England SimSmoke:

The Effect of Vaping and Tobacco Control Policies on Smoking Prevalence and Tobacco Attributable Deaths

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SUMMARY

This report describes the development of a simulation model that examines the potential effect on smoking prevalence and mortality of past and future tobacco control policies and NVP use in England. This model was based on the established *SimSmoke* simulation model for tobacco control policies, which has been previously developed and validated for the U.S. and other nations. A previous *Great Britain SimSmoke* model was developed and validated over the time period of 1998 to 2009, and was shown to accurately predict smoking prevalence, and was used to show that policies implemented between 1998 and 2009 were responsible for a 23% reduction in smoking prevalence. The purpose of this study is to extend the Great Britain model to more recent years, but also consider the role of nicotine vaping products (NVPs). To better focus on vaping, we have redeveloped the model to apply to England rather than Great Britain due to the greater availability of data on smoking and vaping. We applied country-specific population size, smoking rates, and tobacco control policy data available for England.

England SimSmoke assesses, individually and in combination, the effect of seven types of policies: cigarette taxes, smoke-free air laws, tobacco control campaigns, marketing bans, health warnings and standardized packaging, cessation treatments, and youth access policies. We first validated the new model over the period of 2000 through 2012. We then considered the impact of NVPs using an indirect method. Since NVPs are not incorporated into the existing model, we compared predictions from the model when NVPs became more readily available in 2012 through 2018/2019 to the actual smoking rates over the same period. The difference in smoking rates was used to estimate the impact of NVPs. Finally, we considered the impact on deaths attributable to smoking and vaping.

England SimSmoke validated relatively well both for male and female smoking prevalence. Between 2000 and 2012, *SimSmoke* predicted a decline in smoking prevalence for males of 23.4% and females of 28.3%, while the data from the Opinions and Lifestyle Survey (OPN) showed reductions of 23.1% for males and 28.4% for females. The model also generally did well by age group. The model also generally validated well against data from the Health Survey of England (HSE) also for 2000-2012, the Smoking Toolkit Survey (SPS) for 2007-2012, and the Annual Population Survey (APS) for 2010-2012.

England SimSmoke showed that past policies have been relatively effective at reducing smoking. Compared with no new policies implemented after 2000, *SimSmoke* projected that male and female smoking prevalence had both been reduced by 28% by 2018. For individual policies, the reduction in male smoking prevalence by 2018 was 8% due to cigarette price increase, 6% due to smoke-free air laws, 4% due to cessation treatment policies, 4% due to health warnings, and 1% due to tobacco control spending. Similar results were obtained for females.

Based on the counterfactual analysis of NVP use from 2012-2018/19, we found that SimSmoke predicted a relative reduction in adult smoking prevalence of around 10% (9% for males and 11% for females by 2018; 11% and 12% by 2019) compared to a reduction of around 25% (24.6% for males and 26.1% for females by 2018) from the APS survey, around 22% (24.4% for males and 21.1% for females by 2019) from the STS survey, around 18% (24.1% for males and 11.7% for females by 2018) from the OPN survey, and around 15% (16.9% for males and 13.6% for females by 2018) from the HSE survey. Greater relative reductions in the smoking prevalence were observed by age group and gender from the surveys than the No-NVP *SimSmoke* model in general.

We also projected smoking prevalence forward adjusting for the reduction in smoking prevalence inferred for NVPs from the surveys. By adjusting the smoking rate only in 2012-2019, the projected rate for males ages 18 and above fell from unadjusted 19.9% (9.9% relative reduction since 2012) to 16.3% (26.3% relative reduction since 2012) by 2019 and from unadjusted 16.0% (27.3% relative reduction since 2012) to 15.2% (31.2% relative reduction since 2012) by 2052. The projected rate for females ages 18 and above fell from unadjusted 15.7% (11.8% relative reduction since 2012) to 13.2% (26.2% relative reduction since 2012) by 2019 and from unadjusted 11.6% (34.8% relative reduction since 2012) to 11.1% (37.9% relative reduction since 2012) by 2052. Greater reductions were observed for all age groups by 2019 but only for those above age 45 by 2052.

We applied separate adjustments based on the APS and the STS smoking prevalence data. Using the APS adjustment, NVP *SimSmoke* predicted 26,074 male and 17,384 female smoking-attributable deaths (SADs) compared to a No-NVP *SimSmoke* prediction of 26,339 for males and 17,568 for females in 2013, resulting in 265 fewer male and 184 fewer female deaths. Cumulatively over the period 2013-2052, the APS-adjusted NVP *SimSmoke* model predicted 79,425 fewer male SADs and 47,563 fewer females SADs compared to No-NVP *SimSmoke* prediction, resulting in 126,988 fewer total SADs. Using the STS adjustment, *SimSmoke* predicted 158 fewer male and 175 fewer female deaths in 2013. Cumulatively over the period 2013-2052, STS-adjusted NVP *SimSmoke* model predicted 64,482 fewer male SADs and 29,355 fewer females SADs compared to No-NVP *SimSmoke* prediction of 93,837 fewer total SADs.

SimSmoke indicates substantial health gains in terms of a reduction in cigarette smoking attributable to NVP use. The model also helps to identify gaps in surveillance and points to the lack of evaluation schemes that could further show the effectiveness of tobacco control policies

in England. Based on the analysis here, it will be important to develop information on how NVP use affects smoking initiation and cessation and to consider the health implications of regular NVP use.

INTRODUCTION

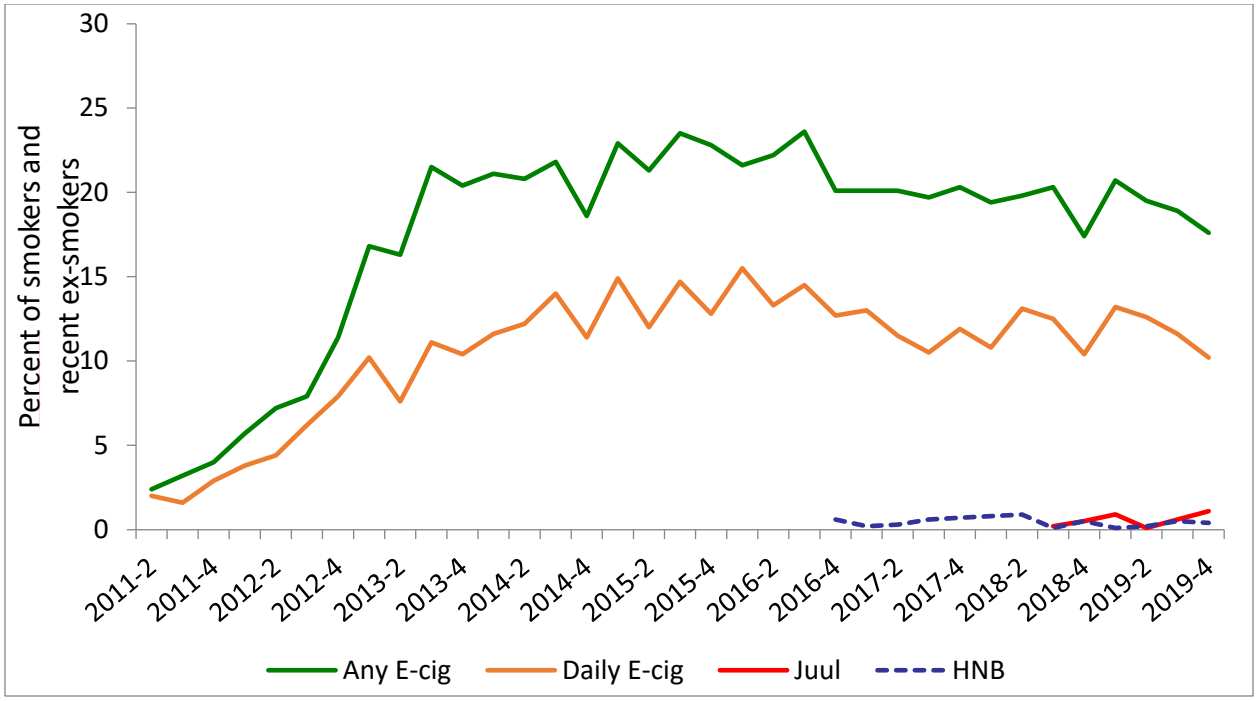
With 7 million deaths each year attributable to tobacco use,[1] the World Health Organization (WHO) has set out the Framework Convention for Tobacco Control, which reaffirms the rights to population health and promotes strategies to prevent and reduce the use of addictive substances like tobacco.[2] Based on this treaty, WHO MPOWER measures[3] were introduced to define a set of policies to assist countries in achieving their commitments to reduce tobacco demand. England has been one of the more active countries in Europe in meeting these goals. Since 1998, England has increased cigarette taxes, limited youth access and implemented smoke-free laws, strong health warnings, strong marketing restrictions and plain packaging.[4] In addition, UK cessation services have been available and publicized since 1999.

Simulation models combine information from different sources to provide a useful tool for examining how the effects of public policies unfold over time in complex social systems.[5,6] Simulation models examining the effect of tobacco control policies have been developed by Mendez and Warner,[7,8] Tengs et al.,[9-11] Ahmad,[12-14] and Levy et al.[6,15-17] The *SimSmoke* model of Levy et al. simultaneously considers a broader array of public policies than other models[18] and has been validated in many countries[19-32] and states.[33-38]

SimSmoke was previously adapted to Great Britain using population, smoking rates, and tobacco policy data specific to the country.[32] *Great Britain SimSmoke* was validated over the period 1998 to 2009, and was shown to accurately predict smoking prevalence. By comparing model predictions to a counterfactual with no new policies implemented, the model estimated that policies implemented between 1998 and 2009 were responsible for a 23% reduction in smoking prevalence, mainly due to increased cigarette taxes, smoke-free air laws, marketing bans and cessation treatment policies. The model also projected that 168,000 smoking-attributable deaths (SADs) would be averted by 2040 as a result of these policies.[32]

The purpose of this study is to extend the Great Britain model to more recent years, but also consider the role of nicotine vaping products (NVPs). To better focus on vaping, we have redeveloped the model to apply to England rather than Great Britain. England has had less restrictive policies towards NVPs than most other nations.[39-41] Prior to 2013, the UK regulated NVPs as consumer products subject to product safety regulations. The UK then regulated all nicotine-containing e-cigarettes as medicines under the UK Medicines and Healthcare Product Regulatory Agency in 2013. Subsequently, the Agency also set minimum standards for the safety and quality of all NVP devices and liquids (including limits on nicotine content), provided information to consumers, and protected children (prohibiting sales to those under age 18).

Figure 1. Trends in NVP Use Among Smokers and Recent Quitters, England, 2011-2019



Using data from the Smoking Toolkit Study, growth in NVP use in England can be seen in Figure 1. NVPs first came onto the market in 2009, but were only used by about 3% of smokers and ex-smokers in 2011. The rates increased to about 7% in 2012, but then gained popularity in 2013[42,43] when third generation vaping devices became available, increasing to

about 18%. Since 2018, the past month user rates have hovered between about 18% and 23%. Similar trends were observed among daily users, which accounted for about 60% of total users. Among all adults, NVP use has remained at about 5%-6% in 2013-2019.[44] Consequently, our analysis focuses on the potential impact of NVP use beginning in 2012.

Rather than explicitly modeling the direct and indirect impacts of NVPs on smoking, we have developed an indirect method for estimating NVPs' impact. We first validated the model over the pre-vaping period (2000-2012), before the more widespread use of NVPs by smokers. We then took advantage of the ability of SimSmoke to predict smoking prevalence in the absence of NVP taking into account the effect of new cigarette-oriented policies are implemented. Since the model does not incorporate vaping but does incorporate the impact of tobacco control policies over the period 2013-2019, the post-vaping predictions of smoking rates from 2012 through 2019 serve as a No-vaping counterfactual of what smoking rates would have been in the absence of vaping. Since the impact of vaping on smoking rates is reflected in actual smoking rates obtained from national surveys, we estimated their impact on smoking prevalence by comparing the predicted smoking rates under the No-vaping counterfactual to actual smoking rates from surveys over the period of 2013-2019. Additionally, we estimated the impact of tobacco control policies and of NVPs' impact on smoking-attributable deaths as well as on smoking prevalence.

METHODS

SimSmoke includes separate components for population, smoking prevalence, smoking-attributable deaths, and tobacco control policies.[6,16,17] England *SimSmoke* begins with the population in 2000, and allows for the population to change through births, deaths, and migration, and for smoking to change through initiation, cessation and relapse and through

policy changes. We first describe the development of the model in the absence of NVPs. We then describe the method for determining the impact of NVPs on smoking.

Population model

England had a population of 49 million by mid-2000 (24 million males and 25 million females) and of 55 million by mid-2017 (27 million males and 28 million females). Population estimate data by single age and gender in 2000-2009 and 2011-2017 (separate files for 2000, ..., 2011, 2012-2016, 2017) and population projection by single age and gender in 2018-2116 were obtained from the UK Office of National Statistics[45] (ONS, www.ons.gov.uk). Population by single age and gender in 2010 was averaged from the data in 2009 and 2011. We used the population by single age and gender to establish the model in its initial year 2000.

Over time, the population normally evolves through births, deaths and net international migration. Due to the small percentage (<1%) of the total population,[45] special populations (members of the armed forces and prisoners) were assumed to follow the same natural changes (births, deaths, and aging) as the general population. Since initiation into cigarette takes place after age 14 in the model, we replaced the number of never smokers through age 14 with population data. For later ages since 2001, we allowed for different death rates for current, former and never cigarette users. Using number of deaths on the ONS website[46] and the corresponding population by single age and gender, we estimated the all-cause death rate in 2000-2017 (except 2010). Between 2000 and 2017, the death rates for males (females) decreased by 43% (46%) from 0.08% to 0.05% (0.03% to 0.02%) at age 20, by 30% (27%) from 1.10% to 0.77% (0.67% to 0.49%) at age 70, and by 33% (28%) from 8.24% to 5.55% (5.39% to 3.97%) by age 80. Since the population data for England and Wales in 2010 were not available, we took the average of the death rates in 2009 and 2011 to represent the rates in 2010. The inferred death

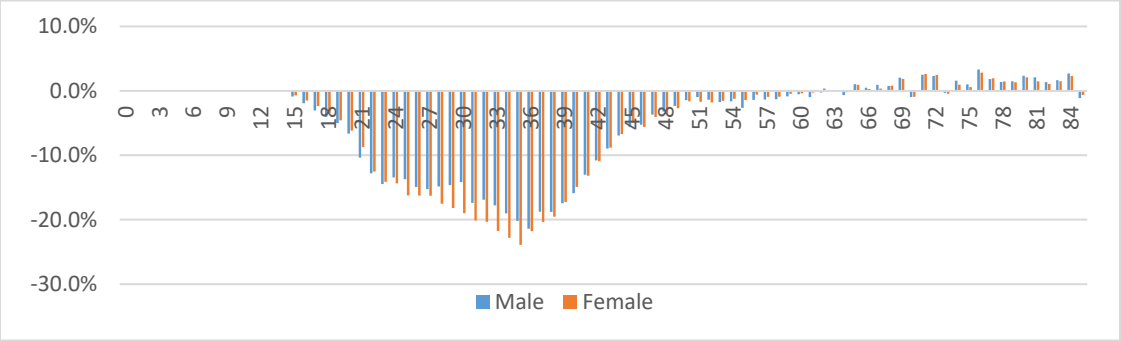
rates in England and Wales were applied to England. After 2017, we assumed that the death rates by gender at each age were equal to the average of the rates in 2015-2017, except with an additional adjustment (1.4% downward annually) to age 60 and above for both genders.

The number of international migration by age group and gender to England and Wales in 2000-2017 was collected from the Office of National Statistics (ONS).[45] No significant trend was observed in net migration, with an average of 59.1 thousand (k) (range: 35k-85k) males at age 15-24 (5.3k, range: -3k-11k, for females), 38.8k (range: 12k-80k) males (60.6k, range: 32k-81k, for females) at age 25-44 that moved in; 2.2k (range: -14k-9k) males (-34.9k, range: -70k-3k, for females) at age 45-64 , and 0.11k (range: -5k-3k) males (-1.11k, range: -10k-9k, for females) at age 65 and above that moved out. The annual net migration each year (2000-2017) in each age group was divided by the corresponding population for England in 2000-2017. We applied the average rate in last three years (2015-2017) for future years, which was 1.7%, 0.7%, 0.1%, and 0.0% for ages 15-24, 25-44, 45-64, and 65 and above for males, and 2.2%, 0.7%, 0.1%, and 0.0% for the same age groups for females.

Population Validation

Without adjusting for immigration, the relative differences in the population estimated by *SimSmoke* and that of ONS by age and gender in 2017 are presented in Figure 2, measured by the difference between the model and ONS estimate divided by the ONS population. The overall population was underestimated by 6.7% for males and 6.9% for females, underestimating by as much as 21.4% for males and 23.9% for females for some ages but with the relative difference of less than 3% after age 50. No difference is observed before age 15, because we applied the population estimate from ONS.

Figure 2. Relative difference in population between *SimSmoke* and data from UK Office of National Statistics w/out immigration adjustment, 2017



We applied the annual net immigration, with the relative difference in 2017 shown in Figure 3. Upon calibrating, we set a lower rate (about one-third of the average in 2015-2017) for those at age 15-24 (0.7% for both genders) and 25-44 (0.3% for males and 0.2% for females) since 2018, but maintained the average for age 45-64 and 65 and above. With annual net immigration rate incorporated, we overestimated the total population by less than 0.5% on average for both males and females age 15+ in 2017. Figure 3 shows that the population was overestimated by as much as 6.6% for males and 6.3% for females at ages 15-32 and underestimated by less than 10% for males and 11% for females ages 33-42, with less than 5% variation for both genders after age 43.

Figure 3. Relative difference in population between *SimSmoke* and data from UK Office of National Statistics with immigration adjustment, 2017

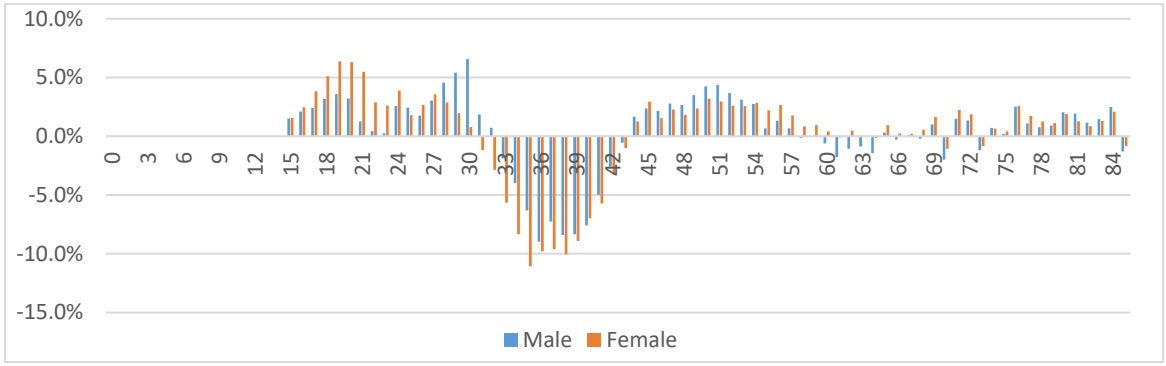
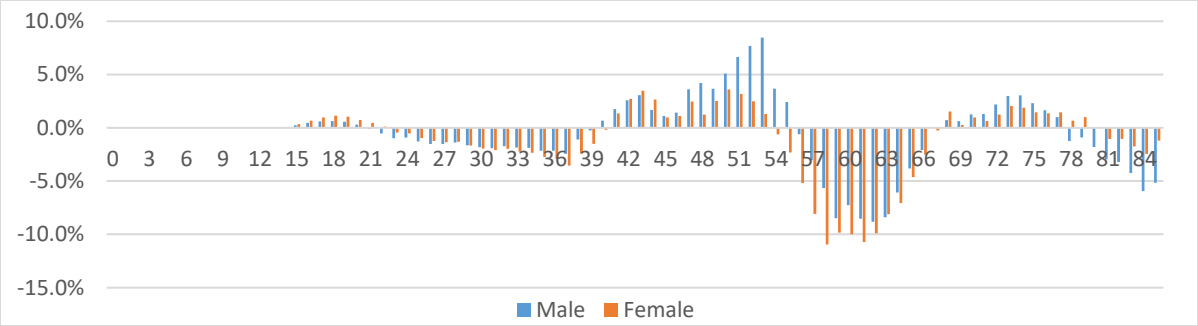


Figure 4 shows that the model under-estimated the total population by 0.5% for males

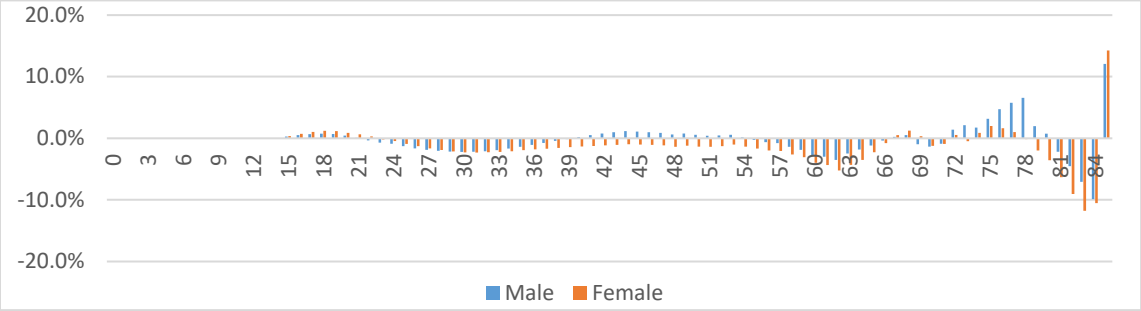
age 15+ and 1.1% for females age 15+ in 2040. The model over-estimated the population by as much as 8.5% for age 53 males, under-estimated the population by as much as 11.0% at age 58 for males and 8.8% at age 62, and with less than 4% variation at other ages except males age 84.

Figure 4. Relative difference from *SimSmoke* and population with immigration adjustment, 2040



In 2065, the total population was over-estimated by 0.5% for males age 15+ and under-estimated by 0.2% for females age 15+, as seen in figure 5. The population was overestimated by as much as 6.6% for males age 78, under-estimated as much as 11.3% for females at age 83, but with the difference of less than 5% for both males and females at ages below 75.

Figure 5. Relative difference from SimSmoke and population with immigration adjustment, 2065



Smoking Model

In modeling the smoking prevalence over time, we employ the methodology and assumptions used in previously validated *SimSmoke* models, i.e., that (cigarette) smoking initiation and cessation rates are age- and gender-specific and remain stable over time subject to changes in policies. The model begins with current and former smoking prevalence from the

Opinions and Lifestyle Survey[47] in 2000. Never smokers are defined as those who do not now smoke and have never regularly smoked cigarettes. Current smokers are defined as those who now regularly smoke. Former smokers are defined as those who do not now smoke, but have smoked regularly in the past. Former cigarette smokers are asked the number of years ago that they quit and are tracked by years quit. However, due to small sample sizes for each age group, we used the distribution of former smokers by age and quit years (<1 to 16+ years) in the US (1993 Tobacco Use Supplement-Current Population Survey[48]) to estimate the former smokers by age and quit years in England.

Due to empirical challenges in measuring the initiation and quitting, and to ensure stability and internal consistency of the model, *SimSmoke* applies smoking prevalence by age in the initial year to estimate initiation net of quitting. Specifically, net initiation is measured as the difference between smoking prevalence at a given age and the previous age. Because the smoking rates increased to the maximum until age 25 for males and 19 for females, net initiation was applied through those ages for each gender.

Cessation is incorporated from the next age of net initiation (age 26 for males and 20 for females). Cessation rates by age groups in the initial year were estimated as the ratio of new quitters and the sum of current smokers and new quitters in 2000, i.e. (quit ≤ 1 year)/(current smokers + quit ≤ 1 year). The prevalence of smokers and new quitters was obtained from the 2000 OPN-ONS, and new quitters were measured as those who quit smoking less or equal to one year. The data were then smoothed using a 7-year moving average method. Since age and gender-specific relapse rates by quit years were not available in England, we applied the rates for smokers as in US *SimSmoke*.[49-51] These rates are maintained over time, while initiation and cessation rates may change as a result of new implemented tobacco control policies.

To estimate the prevalence of never, current, and former smokers over time, we also need the death rates by smoking status. Since the death rates of specific types of smokers are not available, age-, gender- and year-specific overall death rates ($DR^{Overall}_{g,a,t}$) were used which were derived from the overall number of deaths and population in England and Wales collected from ONS. The relative risk of smoking (compared with never smoking) in US *SimSmoke* is applied in the calculation, as they are similar to those in England.[52-54] The mathematical equations for estimation of death rates by smoking status are shown in Appendix (Smoking-Attributable Death Model). The death rates are also used to estimate the health impacts, smoking-attributable deaths (SADs), over time. SADs are estimated for each age and smoking group by multiplying the number of current or former smokers (product of smoking prevalence and population) in that group by the difference between the death rate of that smoking group and the death rate of never smokers.

