Projecting the future smoking prevalence in Norway

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Abstract

Background: Norway has achieved a noteworthy reduction in smoking prevalence over the past forty years. In 2015, 13% of Norwegians aged 13-74 smoked daily and a further 9% smoked occasionally. One of the objectives of the Norwegian 2013-2016 national strategy for tobacco control is to achieve a reduction in the daily smoking prevalence to less than 10% by 2016. This paper aims to estimate how long it will take for Norway to achieve the 10% smoking prevalence. **Methods**: A dynamic forecasting model using smoking prevalence data from national survey data on the prevalence of current, former and never smokers in the Norwegian population from 1985 to 2012 was used to estimate future smoking prevalence in the Norwegian population based on a continuation of current patterns in smoking cessation and initiation rates. **Results**: The result suggests that Norway's smoking prevalence among men and women will continue to decline if current trends of smoking initiation and cessation continue. Our model predicts, based on figures for 1985-2012, that the prevalence of current daily and occasional smoking rates combined among men and women will not fall below the 10% mark until 2029 for men and 2026 for women, if current trends continue. **Conclusion**: Smoking is likely to remain an important public health issue in Norway for many years. New strategies are needed to accelerate the decline in smoking in Norway.

Keywords: smoking cessation, smoking epidemiology, Norway, statistical models

Introduction

With a long history of tobacco control,[1] Norway has achieved a remarkable reduction in smoking prevalence over the past forty years. The percentage of Norwegians who smoke daily has declined from around 43% in 1973 to 13% in 2014.[2] The reduction in smoking prevalence has been most dramatic among men, with rates of daily smoking declining from 51% in 1973 to 14% in 2014, while rates of daily smoking among women has declined from 32% to 13% over the same time period.[3]

Norway was one of the first countries to endorse a comprehensive tobacco control act that resulted in a significant decline in smoking prevalence.[1] The availability of snus, a moist smokeless tobacco product originating in Sweden that is placed under the top lip, on the Norwegian tobacco market might also be of importance for the decline in smoking rates.[23] The Norwegian 2013-2016 national strategy for tobacco control includes increasing tobacco taxation, enforcing comprehensive advertising bans, placing graphic health warnings on tobacco packs, and restricting smoking in public areas and workplaces.[3, 4] Norway is also currently considering introducing plain packaging legislation; a measure previously introduced in Australia in 2012 and due to be introduced in France, UK and Ireland in 2016, which ensures that all tobacco products are sold in standardised packs without company logos or colours.[5] This strategy therefore aims to minimize smoking uptake by making tobacco products less appealing to young non-smokers and to make health warnings on packs more noticeable to current smokers.[5, 6]

Despite a nearly 50% reduction in smoking prevalence since 2004, Norway endeavours to further reduce smoking prevalence. The Norwegian government has set three goals in their

2013-2016 national strategy for tobacco control. The most ambitious of these goals is to reduce the daily smoking prevalence among adults aged 16-74 to less than 10% by 2016 and to 6% among young people aged 16-24; and to prevent people born after 2000 from starting to smoke—creating a tobacco free generation.[3] This 10% smoking prevalence can only be achieved if approximately 300,000 smokers or 43% of the current smoking population quit smoking.

To estimate how long it will take for Norway to achieve the 10% smoking prevalence, we used a dynamic forecasting Markov model to project the future smoking prevalence based on a continuation of current patterns in smoking cessation and initiation rates (see Figure 1).

Methods

Our modelling approach is an adaption of Gartner et al,[7] however rather than estimating current uptake and cessation rates in a separate model to the dynamic forecasting model, we now estimate all parameters (uptake, cessation rates and the projected smoking prevalence) concurrently in the one model, which reduced the uncertainty in the projected smoking prevalence estimates. However, this method meant it was not possible to combine the men and women into the one model as it was not possible to run two independent minimisation routines concurrently in the one model (one for women and one for men) and hence separate models for men and women were built.

The models were constructed in Microsoft Excel (Microsoft, Redmond, Washington, USA) using: (1) demographic data from Statistics Norway on the population size in 1-year age

bands for men and women in the baseline year of 1985; (2) year-specific probabilities of dying at each age for men and women; (3) national survey data on the prevalence of current, former and never smokers in the Norwegian population from 1985 to 2012; (4) age-specific and sex-specific relative risks of dying in current and former smokers compared to never smokers from the American Cancer Society's Cancer Prevention Study II (CPSII) (M Thun, personal communication). We used Monte Carlo simulation implemented with Ersatz,[8] add-in software for Excel to estimate the cessation rates and to determine the uncertainty in the estimated projections.

Observed current and former smoking prevalence

We used national survey data on the prevalence of current and former smoking in men and women in 1-year intervals from 1985 to 2012 in the age groups 20-24,....60-64, 64-69 and 70-79 (see Supplementary Tables 1 and 2).[2] Current smokers included daily and occasional smokers; former smokers were former daily smokers; and never smokers included never and former occasional smokers who had never smoked daily. The effect of this categorisation was examined in sensitivity analyses by recalculating the model with the following categories: current smokers including only current daily smokers; former smokers including former daily smokers and all current occasional smokers and never smokers including never smokers and former occasional smokers (see Appendix). The distribution in each survey year over the three states of current, former, and never smokers was assumed to have a Dirichlet distribution,[9] with the numbers as observed in the surveys as parameters.

