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ORIGINAL RESEARCH

Impact of Smoking Reduction Scenarios on the Burden of Myocardial Infarction in the French Population Until 2035

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Aim: Myocardial infarction (MI) is a cardiovascular disease caused by necrosis of the myocardium, which places a heavy burden on patients. In France, the proportion of daily smokers remains high, reaching at 25.5% in 2020. We evaluated the impact of smoking reduction scenarios on the projection of MI prevalence, mean age of incident cases and number of MI prevented cases until 2035.

Methods and Results: The French government has introduced smoking cessation policies that have led to an annual decrease in smoking prevalence. Based on this annual decline, we implemented three scenarios (SC) simulating an annual decrease in the proportion of smokers aged over 35 (SC1: 1%, ie, natural evolution without intervention, SC2: 2%, SC3: 9.87%) and a fourth scenario (SC4) in which there is a complete discontinuation of smoking from 2024 onwards using MI hospitalization and demographic data, estimations for the proportion of daily smokers between 35 and 95 years and multi-state models. Between 2023 and 2035, MI prevalence increased from 3.18% to 4.23% in males and from 1.00% to 1.46% in females under SC1. MI prevalence was equal to 4.21%, 4.06%, and 3.82% in males and 1.45%, 1.40%, and 1.34% in females in 2035 according to SC2, SC3, and SC4, respectively. Compared with SC1, 0.68% MI cases would be prevented with SC2, 4.52% with SC3 and 10.34% with SC4, with almost half of cases being prevented before 65 years of age. The increase in the mean age of MI incident cases ranged from 3 to 4 years among males and from 1 to 2 years among females.

Conclusion: While reducing tobacco use could substantially reduce the number of MI cases prevented, its prevalence would continue to increase due to the ageing population. An integrated prevention strategy that includes the leading cardiovascular risk factors should more efficiently reduce the future burden of MI.

Keywords: myocardial infarction, prevalence, burden, projection, tobacco control, smoking prevalence

Introduction

Cardiovascular diseases represent a hefty burden throughout the world.[1] In addition, they expose people to severe and disabling after-effects and impact the quality of life of patients.[2] Ischemic heart disease, including myocardial infarction (MI), has been identified as the second leading cause of disability-adjusted life years in the world.[1]

Several studies have forecasted an increase in both the incidence and prevalence of ischemic heart disease, including MI, until at least 2030 in different countries such as the United States, Germany, Australia, Sweden, and China.[3–9] In a previous work, we projected an increase in the prevalence and number of prevalent cases of MI in France between 2015 and 2035, with cases almost doubling in males and females between 2015 and 2035 and an increase in the number of cases in females under 75 years (mean age at MI).[10] This projected increase in MI prevalence in France was partly related to demographics, especially the ageing population, in addition to the dynamics of cardiovascular risk factors in the population.

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Among cardiovascular risk factors, smoking has one of the highest attributable fraction for MI.[11–13] Countries such as the United States, Canada, Australia, and United Kingdom have reduced the proportion of daily smokers to below 20% by implementing measures to limit smoking[14–16] In comparison to these countries, the proportion of daily smokers remains high in France at 25.5% in 2020 (29.1% for males and 22.0% for females) despite a decrease since 2000. This is partly explained by the later implementation of tobacco control measures in France compared with other countries (eg, taxes on tobacco, ban on tobacco advertising, tobacco prevention campaigns, smoke-free policies, plain packaging of tobacco products, quit smoking services). To address this risk factor, the French government introduced a series of measures targeting several emblematic actions such as tobacco plain packaging, extending the right to prescribe nicotine substitution treatments, and the creation of a tobacco-free month ("mois sans tabac"), which has led to encouraging results in terms of smoking reduction.[17,18]

The aim of this work was to estimate the expected impact of different smoking reduction scenarios on the burden of MI in the population until 2035 using an illness-death model useful to evaluate public health policies.

Methods

In this study, we used three separate date sources: hospitalizations for a MI from the French national health data system, demographic data from the National Institute of Statistics and Economic Studies and smoking data from the *Baromètre de Santé publique France*. In order to estimate MI prevalence, number of prevalent of MI cases, mean age of MI incident cases and number of MI prevented cases according to the different smoking reduction scenarios, we will first introduce the illness-death model. Secondly, we will describe how to estimate the intensity transitions λ_{01} (MI hospitalization rate incidence, λ_{02} (mortality in healthy subjects) and λ_{12} (mortality of diseased individuals). Thirdly, we will explain the models used and the estimation of the transition intensities according to smoking status. Finally, we will finish with a description of the four reduction smoking scenarios implemented.

Myocardial Infarction Hospitalization

Patients were identified from the French national health data system (SNDS), which includes a hospital discharge database (Programme de médicalisation des systèmes d'information – Médecine, chirurgie, obstétrique, PMSI-MCO) that covers almost the entire French population (Supplementary Table S1). Our study included all patients hospitalized between January 1, 2007, and December 31, 2015, who had a main diagnosis of MI (codes I21-I23 in the 10th Revision of International Classification of Diseases [ICD-10]) and stayed for at least one night in hospital or died on the day of hospital admission. We excluded patients with a personal history of MI in the 2 years preceding the date of hospitalization (data unavailable prior to 2005).