Policy Effects

Policy effect sizes are in terms of percentage reductions. They are applied to the smoking prevalence in the year in which the policy is implemented and, unless otherwise specified, are applied to initiation and cessation rates in future years if the policy is sustained. In the absence of synergies, the effect of a second policy simultaneously implemented is reduced by the effect of the first policy. The policy effect sizes used to generate the predicted effects in the model are based on thorough reviews of the literatures and updates, and the advice of an expert panel.[32] These effects for England are determined primarily from studies for England or the UK and other high income nations. Policies and potential effect sizes are summarized in Table 1.

In *SimSmoke*, the effect of each policy depends on its initial level (e.g., the incremental effect of a complete worksite law ban is less when a nation already has a partial worksite ban),

and, unless otherwise specified, the effect size corresponds to the effect relative to no policy. Because changes in policy affect the future path of smoking prevalence in *SimSmoke*, we track policy levels from the start date of the model, 2000, to the most recent date, 2019. The level of a policy is based on information in the WHO MPOWER reports[3,55-58] and data from other organizations that provide information on tobacco control in the Great Britain.[59]

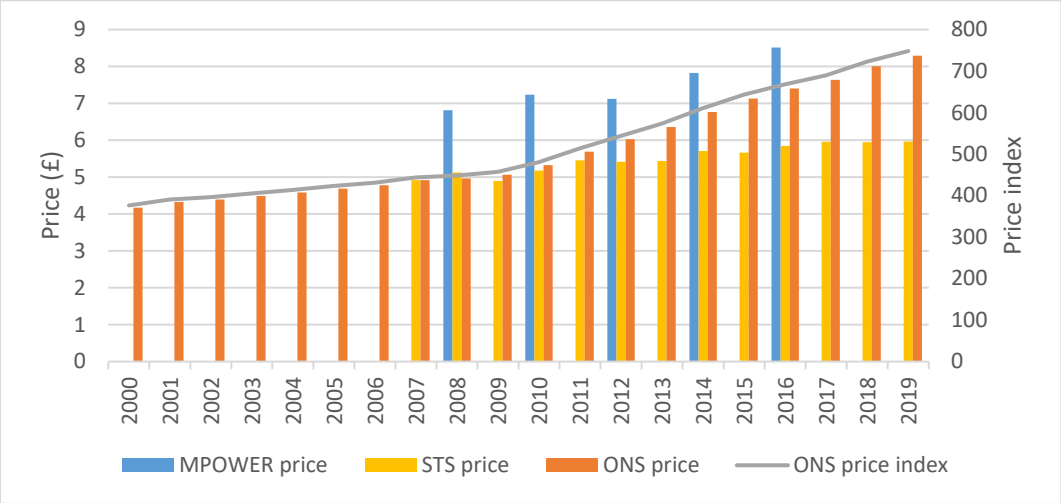
Cigarette Price and Taxes

Changes in price are translated into changes in smoking prevalence through an equation dependent on price elasticities as described in Levy et al.[60] The price elasticities are the standard measures obtained from large literature on cigarette demand.[61] Chaloupka et al.[61] found that high income nations have total price elasticities between -0.3 and -0.5, averaging -0.4. Studies conducted for the UK obtain elasticities consistent with that range.[62-65] Taking into account U.S. studies distinguishing the price responsiveness by age,[66] the model applies prevalence elasticities of -0.4 for those through age 18, -0.3 for ages 18 to 24, -0.2 for ages 25 to 34, -0.1 for ages 35 to 64, and -0.2 for ages 65 and above. We also note that the UK faces smuggling from abroad, but has had an anti-smuggling enforcement program in place since 2001.[67] We apply the price elasticities by age group in U.S. for the England *SimSmoke* model, and presume that the issue of smuggling from abroad will not affect the elasticities over time. Sensitivity analysis is conducted at 75% to 125% of these values.

Data on price were collected from three sources: STS, ONS, and MPOWER. Cigarette price indices (1987-2019, Jan 1987=100) and consumer price indices (CPI) for all household items (1988-2019) were obtained for the UK ONS.[68] Using the England Smoking Toolkit Study (STS), average weekly smoking expenditure and consumption (available quarterly in 2007-2017 and monthly in January-November 2019)[69-71] were converted into average spending per pack of

cigarette by dividing cigarette expenditures by the consumption (assuming 20 sticks per pack) in those years and then adjusted by the CPI from ONS. We also obtained data from MPOWER Reports based on price of the most popular brand. All data are inflation-adjusted to 2015.

Figure 6: CPI-Adjusted (2015=100) Cigarette Prices and Indices from Multiple Sources, 2000-2019



* STS = Smoking Toolkit Study. ONS = Office of National Statistics. ONS price index (unit free) is scaled using the ratio between STS and ONS in 2007 (unadjusted price in STS = £4.1: unadjusted ONS index =370).

The inflation-adjusted prices are illustrated in Figure 6. For the years 2008-2016 (when comparable price data was available), prices increased by 49.1% according to the UK ONS, by 24.9% according to MPOWER, and by 14.1% based on STS data. We note that ONS and STS prices were similar in 2007 to 2010, and later diverged. The less proportional increase in the price paid indicated by the STS measure is consistent with findings that smokers in England have used cost minimizing strategies to reduce their expenditures, and thus that price reflects actual prices paid.[72-75] The upward trend in the MPOWER price is generally more than the STS price and less than the ONS prices. We chose ONS prices for 2000-2006 and STS prices for 2007-2019. We also conducted sensitivity analysis using only ONS prices for all year in 2000-2019.

After 2019, prices change with changes in the total excise tax per pack, which is the sum of the ad valorem tax and the excise specific tax as a percent of prices, as obtained from MPOWER Reports.[3,55-58] The tax rate used in the model includes the ad valorem tax, the excise specific tax as a percent of price, and the value added tax. According to MPOWER reports, the average specific tax of the most sold brand increased from 39.53% (£2.24 per pack) of the final price in 2008 to 37.85% (£2.38) in 2010, 46.95% (£3.10) in 2012, 48.99% (£3.68) in 2014 and 47.33% (£3.92) in 2016. The ad valorem tax declined from 24% of the final price in 2008-2010 to 16.5% in 2012-2016. The total excise tax remained at nearly 63% in 2008-2016 (63.53% in 2008, 61.85% in 2010, 63.45% in 2012, 65.49% in 2014, and 63.83% in 2016). The specific excise tax increased to £207.99 per 1000 cigarettes (£4.16 per pack) on May 20, 2017 and to £217.23 (£4.34) in Nov 22, 2017, and to £228.29 (£4.57) on Oct 29, 2018, while the ad valorem tax remained unchanged (16.5% of the final price).[76] The total excise tax since 2017 was estimated as 63.8% of final price.

Smoke-Free Air Laws

The smoke-free air module consists of restrictions on: 1) worksites, 2) restaurants, 3) pubs and bars, and 4) other public places. MPOWER distinguishes the level of worksite bans by none, partial (work areas, but not common areas), in all workplaces except in ventilated areas, and complete, and the level of restaurant bans as none, restricted to separate areas or smoke-free in all indoor areas. A ban in other public places is designated if there are bans in transit, malls, recreational arenas and retail stores. For each of the bans, the effects depend on enforcement and publicity. Levels of enforcement in *SimSmoke* model (scores from 1 to 10) are based on the MPOWER Report.[3,55-58] The level of publicity is determined based on the level of tobacco control campaigns, and thus reflects a synergy related to a broader tobacco control campaign

(e.g., through greater awareness of the dangers of second hand smoke). We set 100% as the publicity for high level of tobacco control campaigns, 75% for median level, 50% for low level, and 0% for no policy implemented.

With a high level of enforcement and publicity, a restaurant ban has a 2% effect, a pub and bar ban has a 1% effect, a full worksite ban has a 6% effect (the ban in indoor offices only has a 4% effect and the ban in 2 of the 3 of health facilities, universities and government facilities has a 2% effect), and a ban in other public places has a 1% effect. Sensitivity analysis is conducted at 50% to 150% of these values. The effect sizes are based primarily on studies of restrictions by private worksites and smoke-free-air laws for high income countries. The basis for these estimates is described in Levy et al.[77-79] For worksites, the effect size is consistent with Fichtenberg and Glantz.[80] Effects of similar or larger impact in relative terms have been observed in recent studies for Korea,[81] Norway,[82] Finland [83] and Spain.[84] The effect of bans in restaurants, bars and other public places, and of their enforcement has received little attention. The effects are scaled based on the value of the MPOWER smoke-free air law enforcement variable and publicity (e.g., the effects are halved in the absence of any enforcement and publicity).

No studies of the effect of smoke-free indoor air laws on smoking prevalence or consumption were found for Great Britain, so we rely primarily on the studies conducted for the U.S. with consideration of work-related factors specific to Great Britain. The effects of the worksite laws apply only to those who are currently working and work indoors, and are adjusted for unemployment and percent employed in agriculture. The percent of the workers employed in agriculture is set at 1.7% and the rate of unemployment averages is set at 5% for all years. Both are estimated based on the UK economy data from the World Factbook.[85]

After having weak smoke-free air laws, comprehensive smoke-free air legislation covering almost all workplaces and enclosed public places, including bars and restaurants, was enacted throughout the UK via the 2007 Health Act.[4] Authorities and legislative bans were in place sub-nationally, but the extent of enforcement is unknown. The value for "Bans in health facilities, universities, and government facilities (2 of 3)" is set at 100% with no restaurant or bar ban for 2000 through 2006, increasing to a full worksite, and restaurant and bar ban in England in 2007. Bans in other public places are assumed at full coverage in 2000-2019. Based on MPOWER Reports, the enforcement of smoke-free air laws for 2000-2019 is set at level 10 and remains at that level.

Marketing Restrictions

The marketing restrictions module in *SimSmoke* corresponds to bans on advertising, promotion and sponsorship in the MPOWER report: 1) no policy, 2) partial advertising ban, 3) full advertising (direct) ban, and 4) complete direct and indirect marketing bans. The effect sizes for marketing bans are based on Levy et al.,[79] relying primarily on Saffer and Chaloupka[86] and Blecher.[87] With a complete ban on direct and indirect marketing in a high income nation, *SimSmoke* reduces prevalence by 5%, increases cessation by 4% and reduces initiation by 8%. With a moderate policy, prevalence is reduced by 3%, cessation is increased by 2% and initiation is reduced by 4%. With a minimal policy, prevalence is reduced by 1%, cessation is not affected, and initiation is reduced by 1%. Sensitivity analysis is conducted at 50% to 150% of these values. The effects of enforcement have not been studied. Like for smoke-free laws, the effects in *SimSmoke* are scaled for incomplete enforcement (the effects are halved when MPOWER value of enforcement is zero). Based on data in the MPOWER report, marketing bans are considered to have ten levels of enforcement (1 to 10).

In 1998, England had a ban on advertising in some media. In 2003, direct mailing of tobacco advertising was banned, followed by the ban of tobacco sponsorship of domestic sporting events. Additionally, the Tobacco Advertising and Promotion Act 2002 came into effect in February of 2003, making it illegal to advertise tobacco products on billboards, in newspapers, and in magazines. These restrictions shifted the UK's advertising efforts from a minimal ban to a moderate advertising ban. Furthermore, regulations governing advertising at the point of sales came into effect in 2004. These regulations limit advertising size per outlet. Other UK-wide marketing regulations relating to brand sharing (SI 2004 No. 1824) also came into effect. Additionally, the ban on tobacco sponsorship of international events, such as Formula One motor racing, entered into force in 2005. Regulations on brand-sharing and the prohibition of tobacco advertising on the internet (SI 2006, No. 2369) were also initiated. The display of tobacco products in large shops has been prohibited since April 2012, and in smaller shops since April 2015 through Tobacco Advertising and Promotion Regulations 2010 which implemented section 21 of the Health Act 2009,[4] and a recent study suggests that the policy slowly became effective.

We set the initial level of marketing restrictions as minimal ban in 2000, increasing in steps to a moderate marketing ban in 2003, followed by an increase to 50% total marketing ban and 50% moderate marketing ban in 2006-2011. The levels were increased to an 80% full and 20% moderate marketing ban in 2012, and increased to a 90% full and 10% moderate marketing ban in 2015 (when some forms of sponsorship were still permitted). Enforcement is set at 10 for all years based on the 2010 MPOWER reports.

Health Warnings and Standardized Packaging

The health warnings policy module in *SimSmoke* corresponds to the Health Warnings in the MPOWER report. The MPOWER report provides 4 levels for health warnings: no policy,

minimal policy (< 30% of the principal display area of the pack), moderate policy (a warning that covers at least 30% of the principal display area of the pack and includes 1 to 7 of the seven pack warning criteria outlined in the Technical Note of Appendix II), and strong (a warning that covers at least 50% of the principal display area of the pack and includes all seven pack warning criteria outlined in the Technical Note I, including graphic warnings).

With strong health warnings, prevalence is reduced by 4%, cessation is increased by 10% and initiation is reduced by 6%. When moderate, prevalence is reduced by 2%, cessation is increased by 4% and initiation is reduced by 2%. When low, prevalence is reduced by 1%, cessation is increased by 2%, and initiation is reduced by 1%. Evidence on the effects of health warnings is provided in Levy et al.[88] Sensitivity analysis is conducted at 50% to 150% of these values.

Health warnings in the UK were considered at a 100% low level in 2000, increasing to a 100% moderate level in 2004-2007 with warnings increased to 30% of the pack, and increasing to 90% high and 10% moderate level in 2008-2015 (graphic warnings became mandatory in 2008). In 2016, packs were required to have 65% of their front and back surface covered in graphic and text health warnings and considered a high level. The policy was 100% high level in 2016-2019.

In addition to strong health warnings, the UK became the first European country in 2017 to introduce standardized packaging of tobacco products.[4] The regulations required that the outside of the pack is drab brown with a matt finish, with text to be in a grey Helvetica typeface with a prescribed maximum size, brand and variant names appearing once on the front, top and bottom surfaces, a specific shape, and no inserts.[4]

Plain packaging was not included in previous versions of *SimSmoke*. Considered a package policy, and one implemented in addition to graphic warnings (i.e., high level warnings), plain package warnings was added to the England model in terms of the percentage reduction in prevalence and initiation and the percent increase in cessation relative to the highest level of health warnings. The plain cigarette packaging policy increases from 0% for 2000-2016 and 100% for 2017. Based primarily on a recent Cochrane review[89] with similar findings in other reviews,[90-92] we estimate an additional (on top of health warnings) reduction in smoking prevalence of 2% in the first year with initiation reduced by 2% and cessation increased by 2% in future years.

Tobacco Control Campaigns

The intent of the tobacco control/media campaign module is not only to capture the establishment of an organized tobacco control campaign but also to incorporate the impact of funded programs. The main component of most campaigns is communication through media and other sources, including publicity generated through local programs. Campaigns are classified as high, medium, or low. A low-level campaign includes a national agency and at least some level of funding. To qualify at a medium-level, the requirements must be met for a low-level campaign plus expenditures over $0.25 USD per capita. A high-level campaign meets the requirements for a low-level campaign plus has expenditures over $1.00 USD per capita. In developing these measures, we consider information from the earlier *Great Britain SimSmoke*.

Campaigns with demonstrated effectiveness are those that involve a strong media component and grassroots organization in countries and states, such as those in California, Arizona, Australia, Massachusetts, and Thailand. With a well-funded tobacco control campaign in place in conjunction with other policies, the effect size is 6.5%. The effect size of a

moderately funded campaign is 3.25%, and a low funded campaign is 1.63%. Without other policies in place, the effects are reduced by half. The effect of mass media campaigns has been described in Levy et al.,[79,93,94] with consistent results in a recent review[95] and some other recent studies.[96-99] A recent study for England[100] indicated effects on quit success, roughly at the mid-level of expenditures. Sensitivity analysis of the effect sizes is conducted at 50% to 150% of these values.

Data on expenditures were not available for England from MPOWER Reports. The tobacco control campaign level is based on information obtained for our previous Great Britain model. Media campaign expenditures were about 5 million pounds per year through 2007 (less than $0.10 per capita). More recent information indicates that media expenditures have totaled about 14 million pounds per year since 2007, which translate to $0.25 USD per capita, but media campaigns are only part of tobacco control expenditures.[100] In 2000, media campaigns were set at a low level, and then increased to a moderate level in 2004, and are maintained at that level. In addition, we also employ a low-level media campaign policy, instead of a moderate-level, in 2010-2019 in the model for sensitivity analysis.

Cessation Treatment Policies/Programs

The cessation treatment policy module in *SimSmoke* includes four primary sub-policies: pharmacotherapy (PT) availability, financial coverage of treatments, quit lines, and health care provider involvement.

The PT availability sub-policy option corresponds to the information in MPOWER Reports regarding whether nicotine replacement treatment (NRT) and/or non-nicotine replacement therapy, such as Bupropion and Varenicline, are available and where they may be obtained. If PT (NRT, Bupropion, and Varenicline) is available and NRT is available without

prescription, then prevalence is reduced by 1.0% in the first year of the policy and the pre-policy cessation rate is increased by 4% in all years after the first. The effect is reduced by 25% for each of the availability conditions not met, with NRT indicator given twice the weight as Bupropion and with the weight reduced by 50% if NRT is only available in a pharmacy (with a prescription required). There is no effect on initiation.

Treatment coverage policies previously followed MPOWER Reports which distinguish place of provision of cessation treatments by the following: primary care facilities, hospitals, offices of health professionals, community, and other, designated either "yes in some (half effect)" or "yes in most (full effect)" and zero otherwise. These have been replaced by separate categories for percent financially covered separately for pharmacotherapy and behavioral therapy. With a high-level campaign, prevalence is reduced by 2.25% in the first year of the policy and the cessation rate is increased by 8% in all future years. In the absence of tobacco control campaigns, the effects are reduced by 25%. The effects are consistent with those in previous versions of *SimSmoke.*[79,101-103] Evidence from Brazil [104] and Great Britain [105] is consistent with the above postulated effects.

In MPOWER Reports, quit lines are distinguished by whether or not the population has access to a toll-free quitline, but *SimSmoke* also distinguishes by type of quitline, with the quit line categorized as passive, active, or active with a follow-up. The effect of quit lines also depends on publicity, using the same equation as used for the financial access sub-policy. Prevalence is reduced by 3.0% in the first year of the policy, and the cessation rate is increased by 5% in all following years based on evidence in Levy et al.[79] Sensitivity analysis is conducted at 50% to 150% of all above values.

In Great Britain, NRT was available by prescription since 1995, but, in 2001, it became available at general stores or pharmacies without a prescription. Bupropion became available for usage for cessation treatment with a doctor's prescription in 2000. Both PT treatments were available throughout the tracking period ending in 2019. Varenicline became available in England in 2006.[106] While the UK is generally considered a single cohesive unit in this report, cessation treatment policies varied for the different parts of the UK. Cessation services were minimal from 1998 until 2001. Starting in 1998, passive quit line services were available. Pilot smoking cessation services projects were run from 2000 to 2003. The quit line is viewed as passive in 2000 and active with follow-up during 2001-2019. In 2001, health care provider involvement in cessation services generally increased by 25% and remained constant throughout the remainder of the tracking period. Health care provider involvement is set at 50% in 2000 and increased to 75% in 2001-2019.

Compared to the previous Great Britain model, we modelled cessation treatment coverage as some places for physician offices, hospitals, community centers, provider offices and others in 2000, and then to all places for each of the types of providers in 2003. In the England model, both behavioral and pharmacotherapy coverage are at 25% (partial) in 2000, increasing to fully covered in 2003.

Youth Access

Youth access policies consider enforcement, publicity, self-service, and vending machine bans. The model considers three levels of enforcement: strongly enforced and publicized (the retailer violation rate is less than 5%); well enforced, but with little community support (the retailer violation rate is more than 5% and below 16%); weak enforcement (the retailer violation rate is more than 16% and below 30%); and no enforcement (the retailer violation rate is more

than 30%). As retail sales to youth are reduced, youth switch to non-retail sources such as theft, older peers and parents. This substitution limits the assumed effect of youth access policies to a maximum estimated 16% reduction in youth smoking initiation for 16 and 17 years old, although the effect on 10-15 years old is 1.5 times that on 16 and 17-year-olds. These effects are enhanced by 8% in relative terms with a vending machine ban, by 2% with a self-service ban, and by 10% with publicity. A strongly enforced policy can reduce smoking prevalence by those under the age of 18 by as much as 25%. Sensitivity analysis is conducted at 50% to 150% of these values.

The minimum age for the purchase of tobacco in England was raised from 16 to 18 in October 2007. Tobacco products can be sold from any retail outlet but retailers have a duty to ensure tobacco products are not sold to anyone under the age of 18. We set youth access to no policy until 2008, and maintain at a low level from 2009 onwards. There were no bans on vending machines or self-service displays.

Model Outcomes, Calibration and Validation

As described above, the model estimates the effects over time for two primary outcomes: current smoking prevalence and smoking-attributable deaths. Smoking prevalence is provided for the population ages 16 and above. Separate results are provided for males and females. The model estimates these outcomes for the tracking period, which is from 2000 to 2019, and projects future outcomes for 2020 through 2052.

Smoking prevalence was first calibrated against smoking prevalence from OPN surveys through 2004 for age groups 16-24, 25-34, 35-49, 50-59, and 60+, when NVP use was still minimal. The model was calibrated by increasing all initiation rates by 0.25% for males and 0.3% for females, then increasing the first year relapse rates by 5% for male ages 31-33 and 40-

44, 50% for female ages 20-23, 45% for female ages 24-26, 35% for female ages 27-29, and 25% for female ages 30-39.

The model was validated over the pre-NVP period, 2000 to 2012. To validate the model, model predictions of current smoking prevalence that incorporated all implemented policies were compared to current smoking prevalence rates from four surveys. We used nationally representative surveys that were collected annually for at least recent years.

First, we used the 2000 to 2012 OPN surveys[47] available by gender for ages 16+, 16-24, 25-34, 35-49, 50-59, 60+, with cigarette use defined as those who now regularly smoke. This nationally representative household survey contains at least 6500 observations each year. The model was also validated over the same time period using the 2000-2012 nationally representative Health Survey for England (HSE).[107] This household survey contains 7000-8000 observations for most years and is available by gender for ages 16+, 16-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75+. Current smokers were defined as those who currently smoke regularly and former smokers as those who "used to smoke cigarettes regularly." For purposes of comparison, age groups 45-54 and 55-64 were combined as 45-64 and age groups 65-74 and 75+ were combined as 65 and above weighted by the OPN population each year.

The smoking prevalence was also validated against a larger scale household survey (152 thousand observations in 2018 for England) conducted by ONS (Annual Population Survey, APS-ONS) in 2010-2012.[108] This data was available by gender for age groups 16+, 18-24, 25-34, 35-44, 45-54, 55-64, and 65 and above. Current smokers was defined as "smoke nowadays" before 2016 and "smoke nowadays and smoked regularly" since 2016 and the measure of former smokers was defined as "smoked" before 2015 and "regularly smoked but not nowadays" since 2016. Age groups 45-54 and 55-64 were combined as 45-64 using ONS population.

Finally, cigarette prevalence was also validated against 2007-2012 data from the England Smoking Toolkit Study (STS).[44] This household survey contains data on approximately 1,800 adults aged 16 and above and was stratified by gender and age group (16-24, 25-44, 45-64, 65 and above). The data is available by month since November 2016 through November 2019, which was averaged into yearly data. To avoid bias, prevalence in November and December 2016 was not used for validation. Unlike the OPN ("currently use"), current cigarette smokers were defined as those who smoke cigarettes (including hand-rolled) daily or non-daily, and thus did not distinguish regular use.

The 95% confidence interval for all above four surveys are available in limited years before 2012 by age group and gender, but are not available when two smaller age groups (e.g., 25-34 and 35-44) combined into a large one (25-44).