As in Gartner et al,[7] the model assumed that all smoking uptake occurs at age 20, because adolescents who commence and stop smoking before age 20 are unlikely to incur smoking-related health risks. The observed prevalence of current smoking in 20–24 year olds was used to determine the proportion of 20 year olds who took up smoking. The forecasted proportion of 20 year olds taking up smoking for 2013 onwards was estimated by fitting a linear equation to the prevalence of current smoking from 2001-2012 in the 20-24 age group. The annual change from this equation expressed as a relative risk is used to project the future current smoker proportions.

Probability of dying in never, former and current smokers

The sex-specific and year-specific mortality rates for never, current, and former smokers were determined from the mortality rate in the total population, the prevalence of current and former smoking in the population and the relative risk of dying in current and former smokers from the CPSII study (see Supplementary material). The age-specific and sex-specific probability of dying among never smokers was assumed to remain constant from 2012 onwards.

The population numbers and numbers of deaths (and consequently the mortality rates) are assumed to not have uncertainty since these are whole population observations and not samples. The relative risks of dying are assumed to have a lognormal distribution as implemented in the Ersatz ErRelativeRisk function. This function takes the RR and the SE[ln(RR)] as parameters. The function implements a correction which ensures that the average of the returned random RRs equals RR (instead of RR+0.5 SE[ln(RR)]^2).[10]

Number of never, current and former smokers

For the years 1985-2012, the number of men and women in the Norwegian population alive at each age from 0 to 100+ was obtained from Statistics Norway.[11] The population was divided into three groups: current, former, and never smokers. The prevalence in each group was estimated from the prevalence of current and former smoking at each age in national survey data. After the baseline year (1985), each of these subpopulations was followed according to a Markov process (see Figure 1). The number of never, current and former smokers at each age and in the years following the baseline year, was then estimated from (1) the number of each cohort in the preceding year, (2) the probability of death among never, current and former smokers; and (3) the proportional change in current smoking (see Appendix). Yearly births were added to the model from 1985 to 2012, with projected births added from 2013 to 2035.

[**Insert Figure 1 here** - Overview of the Markov model[7]]

Cessation rates

The cessation rates for each 5 year age group starting from 20-24 until 70-79 years in two time periods (1985-2000 and 2001-2012) for men and women were estimated using the method of weighted least squares. This procedure selected the set of cessation values that reproduced as closely as possible the observed past prevalence of smoking from 1985 to 2012. In order to account for the different sample sizes in each of the surveys we used the inverse of the variance of the observations to weight the observed smoking prevalence estimates in each year. In the Monte Carlo simulation, at each iteration, random numbers were drawn from the distributions of all the parameters in the model. Next, the Down-hill

Simplex method was used to fit the cessation rates and the linear equation such that the model's outcomes closely reproduced the randomly drawn survey numbers. The fitted values for the 2001-2012 cessation rates were then used to calculate the model outcomes (the projected number of current, former and never smokers for 2013-2035) for that iteration. The procedure was repeated 2000 times. The resulting distributions of the cessation rates were plotted as histograms that revealed the distributions approximated a bell-curve.

Rate of decline in smoking initiation

We determined the average yearly decline in smoking initiation in 20 year olds between 2001 and 2012 for men and women separately from the linear regression line through the observations in the national survey data from 2001 to 2012.

Prevalence projections 2013-2035

The projected number of current, former and never smokers for each year from 2013 to 2035 was calculated for men and women using the estimated age-specific and sex-specific cessation rates for 2001-2012.

Results

Cessation rates and decline in smoking initiation

The estimated yearly rates of decline in rate of smoking initiation among 20 year olds and cessation rates are shown in Table 1 (with lower and upper limits of the 95% UIs). Positive rates indicate a net overall decline in smoking prevalence in that age group in that time period, while negative rates indicate an increase. In men, the initiation rates steadily

declined during the period 2001-2012, however, during the period 1985-2000 the initiation rate was almost stable. Women showed a decline in initiation rate within both periods but higher rates in 2001-2012. In both men and women, the cessation rate was highest in the 70-79 years age group in period 2001-2012.

[**Insert Table 1 here -** Yearly smoking cessation rates and annual decline in initiation rates]

Model fit

The model produced a good fit of the estimated smoking prevalence for 1985-2012 to the observed values from the survey data as indicated by R^2 of 0.933 for male smoking prevalence and R^2 of 0.932 for female smoking prevalence (see Figure 2).

[**Insert Figure 2 here -** Smoking Prevalence in Men and Women from 2001 until 2012]

Forecasting results

Under the assumption that current trends in cessation and initiation rates will continue unchanged in Norway, our model predicts that smoking prevalence in men aged 20+ to fall to 19% (95% UI 18 % - 20%) in 2016 and to 7% (95% UI 4%- 9%) by 2035. For women, the model predicts 17% (95% UI 16%-18 %) smoking prevalence in the population aged 20+ by 2016 and 5% (95% UI 3%-6%) in 2035 (See Figure 3).

[**Insert Figure 3 here** - Projected Smoking Prevalence in Men and Women]

Discussion

Our model suggests that the reduction in Norway's smoking prevalence among men and women, observed since 1973, will continue to decline if current trends of smoking initiation and cessation continue. However, smoking will not fall below the 10% mark until 2029 for

men and 2026 for women. Our model also predicted the prevalence of current smoking rates for 2016 among men and women as 19% and 17% respectively, or 18% overall, which is substantially higher than the Norwegian government's 2016 daily smoking prevalence goal of 10%. However, it should be noted that we included occasional smokers in our definition of current smoker, while the target prevalence references only daily smokers. We also ran the model with current smokers restricted to daily smokers (see Appendix). The forecasted current smoking prevalence rates for 2016 were 12% for men and 13% for women, which is still above the 10% goal. However, under this definition for current smoking, the model estimates that smoking prevalence will fall below the 10% mark in 2018 for men (9.9%) and 2021 for women (9.8%).