Demographic Data

Estimates of the French population on January 1 and age-specific mortality rates (from 35 to 95 years) by sex for each year from 1955 to 2070 were obtained from the National Institute of Statistics and Economic Studies (INSEE). Data for the years before 2013 were taken from censuses, while post-2013 data were based on INSEE projections.

Smoking Data

For more than 25 years, the attitudes and health behaviors of people living in France have been investigated through a survey system aiming to orientate prevention and information policies for the population. In this system known as *Baromètre de Santé publique France*, repeated cross-sectional surveys monitor the main behaviors, attitudes, and perceptions of the population relating to risk-taking and health risks such as smoking. These surveys involve interviewing representative samples of the French population using a computer-assisted telephone interview system. The surveys provide a glimpse into a given health condition at a given moment in time. The annual proportions of non-smokers, former smokers, and smokers between 35 and 75 years by 5-year age group in males and females from 2000 to 2020 were estimated. To ensure the representativeness of our sample, the estimates were weighted to take account of the probability of inclusion in the study and corrected for non-participation using a margin calibration on a reference population. We considered the proportions for the age group of 76–95 years to be equal to those for 75 years. For the years before 2000 and after 2020, we assumed that the proportions were similar to those for 2000 and 2020, respectively. Non-smokers were defined as individuals who had never smoked, former smokers as individuals who had quit smoking, and smokers as individuals who smoked daily or occasionally.

Illness-Death Model

The "illness-death" model is a three-state non-homogeneous Markov model: state 0 (alive, no MI), state 1 (alive, with MI), and state 2 (dead) (Supplementary Figure S1).[19] The model is considered irreversible as an individual cannot recover from disease or death (ie, cannot return to state 0). Transition λ_{01} represents the incidence rate of MI, λ_{02} the mortality rate among people without MI, and λ_{12} the mortality rate among people with MI.

Estimation of λ_{01}

We defined the MI incidence rate (denoted λ_{01}) as equal to the MI hospitalization incidence rate, because all MI cases who are alive are systematically hospitalized in France. An age-cohort model was used to model $\lambda_{01}(a,c)$ for a given age a and cohort c:

$$Y(a,c) \sim \text{Poisson}(m(a,c) \times \lambda_{01}(a,c))$$

$$\log(\lambda_{01}(a,c)) = f(a) + g(c)$$

where Y(a,c) is the number of MI incident cases, m(a,c) the number of person-years, f(a) the age effect, and g(c) the cohort effect. We also assumed that $\lambda_{01}(a,c)$ was null before a given age a_0 (35 years in this study) as MI is rare before this age:

$$\lambda_{01}(a,c) = 0 \; for \; a \leq a_0$$

More details on how to estimate the MI hospitalization incidence rate using an age-cohort model in the Supplementary Methods.

Estimation of λ_{02}

The mortality of healthy subjects (without MI) was assumed to be equivalent to the mortality of the general population, denoted by λ_2. This assumption is appropriate, because both MI prevalence and MI mortality are low (2.52% in males and 0.85% in females in 2015 for MI prevalence).[10,20] The age-specific mortality rate for healthy subjects for a cohort c is therefore:

$$\lambda_{02}(a,c) = \lambda_2(a,c)$$

A Gompertz-Makeham model was fitted to the INSEE mortality rates to obtain a continuous function of age for each cohort.

Estimation of λ_{12}

The mortality of diseased individuals was considered proportional to that of healthy individuals with a relative risk depending on the time since disease onset. We denote RR_{d1} as the relative risk associated with the first year following the MI event and RR_{d2} as the relative risk thereafter. Mortality in the first year after MI was thus:

$$\lambda_{12}(a,c) = \lambda_{02}(a,c) \times RR_{d_1}$$

While mortality in the subsequent years was:

$$\lambda_{12}(a,c) = \lambda_{02}(a,c) \times RR_{d_2}$$

We estimated RR_{d1} and RR_{d2} using a Cox regression with age as the time scale and the delay after MI occurrence, which was taken as a time-dependent variable (Supplementary Table S2).

Model by Smoking Status

In our study, we considered that individuals were either non-smokers, former smokers, or smokers. We used a model for each smoking status: a classic illness-death model for non-smokers and former smokers (Supplementary Figure S2) and a six-state model for smokers (Figure 1). At their entry in the models, all individuals were aged 35 years. We thus