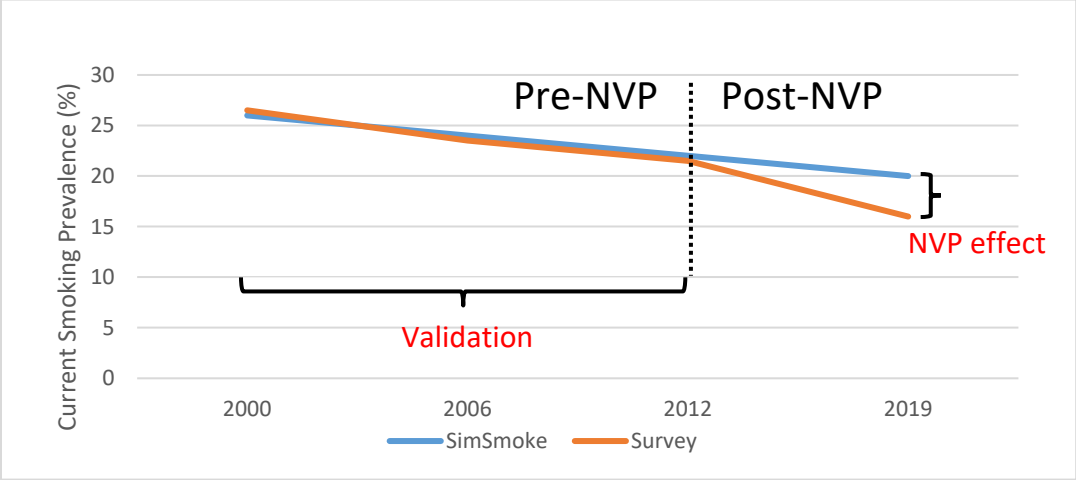
The Effects of Policies Implemented Between 2000 and 2019

Upon validating the model, we considered the impact of policies implemented between 2000 and 2019 as a gauge of the role of different policies. We first estimated the "No-policy Scenario," whereby tobacco control policies were maintained at their 2000 level. We then considered the effects of policies by modeling the effect of each implemented policy in isolation and all policies combined. In comparing the effects of policies to the "No-policy Scenario," we focused on the relative change in smoking prevalence, i.e., the change in smoking prevalence relative to the No-Policy Scenarios. To gauge public health outcomes, we considered SADs over the period of 2000-2040. In addition, we calculated lives saved as the difference between the number of SADs under each policy to the number of deaths under the No-policy Scenario, estimated through 2040.

Gauging the Effects of NVPs Relative to a No-NVP Counterfactual

We estimated the potential impact of NVPs by comparing the projected trend in smoking prevalence that would have occurred in the absence of vaping based on the model to actual trends in smoking prevalence from national surveys (figure 7). Specifically, with *SimSmoke* validated through the pre-NVP period (before NVPs became popular, i.e., 2000-2012), smoking prevalence was projected over the post-NVP period (when NVPs were being used, 2012-2019) while incorporating non-NVP tobacco control policy changes that occurred during those years. Since the model does not explicitly incorporate NVP use or policies, the extrapolation from pre-vaping trends provides the no-vaping "counterfactual," i.e., post-vaping predictions of smoking prevalence in the absence of NVPs. We then compared this post-vaping counterfactual to nationally-representative smoking prevalence data over the post-vaping time period, i.e., the "actual" smoking prevalence with NVP use.

Figure 7: Conceptual relation of the No-NVP SimSmoke model prediction vs the national surveys during the 2000-12 pre-NVP (for validation) period in and 2012-19 post-NVP period



The difference in the projected and actual smoking prevalence served as an indirect estimate of the impact of NVP use on cigarette prevalence. Since estimates at any point in time and trends in smoking prevalence vary for the different surveys, we compared the relative

change in smoking prevalence from *SimSmoke* to the relative change in smoking prevalence from surveys over the vaping period, where SmokPrev was defined as smoking prevalence either from a survey or from *SimSmoke* and the relative change in 2012-2019 was calculated using the formula $(SmokPrev_{2019} - SmokPrev_{2012})/ SmokPrev_{2012}$. We then measured the potential impact on NVPs above and beyond the impact of policies by subtracting the relative change in the *SimSmoke* predicted rates from the relative change in survey estimated rates. A greater (smaller) relative reduction from the surveys compared to that from *SimSmoke* is consistent with a harm-reducing (harm-increasing) impact of NVPs in terms of the reduction in smoking prevalence.

These analyses were conducted by age and gender separately comparing the relative reduction from the OPN, HSE, APS and STS surveys to those from *SimSmoke*. We compared the rates across surveys for the same age groups and gender to derive a range of potential NVP stratified impacts on smoking prevalence by age and gender. As a gauge of uncertainty, we also apply the upper and lower bounds of the confidence intervals of each survey in 2019 to obtain the implied range of impacts (e.g., upper bound of the relative reduction = (lower bound of prevalence 2019-prevalence 2012)/prevalence 2012).

The Effects of NVPs on Smoking Prevalence and Smoking-Attributable Deaths

Once we estimated the relative reduction in smoking prevalence and their 95% confidence interval beyond the *SimSmoke* projections over the post-vaping period (additional impact of vaping), we incorporated the effects of NVPs on smoking prevalence in 2012-2018 back into the *SimSmoke* model. We then compared these reductions under the NVP Scenario to the No-vaping Scenario to estimate the impact of NVPs on smoking prevalence and smoking-attributable deaths through the year 2052.

We first developed estimates of yearly changes due to NVPs over the years 2012-2019 by

age and gender. To gauge the impact of NVP use in 2012-2019 by age groups, we first estimated the average annual reduction in smoking prevalence by age group from each of the surveys assuming a constant relative reduction as implied by an exponential function to the percent reduction in the smoking prevalence, i.e., 1- $(SmokePrev_{2019} / SmokePrev_{2012})^{1/7}$ = the percent reduction in smoking prevalence each year. We conducted the same analysis for *SimSmoke* predictions by age groups to correct for underlying trends and the effects of policies on smoking prevalence. The average year reduction derived for *SimSmoke* was then subtracted from the rates derived from the surveys to obtain the yearly NVP adjustment to the smoking prevalence in *SimSmoke*. We applied an optimistic (higher adjuster) and a pessimistic rate (lower adjuster) to the model. The NVP adjuster were developed for the 16/18-24 (generalized to all ages under 24 in the model), 25-44 (or 25-34 and 35-44 separately), 45-64 (or 45-54 and 55-64 separately) and 65 and above age groups by gender and were applied to the non-adjusted *SimSmoke* predictions (without NVP adjustment).

The NVP-adjusted smoking trend using *SimSmoke* was estimated by incorporating the NVP adjustments into the *SimSmoke* model as a new permanent reduction each year to the unadjusted smoking prevalence prediction by age and gender. *SimSmoke* projected smoking prevalence at age $a+1$ in year $t+1$ equal to the *SimSmoke* projected smoking prevalence at age a in year t multiplied by (1 – cessation rate at age a - NVP adjustment at age a). The reduction in smoking population due to the NVP adjustment was relocated to never smokers through the last age of smoking initiation and to former smokers one year quit assuming no relapse (kept separate from other former smokers in the model who do not quit due to NVPs) after the last age of initiation. Due to the uncertainty in how NVP use affects future smoking, the model only incorporates an NVP adjustment in 2012-2019 (first in 2012-13 transition and last in 2018-19

transition) and no NVP adjustment was made after 2019, i.e., the NVP adjustment = 0 after 2019.

We compared the No-vaping *SimSmoke* prediction with the NVP-adjusted *SimSmoke* prediction in 2012-2052 on smoking prevalence and on smoking-attributable deaths (SADs) to obtain the impact of NVP use during 2012-2019.

RESULTS

Validation of Smoking Prevalence

SimSmoke predictions incorporating policy changes were validated against OPN and HSE estimates for 2000-2012 and against STS estimates from 2007 to 2012 for smoking prevalence, as shown in Table 2. For OPN and HSE, we also distinguished the relative changes over the years 2000-2007 and 2000-2012.

For the adult population (ages 16 and above), *SimSmoke* predicted that male (female) cigarette smoking prevalence fell from 28.6% (24.9%) in 2000 to 23.5% (19.9%) in 2007 and to 21.8% (18.1%) in 2012, while OPN data shows a decline from 28.6% (25.0%) in 2000 to 22.0% (19.2%) in 2007, to 22.0% (17.9%) in 2012. In terms of relative reductions, the OPN data indicated a decrease of 23.1% in adult male smokers (vs. 23.2% adult female smokers), while SimSmoke projected a relative reduction of 17.9% (20.1%) between 2000 and 2007. For the period between 2000 and 2012, the relative reduction based on OPN data resulted in 23.1% for adult males (vs. 28.4% females), compared to the SimSmoke projected reduction of 23.7% (27.2%). Thus, the relative reduction differed by 5% (3%) for males (females) in 2000-2007 and by -0.4% (1.2%) for males (females) in 2000-2012.

In examining reductions by age groups, the model also did well (within 6% variation) for most age groups in 2000-2007 and 2000-2012, except for males ages 16-24 and females ages 16-

24 and 60+ in 2000-2012. For males (females) ages 16-24, the relative reduction in OPN smoking was 16.1% (18.6%) compared with a 19.1% (18.6%) relative reduction from *SimSmoke* during 2000-2007 and 32.4% (32.6%) during 2000-2012 from OPN compared with 24.9% (25.0%) from *SimSmoke*. We note, however, that our predictions for this age group were sensitive to the year chosen, since OPN smoking prevalence for males in that age group fell precipitously between 2011 and 2012. For male (female) smoking ages 25-34, the relative reduction in OPN was 25.9% (27.7%) during 2000-2007 and 19.0% (32.1%) during 2000-2012, compared with a 20.8% (18.5%) during 2000-2007 and 25.3% (22.7%) during 2000-2012 relative reduction from *SimSmoke*. For male (female) smoking ages 35-59, the relative reduction in OPN (weighted average of age 34-49 and 50-59) was 20.0% (20.0%) during 2000-2007 and 20.8% (26.6%) during 2000-2012 compared with 13.7% (17.7%) during 2000-2007 and 19.7% (24.5%) during 2000-2012 from *SimSmoke*. For male (female) smoking over age 60, the OPN relative reduction was 22.6% (25.7%) during 2000-2007 and 18.2% (23.0%) during 2000-2012 compared with 17.2% (26.4%) during 2000-2007 and 21.8% (35.5%) during 2000-2012 from *SimSmoke*.

Adults age 16+ male (female) smoking rate from the HSE showed a 13.8% (16.6%) relative reduction between 2000 and 2007 and a 19.5% (29.6%) relative reduction between 2000 and 2012, compared to 17.9% (20.1%) and 23.7% (27.2%) relative reduction predicted by *SimSmoke*. For male (female) smoking ages 16-24, the relative reduction in HSE was 23.7% (24.5%) during 2000-2007 and 21.8% (36.1%) during 2000-2012 compared with a 19.1% (18.6%) relative reduction during 2000-2007 and 24.9% (25.0%) during 2000-2012 from *SimSmoke*. For male (female) smoking ages 25-44, the relative reduction in HSE (weighted average of age 25-34 and 35-44) was 15.1% (14.3%) during 2000-2007 and 21.0% (34.2%)

during 2000-2012, compared with a 17.2% (18.1%) during 2000-2007 and a 21.9% (23.5%) during 2000-2012 from *SimSmoke*. For male (female) smoking ages 45-64, the relative reduction in HSE was 15.0% (11.3%) during 2000-2007 and 16.7% (16.2%) during 2000-2012 compared with a 13.8% (20.2%) during 2000-2007 and a 18.3% (25.9%) during 2000-2012 from *SimSmoke*. For male (female) smoking ages over 65, the relative reduction in HSE was 1.0% (29.4%) during 2000-2007 and 28.3% (37.3%) during 2000-2012 compared with 26.4% (28.8%) during 2000-2007 and 29.2% (37.8%) during 2000-2012 from *SimSmoke*. By age groups, the model also did well (within 10%) for the difference in relative reduction for most age groups, except for males ages 65 and above during 2000-2007.

Adult age 16+ male (female) smoking from the STS shows a 13.5% (20.9%) relative reduction between 2007 and 2012 compared to a 7.2% (8.8%) relative reduction predicted by *SimSmoke*. The relative reduction differed by 6.3% (12.1%) for males (females) in 2007-2012. For male (female) smoking ages 16-24, the 2007-2012 relative reduction in STS was 23.5% (34.2%) compared with a 7.2% (7.8%) relative reduction from *SimSmoke*. For male (female) smoking ages 25-44, the 2007-2012 relative reduction in STS was 4.5% (21.3%) compared with a 5.8% (6.6%) from *SimSmoke*. For male (female) smoking ages 45-64, the 2007-2012 relative reduction in STS was 16.6% (16.1%) compared with a 5.3% (7.2%) from *SimSmoke*. For male (female) smoking ages over 65, the 2007-2012 relative reduction in STS was 15.4% (3.3%) compared with 3.8% (12.6%) from *SimSmoke*. By age groups, the model generally under-estimated the relative reduction by an absolute 10-26% compared to the STS, except males age 25-44 (over-estimated by 0.3%) and females age 65 and above (overestimated by 9.4%).

Adult ages 18 and above male (female) smoking from the APS shows a 1.1% (4.3%) relative reduction between 2010 and 2012 compared to a 2.6% (3.2%) relative reduction

predicted by *SimSmoke*. For male (female) smoking ages 18-24, the 2010-2012 relative reduction in APS was 1.0% (8.6%) compared with a 3.0% (3.1%) relative reduction from *SimSmoke*. For male (female) smoking ages 25-44, the 2010-2012 relative reduction in APS was -1.3% (4.9%) compared with a 2.1% (2.3%) from *SimSmoke*. For male (female) smoking ages 45-65, the 2010-2012 relative reduction in APS was 0.0% (-1.3%) compared with a 1.6% (2.1%) from *SimSmoke*. For male (female) smoking ages over 65, the 2010-2012 relative reduction in APS was 11.8% (7.1%) compared with 0.2% (4.0%) from *SimSmoke*. By age groups, the model also did well (within 3%) for most age groups, except for males ages 65 and above (underestimated by 12%) and females ages 18-24 (underestimated by 6%).

Impact of Policies on Smoking Prevalence in the No-Vaping Counterfactual in 2000-2019

The effects of policies implemented between 2000 and 2019 in England are shown separately for male and female prevalence rates and smoking-attributable deaths in Table 3a. In 1993, the number of total smoking-attributable deaths was 40,819 for males and 27,406 for females. With policies implemented, this number decreased to 35,831 male and 22,241 female deaths in 2019. Compared with no new policies implemented after 2000, *SimSmoke* projected that male smoking prevalence had been reduced by 28% by 2019 increasing to 35% by 2040 and female smoking prevalence had been reduced by 30% by 2019 increasing to 36% in 2040. A total of 77,454 male and 58,744 females cumulative smoking-attributable deaths were averted by 2019 and 278,448 males and 194,222 female premature deaths will be averted by 2040.

Among individual policies, price increases alone were estimated to have reduced male smoking rates in relative terms by 8% in 2019 increasing to 11% by 2040. Smoke-free air laws yielded a 6% relative reduction in male smoking by 2019 increasing to 7% by 2040. The relative reductions were 4% by 2019 and 2040 for cessation treatments, 1% by 2019 and 2040 for

tobacco control expenditures, 5% in 2019 increasing to 6% in 2040 for health warnings (including plain packaging), and 0% increasing to 1% for youth access enforcement. For male smokers in 2040, taxes represented 30% of total policy effects, followed by smoke-free air laws (19%), and health warnings (18%). Similar results were obtained for females.

Validation Sensitivity Analysis of Applying Only ONS Cigarette Price Index

The analysis above used a combined dataset for the price module in the model and we used the ONS cigarette price index in 2000-2007 and the estimated STS cigarette price in 2007-2012 for the validation. We also simulated the smoking prevalence using only the ONS cigarette price index over the validation period 2000-2012 (table 4b). Compared with CPI-adjusted STS price in 2007-2012 that increased by 10.2% (from $4.1 to $5.2), CPI-adjusted ONS cigarette price index in 2007-2012 increased by 22.5% (from $4.1 to $6.03 when match with STS price in 2007), implying an 11% (122.5%/110.5%) relative difference over 2007-2012. The greater increase from using only STS price index resulted in a greater predicted prevalence reduction. The relative reduction for male (female) adults age 18 and above was 8.4% (10.0%) in 2007-2012, which is 1.3% (1.2%) greater in absolute terms compared with 7.1% (8.8%) using combined price data. The relative reduction for males (females) age 18-24 was 10.3% (10.8%) in 2007-2012 which is 2.9% (3.0%) greater in absolute terms compared with 7.4% (7.8%) using combined price data. The relative reduction for males (females) age 25-44 was 6.8% (7.7%) in 2007-2012 which is 1.0% (1.1%) greater in absolute terms compared with 5.8% (6.6%) using combined price data. The relative reduction for males (females) age 45-64 was 5.9% (7.8%) in 2007-2012 which is 0.6% (0.6%) greater in absolute terms compared with 5.3% (7.2%) using combined price data. The relative reduction for males (females) age 65 and above was 5.2% (13.9%) in 2007-2012, 1.3% (1.1%) greater in absolute terms compared with 3.8% (12.6%)

using combined price data. Younger age groups (e.g., 3.0% change for age 16-24) showed greater change in the relative reduction compared with that in older age groups (e.g. 1.2% change for age 45-64).

Impact of Policies on Smoking Prevalence in the No-Vaping Counterfactual in 2000-2019

The effects of policies implemented between 2000 and 2019 in England are shown separately for male and female prevalence rates and smoking-attributable deaths in Table 3a. In 1993, the number of total tobacco-attributable deaths was 40,819 for males and 27,406 for females. With policies implemented, this number decreased to 35,831 male and 22,241 female deaths in 2019. Compared with no new policies implemented after 2000, *SimSmoke* projected that male smoking prevalence had been reduced by 28% by 2019 increasing to 35% by 2040 and female smoking prevalence had been reduced by 30% by 2019 increasing to 36% in 2040. A total of 77,454 male and 58,744 females cumulative smoking-attributable deaths were averted by 2019 and 278,448 males and 194,222 female premature deaths will be averted by 2040.

Among individual policies, price increases alone were estimated to have reduced male smoking rates in relative terms by 8% in 2019 increasing to 11% by 2040. Smoke-free air laws yielded a 6% relative reduction in male smoking by 2019 increasing to 7% by 2040. The relative reductions were 4% by 2019 and 2040 for cessation treatments, 1% by 2019 and 2040 for tobacco control expenditures, 5% in 2019 increasing to 6% in 2040 for health warnings (including plain packaging), and 0% increasing to 1% for youth access enforcement. For male smokers in 2040, taxes represented 30% of total policy effects, followed by smoke-free air laws (19%), and health warnings (18%). Similar results were obtained for females.

Impact of Policies on Smoking Prevalence in the No-Vaping Counterfactual of Policies Implemented from 2012-2019

Because the analysis of the implied impact of NVPs depends most directly on policy impacts during the post-2012 period (after NVPs), we consider the impact of policies over the period 2012-2019. The effects of policies implemented between 2012 and 2019 in England are shown separately for male and female prevalence rates and smoking-attributable deaths in Table 3b. In 2012, the smoking prevalence for age 18 and above (adult) is 22.0% for males and 18.2% for females. If no policy changed after 2012, the smoking prevalence would be reduced to 20.9% for males and 17.1% for females by 2019. With the three policies increased after 2019, including cigarette taxes/ marketing restrictions ban /health warning, the adult smoking prevalence for in 2019 for each would decline to 20.5% / 20.9% / 20.9% for males and 16.7% / 17.1% / 17.1% for females, which are 2.1% / 0.2% / 0.2% lower for males and 2.2% / 0.2% / 0.2% lower for females in relative terms. When all policies were implemented (actual status quo), the adult smoking prevalence declines to 20.4% for males and 16.6% for females in 2019, which are 2.6% lower for males and 2.7% for females.

Sensitivity Analysis of Altering the Policies Effects Sizes in 2012-2019 of Policies Implemented between 2000 and 2019

The analysis in Table 3.b. focused only on policies implemented between 2012 and 2019. However, some policies implemented before 2012 continue to have impacts after 2019. The result for altering the effect sizes of all policies including residual effects in 2012-2019 of policies implemented between 2000-2019 relative to their lower and upper bounds in 2012-2019 is shown in table 4a. By setting all effect sizes to the lower value (reduce 25% for price elasticity and 50% for others), the smoking prevalence for age 18+ in 2012-2019 was reduced by

2.6%, which is 4.7% lower than the best estimated reduction (7.3%) for males, and reduced by 3.6% which is 4.8% lower than the best estimated reduction (8.4%) for females. By setting all effect sizes to the greater value (increase 25% for price elasticity and 50% for others), the smoking prevalence for age 18+ in 2012-2019 increased by 12.0% which is 4.7% higher than the best estimated reduction (7.3%) for males and increased by 13.2% which is 4.8% higher than the best estimated reduction (8.4%) for females. By single policy, a relative reduction in the smoking rate for age 18+ in 2012-2019 is most sensitive to the cessation treatment which may increase or fall by 1.1% when its effect size is increased or decreased for both genders. Next is health warnings (+/-1.0%), price and tax (+/-0.8%), smoke-free air laws (+/-0.8%), marketing bans (+/-0.7%), mass media campaign (+/-0.3%), and youth access (+/-0.1%) for both genders.

The impact of altering the effect sizes also varied by age group. The relative reduction for ages 18-24 may increase or decrease by 9%-10% when all effect sizes increased or decreased, only 3% for ages 25-44 and 3%-4% for ages 45-64, and 7%-8% for ages 65+.

Sensitivity Analysis of Smoking Prevalence in the No-Vaping Counterfactual in 2012-2019 of Marginally Increased Policies in 2012-2019

To focus on the specific policies implemented between 2012-2019, we conducted sensitivity analysis only on policies implemented between 2012 and 2019 and not on those policies stayed unchanged after 2012. The sensitivity analysis for altering the effect sizes only for the marginal increase in the implemented in 2012-2019 polices (only applicable to price, marketing bans, and health warnings) is shown in table 4b. For age 18 and above, by assuming 25% higher and lower for the effect sizes only in the increased portion of price, the relative reduction in 2012-2019 would vary by 0.6% (0.6% lower for the reduced effect size and higher for the increased effect size) from the best estimated 7.3% reduction for males, and 8.4% for

females. By assuming 50% higher and lower for the effect sizes only in the increased portion of marketing bans, the relative reduction in 2012-2019 would vary by 0.1% (0.1% lower for the reduced effect size and higher for the increased effect size). By assuming 50% higher and lower for the effect sizes only in the increased portion of health warnings, the relative reduction in 2012-2019 would vary by 0.1-0.2% (0.2% lower for the reduced effect size and 0.1% higher for the increased effect size). By assuming all three policies at their low and high levels at the same time, the relative reduction in 2012-2019 would vary by 0.8-0.9% (6.5%-8.1% relative reduction for males, and 7.5-9.2% for females). The impact of altering the effect sizes in the increased portion of the policies also varied by age group and is most affective for those age 18-24.

Validation and Sensitivity Analysis of Applying the ONS Cigarette Price Index

The analysis above used a combined dataset for the price module in the model, in which we used the ONS cigarette price index in 2000-2007 and the estimated STS cigarette price in 2007-2012 for the validation. We also simulated the smoking prevalence using only the ONS cigarette price index over the validation period 2000-2012 (table 4c). Compared with CPI-adjusted STS price in 2007-2012 that increased by 10.2% (from $4.1 to $5.2), CPI-adjusted ONS cigarette price index in 2007-2012 increased by 22.5% (from $4.1 to $6.03 when match with STS price in 2007), implying an 11% (122.5%/110.5%) relative difference over 2007-2012. The greater increase from using only STS price index resulted in a greater predicted prevalence reduction. The relative reduction for male (female) adults age 18 and above was 8.4% (10.0%) in 2007-2012, which is 1.3% (1.2%) greater in absolute terms compared with 7.1% (8.8%) using combined price data. The relative reduction for males (females) age 18-24 was 10.3% (10.8%) in 2007-2012 which is 2.9% (3.0%) greater in absolute terms compared with 7.4% (7.8%) using combined price data. The relative reduction for males (females) age 25-44 was 6.8% (7.7%) in

2007-2012 which is 1.0% (1.1%) greater in absolute terms compared with 5.8% (6.6%) using combined price data. The relative reduction for males (females) age 45-64 was 5.9% (7.8%) in 2007-2012 which is 0.6% (0.6%) greater in absolute terms compared with 5.3% (7.2%) using combined price data. The relative reduction for males (females) age 65 and above was 5.2% (13.9%) in 2007-2012, 1.3% (1.1%) greater in absolute terms compared with 3.8% (12.6%) using combined price data. Younger age groups (e.g., 3.0% change for age 16-24) showed greater change in the relative reduction compared with that in older age groups (e.g. 1.2% change for age 45-64).

The results for altering the policy levels (only applicable for price in 2007-2019 and media campaign levels in 2010-2019) to alternative specifications is shown in table 4c. For age 18 and above, compared to the best estimated that reduced by 29.1% for males and 33.1% for females in 2000-2019, using only ONS price data would obtain 33.1% relative reduction for males and 37.0% for females which are 4% higher for both genders, and assuming a low-level media campaign since 2010 would obtain 27.8% relative reduction for males and 31.8% for females, which are 1.3% lower for both genders. The impact of altering the altering the policies levels is consistent across age groups.

The Implied Impact of NVPs on Smoking Prevalence Relative to the No-Vaping Counterfactual in 2012-2019

To estimate the potential impact of NVPs, we compared the projected trend in smoking prevalence that would have occurred in the absence of vaping from *SimSmoke* to data on actual trends in smoking prevalence over the period 2012-2018/19 from four national surveys. The results are presented in Table 5.