The reason we included occasional smokers in our definition of current smoker is that almost half the occasional smokers in the survey data reported a weekly intake of five or more cigarettes, indicating relatively high consumption. Similar to regular smoking, occasional smoking has been linked to a number of adverse events. Among men, occasional smoking is associated with an increased risk of total mortality and cardiovascular mortality[12, 26] and increased risk of having coronary heart disease.[13] Among women, occasional smoking is associated with reduced birth weight in children[14] and greater risk of myocardial infarction and total mortality.[15] Previous attempts to reduce smoking prevalence have focused mainly on daily smokers as the highest risk group while neglecting occasional smokers. Consequently, occasional smoking prevalence has remained stable at around 10% for the last 30 years.[2] The no safe cigarette "smoking-non-smoking" campaign, introduced in January 2013, specifically targeted occasional smokers and was a good initiative by the

Norwegian government to reduce the number of occasional smokers.[16]

New strategies are needed to accelerate the decline in smoking in Norway. A promising strategy is the introduction of standardised tobacco packaging or plain packaging by the Norwegian Ministry of Health and Care Services in 2015.[17] It is suggested that the introduction of mandatory plain packaging for tobacco products would: reduce the attractiveness of tobacco products;[18, 19] increase the noticeability of health warnings and messages;[20] and reduce smokers' misperceptions about the harmfulness of tobacco products as pack branding features such as colours are used to convey messages of reduced harm, such as lighter pack colours used to signify 'light' cigarettes.[21] Studies in Australia, the first country to introduce plain packaging in 2012, showed that the introduction of plain packaging of cigarettes coupled with larger graphic health warnings has reduced the appeal of smoking among adolescents and adults.[6, 19] Plain packaging also contributes to making the image of smoking less positive which has the potential to reduce smoking uptake among adolescents.[22]

In addition, harm reduction strategies (e.g. switching from cigarettes to nicotine replacement therapy, snus or e-cigarettes) offer an additional approach that could encourage adults to quit or reduce their smoking. In Norway, the decline in smoking has been paralleled by an increase in the use of snus. In 2014, the percentage of daily snus use was 9%, a 33% increase from 2004.[23] Snus could contribute to the decline in smoking prevalence via two main pathways, either as a tool to assist quitting amongst smokers or as an alternative nicotine product for tobacco-prone youth.[23] Further, some studies have suggested that snus is a more effective cessation aid compared to other pharmacological

nicotine products.[23] There is also a growing body of research that demonstrates the potential role of e-cigarettes as a cessation tool.[24] Cobb et al (2015)[25] has recently developed a Markov model to operationalize the complex states and transitions that must be examined simultaneously and dynamically over time to determine the impact of alternative nicotine products such as snus and e-cigarettes.

Limitations

In our model, we were only able to estimate gender-specific smoking prevalence, rather than a combined overall prevalence. Unlike the definition of current smoking used in government estimates of smoking prevalence which includes only daily smokers, we included occasional smokers as well which produced higher estimates for the prevalence of current smoking. How best to define a current smoker is not clear. In terms of health outcomes, regular occasional smoking (e.g. weekly) will still confer substantial health risks and hence reducing this low-rate of smoking in the population is also important.[26, 27]

Our modelling also looked only at net cessation, and therefore did not explicitly model people who take up smoking after the age of 20, or people who repeatedly quit and relapse. The former group will be small and will therefore not affect results much. The latter group is larger but will on balance probably be captured either in the former or current smoker groups. The excess risk of dying is modelled simply as a relative risk for current and former smokers. In reality, smoking-related mortality depends on a large number of variables such as number of smoking years, smoking intensity, time since quitting, etc. However, the simple approach we took is sufficiently precise for the purpose of projecting the future smoking prevalence, the main determinants of which are the initiation rate and the

cessation rates. Our Markov model also only examined one tobacco product (cigarettes) and did not include other forms of tobacco, such as snus, or non-tobacco nicotine products, such as e-cigarettes.

Conclusion

Norway's smoking prevalence will continue to decline if the current rates of initiation and cessation are maintained. However, based on a continuation of current smoking and initiation patterns, smoking will remain an important public health issue in Norway for some time to come. More and new strategies are needed to increase cessation in current smokers and to lower the initiation rates.

Conflict of interest

JJB owns Epigear International, which sells the Ersatz software used in the analyses.

Key points

- A dynamic forecasting model shows that smoking prevalence in Norway will continue to decline

- The smoking prevalence will not fall below 10% until 2029 for men and 2026 for women

- Smoking will remain an important public health issue in Norway for years to come and new strategies are needed to accelerate the decline in smoking.

References

1. World Health Organisation. Joint national capacity assessment on the implementation of effective tobacco control policies in Norway 2010. Available at: https://www.regjeringen.no/globalassets/upload/hod/capacityassessmreportnorway.pdf (29 April 2016, date last accessed)

2. Statistics Norway. Smoking habits, 2015. Available from: https://www.ssb.no/en/helse/statistikker/royk (29 April 2016, date last accessed)

3. Norwegian Directorate of Health. A tobacco-free future. National Strategy for tobacco control 2013-2016. Available at: http://helsedirektoratet.no/english/tobacco-control (29 April 2016, date las accessed)

4. Halkjelsvik T, Lund KE, Kraft P, Rise J. Fear appeals in advanced tobacco control environments: the impact of a national mass media campaign in Norway. Health Educ Res 2013; 28:888-97.