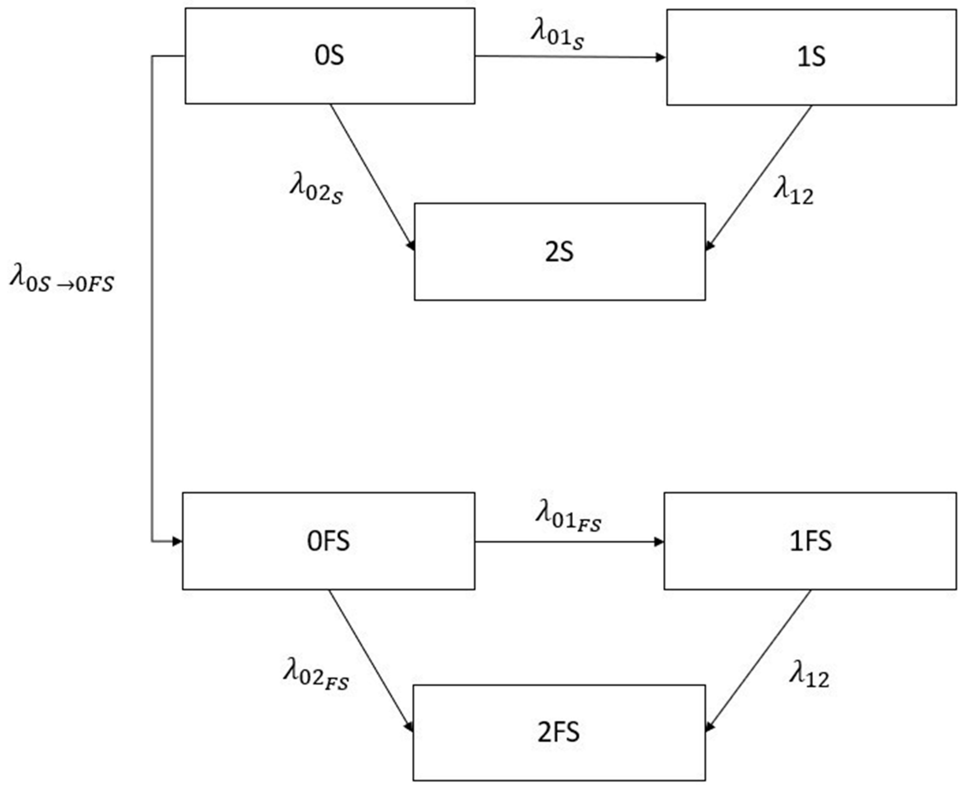


Figure 1 Six-state model for smokers. λ_{01S} and λ_{01FS} are the incidence rate of MI, $\lambda_{02S}$and λ_{02FS} the mortality rate of healthy individuals for smokers and new former smokers, respectively, and λ_{12} the mortality rate of diseased individuals in the general population. The term $\lambda_{0S\rightarrow 0FS}$ models the smoking cessation rate of smokers.

assumed that a non-smoker would not start smoking after that age and that a former smoker would not resume. This assumption seems reasonable given our inclusion of people aged 35 years with the aim to study the effect of a decrease in the proportion of smokers. Nevertheless, smokers could stop smoking throughout their lifetime (from the age of 35 until 95 years). In the model of non-smokers and former smokers, we defined λ_{01NS} and λ_{01FS} as the incidence rate of MI, λ_{02NS} and λ_{02FS} as the mortality rate in healthy individuals for non-smokers and former smokers, respectively. In the six-state model, smokers can stop smoking, thus becoming new former smokers and thus being classified as former smokers as described above. We defined λ_{01S} and λ_{01FS} as the incidence rate of MI and λ_{02S} and λ_{02FS} as the mortality rate of healthy individuals for smokers and new former smokers, respectively. Note that the transition intensities for new former smokers are equal to those of former smokers. The term $\lambda_{0S\rightarrow 0FS}$ models the smoking cessation rate of smokers.

Estimation of Transition Intensities by Smoking Status

MI incidence rate in the general population is expressed in terms of the incidence rates and proportions of individuals according to smoking status. Therefore, we can deduce the incidence rate according to smoking status, as well as the different excess risks of developing a myocardial infarction in former smokers and smokers compared with non-smokers. These excess risks are taken from the literature (Supplementary Table S3).[11,21,22] The same logic was applied to the mortality rate of healthy subjects. All formulas are given in Supplementary Methods.

Several studies have reported lower mortality after a MI in smokers compared with non-smokers. This phenomenon is known as the “smokers’ paradox” and several hypotheses have been put forward to explain it. Smokers have a better survival rate because they develop MI at a younger age and have fewer co-morbidities than non-smokers. The phenomenon could also be explained by a bias linked to hospital admission, since smokers arriving at hospital are already survivors, the others having died before their admission.[23]

Nevertheless, other studies have shown that the better survival after myocardial infarction in smokers compared with non-smokers disappears when survival is adjusted for age and comorbidity variables. Currently, there is still no consensus, although a growing number of recent studies show that the smokers' paradox does not exist and is linked to problems of bias and population selection.[24] Therefore, we did not distinguish the mortality of diseased individuals according to their smoking status, because the literature has not shown differential mortalities following MI.

Transition intensities are used to calculate transition probabilities in order to compute MI prevalence, MI number of prevalent cases, mean age of MI incident cases and number of MI prevented cases. Besides, the transition intensities are estimated in continuous time. For the same individual, it is therefore possible to have several transitions in the same year: an individual can develop a MI and then die, for example. In addition, we are working with transition intensities that depend on both age and cohort, and with individuals aged between 35 and 95. For a given year from 2015 to 2035, we have individuals aged 35 from 61 different generations. We therefore calculate 61 different transition probabilities and have a different population of 35-year-old for each year. These probabilities are calculated between the age of 35 and a given age that varies between 35 and 95.