For males ages 16 and above, OPN data showed a relative reduction in smoking

prevalence of about 21% (with the range from 11% to 31%) in 2012-2019, which was 14% (with the range from 4% to 24%) higher than the *SimSmoke* estimate. For females of the same age group, OPN data showed a reduction of 23% (12%, 34%), 15% (4%, 25%) higher than *SimSmoke*. HSE showed a relative reduction in male (female) smoking prevalence of about 17% with the range from 10% to 23% (14% with the range from 6% to 21%) in 2012-2018, 11% with the range from 4% to 17% (6% with the range from -1% to 13%) higher than *SimSmoke*. STS showed a relative reduction in male (female) smoking prevalence of about 24% with the range from 21% to 28% (21% with the range from 17% to 25%) in 2012-2019, 17% with the range from 14% to 21% (13% with the range from 9% to 17%) higher than *SimSmoke*. For ages 18 and above, APS, the largest survey with the most stable patterns, showed a relative reduction of male (female) smoking prevalence about 28% with the range from 26% to 29% (29% with the range from 27% to 31%) in 2012-2019, 20% with the range from 19% to 22% (20% with the range from 19% to 22%) higher than *SimSmoke*. The difference implies potential reductions of 4%-24% for males and -1%-25% for females associated with NVPs in 2012-2018/19.

For males ages 16-24, OPN showed a relative reduction in smoking prevalence of 3% (with the range from -38% to 43%) in 2012-2019, suggesting a decline of 4% (-36%, 45%) from *SimSmoke*. For females, OPN showed a reduction of 25% (-11%, 61%), 18% (-18%, 54%) higher than *SimSmoke*. HSE showed a relative reduction in male (female) smoking prevalence of 13% with the range from -6% to 29% (28% with the range from 5% to 46%) in 2012-2018, 6% with the range from -12% to 22% (21% with the range from -2% to 39%) higher than *SimSmoke*. STS showed a relative reduction of 18% with the range from 10% to 27% (31%, 22%-39%), 11% with the range from 3% to 20% (24%, 15%-32%) higher than *SimSmoke* by 2019. For ages 18-24, APS showed a relative reduction of 34% with the range from 30% to 39% (39%, 35%-

44%) in 2012-2019, 27% with the range from 23% to 32% (32%, 27%-37%) higher than *SimSmoke*.

For males ages 25-34, OPN showed a relative reduction in smoking prevalence of 22% (with the range from -4% to 48%) in 2012-2019, suggesting an increase of 15% (-11%, 41%) from *SimSmoke*. For females, OPN showed a reduction of 3% (-28%, 34%), 4% (-27%, 35%) lower than *SimSmoke*. HSE showed a relative reduction in smoking prevalence of 4% (with the range from -10% to 17%) in 2012-2018, suggesting a decrease of 2% (-12%, 16%) from *SimSmoke*. For females, HSE showed an increase of 3% (-11%, 19%), 9% (-6%, 25%) lower than *SimSmoke*. APS showed a relative reduction in smoking prevalence of 25% (with the range from 22% to 29%) in 2012-2019, suggesting an increase of 19% (15%, 22%) from *SimSmoke*. For females, APS showed a reduction of 22% (18%, 26%), 15% (11%, 19%) higher than *SimSmoke*.

For ages 25-44, HSE showed a relative decline in male smoking prevalence of 15%, 9% higher than *SimSmoke*. For females, HSE showed a reduction of 5%, 1% lower than *SimSmoke*. STS showed a relative reduction for male (female) smoking prevalence of 27% with the range from 22% to 31% (12%, 5%-18%) in 2012-2019, 20% with the range from 15% to 25% (5%, -1%-12%) higher than *SimSmoke*. APS showed a relative decline in male smoking prevalence of 15%, 9% higher than *SimSmoke*. For females, APS showed a reduction of 27%, 21% higher than *SimSmoke*.

For males ages 35-44, HSE showed a relative decline in smoking prevalence of 26% (13%-38%) in 2012-2018, 20% (6%-32%) higher than *SimSmoke*. For females, HSE showed a reduction of 14% (-2%-28%), 7% (-9%-21%) higher than *SimSmoke*. APS showed a relative decline in smoking prevalence of 30% (26%-33%) in 2012-2019, 23% (20%-26%) higher than

SimSmoke. For females, APS showed a reduction of 33% (30%-37%), 26% (23%-30%) higher than *SimSmoke*.

For males ages 35-49, OPN showed a relative decline in smoking prevalence of 29% (11%-48%) in 2012-2019, 24% (6%-43%) higher than *SimSmoke*. For females, OPN showed a reduction of 33% (11%-55%), 26% (4%-49%) higher than *SimSmoke*.

For males ages 35-59, OPN showed a relative reduction in male (female) smoking prevalence of 22% (29%) in 2012-2019, 17% (21%) higher than *SimSmoke*.

For males ages 45-54, HSE showed a relative decline in smoking prevalence of 14% (-3%-29%) in 2012-2018, 14% (-3%-29%) higher than *SimSmoke*. For females, HSE showed a reduction of 14% (-0.3%-28%), 10% (-5%-23%) higher than *SimSmoke*. APS showed a relative decline in male smoking prevalence of 23% (19%-26%) in 2012-2019, 22% (18%-26%) higher than *SimSmoke*. For females, APS showed a reduction of 26% (22%-29%), 20% (17%-24%) higher than *SimSmoke*.

For males ages 45-64 over the period 2012-2018, HSE showed a relative decline in smoking prevalence of 16%, 12% higher than *SimSmoke*. For females, HSE showed a reduction of 13%, 7% higher than *SimSmoke*. STS showed a relative decline in male smoking prevalence of 23% (17%-29%) in 2012-2019, 18% (12%-24%) higher than *SimSmoke*. For females, STS showed a reduction of 20% (13%-26%), 13% (7%-20%) higher than *SimSmoke*. APS showed a relative reduction for male (female) smoking prevalence of 24% (24%) in 2012-2019, 19% (18%) higher than *SimSmoke*.

For males ages 50-59, OPN showed a relative decline in smoking prevalence of 10% (-14%-33%) in 2012-2019, 7% (-17%-30%) higher than *SimSmoke*. For females, OPN showed a reduction of 20% (-4%-43%), 13% (-11%-37%) higher than *SimSmoke*.

For males ages 55-64 over the period 2012-2018, HSE showed a relative decline in smoking prevalence of 18% (-1%-34%), 9% (-9%-25%) higher than *SimSmoke*. For females, HSE showed a reduction of 9% (-10%-25%), 4% (-15%-20%) higher than *SimSmoke*. APS showed a relative decline in male smoking prevalence of 25% (21%-28%) in 2012-2019, 15% (11%-19%) higher than *SimSmoke*. For females, APS showed a reduction of 23% (19%-27%), 17% (13%-21%) higher than *SimSmoke*.

For males ages 60+ over the period 2012-2019, OPN showed a relative decline in smoking prevalence of 27% (12%-42%), 18% (3%-33%) higher than *SimSmoke*. For females, OPN showed a reduction of 26% (14%-40%), 16% (3%-30%) higher than *SimSmoke*.

For males ages 65-74 over the period 2012-2018, HSE showed a relative decline in smoking prevalence of 17% (-5%-34%), 12% (-10%-29%) higher than *SimSmoke*. For females, HSE showed a reduction of 19% (-2%-36%), 8% (-13%-25%) higher than *SimSmoke*.

For age 65 and above, HSE showed a relative reduction in male (female) smoking prevalence of 18% (16%) in 2012-2018, 12% (6%) higher than *SimSmoke*. STS showed a relative decline in smoking prevalence of 11% (-2%-23%) in 2012-2019, 4% (-8%-17%) higher than *SimSmoke*. For females, STS showed a reduction of 29% (19%-38%), 17% (7%-27%) higher than *SimSmoke*. APS showed a relative decline in smoking prevalence of 20% (15%-25%) in 2012-2019, 14% (9%-18%) higher than *SimSmoke*. For females, APS showed a reduction of 27% (22%-31%), 15% (11%-19%) higher than *SimSmoke*.

For males ages 75+ over the period 2012-2018, HSE showed a relative decline in smoking prevalence of 21% (-30%-53%), 16% (-35%-47%) higher than *SimSmoke*. For females, HSE showed a reduction of 13% (-21%-39%), 3% (-32%-28%) higher than *SimSmoke*.

In general, the impacts are greatest at younger ages, where NVP use is generally found to

be highest, consistent with evidence that e-cigarette use is most prevalent at those ages. The effect of NVPs over the 2012-2019 varies depending on the survey. The results by age from the OPN show considerable instability. We focus on the APS (ages 18 and above) and the STS results (ages 16 and above) with the range based on their 95% CIs in 2019, although HSE and OPN results are generally between those two estimates. For all adults, the APS and STS in 2012-2019 results indicate relative reductions in the range of 14%-22% for males and 9%-22% for females lower than those predictions in the *SimSmoke* No-vaping Scenario. By age group, the same two surveys indicate ranges of 3%-32% for males and 15%-36% for females at ages 16 (18)-24, of 15%-26% for males and -1%-30% for females ages 25-44, of 11%-26% for males and 7%-24% for females ages 45-64, and of -8%-18% for males and 7%-27% for females ages 65 and above.

Impact of NVP Use during 2012-2019 on Future Smoking Prevalence and Smoking-Attributable Deaths

The estimates above from the APS and STS on the relative reduction in smoking prevalence by age and gender over 2012-2019 were converted into annual average relative reductions by gender and age group and applied to the *SimSmoke* model to obtain predictions in the NVP Scenario. The predictions for smoking prevalence and SADs from the NVP and the No-NVP Scenario (the adjusted and unadjusted *SimSmoke* predictions) were then compared, as shown in Tables 6 and 7.

When converted to the annual reductions, the smoking prevalence for males (females) in APS data annually fell by 4.5% with the range of 4.2%-4.8% (4.7% with the range of 4.4%-5.1%) for ages 18 and above, 5.8% with the range of 4.9%-6.7% (6.8%, 5.9%-7.9%) for ages 18-24, 4.1% with the range of 3.5%-4.7% (3.4%, 2.8%-4.1%) for ages 25-34, 4.9% with the range

of 4.3%-5.5% (5.6%, 5.0%-6.4%) for ages 35-44, 3.6% with the range of 3.0%-4.3% (4.1%, 3.6%-4.9%) for ages 45-54, 4.0% with the range of 3.3%-4.6% (3.6%, 2.9%-4.4%) for ages 55-64, and 3.1% with the range of 2.3%-4.0% (4.3%, 3.5%-5.2%) for ages 65 and above. While the male (female) prevalence in the STS data annually fell by 3.9% with the range of 3.3%-4.5% (3.3%, 2.7%-4.0%) for ages 16 and above, 2.8% with the range of 1.4%-4.3% (5.1%, 3.5%-6.9%) for ages 16-24, 4.3% with the range of 3.4%-5.2% (1.8%, 0.8%-2.8%) for ages 25-44, 3.6% with the range of 2.6%-4.8% (3.1%, 2.0%-4.3%) for ages 45-64, and 1.6% with the range of -0.3%-3.8% (4.7%, 3.0%-6.6%) for ages 65 and above. The males (females) smoking prevalence from the unadjusted (No-NVP) *SimSmoke* fell 1.1% (1.2%) annually for ages 16 and above, 1.1% (1.2%) for ages 18 and above, 1.0% (1.0%) for ages 16-24, 1.0% (1.1%) for ages 18-24, 1.0% (1.0%) for ages 25-34, 0.9% (0.9%) for ages 25-44, 1.0% (1.1%) for ages 35-44, 0.1% (0.9%) for ages 45-54, 0.7% (0.9%) for ages 45-64, 1.4% (0.9%) for ages 55-64, and 0.9% (1.8%) for ages 65 and above. Subtracting the male (female) annual reduction in *SimSmoke* from the surveys, the NVP adjuster using APS was estimated as 4.8% with the range of 3.9%-5.7% (5.7%, 4.8%-6.8%) for ages 18-24, 3.1% with the range of 2.5%-3.7% (2.4%, 1.8%-3.1%) for ages 25-34, 3.9% with the range of 3.3%-4.6% (4.5%, 3.9%-5.3%) for ages 35-44, 3.5% with the range of 2.9%-4.2% (3.3%, 2.7%-4.0%) for ages 45-54, 2.6% with the range of 1.9%-3.2% (2.7%, 2.1%-3.5%) for ages 55-64, and 2.2% with the range of 1.4%-3.0% (2.6%, 1.8%-3.4%) for ages 65 and above. From STS, the male (female) NVP adjuster was 1.8% with the range of 0.4%-3.3% (4.0%, 2.4%-5.8%) for ages 16-24, 3.4% with the range of 2.5%-4.3% (0.8%, -0.1%-1.9%) for ages 25-44, 2.9% with the range of 1.9%-4.1% (2.2%, 1.1%-3.3%) for ages 45-64, and 0.7% with the range of -1.2%-2.8% (2.9%, 1.2%-4.9%) for ages 65 and above.

By incorporating the NVP adjusters to the model, the APS and STS NVP-adjusted *SimSmoke* model predicted similar reductions in 2012-2018/19 as the APS and STS surveys for all adults by gender. In APS, Male (female) smoking prevalence at ages 18+ fell 28% with the range of 26%-29% (29%, 27%-31%) from 2012 to 2019, compared with a relative reduction of 26% with the range of 22%-29% (25%, 22%-29%) in the APS NVP-adjusted *SimSmoke.* In STS, male (female) smoking prevalence for ages 16 and above fell 24% with the range of 21%-28% (21%, 17%-25%) from 2012-2019, compared with a relative reduction of 21% with the range of 16%-27% (19%, 12%-25%) in STS NVP-adjusted *SimSmoke*. Similar reductions are also obtained between the NVP-adjusted *SimSmoke* model and the surveys by gender and age group.

We then compared the predictions from the NVP-adjusted *SimSmoke* for 2012-2052 to those of the unadjusted *SimSmoke*. The relative reduction of male (female) smoking prevalence from APS NVP-adjusted *SimSmoke* was 33% with the range of 31%-34% (40%, 38%-42%) at ages 45-64 compared to a 22% (30%) relative reduction predicted by No-vaping *SimSmoke* model, and a 52% with the range of 50%-54% (49%, 47%-51%) relative reduction at ages 65 and above compared to 42% (41%) in the unadjusted model. The relative reduction of male (female) smoking prevalence from STS NVP-adjusted *SimSmoke* was 27% with the range of 24%-31% (36%, 33%-39%) at ages 45-64 and a 53% with the range of 50%-55% (45%, 41%-48%) relative reduction at ages 65 and above. No difference for both genders at younger ages (ages 16-44) during the long-term prediction.

Using the APS adjustment, *SimSmoke* predicted 27,673 male and 17,761 female SADs compared to a No-NVP *SimSmoke* prediction of 28,052 for males and 17,998 for females in 2013, resulting in 378 fewer male and 236 fewer female SADs in 2013. Cumulatively over the period 2012-2052, the APS NVP-adjusted model predicted 107,238 fewer male and 58,422

fewer females SADs (165,660 fewer total SADs) compared to the No-NVP *SimSmoke* prediction. Using the STS adjustment, *SimSmoke* predicted 237 fewer male and 224 fewer female SADs in 2013. Cumulatively over the period 2012-2052, STS-adjusted NVP *SimSmoke* predicted 87,102 fewer male SADs and 41,516 fewer female SADs (128,617 fewer total SADs) compared to the No-NVP prediction.

DISCUSSION

Due to the inherent uncertainty in developing stable transitions involving NVP use, we have developed a novel, indirect method for gauging the impact of NVPs. *England SimSmok*e validated well through the year 2012, just before NVP use became more widespread. By comparing the projected trends in smoking from 2012-2019 (the No-NVP counterfactual) to actual trends from four different surveys, we indirectly inferred the potential effects of NVPs on cigarette use. Based on this methodology, we estimated the implied NVP-related relative reduction in adult smoking prevalence of about 20.2% for males and 20.4% for females using the APS, the largest survey. The implied relative reductions were larger for the 18-24 age group, but otherwise relatively consistent across age groups.

The results indicate that NVPs played an important role in reducing smoking prevalence in England in 2012-2019. Other studies have found significant impacts of NVPs on smoking cessation[52,57-63] and initiation[64] in England. Based on a time-series analysis with a 34.3% quit attempt rate of which 35.2% used e-cigarettes with a 6% increase in quit success rate and 5.4% increase in overall quit rate, Beard et al.[52] estimated between 0.7% (34.3%×35.2%×6%) and 1% (18.5% smokers×5.4% quit rate per smoker) of smokers additionally quit as a consequence of e-cigarette use in 2017, similar to an earlier estimate.[59] The Beard et al. rates are lower than our annual estimated annual reduction of about 3% from APS and 2% from STS, but are based on

data for 2017 before the relatively larger smoking reduction observed in 2018 and 2019 and do not incorporate any impact of NVP use on initiation, long-term relapse and quitting by other smokers. For example, contact with individuals using NVPs was found to increase the likelihood of smoker quit attempts and quit success.[65]

We also estimated the impact of the 2012-2019 NVP-related reduction in smoking prevalence on smoking-attributable deaths. Based on the APS estimates, we projected 166,000 fewer smoking-attributable deaths from 2012-2052. While some of the reduction in smoking-attributable deaths will be offset by NVP-attributable deaths, the mortality risks of exclusive NVP use are expected to be substantially less than for smokers.[66-68] In addition, our estimates are only for the reduction in smoking prevalence inferred for NVP use during the years 2012-2019. Additional smoking-attributable deaths would be averted from any NVP-induced reduction in smoking after 2019, although those who had previously switched to NVPs or quit all use may also relapse back to smoking.

Our results is subject to limitations. The results depend on the assumption built into the model and the data used in the model. The impact of NVPs is inferred based on the *SimSmoke* projection of smoking prevalence in the absence of NVP, but controlling for the impact of new and previously implemented tobacco control policies. This method assumes that vaping was the only factor not modelled that would have substantially influenced smoking prevalence trends. However, the inferred impact of NVPs may be due to other factors not incorporated into the model, such as changes in the effectiveness of policies, cigarette companies' reactions to policies or changes in attitude toward risks as reflected by changes in alcohol consumption.[69,70] Nevertheless, *England SimSmoke* was validated for years 2000-2012 (before NVPs became

popular) and generally performed well, and *SimSmoke*[14-25] has generally been well-validated for countries that have implemented a wide range of policies.

The model depends on a particular set of policy effect sizes that define the magnitude and time pattern of policy impacts. Over the post-2012 period (when NVPs became more prominent), only cigarette prices, marketing restrictions and packaging policies changed. Using upper and lower bounds for policy effects (+/-50% of the policy effect, except +/- 25% for taxes) based on a literature review,[71] we applied these bounds to policy changes in SimSmoke projections over the time period 2012-2019. The relative reduction in the adult smoking prevalence was 7.3% (6.5%-8.1%) for males and 8.4% (7.5%- 9.2%) for females. Thus, the uncertainty regarding policy changes for 2012-2019 was found to contribute to only an 0.8% absolute variation in the male and female SimSmoke projections for 2019, thus having little impact on the projected net impact of NVP. For example, based on the APS prevalence, the implied NVP impact for males is 20.2% (19.4%- 21.0%), thus implying 4% (0.8%/20.2%) of the variation. The effects were greatest for price, which alone contributed to 0.6% of the 0.8% deviation.

We also considered different measures of policy levels. When we used an ONS cigarette price index (based on retail prices) instead of STS prices (based on prices paid) during 2007-2019, the inferred impact of NVPs on smoking prevalence was reduced in absolute terms by 4.1% (approximately half of the 7.3%-8.4 relative reduction due to policies) in 2012-2019. In addition, two studies[72,73] indicate that media campaigns were substantially reduced in 2010 (to what would be considered a low level). When we denoted a low instead of a moderate level media campaign in 2010-2019, the inferred impact of NVPs increased in absolute terms by 0.5% by 2019, thus implying a larger impact.

While we attribute a relatively small impact of the recent decline smoking prevalence to policies, strong cigarette-oriented policies in England both before and after 2012 may have played a major role by enhancing the impact of NVPs. In examining trends in smoking prevalence relative to a scenario where policies are maintained at 2000 levels, *England SimSmoke* projects that smoking prevalence had been reduced by about 29% between 2000 and 2019 due to policies. Conducting the same for the period 2012-2019, only 36% (2.7%/7.3%) of male and 33% (2.7%/8.4%) of the female relative reduction in smoking prevalence was attributable to policies by 2019. However, the effect of past and newly implemented cigarette-oriented policies may have been enhanced by the availability of NVPs, since smokers had a potentially viable alternative to cigarettes. For example, NVPs have been found to be a substitute for cigarettes in demand studies[74-77] and NVPs have been used in England as an alternative by those having failed with traditional cessation treatments.[6-9,78,79] Thus, by providing a viable substitute for smoking, part of the impact of NVPs may be the indirect impact of making past and newly implemented cigarette-oriented policies more effective.

Another limitation is that the NVP-related impacts depend of the accuracy of estimates from the surveys. Because the estimates of prevalence for a given year vary considerably among the surveys and in comparison to SimSmoke projections, we focused on relative reductions in smoking prevalence (i.e., relative to initial prevalence levels) from *SimSmoke* and from surveys. However, the relative reductions varied substantially from survey to survey, thus providing an indication of the uncertainty in our results. We also conducted a sensitivity analysis based on the 95% confidence intervals in the 2019 survey estimates to further indicate the uncertainty in our estimates, which indicated considerable uncertainty. We note that these estimates imply greater uncertainty for specific age groups, especially those at younger ages. Further, our validation in

some cases depended on the year chosen for some surveys. When we examined the sensitivity of results to the initial and final year chosen for examining NVP-related impacts, we obtained similar results using the years 2011, 2012 and 2013 as the initial projection years, but results were more sensitive to the choice of the final projection year. For example, the STS male (female) smoking prevalence showed a relative reduction of 24% (21%) for 2012-2019 compared to a reduction of 15% (13%) for 2012-2018 reduction.

In conclusion, England provides a valuable case study because it already had strong tobacco control policies directed at smoking. Yet, our analysis indicates substantial reductions associated with NVP use observed across both genders and all age groups. While our model does not distinguish the role of NVP-oriented from cigarette-oriented policies, the impact of NVPs may have been greater due to the strong cigarette-oriented policies working in tandem with relatively extensive, but proportionate NVP policies. Further research using models that explicitly incorporate NVP use and the resulting transitions to and from cigarette use and studies evaluating the impact of cigarette-oriented vis-a-vis NVP-oriented policies can shed further light on the public health impact of NVPs. However, as new models are developed, it will be important to compare the results of the different models in order to develop a better understanding of the impact of NVPs.

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Mathematical Appendix

The No-VNP Scenario

SimSmoke divides the population in the base year (2000) into (1) never smokers (*Never*), (2) smokers (*Smoker)*, and (3) 17 categories of former smokers (FS_q, q<1, 1, …, ≥16) corresponding to quit years (q) since last time smoking.

After the base year, individuals are classified as never smokers from birth until they initiate (*Init*) smoking or die (with smoking specific death rate *DR*). Because the population does not become smokers before age 15, we use the population data at age 0-14 from ONS for all years as the population of never smokers instead of projecting new births from age 0. Since age 15, the never smoker population, distinguished by gender g, age a, and time t, as described by:

$$Never_{g,a+1,t+1} = Never_{g,a,t} * (1 - DR^{N}_{g,a}) * (1\text{-}Init^{N}_{g,a,t}) \quad 1.1)$$

Initiation depends on current (not past) initiation rates, which vary by age and gender. They are measured by changes in base year prevalence from age 15 to age through ages 25 for males and age 19 females, they incorporate initiation minus cessation, thus reflecting net initiation.