5. Brennan E, Durkin S, Coomber K, Zacher M, Scollo M, Wakefield M. Are quitting-related cognitions and behaviours predicted by proximal responses to plain packaging with larger health warnings? Findings from a national cohort study with Australian adult smokers. Tob Control 2015; 24:ii33-ii41.

6. Durkin S, Brennan E, Coomber K, Zacher M, Scollo M, Wakefield M. Short-term

changes in quitting-related cognitions and behaviours after the implementation of plain packaging with larger health warnings: Findings from a national cohort study with Australian adult smokers. Tob Control 2015; 24:ii26-ii32.

7.   Gartner CE, Barendregt JJ, Hall WD. Predicting the future prevalence of cigarette smoking in Australia: How low can we go and by when? Tob Control 2009;18:183-9.

8.   Barendregt JJ. Ersatz. Brisbane: EpiGear; 2007.

9.   Briggs AH, Ades AE, Price MJ. Probabilistic sensitivity analysis for decision trees with multiple branches: Use of the Dirichlet distribution in a Bayesian framework. Med Decis Making 2003;23:341-50.

10.   Barendregt JJ. The effect size in uncertainty analysis. Value Health 2010;13:388-91.

11.   Statistics Norway. Population and population changes 2016. Available from: https://www.ssb.no/statistikkbanken/selectvarval/Define.asp?subjectcode=&ProductId=&MainTable=FolkemEttAarig&nvl=&PLanguage=1&nyTmpVar=true&CMSSubjectArea=befolkning&KortNavnWeb=folkemengde&StatVariant=&checked=true.   (29 April 2016, date last accessed)

12.   Luoto R, Uutela A, Puska P. Occasional smoking increases total and cardiovascular mortality among men. Nicotine Tob Res 2000;2:133-9.

13.   Rosengren A, Wilhelmsen L, Wedel H. Coronary heart disease, cancer and mortality in male middle-aged light smokers. J Intern Med 1992;231:357-62.

14.   Bjerregaard BK, Raaschou-Nielsen O, Sørensen M, Frederiksen K, Tjønneland A, Rohrmann S, et al. The effect of occasional smoking on smoking-related cancers in the European Prospective Investigation into Cancer and Nutrition (EPIC). Cancer

Cause Control 2006;17:1305-9.

15.   Prescott E, Scharling H, Osler M, Schnohr P. Importance of light smoking and

inhalation habits on risk of myocardial infarction and all cause mortality. A 22 year

follow up of 12 149 men and women in The Copenhagen City Heart Study. J

Epidemiol Commun H 2002;56:702-6.

16.   Nylenna A. Occasional smoking: A new campaign target in Norway. Lancet

2013;381:708-9.

17.   Norwegian Government to consult on proposal for standardized packaging of

tobacco products. [press release 2015]. Available

at:https://www.regjeringen.no/en/aktuelt/foreslar-standardiserte

tobakkspakninger/id2395028/ (29 April 2016, date last accessed)

18.   Wakefield MA, Germain D, Durkin SJ. How does increasingly plainer cigarette

packaging influence adult smokers' perceptions about brand image? An

experimental study. Tob Control 2008;17:416-21.

19.   White V, Williams T, Wakefield M. Has the introduction of plain packaging with

larger graphic health warnings changed adolescents' perceptions of cigarette packs

and brands? Tob Control 2015;24:ii42-ii9.

20.   Beede P, Lawson R. The effect of plain packages on the perception of cigarette

health warnings. Public Health 1992;106:315-22.

21.   Stead M, Moodie C, Angus K, Bauld L, McNeill A, Thomas J, et al. Is consumer

response to plain/standardised tobacco packaging consistent with Framework

Convention on Tobacco Control guidelines? A systematic review of quantitative

studies. PloS ONE 2013;8:e75919.

22. Lund I, Scheffels J. Young smokers and non-smokers perceptions of typical users of plain vs. branded cigarette packs: A between-subjects experimental survey. BMC Public Health 2013;13:1-8.

23. Lund I, Lund KE. How has the availability of snus influenced cigarette smoking in Norway? Int J Environ Res Public Health 2014;11:11705-11717.

24. Fraser D, Weier M, Keane H, Gartner C. Vapers' perspectives on electronic cigarette regulation in Australia. Int J of Drug Policy 2015;26:589-94.

25. Cobb CO, Villanti AC, Graham AL, Pearson JL, Glasser AM, Rath JM, et al. Markov Modeling to estimate the population impact of emerging tobacco products: A proof-of-concept Study. Tob Regul Sci 2015;1:129-41.