Different Scenarios

We compared four scenarios simulating an annual decrease in the proportion of smokers in the French population. The first scenario serves as a basis for comparison for the other three. Our first scenario (SC1) assumes that approximately 1% of smokers quit per year in France (ie, percentage of smokers quitting without any new interventions), while the second scenario (SC2) doubles the smoking cessation rate (ie, 2%). The third scenario (SC3) follows one of the objectives of the ongoing French national tobacco control plan, which aims for a reduction in the proportion of smokers to below 22% among 18–75-year-olds by the end of 2027 with this decrease being maintained until 2035 (around 9.87% of smokers quitting annually). The last scenario (SC4) simulates a sudden discontinuation of all smoking, leading to a proportion of smokers equal to 0. SC4 is not realistic but serves as an extreme comparison. The year of implementation of SC2, SC3, and SC4 is 2023, meaning that the effect will only be observable from 2024 onwards.

It should be noted that for smokers, quitting smoking is considered to be definitive. Besides, the probability of quitting for smokers is the same at any age and for both sexes. For SC1, the proportion of permanent smoking cessation has been obtained by multiplying the percentage of permanent quitters among smokers making a quit (between 2 and 3%)[25–28] by the proportion of smokers making a quit attempt at least one week each year (between 25 and 30%).[29]

All the estimations and projections of prevalence, number of prevalent cases, mean age of incident cases and number of MI prevented cases were computed separately for males and females. Details of the formulas used to compute the epidemiological indicators are presented in the Supplementary Methods. Statistical analyses were conducted using R 4.2.1.

Results

Between 2008 and 2015, 519400 patients aged 35 to 95 years were hospitalized for MI in France (67.4% males and 32.6% females) (Supplementary Table S1).

Figure 2 shows the estimated incidence rate of MI in the general population in 2035 according to sex for SC1, SC3, and SC4. In the scenarios, for both sexes, the greater the decrease in the proportion of smokers per year, the lower the incidence rate was in the general population. Similarly, the size of the population increased in 2035, while the proportion of smokers decreased as shows in Figure 3.

The mean age of MI incident cases increased by about 3 years from 2023 to 2035 in males for scenarios SC1, SC2, and SC3 (around 66 years in 2023 vs 69 years in 2035) and by about 4 years for SC4. For females, the mean age increased by about 1.5 years from 2023 to 2035 for scenarios SC1, SC2, and SC3 (around 72.5 years in 2023 vs 74 years in 2035) and by about 2.5 years for SC4 (Table 1).

For males, MI prevalence increased from 3.18% in 2023 to more than 4.00% in 2035 for all scenarios (4.23% with SC1, 4.21% with SC2 and 4.06% with SC3) except for SC4 (3.82%) (Figure 4). The prevalence among females rose from 1.00% in 2023 to more than 1.40% for all scenarios (1.46% with SC1, 1.45% for SC2 and 1.40% for SC3) except for SC4 (1.34%) (Supplementary Table S4). This corresponds to a 40% increase in the number of prevalent cases of MI