Due to short smoking history of those reduced smokers under the last age of initiation because of the NVP adjustment, those reduced smokers are categorized as never smokers in the model and the projection of never smokers are temporarily revised in 2013-2019 by:

$$Never_{g,a+1,t+1} = Never_{g,a,t} * (1 - DR^{N}_{g,a}) * (1\text{-}Init^{N}_{g,a,t}) + Smoker_{g,a,t} * (1 - DR^{S}_{g,a}) * Adjust_{g,a,t} \quad 1.2)$$

From never smokers, individuals can become smokers through initiation. Smokers may quit smoking through cessation (*Cess*) and former smokers may return to smoking through

relapse (*Relap*). They vary by age and gender and are assumed constant over time subject to changes in policy. The number of current smokers is tracked as:

$$Smoker_{g,a+1,t+1} = Never_{g,a,t}*(1 - DR^{N}_{g,a})*Init^{N}_{g,a,t} + Smoker_{g,a,t}*(1 - DR^{S}_{g,a})*(1\text{-}Cess^{S}_{g,a,t}) + \Sigma^{16+}_{q<1} FS_{g,a,t,q}*(1 - DR^{FS}_{g,a,t,q})*(Relap^{FS}_{g,a,t,q}) \quad 2.1)$$

To gauge the impact of NVP use in 2012-2018/19 by age groups, we first estimated the average annual reduction in smoking prevalence by age group from each of the surveys assuming a constant relative reduction as implied by an exponential function to the percent reduction in the smoking prevalence, i.e., 1- $(SmokePrev_{2018} / SmokePrev_{2012})^{1/6}$ = the percent reduction in smoking prevalence each year. We conducted the same analysis for *SimSmoke* predictions by age groups to correct for underlying trends and the effects of policies on smoking prevalence. The average year reduction derived for *SimSmoke* was then subtracted from the rates derived from the surveys to obtain the yearly NVP adjustment to the smoking prevalence in *SimSmoke*. We applied an optimistic (higher adjuster) and a pessimistic rate (lower adjuster) to the model. No NVP effect was assumed for the two age groups that had greater relative reduction from *SimSmoke* than from the surveys (males age 65 and above and females age 25-44 for STS adjustment). The NVP adjuster ($Adjust_{g,a}$) were developed for the 16/18-24 (generalized to all ages under 24 in the model), 25-44, 45-64 and 65 and above age groups by gender and were applied to the non-adjusted *SimSmoke* predictions (without NVP adjustment). The NVP-adjusted smoking prevalence (*Smoker'*) was estimated by incorporating the NVP adjustments into the *SimSmoke* model as a new permanent reduction each year to the unadjusted smoking prevalence (*Smoker*) prediction by age and gender. *SimSmoke* projected smoking prevalence at age *a+1* in year *t+1* equal to the *SimSmoke* projected smoking prevalence at age *a* in year *t* multiplied by (1

– cessation rate at age *a*-NVP adjustment at age *a*). The second term in the equation for projecting the smokers are temporarily revised in 2013-2019 by

$$+ Smoker_{g,a,t} * (1 - DR^{S}_{g.a}) * (1 - Cess^{S}_{g,a,t} - Adjust_{g,a}) . \quad 2.2)$$

where $Adjust_{g,a} = (Smoker_{g,a+1,2018} - Smoker_{g,a+1,2012})^{1/6}$

New former smokers are determined by the cessation rate and surviving smokers in previous year.

$$FS_{g,a+1,t+1,q<1} = Smoker_{g,a,t} * (1 - DR^{S}_{g.a,t}) * Cess^{S}_{g,a,t} \quad 3.1)$$

After the first year quit, individuals who have been former smokers at least 1, 2, …, 16+ years are defined as:

$$FS_{g,a+1,t+1,q+1} = FS_{g,a,t,q} * (1 - DR^{FS}_{g,a,t,q}) * (1 - Relap^{FS}_{g,a.q}). \quad 3.2)$$

Due to no relapse is assumed to those quitters because of NVP adjustment, those quitters (*FS'*) are tracked separately in years 2013-2019:

$$FS'_{g,a+1,t+1,q<1} = Smoker_{g,a,t} * (1 - DR^{S}_{g.a,t}) * Adjust_{g,a,t} \quad for\ new\ quitters \quad 3.3)$$

$$FS'_{g,a+1,t+1,q+1} = FS'_{g,a,t,q} * (1 - DR^{FS}_{g,a,t,q}) \quad after\ the\ first\ year\ quit \quad 3.4)$$

Relapse rates vary by age and gender and years quit, and are assumed constant over time, independent of changes in policy. They do not depend on past cessation behaviors. For those who have quit smoking for more than fifteen years, we add to the above equation the number of former smokers from the previous year who have quit for more than fifteen years and have not died or relapsed in the previous year.

Smoking-Attributable Death Model

Smoking-attributable deaths are estimated for each age and smoking group by multiplying the number of current or former smokers in that group by the difference between the death rate of that smoking group and the death rate of never smokers. Since the death rates of

specific types of smokers are not available, age-, gender- and year-specific (2000-2009 and 2011-2017) overall death rates ($DR^{Overall}_{g,a,t}$) were used which were derived from the overall number of deaths and population in England and Wales collected from ONS. The death rates by age and gender in 2010 was not available so that we assigned the average of death rates at the same age and gender in 2009 and 2011 for that year. Using the assumed relative risk of smoking ($RR^{S}_{g,a,t}$) from US *SimSmoke* model, we first estimated the relative death risk (compared to the death risk of smokers) of former smokers. These relative risks were then applied to the annually changing overall death rate to obtain their respect annually changing death rates using the standard attribution method.

For the relative risk of former smoking, by assuming a log-linear relationship between the death rate of former smokers and current smokers, we first estimate the relative risk of former exclusive smoking using a time-independent adjuster by years quit (r_q):

$$RR^{FS}_{g,a,q} = exp(r_q * ln(RR^{S}_{g,a})) \quad 4)$$

therefore the relative risk of former smokers compared to smokers is:

$$RR^{FS\ vs\ S}_{g,a,q} = RR^{FS}_{g,a,q} / RR^{S}_{g,a,q}$$

$$= exp(r_q * ln(RR^{S}_{g,a})) / RR^{S}_{g,a.} \quad 5)$$

To estimate the age, gender, year, and smoking group-specific death rates, we applied the standard attribution method and used the age, gender, and year specific number of smokers, relative risks (both relative to never smokers and relative to current smokers), and overall death rates ($DR^{Overall}_{g,a,t}$). The overall death rate could be expressed as:

$$DR^{Overall}_{g,a,t} = Deaths^{Overall}_{g,a,t} / Popn_{g,a,t}$$

$$= (Deaths^{N}_{g,a,t} + Deaths^{S}_{g,a,t} + \Sigma_{a//q} Deaths^{FS}_{g,a,t,q}) / Popn_{g,a,t}$$

$$= [Never_{g,a,t} * DR^{N}_{g,a,t} + Smoker_{g,a,t} * DR^{S}_{g,a,t} + \Sigma_{a//q} (FS_{g,a,t} * DR^{FS}_{g,a,t,q})] / Popn_{g,a,t}$$

$$= (Never_{g,a,t} * DR^{N}_{g,a,t} + Smoker_{g,a,t} * DR^{S}_{g,a,t} + DR^{S}_{g,a,t} * [\Sigma_{a//q} (FS_{g,a,t} * RR^{FS\ vs\ S}_{g,a,q})]) / Popn_{g,a,t}$$

$$= DR^{N}_{g,a,t} * (Never_{g,a,t} + Smoker_{g,a,t} * RR^{S}_{g,a} + RR^{S}_{g,a} * [\Sigma_{a//q} (FS_{g,a,t} * RR^{FS\ vs\ S}_{g,a,q})]) / Popn_{g,a,t} \quad 6)$$

where $Deaths^{Overall}_{g,a,t}$ and $Deaths^{N}_{g,a,t}$ etc represent the numbers of death in each group and $Popn_{g,a,t}$ represent the size of total population for gender *g*, age *a*, and year *t*. Therefore, the death rate of never smokers could be expressed as:

$$DR^{N}_{g,a,t} = DR^{Overall}_{g,a,t} * Popn_{g,a,t} / \{Never_{g,a,t} + Smoker_{g,a,t} * RR^{S}_{g,a} + RR^{S}_{g,a} * [\sum_{a// q} (FS_{g,a,t} * RR^{FS\ vs\ S}_{g,a,q})]\}$$

And the death rate of smokers and former smokers could be expressed as:

$$DR^{S}_{g,a,t} = RR^{S}_{g,a} * DR^{N}_{g,a,t}$$
$$DR^{FS}_{g,a,t} = RR^{FS}_{g,a} * DR^{N}_{g,a,t} = RR^{FS\ vs\ S}_{g,a,q} * DR^{S}_{g,a,t}$$

Policy Effects on Initiation and Cessation Rates

Tobacco control policies affect individuals' intention and decision in smoking initiation and cessation, and they are quantified to adjust the initiation and cessation rates in both the No-NVP period and NVP period.

In both the No-NVP Scenario before 2012 and the NVP Scenario since 2012, the smoking initiation rates and otherwise smoking rates ($Init^{N}_{g,a,t}$) from never smokers are subject to change in policies annually at all ages. The effect of each policy (e.g. Policy A, Policy B, Policy C…) in year t is quantified by a positive number (e.g. $f_{init,A}$ *(Policy A in year t),* $f_{init,B}$*(Policy B in year t),* $f_{init,C}$*(Policy C in year t)…*) and adjusts the initiation rates in a multiplicative fashion:

$Init^{N}_{g,a,t} * f_{init,A}$*(Policy A in year t)* $* f_{init,B}$*(Policy B in year t)* $* f_{init,C}$*(Policy C in year t)…*

and its opposite non-initiation rate is:

$[1 - Init^{N}_{g,a,t} * f_{init,A}$*(Policy A in year t)* $* f_{init,B}$*(Policy B in year t)* $* f_{init,C}$*(Policy C in year t)…]*

in the transition equations from never smokers.

Similar to the policy adjustment made to the multipliers in initiation rates, in both the no-NVP Scenario before 2012 and the NVP Scenario since 2012, the smoking cessation rates from smokers are subject to change in policies annually at all ages. The effect of each policy (e.g.

Policy A, Policy B, Policy C…) in year t is quantified by a positive number (e.g. $f_{cess,A}$ *(Policy A in year t),* $f_{cess,B}$ *(Policy B in year t),* $f_{cess,C}$*(Policy C in year t)…*) and adjusts the cessation rates in a multiplicative fashion:

$Cess^{S}_{g,a,t} * f_{cess,A}$*(Policy A in year t)* $* f_{cess,B}$*(Policy B in year t)* $* f_{cess,C}$*(Policy C in year t)…*

and its opposite smoking rate is:

[1 - $Cess^{S}_{g,a,t} * f_{cess,A}$*(Policy A in year t)* $* f_{cess,B}$*(Policy B in year t)* $* f_{cess,C}$*(Policy C in year t)…]*

in the transition equations from smokers.

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Table 1. Tobacco control policies, specifications and effect sizes applied in England SimSmoke

Policy	Description	Policy Effect Size
Cigarette Excise Taxes		
Cigarette price/tax	The effect of taxes is directly incorporated through the average price after tax. The price elasticity is used to convert the price changes (%) into effect sizes.	Elasticities
		-0.4 for ages 14-17
		-0.3 for ages 18-24
		-0.2 for ages 25-34
		-0.1 for ages 35-64
		-0.2 for ages 65+
Smoke-Free Air Laws		
Worksite smoking ban	Ban in all indoor worksites, with strong enforcement of laws (reduced by 1/3 if allowed in ventilated areas and by 2/3 if allowed in common areas)	-6% prevalence and initiation, +6% cessation
Restaurant smoking ban	Ban in all indoor restaurants (scaled for lower coverage), with strong enforcement of laws	-2% prevalence and initiation, +2% cessation
Pubs and bars smoking ban	Ban in all indoor in pubs and bars (scaled for lower coverage), with strong enforcement of laws	-1% prevalence and initiation, +1% cessation
Other place bans	Ban in 3 out of 4 government buildings (scaled for lower coverage), retail stores, public transportation, and elevators, with strong enforcement of laws	-1% prevalence and initiation, +1% cessation
Enforcement and Publicity	Government agency enforces the laws and publicity via tobacco control campaigns	Effects reduced 50% absent publicity and enforcement
Media Campaigns		
High level media campaign	Campaign publicized heavily with state and local programs with strong funding (>$0.50 USD)	-6.5% prevalence and initiation, +6.5% cessation
Medium level media campaign	Campaign publicized with funding of at least $0.10 USD per capita	-3.25% prevalence and initiation, +3.25% cessation
Low level media campaign	Campaign publicized only sporadically with minimal funding (<$0.10 USD per capita)	-1.63% prevalence and initiation, +1.63% cessation
Marketing Restrictions		
Comprehensive marketing ban	Ban on all forms of direct advertising including point of sale and indirect marketing	-5% prevalence, -8% initiation, +4% cessation
Moderate marketing ban	Ban on broadcast media, newspapers and billboards marketing and at least some indirect marketing (sponsorship, branding, giveaways)	-3% prevalence, -4% initiation, +2% cessation
Minimal marketing ban	Ban on broadcast media advertising	-1% prevalence and -1% initiation only
Enforcement	Government agency enforces the laws	Effects reduced 50% absent enforcement

Health Warnings		
Additional impact of plain packaging with strong health warnings	The outside of the package is drab, with brand and variant names appearing once on the front, top and bottom surfaces, and no inserts.	-2% prevalence -2% initiation, +2% cessation
High health warnings	Labels are large, bold and graphic, and cover at least 50% of pack	-4% prevalence, -6% initiation, +10% cessation
Moderate health warnings	Laws cover at least 30% of package, not bold or graphic	-2% prevalence, -2% initiation, +4% cessation
Low health warnings	Laws cover less than 30% of package, not bold or graphic	-1% prevalence, -1% initiation, +2% cessation
Cessation Treatment Policies		
Availability of pharmacotherapies	Legality of nicotine replacement therapy and/or Bupropion and Varenicline	-1% prevalence, +4% cessation
Cessation treatment financial coverage	Payments to cover pharmacotherapy and behavioral cessation treatment with high publicity (Effect size reduced by 12.5% with moderate publicity and 18.75% with low publicity)	-2.25% prevalence, +8% cessation
Quit line	Three quit line types: passive, proactive and active with follow-up. (Effect size reduced by 1/3 if quit line is proactive, reduced by 2/3 if quit line passive).	-1% prevalence, +6% cessation
Brief interventions	Advice by health care provider to quit and methods provided	-1% prevalence, +6% cessation
All cessation policies combined	Complete availability and reimbursement of pharmaco- and behavioral treatments, quit lines, and brief interventions	-5.68% prevalence, +29.4% cessation
Youth Access Policies		
Strong enforcement & well publicized	Compliance checks conducted 4 times per year per outlet, penalties are potent and enforced with heavy publicity	-16% initiation and prevalence for ages 16-17 and -24% for ages 10-15
Moderate enforcement with some publicity	Compliance checks conducted regularly, penalties are potent, and publicity and merchant training are included	-8% initiation and prevalence ages 16-17 and -12% for ages 10-15
Low enforcement	Compliance checks are conducted sporadically, penalties are weak	-2% initiation and prevalence ages 16-17 and -3% ages 10-15

Notes: Unless otherwise indicated, the effects are in terms of the reduction in prevalence during the first year. The reduction in initiation rates and the increase in quit rates take effects during the years that the policy is in effect.

Table 2. Validation of England SimSmoke current smoking prevalence predictions against national surveys, by age and gender, 2000-2012

Age	Source	2000	2007	2012	*Percent change 2000-2007*	*Percent change 2007-2010*	*Percent change 2010-2012*	*Percent change 2007-2012*	*Percent change 2000-2012*
Male									
16+	SimSmoke	28.6	23.5	21.8	-17.9%	-4.7%	-2.6%	-7.2%	**-23.7%**
	OPN	28.6	22.0	22.0	-23.1%	-8.2%	8.9%	0.0%	**-23.1%**
	HSE	27.6	23.8	22.2	-13.8%	-7.6%	1.1%	-6.6%	**-19.5%**
	STS		25.6	22.1		-8.4%	-5.6%	-13.5%	
18+	SimSmoke	28.8	23.7	22.0	-17.6%	-4.7%	-2.6%	-7.1%	**-23.5%**
	APS			21.8			-1.1%		
16-24	SimSmoke	33.1	26.7	24.8	-19.1%	-4.4%	-2.9%	-7.2%	**-24.9%**
	OPN	33.6	28.2	22.7	-16.1%	-17.7%	-2.2%	-19.5%	**-32.4%**
	HSE	32.5	24.8	25.5	-23.7%	-11.3%	15.5%	2.5%	**-21.8%**
	STS		31.8	24.3		-14.3%	-10.7%	-23.5%	
18-24	SimSmoke	35.7	29.2	27.0	-18.4%	-4.6%	-3.0%	-7.4%	**-24.4%**
	APS			27.4			-1.0%		
25-34	SimSmoke	38.1	30.2	28.5	-20.8%	-3.8%	-1.9%	-5.7%	**-25.3%**
	OPN	39.0	28.9	31.6	-25.9%	-6.9%	17.5%	9.3%	**-19.0%**
	APS			28.8			-2.1%		
	HSE	36.5	34.0	28.2	-7.1%	1.6%	-18.3%	-17.0%	**-22.9%**
25-44	SimSmoke	35.1	29.1	27.4	-17.2%	-3.7%	-2.1%	-5.8%	**-21.9%**
	HSE	35.7	30.3	28.2	-15.1%	0.2%	-7.1%	-6.9%	-21.0%
	STS		30.4	29.0		-2.4%	-2.2%	-4.5%	
	APS			27.3			1.3%		
35-44	SimSmoke	32.0	28.1	26.3	-12.1%	-3.9%	-2.6%	-6.4%	**-17.8%**
	APS			25.8			4.8%		
	HSE	34.8	27.1	28.2	-22.1%	-2.4%	6.6%	4.0%	**-18.9%**
35-49	SimSmoke	31.1	26.8	25.3	-13.9%	-3.8%	-1.7%	-5.5%	**-18.6%**
	OPN	31.1	24.6	24.3	-20.9%	-2.8%	1.7%	-1.2%	**-21.9%**
35-59	SimSmoke	29.4	25.4	23.6	-13.7%	-4.5%	-2.5%	-6.9%	**-19.7%**
	OPN	29.5	23.6	23.4	-20.0%	-5.6%	4.9%	-1.0%	**-20.8%**
45-54	SimSmoke	28.2	23.3	22.1	-17.3%	-3.9%	-1.2%	-5.1%	**-21.5%**
	APS			22.4			2.9%		
	HSE	28.3	25.1	24.1	-11.5%	-16.8%	15.5%	-4.0%	**-15.0%**
45-64	SimSmoke	26.4	22.7	21.5	-13.8%	-3.8%	-1.6%	-5.3%	**-18.3%**
	HSE	26.4	22.5	22.0	-15.0%	-13.0%	12.6%	-2.0%	**-16.7%**
	STS		24.9	20.7		-11.2%	-6.2%	-16.6%	
	APS			20.7			0.0%		

50-59	SimSmoke	26.5	22.7	20.7	-14.4%	-5.7%	-3.2%	-8.7%	**-21.8%**
	OPN	26.9	21.9	21.9	-18.6%	-11.0%	12.3%	0.0%	**-18.6%**
55-64	SimSmoke	24.1	22.1	20.8	-8.1%	-3.7%	-2.2%	-5.9%	**-13.5%**
	APS			18.7			-4.2%		
	HSE	24.1	19.6	19.5	-18.5%	-7.9%	8.0%	-0.6%	**-19.0%**
60+	SimSmoke	16.6	13.8	13.0	-17.2%	-3.1%	-2.5%	-5.6%	**-21.8%**
	OPN	15.9	12.3	13.0	-22.6%	1.6%	4.0%	5.7%	**-18.2%**
65-74	SimSmoke	16.7	13.8	13.8	-17.0%	-1.6%	1.1%	-0.6%	**-17.4%**
	HSE	14.4	13.6	11.8	-5.4%	4.5%	-17.0%	-13.2%	**-17.9%**
65+	SimSmoke	14.5	10.7	10.3	-26.4%	-4.0%	0.2%	-3.8%	**-29.2%**
	HSE	12.0	11.9	8.6	-1.0%	-16.8%	-12.9%	-27.5%	**-28.3%**
	STS		10.9	9.3		-7.3%	-8.8%	-15.4%	
	APS			10.5			-11.8%		
75+	SimSmoke	11.4	6.5	5.6	-42.9%	-11.0%	-3.9%	-14.5%	**-51.1%**
	HSE	8.6	9.6	4.3	12.3%	-56.3%	1.2%	-55.8%	**-50.3%**
Female									
16+	SimSmoke	24.9	19.9	18.1	-20.1%	-5.8%	-3.2%	-8.8%	**-27.2%**
	OPN	25.0	19.2	17.9	-23.2%	-0.5%	-6.3%	-6.8%	**-28.4%**
	HSE	25.0	20.8	17.6	-16.6%	-12.2%	-3.8%	-15.5%	**-29.6%**
	STS		22.8	18.1		-15.0%	-6.9%	-20.9%	
18+	SimSmoke	24.9	19.9	18.2	-19.9%	-5.8%	-3.2%	-8.8%	**-27.0%**
	APS			17.0			-4.3%		
16-24	SimSmoke	31.5	25.6	23.6	-18.6%	-4.8%	-3.1%	-7.8%	**-25.0%**
	OPN	32.2	26.2	21.7	-18.6%	-7.3%	-10.7%	-17.2%	**-32.6%**
	HSE	34.1	25.8	21.8	-24.5%	8.4%	-22.0%	-15.5%	**-36.1%**
	STS		33.8	22.2		-19.8%	-18.0%	-34.2%	
18-24	SimSmoke	33.1	27.4	25.2	-17.3%	-4.9%	-3.1%	-7.8%	**-23.8%**
	APS			23.0			-8.6%		
25-34	SimSmoke	31.8	25.9	24.6	-18.5%	-3.6%	-1.5%	-5.1%	**-22.7%**
	OPN	32.1	23.2	21.8	-27.7%	5.6%	-11.0%	-6.0%	**-32.1%**
	APS			20.7			-5.6%		
	HSE	30.6	25.4	20.9	-16.9%	-13.7%	-4.8%	-17.8%	**-31.7%**
25-44	SimSmoke	30.0	24.6	23.0	-18.1%	-4.4%	-2.3%	-6.6%	**-23.5%**
	HSE	29.9	25.6	19.7	-14.3%	-21.1%	-2.7%	-23.2%	-34.2%
	STS		26.1	20.6		-15.7%	-6.6%	-21.3%	
	APS			19.9			-4.9%		
35-44	SimSmoke	28.2	23.5	21.5	-16.6%	-5.4%	-3.7%	-8.8%	**-24.0%**
	APS			19.0			-4.7%		
	HSE	29.3	25.8	18.5	-11.7%	-27.7%	-0.9%	-28.3%	**-36.8%**
35-49	SimSmoke	27.4	22.8	20.8	-17.1%	-5.6%	-3.0%	-8.4%	**-24.1%**
	OPN	26.7	21.9	20.6	-18.0%	-3.7%	-2.4%	-5.9%	**-22.8%**

35-59	SimSmoke	26.1	21.5	19.7	-17.7%	-5.3%	-3.2%	-8.3%	**-24.5%**
	OPN	26.4	21.2	19.4	-20.0%	-4.5%	-3.9%	-8.2%	**-26.6%**
45-54	SimSmoke	24.9	20.5	19.1	-17.4%	-4.7%	-2.3%	-6.9%	**-23.1%**
	HSE	24.9	22.0	21.3	-11.8%	-12.2%	10.3%	-3.1%	**-14.6%**
	APS			18.7			1.1%		
45-64	SimSmoke	23.7	18.9	17.6	-20.2%	-5.2%	-2.1%	-7.2%	**-25.9%**
	HSE	22.8	20.2	19.1	-11.3%	-11.9%	7.3%	-5.5%	**-16.2%**
	STS		21.8	18.3		-10.8%	-5.9%	-16.1%	
	APS			17.7			1.3%		
50-59	SimSmoke	23.7	19.1	17.7	-19.7%	-4.4%	-2.6%	-6.9%	**-25.2%**
	OPN	26.0	19.8	17.4	-23.8%	-6.1%	-6.5%	-12.1%	**-33.1%**
55-64	SimSmoke	22.3	17.2	15.7	-22.9%	-6.5%	-2.5%	-8.9%	**-29.7%**
	APS			16.4			1.3%		
	HSE	20.2	18.3	16.5	-9.1%	-12.1%	2.3%	-10.1%	**-18.2%**
60+	SimSmoke	15.8	11.7	10.2	-26.4%	-8.1%	-4.7%	-12.4%	**-35.5%**
	OPN	15.2	11.3	11.7	-25.7%	12.4%	-7.9%	3.5%	**-23.0%**
65-74	SimSmoke	17.6	12.7	11.0	-28.2%	-9.4%	-4.3%	-13.3%	**-37.7%**
	HSE	19.3	13.3	11.3	-31.3%	-6.6%	-8.9%	-14.9%	**-41.5%**
65+	SimSmoke	14.3	10.2	8.9	-28.8%	-9.0%	-4.0%	-12.6%	**-37.8%**
	HSE	14.8	10.5	9.3	-29.4%	-7.7%	-3.9%	-11.2%	**-37.3%**
	STS		11.3	10.9		-12.1%	10.1%	-3.3%	
	APS			9.0			-7.1%		
75+	SimSmoke	11.2	7.9	6.8	-29.4%	-9.6%	-4.9%	-14.1%	**-39.3%**
	HSE	10.6	7.9	7.3	-25.4%	-10.9%	3.0%	-8.3%	**-31.6%**

Notes:

1. OPN=Opinion and Lifestyle Survey conducted by UK Office of National Statistics (ONS) that measures those who have smoked cigarette regularly and currently smoke;
2. HSE=Health Survey of England conducted by NHS Digital that measures those who currently smoke;
3. APS=Annual Population Survey conducted by UK Office of National Statistics (ONS) that measures those who smoke nowadays by year 2015 but measures those who regularly smoked and smoke nowadays since 2016.
4. Data from three datasets and SimSmoke are compared by most similar age groups. For unmatching age groups in a figure, e.g. age 16+ and age 18+, the SimSmoke projection for two age groups are both provided.
5. Prevalence from APS and HSE at age 45-64 is a weighted average of age 45-54 and 55-64 by the ONS population
6. Prevalence from HSE at age 65+ is a weighted average of age 65-74 and 75+ by the ONS population
7. Prevalence from HSE and APS at age 25-44 is a weighted average of age 25-34 and 35-44 by the ONS population

Table 3a. Smoking prevalence and smoking attributable deaths projected by the unadjusted SimSmoke model under individual policy scenarios by gender, 2000-2040

Policies	MALES							FEMALES						
Prevalence	**2000**	**2012**	**2019**	**2020**	**2040**	**% change in 2019**	**% change in 2040**	**2000**	**2012**	**2019**	**2020**	**2040**	**% change in 2019**	**% change in 2040**
No policy-change	28.8%	28.9%	28.4%	28.3%	26.5%	-	-	24.9%	24.0%	23.4%	23.3%	21.6%	-	-
Actual/status quo	28.8%	22.0%	20.4%	20.2%	17.4%	-28%	-34%	24.5%	18.0%	16.5%	16.3%	13.9%	-30%	-36%
Price alone	28.8%	27.3%	26.1%	26.0%	23.5%	-8%	-11%	24.7%	22.6%	21.5%	21.3%	19.1%	-8%	-11%
Smoke-free air laws alone	28.8%	27.1%	26.6%	26.5%	24.7%	-6%	-7%	24.9%	22.6%	21.9%	21.8%	20.1%	-6%	-7%
Media campaign alone	28.8%	28.5%	28.1%	28.0%	26.1%	-1%	-1%	24.9%	23.7%	23.2%	23.0%	21.3%	-1%	-1%
Cessation treatment alone	28.8%	27.7%	27.2%	27.1%	25.4%	-4%	-4%	24.6%	23.0%	22.3%	22.2%	20.5%	-5%	-5%
Health warnings alone	28.8%	27.9%	27.1%	27.0%	24.8%	-5%	-6%	24.9%	23.1%	22.3%	22.2%	20.2%	-5%	-6%
Marketing ban alone	28.8%	27.7%	27.0%	26.9%	24.8%	-5%	-6%	24.9%	23.0%	22.3%	22.2%	20.2%	-5%	-6%
Youth access alone	28.8%	28.8%	28.3%	28.2%	26.2%	0%	-1%	24.9%	24.0%	23.3%	23.2%	21.4%	0%	-1%
Smoking-attributable deaths	**2000**	**2012**	**2019**	**2020**	**2040**	**2000-2019**	**2000-2040**	**2000**	**2012**	**2019**	**2020**	**2040**	**2000-2019**	**2000-2040**
No policy change	40,819	32,528	35,831	36,126	36,902	699,649	1,485,510	27,406	21,608	22,241	22,313	23,115	458,479	941,266
Lives saved	**2000**	**2012**	**2019**	**2020**	**2040**	**2000-2019**	**2000-2040**	**2000**	**2012**	**2019**	**2020**	**2040**	**2000-2019**	**2000-2040**
Actual/status quo	-	4,870	7,156	7,456	10,950	77,454	278,448	242	3,611	5,072	5,208	7,286	58,744	194,222
Price alone	-	867	1,394	1,433	2,331	13,894	53,863	92	677	1,009	1,036	1,483	11,261	37,877

Smoke-free air laws alone	-	1,074	1,478	1,515	2,262	15,371	57,083	-	810	1,013	1,041	1,500	11,420	39,308
Media campaign alone	-	221	296	326	454	3,673	12,132	-	161	226	231	307	2,794	8,555
Cessation treatment alone	-	1,288	1,907	1,979	2,806	21,804	74,447	151	967	1,395	1,442	2,014	16,622	54,298
Health warnings alone	-	721	1,168	1,240	2,036	10,758	46,624	-	511	818	848	1,393	7,987	32,410
Marketing ban alone	-	709	1,018	1,038	1,586	11,404	39,857	-	512	712	725	1,039	8,662	27,637
Youth access alone	-	-	-	-	25	-	155	-	-	-	-	17	-	110

Table 3b. Smoking prevalence projected by the No-NVP SimSmoke model under multiple policy scenarios by gender in 2012-2019.

Male							
Age	**Scenario**	**Range**	**2012**	**2015**	**2019**	**% change in 2019**	**Relative reduction in 2012-2019**
18+	No policy change	-	22.0	21.5	20.9		4.8%
	Price & Tax alone	0%	22.0	21.3	20.5	2.1%	6.8%
		-25%	22.0	21.4	20.6	1.5%	6.3%
		+25%	22.0	21.3	20.4	2.7%	7.4%
	Marketing ban alone	0%	22.0	21.5	20.9	0.2%	5.0%
		-50%	22.0	21.5	20.9	0.1%	4.9%
		+50%	22.0	21.5	20.9	0.3%	5.1%
	Health Warning alone	0%	22.0	21.5	20.9	0.2%	5.0%
		-50%	22.0	21.5	20.9	0.1%	4.9%
		+50%	22.0	21.5	20.9	0.4%	5.2%
	All above policies (actual)	0%	22.0	21.3	20.4	2.6%	7.3%
		-25%/-50%	22.0	21.4	20.6	1.7%	6.5%
		+25%/+50%	22.0	21.2	20.2	3.5%	8.1%
18-24	No policy change	-	27.0	26.6	26.3		2.5%
	Price & Tax alone	0%	27.0	26.1	25.3	4.1%	6.5%
		-25%	27.0	26.2	25.5	3.1%	5.5%
		+25%	27.0	25.9	25.0	5.1%	7.5%
	Marketing ban alone	0%	27.0	26.5	26.3	0.3%	2.8%
		-50%	27.0	26.6	26.3	0.1%	2.6%
		+50%	27.0	26.5	26.2	0.4%	2.9%
	Health Warning alone	0%	27.0	26.6	26.2	0.3%	2.8%
		-50%	27.0	26.6	26.3	0.1%	2.6%
		+50%	27.0	26.6	26.2	0.5%	2.9%
	All above policies (actual)	0%	27.0	26.0	25.1	4.7%	7.1%
		-25%/-50%	27.0	26.2	25.4	3.4%	5.8%
		+25%/+50%	27.0	25.9	24.8	6.0%	8.3%

25-44	No policy change	-	27.4	26.9	26.4		3.7%
	Price & Tax alone	0%	27.4	26.7	25.8	2.3%	5.8%
		-25%	27.4	26.7	26.0	1.6%	5.2%
		+25%	27.4	26.6	25.6	2.9%	6.5%
	Marketing ban alone	0%	27.4	26.9	26.3	0.1%	3.8%
		-50%	27.4	26.9	26.4	0.0%	3.7%
		+50%	27.4	26.9	26.3	0.2%	3.9%
	Health Warning alone	0%	27.4	26.9	26.3	0.2%	3.8%
		-50%	27.4	26.9	26.4	0.1%	3.7%
		+50%	27.4	26.9	26.3	0.3%	4.0%
	All above policies (actual)	0%	27.4	26.7	25.7	2.7%	6.3%
		-25%/-50%	27.4	26.7	25.9	1.8%	5.4%
		+25%/+50%	27.4	26.6	25.4	3.6%	7.1%
45-64	No policy change	-	21.5	21.4	20.8		3.3%
	Price & Tax alone	0%	21.5	21.3	20.6	1.1%	4.3%
		-25%	21.5	21.3	20.7	0.7%	4.0%
		+25%	21.5	21.2	20.5	1.4%	4.7%
	Marketing ban alone	0%	21.5	21.3	20.8	0.1%	3.4%
		-50%	21.5	21.4	20.8	0.0%	3.3%
		+50%	21.5	21.3	20.8	0.3%	3.5%
	Health Warning alone	0%	21.5	21.4	20.8	0.2%	3.5%
		-50%	21.5	21.4	20.8	0.1%	3.3%
		+50%	21.5	21.4	20.8	0.4%	3.6%
	All above policies (actual)	0%	21.5	21.2	20.5	1.6%	4.8%
		-25%/-50%	21.5	21.3	20.6	0.9%	4.2%
		+25%/+50%	21.5	21.2	20.4	2.2%	5.4%
65+	No policy change	-	10.3	10.3	9.9		4.0%
	Price & Tax alone	0%	10.3	10.2	9.7	2.0%	5.9%
		-25%	10.3	10.2	9.7	1.4%	5.3%
		+25%	10.3	10.1	9.6	2.6%	6.4%
	Marketing ban alone	0%	10.3	10.3	9.8	0.1%	4.1%
		-50%	10.3	10.3	9.8	0.0%	4.0%
		+50%	10.3	10.3	9.8	0.3%	4.2%
	Health Warning alone	0%	10.3	10.3	9.8	0.3%	4.2%
		-50%	10.3	10.3	9.8	0.1%	4.1%
		+50%	10.3	10.3	9.8	0.5%	4.4%
	All above policies (actual)	0%	10.3	10.2	9.6	2.6%	6.4%
		-25%/-50%	10.3	10.2	9.7	1.6%	5.5%
		+25%/+50%	10.3	10.1	9.5	3.5%	7.3%

Female							
Age	**Scenario**	**Range**	**2012**	**2015**	**2019**	**% change in 2019**	**Relative reduction in 2012-2019**
18+	No policy change	-	18.2	17.7	17.1		5.9%
	Price & Tax alone	0%	18.2	17.5	16.7	2.2%	7.9%
		-25%	18.2	17.6	16.8	1.6%	7.3%
		+25%	18.2	17.5	16.6	2.8%	8.5%
	Marketing ban alone	0%	18.2	17.7	17.1	0.2%	6.0%
		-50%	18.2	17.7	17.1	0.1%	5.9%
		+50%	18.2	17.7	17.1	0.3%	6.1%
	Health Warning alone	0%	18.2	17.7	17.1	0.2%	6.1%
		-50%	18.2	17.7	17.1	0.1%	5.9%
		+50%	18.2	17.7	17.0	0.4%	6.2%
	All above policies (actual)	0%	18.2	17.5	16.6	2.7%	8.4%
		-25%/-50%	18.2	17.6	16.8	1.8%	7.5%
		+25%/+50%	18.2	17.5	16.5	3.6%	9.2%
18-24	No policy change	-	25.2	24.8	24.5		2.8%
	Price & Tax alone	0%	25.2	24.3	23.5	4.2%	6.9%
		-25%	25.2	24.4	23.8	3.2%	5.9%
		+25%	25.2	24.2	23.2	5.3%	7.9%
	Marketing ban alone	0%	25.2	24.7	24.5	0.3%	3.0%
		-50%	25.2	24.8	24.5	0.1%	2.9%
		+50%	25.2	24.7	24.4	0.4%	3.2%
	Health Warning alone	0%	25.2	24.8	24.5	0.3%	3.1%
		-50%	25.2	24.8	24.5	0.1%	2.9%
		+50%	25.2	24.8	24.4	0.5%	3.2%
	All above policies (actual)	0%	25.2	24.2	23.4	4.8%	7.4%
		-25%/-50%	25.2	24.4	23.7	3.5%	6.1%
		+25%/+50%	25.2	24.1	23.0	6.1%	8.7%
25-44	No policy change	-	23.0	22.6	22.2		3.6%
	Price & Tax alone	0%	23.0	22.4	21.6	2.3%	5.8%
		-25%	23.0	22.5	21.8	1.6%	5.2%
		+25%	23.0	22.3	21.5	3.0%	6.5%
	Marketing ban alone	0%	23.0	22.6	22.1	0.1%	3.7%
		-50%	23.0	22.6	22.2	0.0%	3.6%
		+50%	23.0	22.6	22.1	0.2%	3.8%

	Health Warning alone	0%	23.0	22.6	22.1	0.2%	3.8%
		-50%	23.0	22.6	22.1	0.1%	3.6%
		+50%	23.0	22.6	22.1	0.3%	3.9%
	All above policies (actual)	0%	23.0	22.4	21.5	2.8%	6.3%
		-25%/-50%	23.0	22.5	21.8	1.8%	5.3%
		+25%/+50%	23.0	22.3	21.3	3.7%	7.1%
45-64	No policy change	-	17.6	17.3	16.7		4.8%
	Price & Tax alone	0%	17.6	17.2	16.5	1.1%	5.9%
		-25%	17.6	17.3	16.6	0.8%	5.6%
		+25%	17.6	17.2	16.5	1.5%	6.2%
	Marketing ban alone	0%	17.6	17.3	16.7	0.2%	5.0%
		-50%	17.6	17.3	16.7	0.0%	4.9%
		+50%	17.6	17.3	16.7	0.3%	5.1%
	Health Warning alone	0%	17.6	17.3	16.7	0.2%	5.1%
		-50%	17.6	17.3	16.7	0.1%	4.9%
		+50%	17.6	17.3	16.7	0.4%	5.2%
	All above policies (actual)	0%	17.6	17.2	16.5	1.6%	6.4%
		-25%/-50%	17.6	17.3	16.6	1.0%	5.7%
		+25%/+50%	17.6	17.2	16.4	2.2%	7.0%
65+	No policy change	-	8.9	8.5	8.1		9.4%
	Price & Tax alone	0%	8.9	8.5	7.9	2.0%	11.2%
		-25%	8.9	8.5	8.0	1.4%	10.6%
		+25%	8.9	8.4	7.9	2.6%	11.7%
	Marketing ban alone	0%	8.9	8.5	8.1	0.1%	9.5%
		-50%	8.9	8.5	8.1	0.0%	9.4%
		+50%	8.9	8.5	8.0	0.2%	9.6%
	Health Warning alone	0%	8.9	8.5	8.0	0.2%	9.6%
		-50%	8.9	8.5	8.1	0.1%	9.5%
		+50%	8.9	8.5	8.0	0.4%	9.7%
	All above policies (actual)	0%	8.9	8.5	7.9	2.5%	11.7%
		-25%/-50%	8.9	8.5	7.9	1.6%	10.8%
		+25%/+50%	8.9	8.4	7.8	3.4%	12.5%

Table 4a: Sensitivity analysis of smoking prevalence (%) at age 18+ by gender under multiple policy effects sizes in 2012-2019

Male							
Age	**Scenario**	**Range**	**2012**	**2015**	**2019**	**Relative reduction in 2012-2019**	**Difference from best estimate**
18+	Best estimate		22.0	21.3	20.4	7.3%	
	Price & Tax	-25%	22.0	21.4	20.6	6.5%	-0.8%
		+25%	22.0	21.2	20.2	8.1%	0.8%
	Media Campaigns	-50%	22.0	21.3	20.4	7.0%	-0.3%
		+50%	22.0	21.3	20.3	7.6%	0.3%
	Marketing Ban	-50%	22.0	21.4	20.5	6.6%	-0.7%
		+50%	22.0	21.2	20.2	8.0%	0.7%
	Health Warnings	-50%	22.0	21.4	20.6	6.3%	-1.0%
		+50%	22.0	21.2	20.2	8.3%	1.0%
	Youth Access	-50%	22.0	21.3	20.4	7.2%	-0.1%
		+50%	22.0	21.3	20.4	7.4%	0.1%
	Clean Air Laws	-50%	22.0	21.4	20.6	6.5%	-0.8%
		+50%	22.0	21.2	20.2	8.1%	0.8%
	Cessation Treatments	-50%	22.0	21.5	20.6	6.3%	-1.1%
		+50%	22.0	21.2	20.2	8.3%	1.0%
	All above policies	-25%/50%	22.0	21.8	21.4	2.6%	-4.7%
		+25%/50%	22.0	20.8	19.3	12.0%	4.7%
18-24	Best estimate		27.0	26.0	25.1	7.1%	
	Price & Tax	-25%	27.0	26.2	25.7	4.8%	-2.2%
		+25%	27.0	25.8	24.5	9.3%	2.2%
	Media Campaigns	-50%	27.0	26.1	25.3	6.3%	-0.7%
		+50%	27.0	26.0	24.9	7.8%	0.7%
	Marketing Ban	-50%	27.0	26.2	25.7	4.9%	-2.2%
		+50%	27.0	25.8	24.5	9.3%	2.2%
	Health Warnings	-50%	27.0	26.1	25.5	5.4%	-1.7%
		+50%	27.0	25.9	24.6	8.8%	1.7%
	Youth Access	-50%	27.0	26.1	25.3	6.5%	-0.6%
		+50%	27.0	26.0	24.9	7.7%	0.6%
	Clean Air Laws	-50%	27.0	26.2	25.7	5.0%	-2.1%
		+50%	27.0	25.9	24.5	9.2%	2.1%
	Cessation Treatments	-50%	27.0	26.0	25.1	7.1%	0.0%
		+50%	27.0	26.0	25.1	7.1%	0.0%
	All above policies	-25%/50%	27.0	26.7	27.8	-3.1%	-10.1%
		+25%/50%	27.0	25.4	22.7	16.1%	9.0%

25-44	Best estimate		27.4	26.7	25.7	6.3%	
	Price & Tax	-25%	27.4	26.7	25.8	5.6%	-0.7%
		+25%	27.4	26.6	25.5	6.9%	0.7%
	Media Campaigns	-50%	27.4	26.7	25.7	6.1%	-0.2%
		+50%	27.4	26.6	25.6	6.5%	0.2%
	Marketing Ban	-50%	27.4	26.7	25.8	5.8%	-0.4%
		+50%	27.4	26.6	25.5	6.7%	0.5%
	Health Warnings	-50%	27.4	26.7	25.9	5.6%	-0.7%
		+50%	27.4	26.6	25.5	7.0%	0.8%
	Youth Access	-50%	27.4	26.7	25.7	6.3%	0.0%
		+50%	27.4	26.7	25.7	6.3%	0.0%
	Clean Air Laws	-50%	27.4	26.7	25.8	5.8%	-0.5%
		+50%	27.4	26.6	25.5	6.8%	0.5%
	Cessation Treatments	-50%	27.4	26.8	25.9	5.4%	-0.8%
		+50%	27.4	26.5	25.4	7.1%	0.8%
	All above policies	-25%/50%	27.4	27.2	26.6	2.9%	-3.3%
		+25%/50%	27.4	26.1	24.7	9.7%	3.4%
45-64	Best estimate		21.5	21.2	20.5	4.8%	
	Price & Tax	-25%	21.5	21.3	20.6	4.4%	-0.4%
		+25%	21.5	21.2	20.4	5.1%	0.4%
	Media Campaigns	-50%	21.5	21.3	20.6	4.6%	-0.2%
		+50%	21.5	21.2	20.5	5.0%	0.2%
	Marketing Ban	-50%	21.5	21.3	20.6	4.4%	-0.4%
		+50%	21.5	21.2	20.4	5.2%	0.4%
	Health Warnings	-50%	21.5	21.3	20.7	4.0%	-0.8%
		+50%	21.5	21.2	20.3	5.6%	0.8%
	Youth Access	-50%	21.5	21.2	20.5	4.8%	0.0%
		+50%	21.5	21.2	20.5	4.8%	0.0%
	Clean Air Laws	-50%	21.5	21.3	20.6	4.3%	-0.5%
		+50%	21.5	21.2	20.4	5.3%	0.5%
	Cessation Treatments	-50%	21.5	21.4	20.8	3.6%	-1.2%
		+50%	21.5	21.1	20.3	6.0%	1.2%
	All above policies	-25%/50%	21.5	21.6	21.2	1.4%	-3.4%
		+25%/50%	21.5	20.8	19.7	8.4%	3.6%
65+	Best estimate		10.3	10.2	9.6	6.4%	
	Price & Tax	-25%	10.3	10.2	9.7	5.5%	-0.9%
		+25%	10.3	10.1	9.5	7.3%	0.9%
	Media Campaigns	-50%	10.3	10.2	9.6	5.9%	-0.5%
		+50%	10.3	10.1	9.5	6.9%	0.5%
	Marketing Ban	-50%	10.3	10.2	9.7	5.6%	-0.9%
		+50%	10.3	10.1	9.5	7.3%	0.9%

	Health Warnings	-50%	10.3	10.3	9.8	4.6%	-1.8%
		+50%	10.3	10.1	9.4	8.2%	1.8%
	Youth Access	-50%	10.3	10.2	9.6	6.4%	0.0%
		+50%	10.3	10.2	9.6	6.4%	0.0%
	Clean Air Laws	-50%	10.3	10.2	9.7	5.1%	-1.3%
		+50%	10.3	10.1	9.5	7.7%	1.3%
	Cessation Treatments	-50%	10.3	10.3	9.9	3.4%	-3.0%
		+50%	10.3	10.0	9.3	9.3%	2.9%
	All above policies	-25%/50%	10.3	10.6	10.4	-1.8%	-8.2%
		+25%/50%	10.3	9.7	8.7	14.8%	8.4%
Female							
Age			**2012**	**2015**	**2019**	**Relative reduction in 2012-2019**	**Difference from best estimate**
18+	Best estimate		18.2	17.5	16.6	8.4%	
	Price & Tax	-25%	18.2	17.6	16.8	7.6%	-0.8%
		+25%	18.2	17.5	16.5	9.2%	0.8%
	Media Campaigns	-50%	18.2	17.5	16.7	8.1%	-0.3%
		+50%	18.2	17.5	16.6	8.7%	0.3%
	Marketing Ban	-50%	18.2	17.6	16.8	7.7%	-0.7%
		+50%	18.2	17.5	16.5	9.1%	0.7%
	Health Warnings	-50%	18.2	17.6	16.8	7.4%	-1.0%
		+50%	18.2	17.5	16.5	9.4%	1.0%
	Youth Access	-50%	18.2	17.5	16.7	8.3%	-0.1%
		+50%	18.2	17.5	16.6	8.5%	0.1%
	Clean Air Laws	-50%	18.2	17.6	16.8	7.6%	-0.8%
		+50%	18.2	17.5	16.5	9.2%	0.8%
	Cessation Treatments	-50%	18.2	17.6	16.9	7.2%	-1.2%
		+50%	18.2	17.4	16.4	9.5%	1.1%
	All above policies	-25%/50%	18.2	17.9	17.5	3.6%	-4.8%
		+25%/50%	18.2	17.1	15.8	13.2%	4.8%
18-24	Best estimate		25.2	24.2	23.4	7.4%	
	Price & Tax	-25%	25.2	24.4	23.9	5.3%	-2.1%
		+25%	25.2	24.1	22.8	9.5%	2.1%
	Media Campaigns	-50%	25.2	24.3	23.5	6.8%	-0.7%
		+50%	25.2	24.2	23.2	8.1%	0.7%
	Marketing Ban	-50%	25.2	24.4	23.9	5.4%	-2.0%
		+50%	25.2	24.1	22.9	9.4%	2.0%
	Health Warnings	-50%	25.2	24.3	23.7	5.9%	-1.5%
		+50%	25.2	24.2	23.0	9.0%	1.6%

	Youth Access	-50%	25.2	24.3	23.5	6.7%	-0.7%
		+50%	25.2	24.2	23.2	8.1%	0.7%
	Clean Air Laws	-50%	25.2	24.3	23.8	5.5%	-1.9%
		+50%	25.2	24.2	22.9	9.3%	1.9%
	Cessation Treatments	-50%	25.2	24.2	23.4	7.4%	0.0%
		+50%	25.2	24.2	23.4	7.4%	0.0%
	All above policies	-25%/50%	25.2	24.8	25.7	-2.0%	-9.5%
		+25%/50%	25.2	23.8	21.2	15.9%	8.4%
25-44	Best estimate		23.0	22.4	21.5	6.3%	
	Price & Tax	-25%	23.0	22.4	21.7	5.6%	-0.6%
		+25%	23.0	22.3	21.4	6.9%	0.6%
	Media Campaigns	-50%	23.0	22.4	21.6	6.1%	-0.2%
		+50%	23.0	22.4	21.5	6.4%	0.2%
	Marketing Ban	-50%	23.0	22.4	21.6	5.9%	-0.3%
		+50%	23.0	22.3	21.5	6.6%	0.4%
	Health Warnings	-50%	23.0	22.5	21.7	5.6%	-0.7%
		+50%	23.0	22.3	21.4	7.0%	0.7%
	Youth Access	-50%	23.0	22.4	21.5	6.3%	0.0%
		+50%	23.0	22.4	21.5	6.3%	0.0%
	Clean Air Laws	-50%	23.0	22.5	21.6	5.8%	-0.4%
		+50%	23.0	22.3	21.4	6.7%	0.4%
	Cessation Treatments	-50%	23.0	22.5	21.7	5.4%	-0.9%
		+50%	23.0	22.2	21.3	7.1%	0.9%
	All above policies	-25%/50%	23.0	22.8	22.2	3.2%	-3.1%
		+25%/50%	23.0	22.0	20.8	9.5%	3.2%
45-64	Best estimate		17.6	17.2	16.5	6.4%	
	Price & Tax	-25%	17.6	17.2	16.5	6.0%	-0.4%
		+25%	17.6	17.2	16.4	6.8%	0.4%
	Media Campaigns	-50%	17.6	17.2	16.5	6.1%	-0.3%
		+50%	17.6	17.2	16.4	6.6%	0.3%
	Marketing Ban	-50%	17.6	17.3	16.6	5.9%	-0.5%
		+50%	17.6	17.2	16.4	6.9%	0.5%
	Health Warnings	-50%	17.6	17.3	16.6	5.4%	-1.0%
		+50%	17.6	17.1	16.3	7.4%	1.0%
	Youth Access	-50%	17.6	17.2	16.5	6.4%	0.0%
		+50%	17.6	17.2	16.5	6.4%	0.0%
	Clean Air Laws	-50%	17.6	17.3	16.6	5.7%	-0.7%
		+50%	17.6	17.2	16.3	7.0%	0.7%
	Cessation Treatments	-50%	17.6	17.4	16.7	4.9%	-1.5%
		+50%	17.6	17.1	16.2	7.9%	1.5%
	All above policies	-25%/50%	17.6	17.6	17.2	2.2%	-4.2%
		+25%/50%	17.6	16.8	15.7	10.8%	4.4%

65+	Best estimate		8.9	8.5	7.9	11.7%	
	Price & Tax	-25%	8.9	8.5	7.9	10.9%	-0.8%
		+25%	8.9	8.4	7.8	12.5%	0.8%
	Media Campaigns	-50%	8.9	8.5	7.9	11.2%	-0.4%
		+50%	8.9	8.4	7.8	12.1%	0.4%
	Marketing Ban	-50%	8.9	8.5	7.9	10.9%	-0.7%
		+50%	8.9	8.4	7.8	12.4%	0.7%
	Health Warnings	-50%	8.9	8.5	8.0	10.2%	-1.5%
		+50%	8.9	8.4	7.7	13.2%	1.5%
	Youth Access	-50%	8.9	8.5	7.9	11.7%	0.0%
		+50%	8.9	8.5	7.9	11.7%	0.0%
	Clean Air Laws	-50%	8.9	8.5	8.0	10.6%	-1.1%
		+50%	8.9	8.4	7.8	12.8%	1.1%
	Cessation Treatments	-50%	8.9	8.6	8.1	9.1%	-2.5%
		+50%	8.9	8.3	7.6	14.1%	2.4%
	All above policies	-25%/50%	8.9	8.7	8.5	4.8%	-6.9%
		+25%/50%	8.9	8.1	7.2	18.8%	7.2%

Notes:

1. OPN=Opinion and Lifestyle Survey conducted by UK Office of National Statistics (ONS) that measures those who have smoked cigarette regularly and currently smoke;
2. HSE=Health Survey of England conducted by NHS Digital that measures those who currently smoke;
3. APS=Annual Population Survey conducted by UK Office of National Statistics (ONS) that measures those who smoke nowadays by year 2015 but measures those who regularly smoked and smoke nowadays since 2016.