26. Bjartveit K, Tverdal A. Health Consequences of Smoking 1-4 Cigarettes per Day. Tob Control 2005;14:315-20.

27. Tverdal A, Bjartveit K. Health consequences of reduced daily cigarette consumption. Tob Control 2006;15:472-80.

Table 1
Yearly smoking cessation rates and annual decline in initiation rates

	1985–2000 (95% UI)	2001–2012 (95% UI)
Men:		
Decline in initiation in 20-years old	0.0009 (−0.0055 to 0.0074)	0.0111 (0.0001–0.0218)
Cessation in 20–24 years old	0.0088 (0.0043–0.0132)	0.033629 (0.0259–0.0395)
Cessation in 25–29 years old	−0.0204 (−0.0267 to − 0.0158)	0.096575 (0.0939–0.0988)
Cessation in 30–34 years old	0.0083 (0.0008–0.0142)	0.082996 (0.0638–0.0889)
Cessation in 35–39 years old	0.0210 (0.0151–0.0262)	0.064008 (0.0473–0.0721)
Cessation in 40–44 years old	−0.0027 (−0.0095–0.0029)	0.044191 (0.0342–0.0570)
Cessation in 45–49 years old	0.0279 (0.0204–0.0341)	0.050093 (0.0401–0.0628)
Cessation in 50–54 years old	0.0302 (0.0223–0.0373)	0.055179 (0.0376–0.0645)
Cessation in 55–59 years old	−0.0234 (−0.0382 to − 0.0121)	0.011287 (−0.0073–0.0215)
Cessation in 60–64 years old	0.0995 (0.0936–0.1025)	0.095136 (0.0923–0.0983)
Cessation in 65–69 years old	−0.0639 (−0.0821 to − 0.0492)	0.059645 (0.0189–0.0717)
Cessation in 70–79 years old	0.0306 (0.0204–0.03949)	0.114577 (0.1121–0.1172)
Women:		
Decline in initiation in 20-years old	0.0002 (−0.0059 to 0.0063)	0.0173 (0.0068–0.0278)
Cessation in 20–24 years old	0.0032 (−0.0007 to 0.0083)	0.0450 (0.0369–0.0517)
Cessation in 25–29 years old	−0.0134 (−0.0206 to − 0.0079)	0.1077 (0.1054–0.1098)
Cessation in 30–34 years old	0.0004 (−0.0066 to 0.0061)	0.0709 (0.0571–0.0769)
Cessation in 35–39 years old	0.0182 (0.0128–0.0232)	0.0555 (0.0453–0.0692)
Cessation in 40–44 years old	−0.0044 (−0.0118 to 0.0013)	0.0716 (0.0573–0.0794)
Cessation in 45–49 years old	0.0189 (0.0111–0.0259)	0.0263 (0.0101–0.0369)
Cessation in 50–54 years old	0.0218 (0.0135–0.0299)	0.0779 (0.0561–0.0834)
Cessation in 55–59 years old	0.0098 (−0.0022 to 0.0227)	0.0507 (0.0282–0.0593)
Cessation in 60–64 years old	0.0533 (0.0429–0.0648)	0.1052 (0.1052–0.1052)
Cessation in 65–69 years old	−0.0240 (−0.0508 to − 0.0069)	−0.0253 (−0.0739 to − 0.0017)
Cessation in 70–79 years old	−0.0142 (−0.0264 to − 0.0061)	0.1287 (0.1259–0.1313)

Figures

Figure 1 Overview of the Markov model[8]
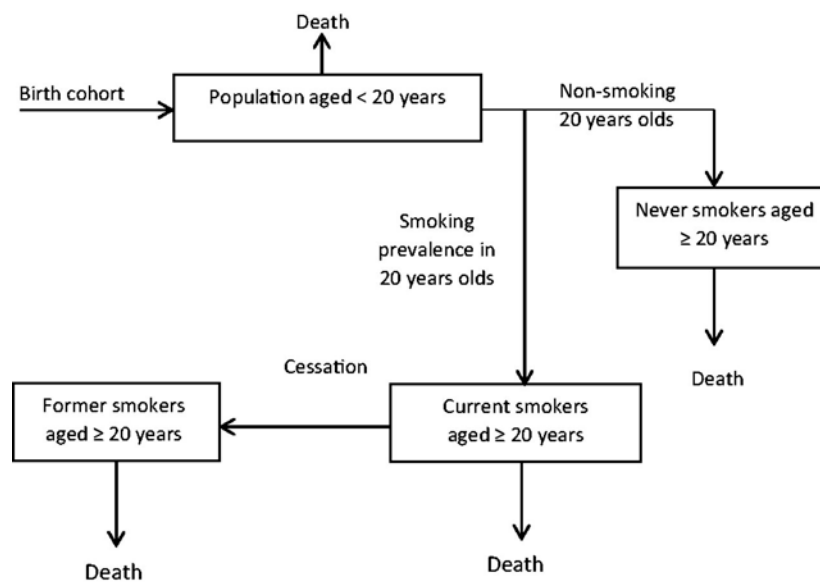
Figure 2 Smoking prevalence in men and women from 2001 until 2012
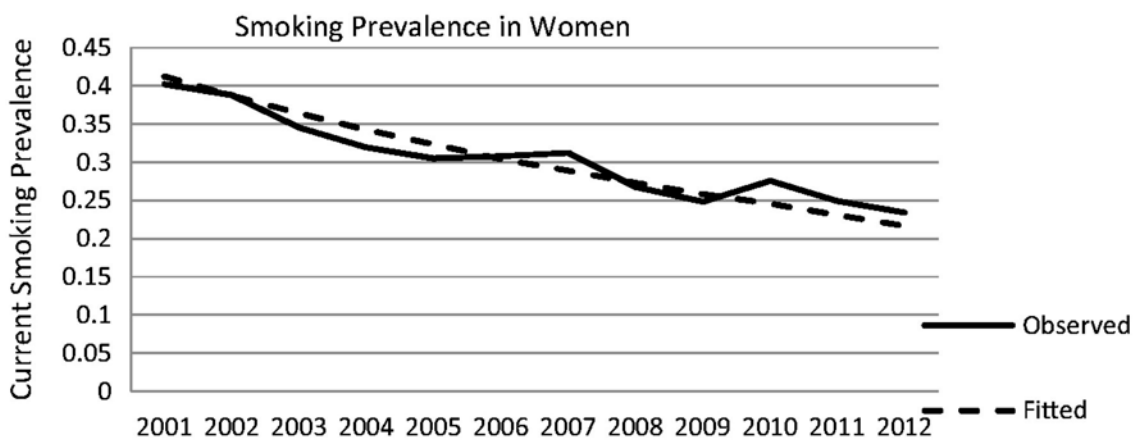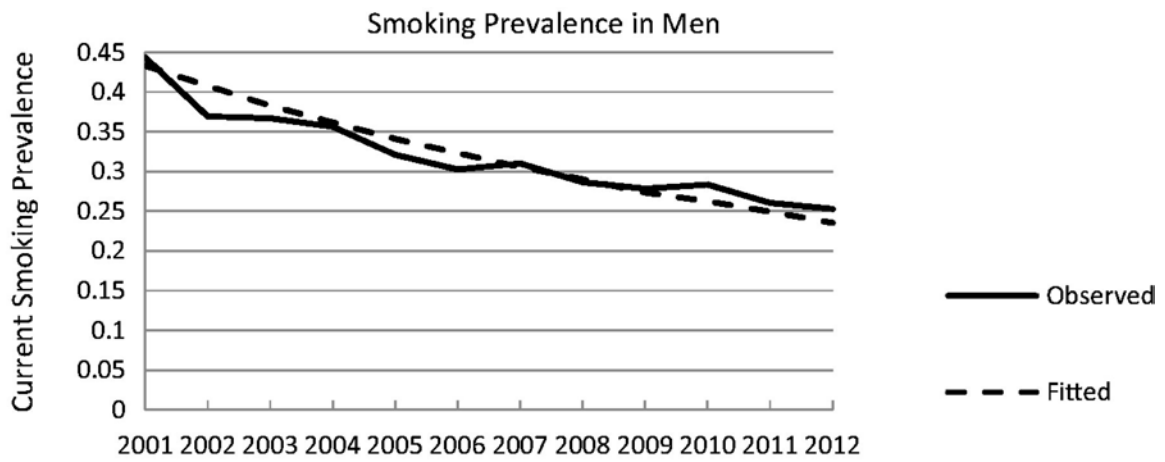
Figure 3 Projected smoking prevalence in men and women