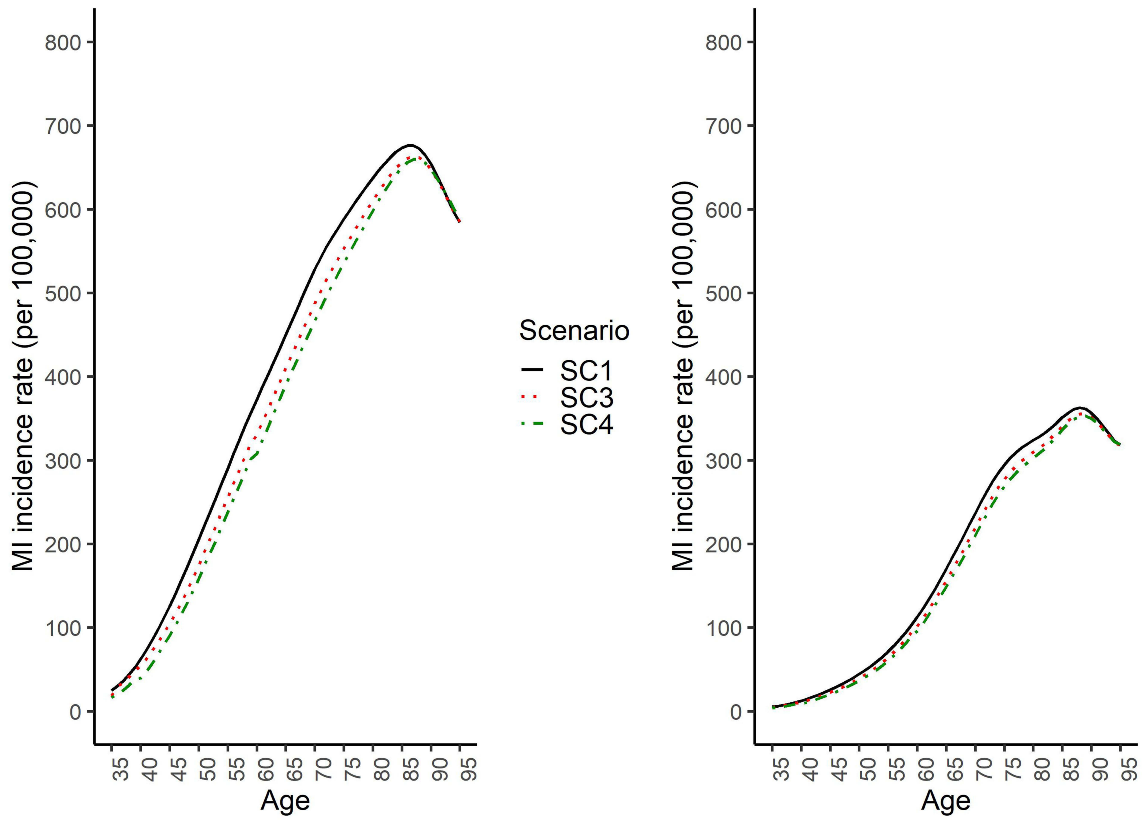


Figure 2 Estimated MI incidence rate in the general population by age in 2035 for males (left) and females (right) according to the scenarios SC1 (solid line), SC3 (dashed line), and SC4 (dotted line), SC2 is not shown because it overlaps with SC1.

Abbreviations: SC1, 1% of smokers quitting per year; SC3: 9.87% of smokers quitting per year; SC4, extreme scenario, no new smokers from 2024.

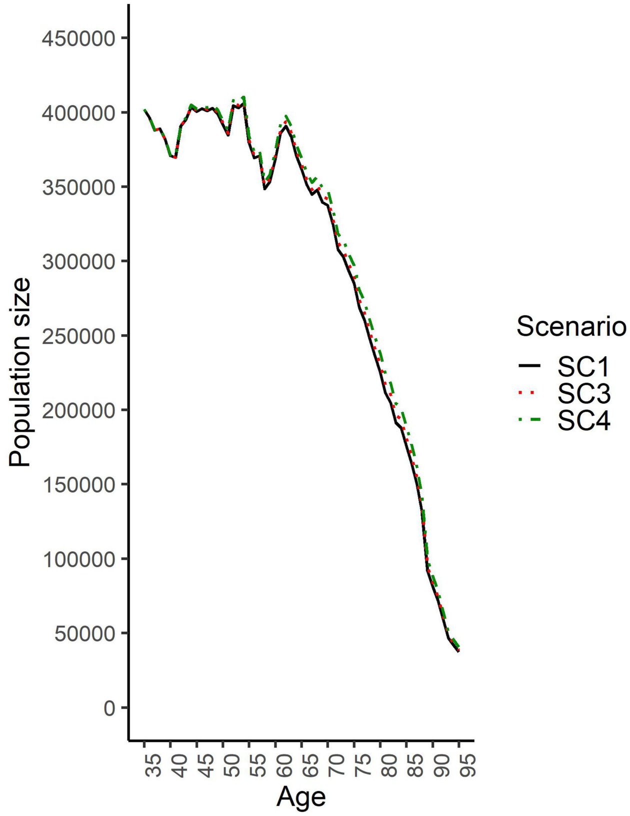
in males and 50% in females for SC1, SC2, and SC3, and 30% in males and 40% in females for SC4 (Supplementary Table S5). The number of MI prevalent cases is depicted in Supplementary Figure S3.

From 2024 to 2035, the implementation of the different scenarios in the population would prevent 6800 cases of MI between 35 and 95 years (5000 in males and 1800 in females) for SC2, 45,000 cases (33,000 in males and 12,000 in females) for SC3, and 103,000 cases (77,000 in males and 26,000 in females) for SC4. More than half of prevented cases were among adults under 65 years (Table 2). The number of prevented deaths from MI in people aged between 35 and 95 years was estimated at 640 deaths (460 in males and 180 in females) for SC2, 4500 deaths (3200 in males and 1300 in females) for SC3, and 12,800 deaths (9300 in males and 3500 in females) for SC4.

Discussion

Our study evaluated the potential benefits of the health policies implemented in France for smoking reduction. We showed that tobacco control interventions improve all epidemiological indicators for MI (number of cases, deaths, early deaths, and age at onset of disease). Indeed, the greater the reduction in the proportion of smokers, the better the indicators are.

We chose to explore tobacco interventions for several reasons. First, tobacco is a well-documented risk factor in the literature, with a high attributable fraction for MI incidence. It is one of the most prevalent risk factors for MI in the French population, and tobacco control measures are probably the most important public health policy in France. By considering smoking cessation in our models, we were able to create several scenarios showing different decreases in the proportion of smokers. However, our models can also be generalized to other risk factors such as cholesterol, hypertension, or diabetes.