Table 4b: Sensitivity analysis of smoking prevalence (%) at age 18+ by gender under multiple policy effects sizes only in the marginal change of the policies in 2012-2019

Male									
Age	**Scenario**	**Range**	**2012**	**2015**	**2018**	**2019**	**Relative reduction in 2012-2019**	**Difference from best estimate**	**Relative difference from best estimate**
18+	Best estimate		22.0	21.3	20.6	20.4	7.3%		
	Price & Tax	-25%	22.0	21.4	20.7	20.5	6.7%	-0.6%	-7.9%
		+25%	22.0	21.3	20.5	20.3	7.9%	0.6%	7.9%
	Marketing Ban	-50%	22.0	21.3	20.6	20.4	7.2%	-0.1%	-1.3%
		+50%	22.0	21.3	20.5	20.4	7.4%	0.1%	1.4%
	Health Warnings	-50%	22.0	21.3	20.6	20.4	7.1%	-0.2%	-2.6%
		+50%	22.0	21.3	20.5	20.4	7.4%	0.1%	1.8%
	All above policies	-25%/50%	22.0	21.4	20.7	20.6	6.5%	-0.9%	-11.8%
		+25%/50%	22.0	21.2	20.4	20.2	8.1%	0.8%	11.1%
18-24	Best estimate		27.0	26.0	25.1	25.1	7.1%		
	Price & Tax	-25%	27.0	26.1	25.4	25.4	6.1%	-1.0%	-13.9%
		+25%	27.0	25.9	24.9	24.8	8.1%	1.0%	13.7%
	Marketing Ban	-50%	27.0	26.0	25.2	25.1	6.9%	-0.1%	-1.9%
		+50%	27.0	26.0	25.1	25.1	7.2%	0.1%	1.9%
	Health Warnings	-50%	27.0	26.0	25.2	25.1	6.9%	-0.2%	-2.5%
		+50%	27.0	26.0	25.1	25.1	7.2%	0.1%	1.8%
	All above policies	-25%/50%	27.0	26.2	25.5	25.4	5.8%	-1.3%	-18.3%
		+25%/50%	27.0	25.9	24.8	24.8	8.3%	1.2%	17.4%
25-44	Best estimate		27.4	26.7	25.8	25.7	6.3%		
	Price & Tax	-25%	27.4	26.7	26.0	25.8	5.6%	-0.6%	-10.2%
		+25%	27.4	26.6	25.7	25.5	6.9%	0.6%	10.2%
	Marketing Ban	-50%	27.4	26.7	25.8	25.7	6.2%	-0.1%	-1.2%
		+50%	27.4	26.6	25.8	25.6	6.4%	0.1%	1.6%
	Health Warnings	-50%	27.4	26.7	25.9	25.7	6.1%	-0.2%	-2.9%
		+50%	27.4	26.7	25.8	25.6	6.4%	0.1%	2.0%
	All above policies	-25%/50%	27.4	26.7	26.0	25.9	5.4%	-0.9%	-14.4%
		+25%/50%	27.4	26.6	25.6	25.4	7.1%	0.9%	13.8%
45-64	Best estimate		21.5	21.2	20.7	20.5	4.8%		
	Price & Tax	-25%	21.5	21.3	20.8	20.6	4.5%	-0.3%	-0.3%
		+25%	21.5	21.2	20.7	20.4	5.1%	0.3%	0.3%
	Marketing Ban	-50%	21.5	21.2	20.7	20.5	4.7%	-0.1%	-0.1%
		+50%	21.5	21.2	20.7	20.5	4.9%	0.1%	0.1%
	Health Warnings	-50%	21.5	21.2	20.8	20.5	4.6%	-0.2%	-0.2%
		+50%	21.5	21.2	20.7	20.5	4.9%	0.1%	0.1%
	All above policies	-25%/50%	21.5	21.3	20.9	20.6	4.2%	-0.6%	-0.6%
		+25%/50%	21.5	21.2	20.6	20.4	5.4%	0.6%	0.6%

65+	Best estimate		10.3	10.2	9.7	9.6	6.4%		
	Price & Tax	-25%	10.3	10.2	9.8	9.7	5.8%	-0.6%	-9.2%
		+25%	10.3	10.1	9.7	9.5	7.0%	0.6%	9.1%
	Marketing Ban	-50%	10.3	10.2	9.7	9.6	6.3%	-0.1%	-1.4%
		+50%	10.3	10.2	9.7	9.6	6.5%	0.1%	1.7%
	Health Warnings	-50%	10.3	10.2	9.8	9.6	6.2%	-0.2%	-3.8%
		+50%	10.3	10.2	9.7	9.6	6.6%	0.2%	2.7%
	All above policies	-25%/50%	10.3	10.2	9.8	9.7	5.5%	-0.9%	-14.4%
		+25%/50%	10.3	10.1	9.6	9.5	7.3%	0.9%	13.6%
Female									
Age	**Scenario**		**2012**	**2015**	**2018**	**2019**	**Relative reduction in 2012-2019**	**Difference from best estimate**	**Relative difference from best estimate**
18+	Best estimate		18.2	17.5	16.8	16.6	8.4%		
	Price & Tax	-25%	18.2	17.6	16.9	16.8	7.8%	-0.6%	-7.0%
		+25%	18.2	17.5	16.7	16.5	9.0%	0.6%	7.0%
	Marketing Ban	-50%	18.2	17.5	16.8	16.7	8.3%	-0.1%	-1.1%
		+50%	18.2	17.5	16.8	16.6	8.5%	0.1%	1.2%
	Health Warnings	-50%	18.2	17.5	16.9	16.7	8.2%	-0.2%	-2.2%
		+50%	18.2	17.5	16.8	16.6	8.5%	0.1%	1.6%
	All above policies	-25%/50%	18.2	17.6	17.0	16.8	7.5%	-0.9%	-10.4%
		+25%/50%	18.2	17.5	16.7	16.5	9.2%	0.8%	9.8%
18-24	Best estimate		25.2	24.2	23.4	23.4	7.4%		
	Price & Tax	-25%	25.2	24.4	23.6	23.6	6.4%	-1.0%	-13.6%
		+25%	25.2	24.1	23.2	23.1	8.4%	1.0%	13.4%
	Marketing Ban	-50%	25.2	24.3	23.4	23.4	7.3%	-0.1%	-1.7%
		+50%	25.2	24.2	23.4	23.3	7.6%	0.1%	1.7%
	Health Warnings	-50%	25.2	24.2	23.5	23.4	7.3%	-0.2%	-2.3%
		+50%	25.2	24.2	23.4	23.3	7.6%	0.1%	1.6%
	All above policies	-25%/50%	25.2	24.4	23.7	23.7	6.1%	-1.3%	-17.6%
		+25%/50%	25.2	24.1	23.1	23.0	8.7%	1.2%	16.7%
25-44	Best estimate		23.0	22.4	21.7	21.5	6.3%		
	Price & Tax	-25%	23.0	22.5	21.8	21.7	5.6%	-0.7%	-10.6%
		+25%	23.0	22.3	21.6	21.4	6.9%	0.7%	10.5%
	Marketing Ban	-50%	23.0	22.4	21.7	21.6	6.2%	-0.1%	-1.2%
		+50%	23.0	22.4	21.7	21.5	6.4%	0.1%	1.6%
	Health Warnings	-50%	23.0	22.4	21.7	21.6	6.1%	-0.2%	-2.9%
		+50%	23.0	22.4	21.7	21.5	6.4%	0.1%	2.1%
	All above policies	-25%/50%	23.0	22.5	21.9	21.8	5.3%	-0.9%	-14.8%
		+25%/50%	23.0	22.3	21.5	21.3	7.1%	0.9%	14.1%
45-64	Best estimate		17.6	17.2	16.7	16.5	6.4%		
	Price & Tax	-25%	17.6	17.2	16.7	16.5	6.0%	-0.3%	-5.3%
		+25%	17.6	17.2	16.6	16.4	6.7%	0.3%	5.3%
	Marketing Ban	-50%	17.6	17.2	16.7	16.5	6.3%	-0.1%	-1.6%
		+50%	17.6	17.2	16.7	16.4	6.5%	0.1%	1.6%
		-50%	17.6	17.2	16.7	16.5	6.2%	-0.2%	-3.1%

	Health Warnings	+50%	17.6	17.2	16.6	16.4	6.5%	0.1%	2.2%
	All above policies	-25%/50%	17.6	17.3	16.8	16.6	5.7%	-0.6%	-10.0%
		+25%/50%	17.6	17.2	16.6	16.4	7.0%	0.6%	9.1%
65+	Best estimate		8.9	8.5	8.0	7.9	11.7%		
	Price & Tax	-25%	8.9	8.5	8.0	7.9	11.1%	-0.6%	-4.9%
		+25%	8.9	8.4	7.9	7.8	12.2%	0.6%	4.8%
	Marketing Ban	-50%	8.9	8.5	8.0	7.9	11.6%	-0.1%	-0.6%
		+50%	8.9	8.4	8.0	7.9	11.8%	0.1%	0.9%
	Health Warnings	-50%	8.9	8.5	8.0	7.9	11.5%	-0.2%	-1.8%
		+50%	8.9	8.5	8.0	7.8	11.8%	0.2%	1.3%
	All above policies	-25%/50%	8.9	8.5	8.0	7.9	10.8%	-0.9%	-7.3%
		+25%/50%	8.9	8.4	7.9	7.8	12.5%	0.8%	7.0%

Table 4c: Sensitivity analysis of smoking prevalence (%) at age 18+ by gender under different policy specifications for price and media campaigns

Age	Scenario	2000	2007	2010	2019	Relative reduction in 2007-2019	Relative reduction in 2010-2019
				Male			
18+	Best estimate*	28.8	23.7	22.6	20.4	13.9%	9.7%
	Price (ONS data)**	28.8	23.7	22.6	19.2	18.8%	14.8%
	Media campaign***	28.8	23.7	22.8	20.8	12.4%	9.0%
18-24	Best estimate	35.7	29.2	27.8	25.1	13.9%	9.8%
	Price (ONS data)	35.7	29.2	27.6	22.5	22.8%	18.4%
	Media campaigns	35.7	29.2	28.5	25.6	12.1%	10.0%
25-44	Best estimate	35.1	29.1	28.0	25.7	11.7%	8.2%
	Price (ONS data)	35.1	29.1	28.0	24.1	17.2%	14.1%
	Media campaigns	35.1	29.1	28.2	26.2	9.8%	7.1%
45-64	Best estimate	26.4	22.7	21.9	20.5	9.8%	6.3%
	Price (ONS data)	26.4	22.7	21.9	19.9	12.5%	9.2%
	Media campaigns	26.4	22.7	22.0	20.8	8.7%	5.7%
65+	Best estimate	14.5	10.7	10.2	9.6	9.9%	6.2%
	Price (use ONS data)	14.5	10.7	10.3	9.1	14.9%	11.6%
	Media campaigns	14.5	10.7	10.3	9.8	7.9%	5.2%
				Female			
18+	Best estimate	24.9	19.9	18.8	16.6	16.5%	11.3%
	Price (ONS data)	24.9	19.9	18.8	15.7	21.3%	16.5%
	Media campaigns	24.9	19.9	19.0	17.0	14.9%	10.6%
18-24	Best estimate	33.1	27.4	26.0	23.4	14.7%	10.3%
	Price (ONS data)	33.1	27.4	25.8	20.9	23.6%	19.0%
	Media campaigns	33.1	27.4	26.7	23.8	12.9%	10.5%
25-44	Best estimate	30.0	24.6	23.5	21.5	12.4%	8.4%
	Price (ONS data)	30.0	24.6	23.6	20.2	18.1%	14.5%
	Media campaigns	30.0	24.6	23.7	22.0	10.6%	7.2%

45-64	Best estimate	23.7	18.9	18.0	16.5	13.1%	8.3%
	Price (ONS data)	23.7	18.9	18.0	16.0	15.8%	11.3%
	Media campaigns	23.7	18.9	18.1	16.7	11.9%	7.6%
65+	Best estimate	14.3	10.2	9.3	7.9	22.8%	15.2%
	Price (ONS data)	14.3	10.2	9.3	7.4	27.1%	20.1%
	Media campaigns	14.3	10.2	9.4	8.0	21.1%	14.2%

Notes: *Best estimates are smoking prevalence estimated by model using the mixed ONS and STS price data and moderate level of tobacco control campaigns in 2010-2019

**Smoking prevalence estimated by model using only the ONS price data and moderate level of tobacco control campaigns in 2010-2019

Table 5. Smoking prevalence predictions from unadjusted SimSmoke model compared to national surveys, by age group and gender, 2012-2018/19

Age	Source	2012	2015	2018	2019	Relative reduction in 2012-2018	Relative reduction in 2012-2019	Difference from SimSmoke 2012-2018	Difference from SimSmoke 2012-2019	Average annual reduction	Difference from SimSmoke
					Male						
16+	SimSmoke	21.8	21.15	20.43	20.24	6.3%	7.2%			1.1%	
	OPN	22.0	19.40	16.70	17.30		21.4%		14.2%	3.4%	2.3%
	95% CI		(17.7, 21.1)	(14.5, 18.9)	(15.2, 19.5)		(30.9%, 11.4%)		(23.7%, 4.2%)	(5.1%, 1.7%)	(4.1%, 0.6%)
	HSE	22.2	19.11	18.44		16.9%		10.6%		3.0%	2.0%
	95% CI			(17.0, 20.0)		(23.3%, 10.1%)		(17.0%, 3.8%)		(4.3%, 1.8%)	(3.3%, 0.7%)
	STS	22.1	19.91	18.83	16.72		24.4%		17.2%	3.9%	2.9%
	95% CI	(21.3, 22.9)	(19.1, 20.7)	(18.1, 19.6)	(16.0, 17.4)		(27.7%, 21.1%)		(20.5%, 14.0%)	(4.5%, 3.3%)	(3.5%, 2.3%)
18+	SimSmoke	22.0	21.32	20.57	20.38	6.4%	7.3%			1.1%	
	APS	21.8	19.10	16.40	15.80		27.5%		20.2%	4.5%	3.4%
	95% CI	(21.4, 22.1)	(18.7, 19.4)	(16.1, 16.7)	(15.4, 16.1)		(29.4%, 26.1%)		(22.0%, 18.8%)	(4.8%, 4.2%)	(3.8%, 3.2%)
16-24	SimSmoke	24.8	23.92	23.21	23.15	6.5%	6.8%			1.0%	
	OPN	22.7	24.20	28.40	22.10		2.6%		-4.1%	0.4%	-0.6%
	95% CI		(18.2, 30.3)	(17.7, 39.1)	(12.9, 31.3)		(43.2%, -37.9%)		(36.4%, -44.7%)	(7.8%, -4.7%)	(6.8%, -5.7%)
	HSE	25.5	23.23	22.28		12.5%		6.0%		2.2%	1.2%
	95% CI			(18.2, 26.9)		(28.5%, -5.8%)		(21.9%, -12.3%)		(5.4%, -0.9%)	(4.4%, -1.9%)
	STS	24.3	24.82	21.77	19.93		18.0%		11.2%	2.8%	1.79%
	95% CI	(22.3, 26.3)	(22.6, 27.0)	(19.7, 23.9)	(17.9, 22.0)		(26.5%, 9.5%)			(4.3%, 1.4%)	(3.3%, 0.4%)

18-24	SimSmoke	27.0	26.01	25.14	25.09	6.9%	7.1%		1.0%	
	APS	27.4	22.27	19.24	18.00		34.3%	27.2%	5.8%	4.8%
	95% CI	(26.2, 28.6)	(21.1, 23.4)	(18.0, 20.4)	(16.8, 19.2)		(38.7%, 29.9%)		(6.7%, 4.9%)	(5.7%, 3.9%)
25-34	SimSmoke	28.5	27.77	26.89	26.58	5.6%	6.7%		1.0%	
	OPN	31.6	26.20	18.30	24.70		21.8%	15.1%	3.5%	2.5%
	95% CI		(21.3, 31.1)	(12.5, 24.1)	(16.6, 32.8)		(47.5%, -3.8%)		(8.8%, -0.5%)	(7.8%, -1.5%)
35-59	SimSmoke	23.6	23.01	22.40	22.31	5.2%	5.5%		0.8%	
	SimSmoke age 35-49	25.3	24.86	24.17	24.02	4.5%	5.1%		0.7%	
	SimSmoke age 50-59	20.7	20.19	19.94	19.99	3.7%	3.5%		0.5%	
	OPN	23.4	20.27	17.55	18.21		22.2%	16.7%	3.5%	2.7%
	95% CI									
	OPN age 35-49	24.3	22.30	19.50	17.20		29.2%	24.1%	4.8%	4.1%
	95% CI		(19.0, 25.6)	(15.4, 23.5)	(12.6, 21.7)		(48.1%, 10.7%)	(43.1%, 5.6%)	(9.0%, 1.6%)	(8.2%, 0.9%)
	OPN age 50-59	21.9	17.10	14.70	19.70		10.0%	6.6%	1.5%	1.0%
	95% CI		(13.6, 20.5)	(11.4, 18.0)	(14.6, 24.9)		(33.3%, -13.7%)	(29.9%, -17.2%)	(5.6%, -1.9%)	(5.1%, -2.4%)
60+	SimSmoke	13.0	12.56	12.00	11.82	7.8%	9.2%		1.4%	
	OPN	13.0	11.30	8.70	9.50		26.9%	17.7%	4.4%	3.0%
	95% CI		(9.3, 13.3)	(6.6, 10.9)	(7.5, 11.4)		(42.3%, 12.3%)	(33.1%, 3.1%)	(7.6%, 1.9%)	(6.2%, 0.5%)

25-44	SimSmoke	27.4	26.65	25.82	25.66	**5.7%**	**6.3%**			**0.9%**	
	SimSmoke age 35-44	26.3	25.42	24.56	24.59	6.7%	6.6%			1.0%	
	HSE	28.2	24.55	24.06		14.6%		8.9%		2.6%	1.7%
	HSE age 25-34	28.2	26.67	27.05		4.1%		-1.6%		0.7%	-0.3%
	95% CI			(23.3, 31.1)		(17.3%, -10.4%)		(11.6%, -16.0%)		(3.1%, -1.7%)	(2.1%, -2.6%)
	HSE age 35-44	28.2	22.30	20.81		26.2%		19.5%		4.9%	4.0%
	95% CI			(17.4, 24.7)		(38.2%, 12.5%)		(31.5%, 5.8%)		(7.7%, 2.2%)	(6.7%, 1.2%)
	STS	29.0	25.39	25.01	21.32		26.5%		20.2%	4.3%	3.4%
	95% CI	(27.5, 30.5)	(23.9, 26.9)	(23.5, 26.5)	(19.9, 22.7)		(31.3%, 21.7%)		(25.0%, 15.4%)	(5.2%, 3.4%)	(4.3%, 2.5%)
	APS	27.3	24.33	20.37	19.94		26.9%		20.6%	4.4%	3.5%
	APS age 25-34	28.8	26.50	21.60	21.50		25.3%		18.6%	4.1%	3.1%
	95% CI	(27.8, 29.8)	(25.5, 27.5)	(20.6, 22.6)	(20.6, 22.5)		(28.5%, 21.9%)		(21.8%, 15.2%)	(4.7%, 3.5%)	(3.7%, 2.5%)
	APS age 35-44	25.8	22.00	19.00	18.20		29.5%		22.9%	4.9%	3.9%
	95% CI	(24.9, 26.6)	(21.2, 22.9)	(18.2, 19.9)	(17.3, 19.0)		(32.9%, 26.4%)		(26.4%, 19.8%)	(5.5%, 4.3%)	(4.6%, 3.3%)
45-64	SimSmoke	21.5	21.23	20.72	20.51	3.8%	4.8%			0.7%	
	SimSmoke age 45-54	22.1	22.23	22.14	21.96	-0.1%	0.7%			0.1%	
	SimSmoke age 55-64	20.8	19.93	19.02	18.84	8.5%	9.4%			1.4%	
	HSE	22.0	18.41	18.55		15.8%		12.0%		2.8%	2.1%
	HSE age 45-54	24.1	21.09	20.73		13.9%		14.0%		2.5%	2.4%
	95% CI			(17.2, 24.8)		(28.7%, -3.0%)		(28.8%, -2.9%)		(5.5%, -0.5%)	(5.4%, -0.6%)
	HSE age 55-64	19.5	15.06	15.99		17.9%		9.4%		3.2%	1.8%

	95% CI			(12.9, 19.7)		(33.8%, -0.9%)		(25.2%, -9.4%)		(6.6%, -0.1%)	(5.2%, -1.5%)
	STS	20.7	18.05	17.84	16.02		22.8%		18.0%	3.6%	2.9%
	95% CI	(19.3, 22.1)	(16.7, 19.4)	(16.5, 19.2)	(14.7, 17.3)		(28.9%, 16.7%)		(24.1%, 11.9%)	(4.8%, 2.6%)	(4.1%, 1.9%)
	APS	20.7	18.98	16.77	15.82		23.7%		18.9%	3.8%	3.1%
	APS age 45-54	22.4	20.50	18.20	17.30		22.8%		22.0%	3.6%	3.5%
	95% CI	(21.6, 23.1)	(19.7, 21.3)	(17.4, 19.0)	(16.5, 18.1)		(26.3%, 19.2%)		(25.6%, 18.4%)	(4.3%, 3.0%)	(4.2%, 2.9%)
	APS age 55-64	18.7	17.10	15.10	14.10		24.6%		15.2%	4.0%	2.6%
	95% CI	(18.0, 19.5)	(16.3, 17.8)	(14.3, 15.8)	(13.4, 14.8)		(28.3%, 20.9%)		(18.9%, 11.4%)	(4.6%, 3.3%)	(3.2%, 1.9%)
65+	SimSmoke	10.3	10.17	9.73	9.60	5.1%	6.4%			0.9%	
	SimSmoke age 65-74	13.8	13.68	13.08	12.93	5.0%	6.0%			0.9%	
	SimSmoke age 75+	5.6	5.40	5.25	5.25	5.3%	5.3%			0.8%	
	HSE	8.6	8.46	7.08		17.6%		12.4%		3.2%	2.2%
	HSE age 65-74	11.8	10.59	9.84		16.5%		11.5%		3.0%	2.1%
	95% CI			(7.8, 12.4)		(34.0%, -4.9%)		(29.0%, -9.9%)		(6.7%, -0.8%)	(5.8%, -1.7%)
	HSE age 75+	4.3	5.52	3.36		21.2%		15.8%		3.9%	3.1%
	95% CI			(2.0, 5.5)		(52.5%, -29.7%)		(47.2%, -35.0%)		(11.7%, -4.4%)	(10.9%, -5.2%)
	STS	9.3	9.14	8.46	8.25		10.8%		4.4%	1.6%	0.7%
	95% CI	(7.9, 10.6)	(7.8, 10.4)	(7.3, 9.6)	(7.1, 9.4)		(23.5%, -1.9%)		(17.1%, -8.3%)	(3.8%, -0.3%)	(2.8%, -1.2%)
	APS	10.5	8.90	8.40	8.40		20.0%		13.6%	3.1%	2.2%
	95% CI	(10.0, 11.0)	(8.4, 9.4)	(8.0, 8.9)	(7.9, 8.9)		(24.8%, 15.2%)		(18.3%, 8.8%)	(4.0%, 2.3%)	(3.0%, 1.4%)