Projected Future Smoking Prevalence in Men

Projected Smoking Prevalence in Women
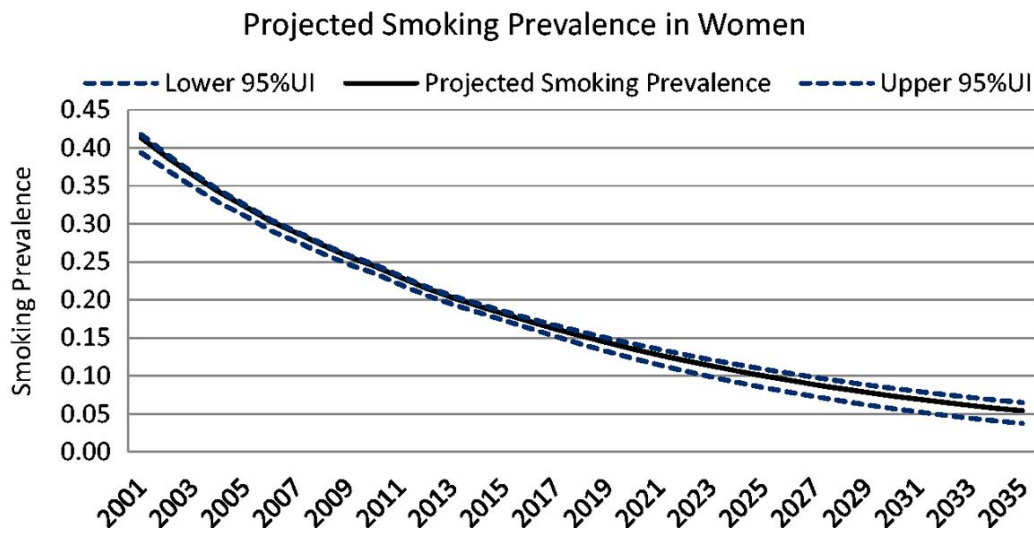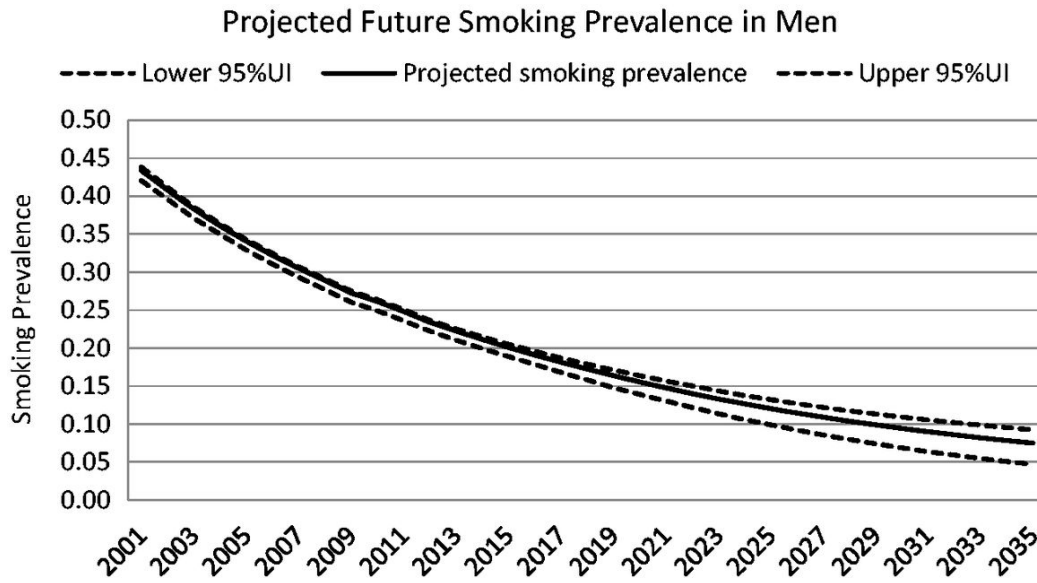
Supplementary File 1