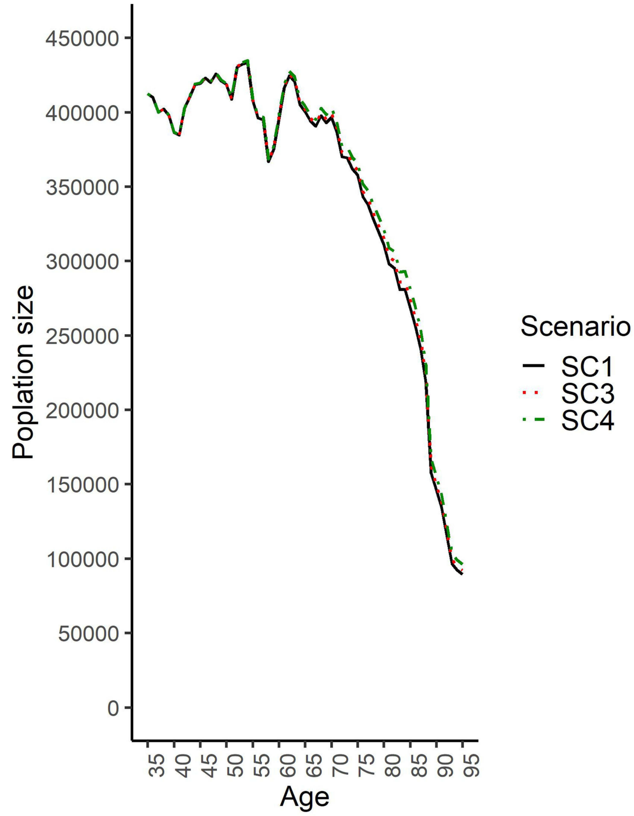


Figure 3 Estimated general population size by age in 2035 for males (left) and for females (right) according to the scenarios SC1 (solid line), SC3 (dashed line), and SC4 (dotted line), SC2 is not shown because it overlaps with SC1.
Abbreviations: SC1, 1% of smokers quitting per year; SC3: 9.87% of smokers quitting per year; SC4, extreme scenario, no new smokers from 2024.

Our results showed that doubling the smoking cessation rate (SC2) has a weak impact on the indicators. For SC2, SC3, and SC4, the number of prevented MI incident cases was high among younger adults (under 65 years), with almost one in two cases being prevented. Several studies showed similar results regarding the number of incident cases avoided with a scenario similar to our scenario SC2.[30–32] The impact of SC4 on the epidemiological indicators may seem low when considering the high attributable fraction of tobacco for MI. One explanation is that removing an important risk factor of mortality in the population induces a greater number of ageing subjects who are likely to develop MI. This has the effect of diminishing the effect observed for a single pathology, although the public health benefit remains important.

Table 1 Estimated Mean Age of Incident Cases of Myocardial Infarction (with 95% Uncertainty Intervals) in France Between 2024 and 2035 by Sex According to Scenarios SC1, SC2, SC3, and SC4

Year	Males				Females			
	SC1	**SC2**	**SC3**	**SC4**	**SC1**	**SC2**	**SC3**	**SC4**
2015	64.63				73.89			
2020	65.48				72.96			
2023	65.96				72.58			
2027	66.77	66.81	67.06	67.96	72.43	72.46	72.67	73.35
2031	67.72	67.79	68.23	68.99	72.84	72.89	73.20	73.71
2035	68.73	68.83	69.41	70.08	73.71	73.78	74.16	74.55
Evolution (2023–2035)	+2.77 (+4.20%)	+2.87 (+4.32%)	+3.45 (+5.23%)	+4.12 (+6.25%)	+1.13 (+1.56%)	+1.20 (+1.65%)	+1.58 (+2.18%)	+1.97 (+2.71%)

Abbreviations: SC1, 1% of smokers quitting per year; SC2, 2% of smokers quitting per year; SC3, 9.87% of smokers quitting per year; SC4, extreme scenario, cessation of smoking from 2024.