Female											
16+	SimSmoke	18.1	17.51	16.82	16.64	7.3%	8.3%			1.2%	
	OPN	17.9	16.40	15.80	13.80		22.9%		14.6%	3.6%	2.4%
	95% CI		(15.0, 17.8)	(13.9, 17.7)	(11.9, 15.7)		(33.5%, 12.3%)		(25.2%, 4.0%)	(5.7%, 1.9%)	(4.4%, 0.6%)
	HSE	17.6	16.66	15.20		13.6%		6.3%		2.4%	1.2%
	95% CI			(14.0, 16.5)		(20.5%, 6.2%)		(13.2%, -1.1%)		(3.7%, 1.1%)	(2.5%, -0.2%)
	STS	18.1	17.59	15.68	14.24		21.1%		12.8%	3.3%	2.1%
	95% CI	(17.3, 18.8)	(16.9, 18.3)	(15.0, 16.4)	(13.6, 14.9)		(24.8%, 17.4%)		(16.5%, 9.1%)	(4.0%, 2.7%)	(2.8%, 1.5%)
18+	SimSmoke	18.2	17.52	16.83	16.64	7.4%	8.4%			1.2%	
	APS	17.0	14.90	12.60	12.10		28.8%		20.4%	4.7%	3.5%
	95% CI	(16.7, 17.3)	(14.6, 15.2)	(12.3, 12.9)	(11.8, 12.4)		(30.6%, 27.1%)		(22.2%, 18.7%)	(5.1%, 4.4%)	(3.8%, 3.2%)
16-24	SimSmoke	23.6	22.73	22.04	21.97	6.7%	7.0%			1.0%	
	OPN	21.7	24.00	19.70	16.20		25.3%		18.4%	4.1%	3.1%
	95% CI		(17.8, 30.2)	(11.9, 27.5)	(8.4, 24.1)		(61.3%, -11.1%)		(54.3%, -18.0%)	(12.7%, -1.5%)	(11.7%, -2.5%)
	HSE	21.8	24.26	15.76		27.7%		21.0%		5.3%	4.2%
	95% CI			(11.8, 20.8)		(46.0%, 4.7%)		(39.3%, -2.0%)		(9.7%, 0.8%)	(8.7%, -0.2%)
	STS	22.2	23.77	20.00	15.45		30.5%		23.5%	5.1%	4.0%
	95% CI	(20.2, 24.3)	(21.5, 26.0)	(17.9, 22.1)	(13.5, 17.4)		(39.2%, 21.8%)			(6.9%, 3.5%)	(5.8%, 2.4%)
18-24	SimSmoke	25.2	24.25	23.41	23.36	7.2%	7.4%			1.1%	
	APS	23.0	19.30	14.60	14.00		39.1%		31.7%	6.8%	5.7%
	95% CI	(22.0, 24.1)	(18.2, 20.4)	(13.6, 15.7)	(12.9, 15.0)		(43.9%, 34.8%)			(7.9%, 5.9%)	(6.8%, 4.8%)

25-34	SimSmoke	24.6	24.10	23.29	22.94	5.3%	6.8%			1.0%	
	OPN	21.8	22.40	22.50	21.20		2.8%		-4.0%	0.4%	-0.6%
	95% CI		(18.7, 26.0)	(17.0, 28.0)	(14.4, 28.0)		(33.9%, -28.4%)			(5.8%, -3.6%)	(4.8%, -4.6%)
35-59	SimSmoke	19.7	18.99	18.32	18.20	6.9%	7.5%			1.1%	
	SimSmoke age 35-49	20.8	20.16	19.50	19.40	6.4%	6.8%			1.0%	
	SimSmoke age 50-59	17.7	17.25	16.73	16.59	5.7%	6.5%			1.0%	
	OPN	19.4	16.84	15.84	13.88		28.5%		21.0%	4.7%	3.6%
	95% CI										
	OPN age 35-49	20.6	17.90	15.80	13.80		33.0%		26.2%	5.6%	4.6%
	95% CI		(15.2, 20.6)	(12.0, 19.6)	(9.2, 18.4)		(55.3%, 10.7%)		(48.5%, 3.9%)	(10.9%, 1.6%)	(9.9%, 0.6%)
	OPN age 50-59	17.4	15.20	15.90	14.00		19.5%		13.1%	3.1%	2.1%
	95% CI		(12.4, 18.1)	(11.7, 20.1)	(9.9, 18.1)		(43.1%, -4.0%)		(36.6%, -10.5%)	(7.7%, -0.6%)	(6.8%, -1.5%)
60+	SimSmoke	10.2	9.68	9.24	9.15	9.5%	10.4%			1.6%	
	OPN	11.7	9.00	10.10	8.60		26.5%		16.1%	4.3%	2.7%
	95% CI		(7.4, 10.6)	(8.0, 12.3)	(7.0, 10.1)		(40.2%, 13.7%)		(29.8%, 3.3%)	(7.1%, 2.1%)	(5.5%, 0.5%)
25-44	SimSmoke	23.0	22.39	21.71	21.54	5.5%	6.3%			0.9%	
	SimSmoke age 35-44	21.5	20.58	19.89	19.93	7.4%	7.2%			1.1%	
	HSE	19.7	20.67	18.78		4.6%		-0.9%		0.8%	-0.1%
	HSE age 25-34	20.9	21.59	21.54		-3.2%		-8.5%		-0.5%	-1.5%
	95% CI			(18.5, 24.9)		(11.2%, -19.2%)		(5.9%, -24.6%)		(2.0%, -3.0%)	(1.0%, -4.0%)

	HSE age 35-44	18.5	19.70	15.86		14.3%		7.0%		2.5%	1.5%
	95% CI			(13.3, 18.8)		(28.2%, -1.7%)		(20.8%, -9.0%)		(5.4%, -0.3%)	(4.3%, -1.3%)
	STS	20.6	20.31	19.31	18.16		11.6%		5.4%	1.8%	0.8%
	95% CI	(19.2, 21.9)	(18.9, 21.7)	(18.0, 20.6)	(16.9, 19.5)		(18.0%, 5.3%)		(11.7%, -1.0%)	(2.8%, 0.8%)	(1.9%, -0.1%)
	APS	19.9	17.73	14.99	14.49		27.0%		20.8%	4.4%	3.5%
	APS age 25-34	20.7	19.20	16.40	16.20		21.7%		15.0%	3.4%	2.4%
	95% CI	(19.9, 21.5)	(18.4, 20.0)	(15.6, 17.2)	(15.4, 17.0)		(25.6%, 17.9%)		(18.8%, 11.1%)	(4.1%, 2.8%)	(3.1%, 1.8%)
	APS age 35-44	19.0	16.20	13.50	12.70		33.2%		26.0%	5.6%	4.5%
	95% CI	(18.3, 19.7)	(15.5, 16.9)	(12.8, 14.1)	(12.0, 13.3)		(36.8%, 30.0%)		(29.7%, 22.8%)	(6.4%, 5.0%)	(5.3%, 3.9%)
45-64	SimSmoke	17.6	17.21	16.67	16.46	5.2%	6.4%			0.9%	
	SimSmoke age 45-54	19.1	18.66	18.21	18.01	4.8%	5.8%			0.9%	
	SimSmoke age 55-64	15.7	15.38	14.86	14.72	5.2%	6.1%			0.9%	
	HSE	19.1	15.69	16.73		12.5%		7.3%		2.2%	1.3%
	HSE age 45-54	21.3	16.86	18.19		14.5%		9.7%		2.6%	1.7%
	95% CI			(15.4, 21.3)		(27.5%, -0.3%)		(22.7%, -5.1%)		(5.2%, -0.1%)	(4.4%, -0.9%)
	HSE age 55-64	16.5	14.24	15.03		8.9%		3.7%		1.5%	0.7%
	95% CI			(12.4, 18.1)		(25.1%, -10.0%)		(19.8%, -15.2%)		(4.7%, -1.6%)	(3.8%, -2.5%)
	STS	18.3	18.49	15.29	14.67		19.8%		13.4%	3.1%	2.2%
	95% CI	(17.0, 19.6)	(17.1, 19.8)	(14.1, 16.5)	(13.5, 15.9)		(26.4%, 13.1%)		(20.0%, 6.8%)	(4.3%, 2.0%)	(3.3%, 1.1%)
	APS	17.7	15.49	13.84	13.34		24.5%		18.1%	3.9%	3.0%
	APS age 45-54	18.7	16.70	14.50	13.90		25.7%		19.8%	4.1%	3.3%
	95% CI	(18.0, 19.3)	(16.1, 17.4)	(13.8, 15.2)	(13.2, 14.5)		(29.4%, 22.5%)		(23.6%, 16.6%)	(4.9%, 3.6%)	(4.0%, 2.7%)

	APS age 55-64	16.4	13.90	13.10	12.70		22.6%		16.5%	3.6%	2.7%
	95% CI	(15.8, 17.1)	(13.3, 14.6)	(12.4, 13.7)	(12.0, 13.3)		(26.8%, 18.9%)		(20.8%, 12.8%)	(4.4%, 2.9%)	(3.5%, 2.1%)
65+	SimSmoke	8.9	8.45	7.97	7.86	10.4%	11.7%			1.8%	
	SimSmoke age 65-74	11.0	10.37	9.75	9.64	11.3%	12.3%			1.9%	
	SimSmoke age 75+	6.8	6.41	6.05	5.97	10.9%	12.0%			1.8%	
	HSE	9.3	7.92	7.77		16.3%		5.8%		2.9%	1.2%
	HSE age 65-74	11.3	10.83	9.15		18.9%		7.7%		3.4%	1.6%
	95% CI			(7.2, 11.5)		(35.9%, -2.0%)		(24.6%, -13.2%)		(7.1%, -0.3%)	(5.3%, -2.2%)
	HSE age 75+	7.3	4.81	6.29		13.4%		2.5%		2.4%	0.6%
	95% CI			(4.5, 8.8)		(38.6%, -21.1%)		(27.7%, -32.0%)		(7.8%, -3.2%)	(6.0%, -5.1%)
	STS	10.9	8.73	8.76	7.78		28.6%		16.9%	4.7%	2.9%
	95% CI	(9.6, 12.2)	(7.6, 9.9)	(7.7, 9.9)	(6.7, 8.8)		(38.2%, 19.0%)		(26.5%, 7.3%)	(6.6%, 3.0%)	(4.9%, 1.2%)
	APS	9.0	8.10	6.90	6.60		26.7%		15.0%	4.3%	2.6%
	95% CI	(8.5, 9.4)	(7.7, 8.5)	(6.5, 7.3)	(6.2, 7.0)		(31.1%, 22.2%)		(19.4%, 10.6%)	(5.2%, 3.5%)	(3.4%, 1.8%)

Notes: 1. OPN=Opinion and Lifestyle Survey conducted by UK Office of National Statistics (ONS) that measures those who have smoked cigarette regularly and currently smoke;

2. HSE=Health Survey of England conducted by NHS Digital that measures those who currently smoke;

3. APS=Annual Population Survey conducted by UK Office of National Statistics (ONS) that measures those who smoke nowadays by year 2015 but measures those who regularly smoked and smoke nowadays since 2016.

4. Data from three datasets and SimSmoke are compared by most similar age groups. For unmatching age groups in a figure, e.g. age 16+ and age 18+, the SimSmoke projection for two age groups are both provided.

5. Prevalence from APS and HSE at age 45-64 is a weighted average of age 45-54 and 55-64 by the ONS population

6. Prevalence from HSE at age 65+ is a weighted average of age 65-74 and 75+ by the ONS population

7. Prevalence from HSE and APS at age 25-44 is a weighted average of age 25-34 and 35-44 by the ONS population

Table 6. Projected smoking prevalence (%), No-NVP SimSmoke vs NVP SimSmoke, age 16 and above by gender, 2012-2052

Age	Adjustment	2012	2019	2052	*Percent change 2012-2019*	*Difference by 2019*	*Percent change 2012-2052*	*Difference by 2052*
Male								
16+	**No**	21.81	20.24	16.52	-7.2%		-24.3%	
	STS	21.81	17.17	15.88	-21.3%	-14.1%	-27.2%	-2.9%
	Range	(21.8, 21.8)	(15.9, 18.4)	(15.6, 16.1)	(-26.9%, -15.7%)	(-19.7%, -8.5%)	(-28.5%, -26.0%)	(-4.2%, -1.7%)
18+	**No**	21.99	20.38	16.55	-7.3%		-24.7%	
	APS	21.99	16.34	15.57	-25.7%	-18.4%	-29.2%	-4.5%
	Range	(22.0, 22.0)	(15.6, 17.1)	(15.4, 15.7)	(-28.9%, -22.4%)	(-21.5%, -15.1%)	(-29.9%, -28.4%)	(-5.2%, -3.7%)
16-24	**No**	24.83	23.15	22.78	-6.8%		-8.3%	
	STS	24.83	21.68	22.78	-12.7%	-5.9%	-8.3%	0.0%
	Range	(24.8, 24.8)	(20.5, 22.8)	(22.8, 22.8)	(-17.3%, -8.2%)	(-10.5%, -1.4%)	(-8.3%, -8.3%)	(0.0%, 0.0%)
18-24	**No**	27.01	25.09	24.83	-7.1%		-8.1%	
	APS	27.01	20.67	24.83	-23.5%	-16.4%	-8.1%	0.0%
	Range	(27.0, 27.0)	(19.9, 21.4)	(24.8, 24.8)	(-26.3%, -20.7%)	(-19.2%, -13.6%)	(-8.1%, -8.1%)	(0.0%, 0.0%)
25-44	**No**	27.39	25.66	23.58	-6.3%		-13.9%	
	STS	27.39	21.15	23.58	-22.8%	-16.5%	-13.9%	0.0%
	Range	(27.4, 27.4)	(19.7, 22.6)	(23.6, 23.6)	(-28.2%, -17.3%)	(-21.9%, -11.1%)	(-13.9%, -13.9%)	(0.0%, 0.0%)
	APS	27.39	20.26	23.58	-26.0%	-19.7%	-13.9%	0.0%
	Range	(27.4, 27.4)	(19.4, 21.2)	(23.6, 23.6)	(-29.3%, -22.5%)	(-23.0%, -16.2%)	(-13.9%, -13.9%)	(0.0%, 0.0%)
45-64	**No**	21.54	20.51	16.78	-4.8%		-22.1%	
	STS	21.54	16.76	15.64	-22.2%	-17.4%	-27.4%	-5.3%
	Range	(21.5, 21.5)	(15.6, 17.9)	(15.0, 16.3)	(-27.7%, -16.7%)	(-22.9%, -11.9%)	(-30.6%, -24.2%)	(-8.5%, -2.1%)
	APS	21.54	16.32	14.51	-24.2%	-19.4%	-32.6%	-10.5%
	Range	(21.5, 21.5)	(15.6, 17.0)	(14.1, 14.9)	(-27.4%, -21.0%)	(-22.6%, -16.2%)	(-34.4%, -30.9%)	(-12.3%, -8.8%)

65+	**No**	10.26	9.60	5.99	-6.4%		-41.6%	
	STS	10.26	8.73	4.87	-14.9%	-8.5%	-52.5%	-10.9%
	Range	(10.3, 10.3)	(7.8, 9.7)	(4.6, 5.1)	(-23.9%, -5.9%)	(-17.5%, 0.5%)	(-55.3%, -49.8%)	(-13.6%, -8.2%)
	APS	10.26	8.10	4.91	-21.0%	-14.6%	-52.2%	-10.5%
	Range	(10.3, 10.3)	(7.7, 8.5)	(4.7, 5.1)	(-24.8%, -17.2%)	(-18.4%, -10.8%)	(-53.9%, -50.2%)	(-12.3%, -8.6%)
Female								
16+	**No**	18.14	16.64	13.24	-8.3%		-27.0%	
	STS	18.14	14.79	12.83	-18.5%	-10.2%	-29.3%	-2.3%
	Range	(18.1, 18.1)	(13.7, 15.9)	(12.6, 13.1)	(-24.7%, -12.3%)	(-16.4%, -4.0%)	(-30.6%, -27.9%)	(-3.6%, -0.9%)
18+	**No**	18.17	16.64	13.16	-8.4%		-27.6%	
	APS	18.17	13.56	12.43	-25.4%	-17.0%	-31.6%	-4.0%
	Range	(18.2, 18.2)	(12.9, 14.2)	(12.3, 12.6)	(-29.0%, -22.0%)	(-20.6%, -13.6%)	(-32.4%, -30.8%)	(-4.8%, -3.2%)
16-24	**No**	23.62	21.97	21.65	-7.0%		-8.4%	
	STS	23.62	18.84	21.65	-20.2%	-13.3%	-8.4%	0.0%
	Range	(23.6, 23.6)	(17.6, 20.0)	(21.6, 21.6)	(-25.5%, -15.1%)	(-18.5%, -8.2%)	(-8.4%, -8.4%)	(0.0%, 0.0%)
18-24	**No**	25.23	23.36	23.11	-7.4%		-8.4%	
	APS	25.23	18.16	23.11	-28.0%	-20.6%	-8.4%	0.0%
	Range	(25.2, 25.2)	(17.3, 18.9)	(23.1, 23.1)	(-31.4%, -25.0%)	(-23.9%, -17.6%)	(-8.4%, -8.4%)	(0.0%, 0.0%)
25-44	**No**	22.98	21.54	19.60	-6.3%		-14.7%	
	STS	22.98	19.81	19.60	-13.8%	-7.5%	-14.7%	0.0%
	Range	(23.0, 23.0)	(18.3, 21.3)	(19.6, 19.6)	(-20.2%, -7.4%)	(-14.0%, -1.1%)	(-14.7%, -14.7%)	(0.0%, 0.0%)
	APS	22.98	17.72	19.60	-22.9%	-16.6%	-14.7%	0.0%
	Range	(23.0, 23.0)	(16.8, 18.6)	(19.6, 19.6)	(-26.8%, -19.1%)	(-20.5%, -12.8%)	(-14.7%, -14.7%)	(0.0%, 0.0%)
45-64	**No**	17.59	16.46	12.36	-6.4%		-29.7%	
	STS	17.59	14.55	11.23	-17.2%	-10.9%	-36.2%	-6.5%
	Range	(17.6, 17.6)	(13.5, 15.6)	(10.7, 11.8)	(-23.4%, -11.1%)	(-17.0%, -4.7%)	(-39.3%, -33.0%)	(-9.7%, -3.4%)
	APS	17.59	13.39	10.60	-23.9%	-17.5%	-39.7%	-10.1%
	Range	(17.6, 17.6)	(12.8, 13.9)	(10.3, 10.9)	(-27.4%, -20.7%)	(-21.0%, -14.4%)	(-41.6%, -38.0%)	(-11.9%, -8.3%)
65+	**No**	8.90	7.86	5.24	-11.7%		-41.1%	
	STS	8.90	6.61	4.93	-25.7%	-14.0%	-44.6%	-3.5%
	Range	(8.9, 8.9)	(5.9, 7.3)	(4.7, 5.2)	(-33.5%, -18.0%)	(-21.8%, -6.3%)	(-47.7%, -41.4%)	(-6.6%, -0.3%)
	APS	8.90	6.59	4.54	-26.0%	-14.4%	-49.0%	-7.9%
	Range	(8.9, 8.9)	(6.3, 6.9)	(4.4, 4.7)	(-29.8%, -22.4%)	(-18.1%, -10.7%)	(-50.9%, -47.1%)	(-9.8%, -6.0%)

Notes: 1 No adjustment refers to the SimSmoke model without NVP adjustment in 2012-2019 and APS and STS adjustments refer to the SimSmoke model with NVP adjustment in 2012-2019 using the greater reduction reflected from the APS and STS surveys.

2 95% CI refers to the implementation of APS and STS adjustments using the annual relative difference in 2012-2019 derived from the lower and upper bound of the 95% confidence intervals from survey in 2019.

Table 7. Projected smoking-attributable deaths and lives saved, unadjusted England SimSmoke compared to STS NVP-adjusted and APS NVP-adjusted England SimSmoke, by gender, 2012-2052

	Adjustment	2012	2019	2032	2052	Total 2012-2019	Total 2012-2052
				Male			
SADs							
	No	27,659	28,675	27,968	23,111	226,162	1,103,472
	STS	27,659	27,048	25,385	20,757	219,734	1,016,370
	Range	(27,659, 27,659)	(25,838, 28,243)	(24,287, 26,460)	(19,950, 21,549)	(214,522, 224,731)	(978,119, 1,053,801)
	APS	27,659	26,315	24,841	20,275	216,540	996,235
	Range	(27,659, 27,659)	(25,769, 26,862)	(24,251, 25,438)	(19,790, 20,778)	(214,191, 218,863)	(975,851, 1,016,971)
Deaths averted	**STS**	-	1,627	2,582	2,354	6,429	87,102
	Range	(0, 0)	(432, 2,837)	(1,508, 3,681)	(1,561, 3,161)	(1,431, 11,640)	(49,671, 125,353)
	APS	-	2,360	3,127	2,836	9,622	107,238
	Range	(0, 0)	(1,813, 2,906)	(2,530, 3,716)	(2,332, 3,320)	(7,299, 11,971)	(86,501, 127,621)
				Female			
SADs							
	No	18,136	17,331	16,665	14,738	141,957	674,943
	STS	18,136	16,047	15,458	13,843	136,532	633,428
	Range	(18,136, 18,136)	(15,318, 16,768)	(14,741, 16,163)	(13,280, 14,398)	(133,323, 139,609)	(608,618, 657,800)
	APS	18,136	15,909	15,001	13,180	136,049	616,521
	Range	(18,136, 18,136)	(15,547, 16,252)	(14,613, 15,359)	(12,849, 13,485)	(134,481, 137,525)	(603,064, 628,991)
Deaths averted	**STS**	-	1,284	1,207	895	5,425	41,516
	Range	(0, 0)	(563, 2,013)	(503, 1,924)	(339, 1,457)	(2,348, 8,633)	(17,143, 66,326)
	APS	-	1,423	1,665	1,558	5,907	58,422
	Range	(0, 0)	(1,079, 1,784)	(1,306, 2,052)	(1,252, 1,888)	(4,432, 7,475)	(45,952, 71,879)
				Both			
SADs							
	No	45,795	46,006	44,633	37,848	368,119	1,778,416

	STS	45,795	43,095	40,843	34,599	356,265	1,649,798
	Range	(45,795, 45,795)	(41,156, 45,011)	(39,028, 42,622)	(33,230, 35,948)	(347,845, 364,340)	(1,586,737, 1,711,601)
	APS	45,795	42,223	39,841	33,455	352,589	1,612,756
	Range	(45,795, 45,795)	(41,316, 43,115)	(38,865, 40,797)	(32,640, 34,264)	(348,672, 356,388)	(1,578,915, 1,645,962)
Deaths averted	**STS**	-	2,911	3,790	3,249	11,853	128,617
	Range	(0, 0)	(995, 4,851)	(2,011, 5,605)	(1,901, 4,619)	(3,779, 20,274)	(66,814, 191,679)
	APS	-	3,783	4,792	4,394	15,530	165,660
	Range	(0, 0)	(2,891, 4,690)	(3,836, 5,768)	(3,585, 5,209)	(11,731, 19,447)	(132,453, 199,501)

Notes: 1 No adjustment refers to the SimSmoke model without NVP adjustment in 2012-2018 and APS and STS adjustments refer to the SimSmoke model with NVP adjustment in 2012-2018 using the greater reduction reflected from the APS and STS surveys.

2 Range refers to the implementation of APS and STS adjustments using the annual relative difference in 2012-2019 derived from the lower and upper bound of the 95% confidence intervals from survey in 2019.