference in the number of SADs with the policy and under the status quo scenario.

**Results**

*Predictions of smoking prevalence from 1999 to 2010*

Between 1999 and 2008, survey data indicate that male smoking prevalence among those aged 15−64 fell by 10.5% compared to a 14.7% reduction predicted by the model, while female prevalence fell 9.7% compared to 7.7% predicted by the model.

Both the male and female models underpredicted the decline in 15−24 year olds, but did much better at older ages. The model overpredicted an increase for those aged 65 and above relative to the Health Behaviour and Health among the Finnish Elderly survey, but that survey only considered daily smokers.

**Role of policies implemented in 2010 to reduce future smoking prevalence and deaths**

The estimates of smoking prevalence under the status quo and under varying policy scenarios are shown in Tables II and III for males and females respectively. The total numbers of projected deaths attributable to smoking and lives saved is displayed in Tables IV and V for males and females respectively.

If tobacco control policies remain unchanged from their 2010 levels, the status quo scenario, male adult smoking is projected to decrease from 25.2% in 2010 to 22.7% by 2020, to 20.7% by 2030, and to 19.5% by 2040. In the status quo scenario, female adult smoking prevalence is projected to fall from 18.6% in 2010 to 18.1% by 2020, and to 16.7% by 2040. The estimated number of SADs in 2010 alone is 8134 (6215 males and 1919 females). Male SADs

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<th>2020</th>
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<td>All above, w/ youth access, w/ 70% tax</td>
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<td>21.3</td>
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% Change in smoking prevalence from status quo

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<td>−5.3</td>
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<td>Strong youth access enforcement</td>
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<td>−23.2</td>
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Values are %.
are projected to rise through 2020 and fall below 2010 levels by 2040. Female SADs are projected to increase by 698 by 2020, by 1458 by 2030, and by 1649 by 2040. Relative to the status quo, increasing excise taxes to 70% of the current price is projected to reduce smoking prevalence in relative terms by 9.1% (9.3%) for males (females) by 2011. By 2040, smoking
prevalence is projected to decline by 18.5% (17.6%) for males (females). With a 70% tax, 585 lives are saved (384 male and 201 female) in 2040. Summing over the years from 2011 through 2040, 10,702 deaths are averted by 2040 with the effects still growing.

Because smoke-free air laws and a marketing ban have already been implemented and are strongly enforced, no further effects are realised. However, there is still scope to strengthen other non-price policies. A stronger warning is projected to yield a 0.2% immediate reduction in smoking rates with about a 1.4% reduction by 2040, and is projected to save 1079 lives over all years by 2040. In addition, a well-funded and well-publicised media campaign yields a 3.6% immediate reduction in 2011 smoking rates, increasing to almost 6% by 2040. With 333 fewer SADs in 2040 alone, a total of 6644 lives are saved by 2040. Treatment policies are projected to reduce smoking rates by 3.4% (3.1%) for males (females) by 2020, growing to 4.7% (4.5%) and averting 203 (112) male (female) SADs by 2040. In total, 5088 deaths are averted by 2040. Strongly enforced youth access laws yield an immediate 0.6% (0.7%) relative reduction in male (female) smoking rates, which grows to 8.0% (9.3%) by 2040. In total, youth access laws are projected to prevent 197 SADs.

The final scenario involves combining all the above policies. Smoking prevalence is initially projected to drop by 14.2% (14.5%) for males (females) relative to the status quo, and by 34.6% (34.0%) for males (females) by 2040. By 2040, a total of 23,045 deaths are averted through implementing a comprehensive policy package.

### Discussion

The SimSmokeFinn model applies population, smoking prevalence, and policy data and modified parameter values for Finland. The model’s projections are supported by validation in Finland and in other countries [6,7]. While some tobacco control policies have been implemented in recent years, Finland can still do more to meet MPOWER targets. SimSmokeFinn projects that smoking prevalence can be decreased by 14.5% in the short term and by 34.0% by 2040 with full implementation of MPOWER policies. In 2040, the male smoking rate would be 12.8% and the female rate would be 11.0% (12% overall). Given the natural progression of tobacco-related illnesses, reductions in smoking prevalence have a relatively small impact on deaths in the short term, but 1286 deaths can be averted in the year 2040 alone. In the absence of the complete set of MPOWER policies, 23,045 additional premature smoking-related deaths will occur by 2040.

About half of the potential reduction in smoking prevalence to 12% by 2040 would be due to increasing the tax rate to 70% (the MPOWER suggested goal). The tax rate has been increased in recent years and is not included in the tracking part of the model,

<table>
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Values are n.
but makes up some of the increase to 70% (at 64% in 2011 from 60% in 2009). However, increasing the cigarette excise tax rate to 75% or even 80%, as some nations have done, could further reduce the smoking rate below 12%.

The model is subject to limitations. The smoking projections are based on 1999 Finland smoking prevalence and initiation data, but cessation rates are based on data from other countries due to gaps in the Finnish data. Estimates of the relative risk of smoking are based primarily on US studies. Notably, the SADs estimates are conservative and do not include deaths due to second-hand smoke exposure. Knowledge of the effects of each policy varies [21]. For example, there are many studies that yield relatively consistent results for the effects of price and many studies that evaluate smoke-free air restrictions with somewhat less consistent results. Less information is available on the impact of health warnings and treatment policies, or the interactive effects of policies. In addition, we do not explicitly consider industry reactions attempting to subvert policies, because previous policy evaluations have not been able to explicitly distinguish these behaviours.

The model considers a limited set of policies based on existing evidence of their effectiveness. Excise taxes may be increased beyond 70%. Other policy options are available to reduce smoking. Cessation treatments may be made more effective by improvements in the treatments themselves, a vaccine, better outreach, or better follow-up. These demand-reduction policies have been supplemented by supply side policies. For example, the recent Tobacco Control Act in Finland places strong emphasis on reducing youth tobacco use by making imports and possession of tobacco by youth illegal, albeit with no penalties for contravening this aspect of the law. Previous studies have given limited attention to this policy, and we have assumed that the focus will be on reducing sales to youth. SimSmokeFinn might underestimate the effects of this policy. In addition, since April 2010, a license is required to sell tobacco at the retail level, which has already substantially reduced the number of points of sale. Other supply side policies might be considered that modify product content. For example, while harm reduction has not been heretofore considered (e.g. the sale of snus is forbidden), smoking rates may be reduced through regulating nicotine content to make cigarettes less addictive.

**Conclusion**

The model shows that significant inroads to reducing smoking prevalence and premature mortality can be achieved through tax increases, a high-intensity media campaign complete with programmes to encourage cessation, a comprehensive cessation treatment programme, stronger health warnings, and enforcement of youth access laws.

The Finnish Government, in its Tobacco Act 2010, aimed to bring the use of tobacco products containing toxic and addictive constituents to an end in Finland. The public health and tobacco control community have agreed a shared vision of achieving this target by 2040 through reductions in prevalence by 10% per annum. This analysis suggests what full implementation of currently feasible, demand-reduction interventions is likely to achieve. SimSmokeFinn predicts that, even with full implementation of MPOWER policies, prevalence would still be about 12% in 2040. Clearly, new and/or more effective policies are needed. More demand-reduction measures, such as improved cessation treatments and higher cigarette taxes, alongside stronger supply-reduction measures, such as product regulation, further youth access, and licensing restrictions, and product content regulations, will be needed if these ambitious aims are to be achieved.

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**Conflict of interest**

The authors declare that there is no conflict of interest. There were no restrictions placed on the material presented in this paper.

**References**