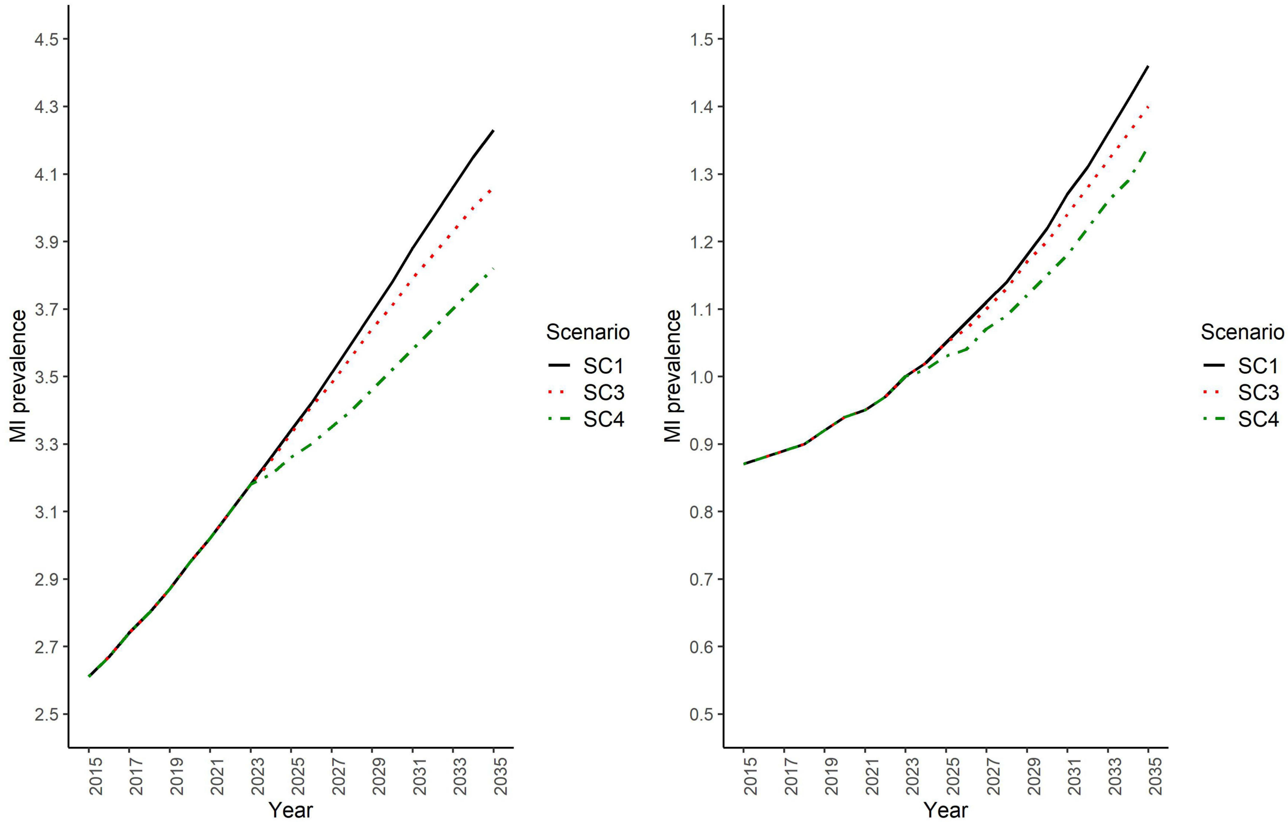


Figure 4 Estimated MI prevalence by year from 2015 to 2035 for males (left) and females (right) according to the scenarios SC1 (solid line), SC3 (dashed line), and SC4 (dotted line), SC2 is not shown because it overlaps with SC1.
Abbreviations: SC1, 1% of smokers quitting per year; SC3: 9.87% of smokers quitting per year; SC4, extreme scenario, no new smokers from 2024.

To measure the real benefit of smoking cessation on health, it would be necessary to evaluate the impact on all tobacco-related diseases.

Despite our encouraging results with the different scenarios showing a decrease in the number of MI incident cases, all-cause mortality, and deaths after MI, MI prevalence would still increase. This increase can be explained by the demographic projections of an ageing population, which will increase the number of people at risk of MI. Further, the stronger the impact of the scenario on the proportion of daily smokers, the better the survival rate, which in turn increases the ageing population. This phenomenon is illustrated by an increase in both the mean age of MI incident cases and the size of the general population between 2023 and 2035 for SC3 and SC4. Nevertheless, the better survival of individuals

Table 2 Estimated Number of Prevented Myocardial Infarction (MI) Cases, Prevented Deaths from All Causes, and Prevented Deaths After a MI Before 65 Years and Between 35 and 95 Years (with 95% Uncertainty Intervals) in France Between 2023 and 2035 by Sex According to the Scenarios SC2, SC3, and SC4

	Males			Females			Total		
	SC2	**SC3**	**SC4**	**SC2**	**SC3**	**SC4**	**SC2**	**SC3**	**SC4**
Number of prevented MI cases before 65 years	3300	22,000	56,000	800	5300	13,000	4100	27,300	69,000
Number of prevented MI cases	5000	33,000	77,000	1800	12,000	26,000	6800	45,000	103 000
Number of prevented deaths from all causes before 65 years	4400	30,000	84,000	2400	16,000	46,000	6800	46,000	130 000
Number of prevented deaths from all causes	21,000	138 000	340,000	19,000	127,000	313 000	40 000	265 000	653 000
Number of prevented deaths after MI before 65 years	100	700	2200	15	100	360	115	800	2560
Number of prevented deaths after MI	460	3200	9300	180	1300	3500	640	4500	12,800

Abbreviations: SC2, 2% of smokers quitting per year; SC3, 9.87% of smokers quitting per year; SC4, extreme scenario, cessation of smoking from 2024.

would lead to an improvement of indicators such as years of life lost and quality-adjusted life years, thus reducing the healthcare costs as shown in different studies.[30–36] A study conducted in the UK estimated the healthcare and social costs avoided for ischemic heart disease to be £7 million for an estimated smoking prevalence of 16.9% in 2015, falling to less than 5% by 2035, which is quite similar to SC3.[36]