APPENDIX 1

Calculation of probability of dying in never, current and former smokers

The age-specific, sex-specific and year-specific probabilities of dying (q) in the total Norwegian population were converted to a mortality rate using the following formula:

$$m_{total_{t,a}} = -\ln(1 - q_{total_{t,a}})$$

Where,

$$m_{total_{t,a}}$$

is the mortality rate in the population aged a at time t

$$q_{total_{t,a}}$$

is the probability of dying in the total population aged *a* at time *t* (obtained from Norwegian

Directorate of Health, Statistic Norway)

The sex-specific, age specific and year specific mortality rates for never, current and former smokers

were determined by:

$$m_{never_{t,a}}$$

$$\frac{m_{total_{t,a}}}{RR_{current_a} \times P_{current_{t,a}} \times RR_{former_a} \times P_{former_{t,a}} + 1 - (P_{current_{t,a}} + P_{former_{t,a}})}$$

$$m_{current_{t,a}} = RR_{current_a} \times m_{never_{t,a}}$$

$$m_{former_{t,a}} = RR_{former_a} \times m_{never_{t,a}}$$

Where

$$m_{never_{t,a}}$$

is the mortality rate in never smoked at age a, time t.

$$RR_{current_a}$$

is the relative risk of dying in current smokers compared to never smokers from Cancer Prevention

Study II (CPSII) at age *a*.

$$P_{current_{t,a}}$$

is the prevalence of current smokers in the population at age a, at time t.

$$RR_{former_a}$$

is the relative risk of dying in former smokers compared to never smokers from CPSII at age a

$$P_{former_{t,a}}$$

is the prevalence of former smokers in the total population at age a, at time t.

The mortality rates were then converted to the probability of dying at age a and time t according to:

$$q_{t,a} = 1 - e^{(-m_{t,a})}$$

Calculation number of never, current and former smokers at each age in the model

The number of never, current and former smokers at each age and in the years following the baseline year is determined according to:

$$Never_{t,a} = Never_{t-1,a-1} \times (1 - q_{never_{t-1,a-1}})$$

$$Current_{t,a} = Current_{t-1,a-1} \times (1 - q_{current_{t-1,a-1}}) \times (1 - C_{t-1,a-1})$$

$$Former_{t,a} = Former_{t-1,a-1} \times \left(1 - q_{former_{t-1,a-1}}\right)$$

$$+Current_{t-1,a-1} \times \left(1 - q_{current_{t-1,a-1}}\right) - Current_{t,a}$$

Except for age 20, which was determined according to:

$$Never_{t,20} = Never_{t-1,19} \times (1 - q_{never_{t-1,19}}) \times (1 - P_{current_{t,20}})$$

$$Current_{t,20} = Current_{t-1,19} \times (1 - q_{never_{t-1,19}}) \times (P_{current_{t,20}})$$

Where:

$$Current_{t,a}$$

is the number of current smokers in the population at age *a* at time *t*

$$Former_{t,a}$$

is the number of former smokers in the population at age *a* at time

$$Never_{t,a}$$

is the number of never smokers in the population at age *a* at time *t*

$$C_{t,a}$$

 is the proportional change in current smoking prevalence at time *t* and age

Supplementary File 2

Supplementary Table 1: Observed prevalence of current smoking between 1985 and 2012 in Norway men aged 20+ years

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Age:														
20-24	0.546	0.453	0.461	0.466	0.468	0.419	0.586	0.510	0.506	0.473	0.52	0.533	0.500	0.533
25-29	0.556	0.629	0.480	0.500	0.465	0.509	0.541	0.527	0.451	0.538	0.506	0.512	0.480	0.449
30-34	0.614	0.564	0.602	0.570	0.559	0.542	0.491	0.576	0.614	0.557	0.440	0.561	0.574	0.447
35-39	0.548	0.558	0.563	0.593	0.565	0.486	0.488	0.531	0.616	0.563	0.429	0.487	0.508	0.421
40-44	0.594	0.480	0.500	0.534	0.400	0.594	0.537	0.491	0.542	0.513	0.478	0.529	0.486	0.429
45-49	0.610	0.541	0.492	0.541	0.438	0.515	0.484	0.596	0.527	0.398	0.536	0.444	0.500	0.485
50-54	0.389	0.443	0.478	0.556	0.430	0.412	0.417	0.423	0.547	0.387	0.368	0.491	0.448	0.508
55-59	0.551	0.473	0.486	0.540	0.532	0.417	0.353	0.426	0.508	0.434	0.243	0.600	0.343	0.326
60-64	0.446	0.386	0.436	0.449	0.527	0.407	0.415	0.426	0.404	0.368	0.263	0.400	0.471	0.222
65-69	0.481	0.481	0.489	0.440	0.354	0.395	0.25	0.366	0.42	0.365	0.300	0.386	0.419	0.222
70-79	0.299	0.314	0.343	0.456	0.433	0.414	0.317	0.365	0.211	0.263	0.383	0.344	0.394	0.208
Overall	0.528	0.498	0.493	0.517	0.491	0.475	0.466	0.486	0.499	0.457	0.425	0.491	0.478	0.419

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Age:														
20-24	0.400	0.521	0.415	0.458	0.328	0.435	0.356	0.414	0.341	0.395	0.255	0.471	0.320	0.222
25-29	0.404	0.482	0.507	0.363	0.363	0.443	0.489	0.258	0.241	0.323	0.452	0.258	0.243	0.225

30-34	0.431	0.48	0.423	0.375	0.375	0.254	0.404	0.339	0.226	0.300	0.192	0.200	0.235	0.333
35-39	0.516	0.463	0.415	0.400	0.446	0.410	0.269	0.339	0.393	0.302	0.263	0.346	0.286	0.236
40-44	0.446	0.458	0.523	0.317	0.403	0.519	0.377	0.2279	0.292	0.339	0.308	0.164	0.226	0.229
45-49	0.4314	0.435	0.588	0.470	0.400	0.343	0.379	0.263	0.308	0.408	0.355	0.241	0.362	0.25
50-54	0.365	0.372	0.442	0.426	0.403	0.375	0.186	0.313	0.417	0.226	0.365	0.339	0.354	0.288
55-59	0.390	0.417	0.404	0.355	0.500	0.292	0.327	0.289	0.421	0.207	0.313	0.348	0.314	0.302
60-64	0.216	0.324	0.353	0.405	0.229	0.407	0.302	0.381	0.340	0.30	0.245	0.318	0.222	0.305
65-69	0.370	0.36	0.276	0.091	0.154	0.212	0.261	0.310	0.237	0.24	0.139	0.167	0.170	0.250
70-79	0.36	0.234	0.344	0.243	0.302	0.164	0.123	0.157	0.128	0.148	0.170	0.265	0.083	0.114
Overall	0.406	0.420	0.443	0.369	0.367	0.356	0.321	0.302	0.310	0.286	0.278	0.283	0.260	0.253

Supplementary Table 2: Observed prevalence of current smoking between 1985 and 2012 in Norway women aged 20+ years

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Age:														
20-24	0.597	0.432	0.485	0.453	0.519	0.466	0.408	0.471	0.420	0.449	0.493	0.444	0.492	0.564
25-29	0.496	0.559	0.577	0.548	0.436	0.579	0.493	0.557	0.588	0.457	0.474	0.383	0.440	0.415
30-34	0.563	0.554	0.619	0.585	0.504	0.522	0.496	0.559	0.527	0.481	0.629	0.476	0.543	0.468
35-39	0.409	0.508	0.496	0.488	0.584	0.577	0.588	0.525	0.559	0.566	0.560	0.514	0.468	0.531
40-44	0.440	0.445	0.436	0.487	0.535	0.512	0.464	0.461	0.48	0.425	0.56	0.478	0.5	0.389
45-49	0.427	0.436	0.522	0.368	0.471	0.396	0.455	0.440	0.4	0.440	0.418	0.508	0.460	0.505
50-54	0.410	0.387	0.309	0.476	0.366	0.388	0.313	0.346	0.338	0.390	0.328	0.471	0.446	0.547
55-59	0.344	0.448	0.385	0.430	0.229	0.351	0.366	0.444	0.412	0.397	0.276	0.481	0.333	0.255
60-64	0.337	0.278	0.326	0.375	0.294	0.395	0.274	0.261	0.367	0.294	0.278	0.25	0.225	0.25
65-69	0.165	0.265	0.256	0.333	0.2	0.231	0.313	0.236	0.291	0.255	0.255	0.143	0.222	0.325
70-79	0.08	0.192	0.180	0.233	0.171	0.189	0.154	0.105	0.212	0.264	0.1	0.25	0.188	0.273
Overall	0.407	0.424	0.438	0.455	0.417	0.435	0.418	0.414	0.432	0.419	0.428	0.424	0.427	0.442

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Age:														
20-24	0.490	0.477	0.403	0.433	0.404	0.371	0.433	0.295	0.459	0.346	0.327	0.40	0.195	0.178
25-29	0.446	0.471	0.443	0.340	0.328	0.292	0.245	0.333	0.383	0.382	0.154	0.289	0.341	0.184
30-34	0.459	0.393	0.469	0.492	0.466	0.368	0.271	0.313	0.308	0.218	0.298	0.297	0.217	0.286
35-39	0.561	0.380	0373	0.444	0.394	0.411	0.297	0.359	0.338	0.172	0.230	0.218	0.192	0.175
40-44	0.434	0.44	0.609	0.397	0.353	0.297	0.321	0.481	0.366	0.288	0.206	0.313	0.293	0.364
45-49	0.606	0.357	0.468	0.467	0.384	0.466	0.302	0302	0.333	0.294	0.311	0.34	0.339	0.283
50-54	0.5	0.340	0.36	0.480	0.418	0.358	0.370	0.373	0.365	0.481	0.3	0.375	0.322	0.378
55-59	0.390	0.439	0.313	0.344	0.298	0.327	0.488	0.3	0.285	0.278	0.236	0.228	0.261	0.188
60-64	0.310	0.282	0.25	0.262	0.278	0.186	0.261	0.286	0.195	0.208	0.289	0.2	0.269	0.176
65-69	0.333	0.333	0.276	0.61	0.2	0.270	0.167	0.077	0.297	0.107	0.256	0.194	0.167	0.222
70-79	0.154	0.170	0.176	0.2	0.206	0.119	0.140	0.138	0.107	0.185	0.118	0.2	0.083	0.158
Overall	0.457	0.372	0.402	0.388	0.345	0.319	0.305	0.308	0.312	0.268	0.248	0.276	0.250	0.234