The increase in MI prevalence due to an ageing population cannot be countered, even by intense public health interventions for one of the main risk factors of MI. Healthcare policies should anticipate this incompressible increase, and the healthcare system should be prepared to adapt both acute hospital care and subsequent out-of-hospital care, as the number of cardiac rehabilitation beds is already limited. The cost of hospitalization for cardiovascular diseases (15.1 billion in 2013)[37] and the management of prevalent cases is already high and set to increase because of MI, not to mention other cardiovascular and chronic diseases. Strong tobacco control interventions improved all the epidemiological indicators of MI, although these interventions should be taken further with ambitious targets and accompanying prevention resources. Compared with countries such as the United States, United Kingdom, Canada, and Australia, which implemented strong tobacco control measures before the 2000s, tobacco control in France has only been a major objective since the 2010s. The French government implemented the National Tobacco Reduction Program (PNRT) for the period 2014–2019, which led to the introduction of the plain tobacco product packaging and the creation of a tobacco-free month in 2016. The National Tobacco Control Program (PNLT) for 2018–2022 aims to reduce the proportion of daily smokers by 2027, continuing up to 2032. Thus, to counteract this increase in MI prevalence, prevention campaigns are needed with ambitious objectives targeting all risk factors of MI. For example, there are many undiagnosed and untreated diabetics and hypertensives in France, with less than one in two being treated with antihypertensive drugs. From this perspective, France lags behind United Kingdom, Canada, and Germany on these two risk factors.[38,39]

Multi-state models and, more specifically, the illness-death model[19] (three state model: alive, diseased, deceased) are widely used for modeling chronic diseases and making projections.[40–43] Other studies use a Markov model or an illness-death model to establish projections for cardiovascular diseases.[3,5,44,45] Others studies have also projected cardiovascular diseases such as in Foreman et al[46] However, their projection method does not consider a risk factor such as smoking, a common risk factor for MI and death.

The illness-death model and multi-state models more generally can make projections based on the incidence of the disease of interest, the mortality of healthy and diseased individuals, as well as the incidence of risk factors. This is particularly important for diseases with a high prevalence and mortality.[40,41] Although this is not the case for MI, we still took into account an age- and cohort-dependent incidence as well as the mortality in healthy individuals. We also differentiated the mortality of diseased individuals by taking into account the time since the onset of the disease.

The validation of ICD-10 codes used to identify myocardial infarction has been the subject of studies such as in Bezin et al.[47] In addition, these codes are very specific with a precise classification of ICD-10 codes,[48,49] precise coding in the PMSI[50] and they are widely used in epidemiological studies.[51] The hospital admissions database provided an exhaustive selection of hospital admissions for MI since 2005. However, it was not possible to remove the entire life MI history of the patients, but two years could be taken into account consistently over the whole period. Although we excluded patients with a personal history of MI in the two years preceding the date of hospitalization, some of them could be recurrent and therefore not necessarily incident and can lead to a slightly overestimation of hospital admissions for myocardial infarction. As smoking status is not included in the SNDS, we used survey data from the *Baromètre de Santé publique France* for the smoking data. Although, there have been no validation studies for smoking data, the survey is a weighted declaration and representative of the French population.[29]

By considering the smoking status of individuals, we were able to model smoking cessation, which allowed us to create different scenarios for the decreasing proportion of smokers. This methodology is suitable for simulating scenarios and evaluating public health policies and can also be used for other risk factors such as hypertension. Furthermore, unlike methodologies based on the potential impact fraction, our methodology takes into account the changes in the incidence rates.[52] The limitations of our methodology relate to some of our assumptions. We assumed that a former smoker remains a former smoker throughout his or her lifetime and that a smoker could stop at any age. Furthermore, we did not take into account the smoking history (number of cigarettes smoked) of individuals when quitting, the duration of smoking, or the time since quitting.

Conclusion

Our study showed the benefit of encouraging smoking cessation as number of prevented MI cases increased with smoking cessation proportions - particularly among the youngest individuals. Given the major impact of the ageing population, the objective of reducing tobacco use must be ambitious in order to strongly impact the various epidemiological indicators. To reduce the future burden of MI in France, prevention must not be limited to a single risk factor. Our models can be generalized to other risk factors as well as to other diseases, thus contributing to the improvement of public health policies.

Data Sharing Statement

The data underlying this article cannot be shared publicly for privacy reasons. Data access is regulated by French legislation: any request for access to the data should be made to the National Institute of Health Data (INDS) and authorization requested from the French Data Protection Authority (CNIL). INSEE data are available at: https://www.insee.fr/fr/statistiques/2496228.

Ethics Approval

To carry out its public interest missions in terms of health monitoring (article L. 1413-1 code de la santé publique*), the French National Public Health Agency has been granted permanent access to the SNDS by French law (code de la santé publique: articles L. 1461-3 I 2° and R. 1461-12 and following). The validation of the study protocol by the National Ethics Committee is not, in this case, required by French law. The French National Public Health Agency is only required to keep an internal record of the studies conducted using these data as part of its public interest missions (article R 1461-17). The analysis of SNDS data by the French National Public Health Agency was performed with the permission of the CNIL (French Data Protection Authority) and by decree (regulatory decision DE-2011–078).

*The public health code (*code de la santé publique*) contains laws (articles beginning with L) and decrees (articles beginning with D or R) used by the French authorities in the field of public health.

All data were fully anonymized. Patients consent is not required and this study adhered to the tenets of the declaration of Helsinki.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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