# Avoidable global cancer deaths and total deaths from smoking

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Abstract | On the basis of current consumption patterns, approximately 450 million adults will be killed by smoking between 2000 and 2050. At least half of these adults will die between 30 and 69 years of age, losing decades of productive life. Cancer and the total deaths due to smoking have fallen sharply in men in high-income countries but will rise globally unless current smokers, most of whom live in low- and middle-income countries, stop smoking before or during middle age. Tripling the taxes on tobacco could rapidly raise cessation rates and deter the initiation of smoking. Higher taxes, regulations on smoking and information for consumers could avoid at least 115 million smoking-associated deaths in the next few decades, including around 25 million cancer deaths.

Tobacco use kills approximately 5–6 million people annually worldwide, accounting for 1 in every 5 male deaths and 1 in 20 female deaths in individuals over 30 years of age[1–4]. On the basis of current smoking patterns, the number of annual deaths due to smoking will rise to around 10 million by 2030, and there will be approximately 1 billion deaths due to smoking in the twenty-first century, of which over 70% will be in low- and middle-income countries outside north America and Europe[1,5]. By contrast, 100 million deaths due to smoking occurred in the twentieth century, of which nearly 70% occurred in high-income countries and in the former socialist economies of Europe[6]. Unless there is widespread cessation of smoking, approximately 450 million deaths will have occurred as a result of smoking by 2050 and most of these will occur in current smokers. An additional 500 million tobacco-related deaths will occur in the second half of the century, mostly in future smokers (FIG. 1).

This Analysis argues that widespread use of a few powerful price, information and regulation interventions could avoid a large proportion of the expected 450 million deaths due to smoking over the next few decades. I first present the epidemiology of smoking-associated disease and explain the importance of the long delay between the onset of smoking and mortality from cancer and other diseases for future disease risks and for the benefits of cessation. This is followed by a discussion of the effectiveness of interventions to rapidly increase cessation rates in low- and middle-income countries. Finally, I present a mathematical projection model that describes the impact of interventions on cancer and total mortality in the 1.1 billion current smokers worldwide.

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## Epidemiology

***Smoking patterns.*** This Analysis focuses on the use of smoked tobacco because it is more common — it accounts for approximately 85% of all tobacco produced worldwide[7] — and because inhaled tobacco causes more disease and more diverse types of disease than does oral tobacco use[8–10]. Similarly, active smoking is more hazardous than exposure to second-hand smoke[8,9,11], although second-hand smoke substantially contributes to illness[12]. Approximately 1.1 billion people worldwide smoke, of whom over 80% reside in low- and middle-income countries. In these countries, around 49% of men and 8% of women above the age of 15 years smoke, in contrast to 37% of men and 21% of women in high-income countries[13]. Over 60% of all smokers live in just 10 countries (listed in order of highest numbers of smokers): China, India, Indonesia, Russian Federation, the United States, Japan, Brazil, Bangladesh, Germany and Turkey[4].

The consumption per adult per day (the number of cigarettes smoked per day, divided by the population of smokers and non-smokers) has decreased by over 50% in the past 2–3 decades in the United States, the United Kingdom, Canada, France and other high-income countries[14]. By contrast, the prevalence of smoking in males has risen sharply in many low- and middle-income countries, such as China and Indonesia (FIG. 2). Smoking in India is mostly in the form of bidi, which are smaller than cigarettes and typically contain only around one-quarter as much tobacco, which is wrapped in the leaf of another plant. Smoking trends for Indian males have been stable, although recent increases in cigarette smoking in young men in urban areas have been reported[15] but not

**At a glance**

- Currently, smoking causes approximately 5–6 million deaths per year, including 31% and 6% of all cancer deaths in middle-aged men and women, respectively. The proportions of male cancer and total deaths due to smoking are falling in high-income countries but rising in low- and middle-income countries.
- Cessation by current smokers is the only practical way to avoid a substantial proportion of tobacco deaths worldwide before 2050.
- Cessation before middle age avoids more than 90% of the lung cancer mortality attributable to smoking and markedly reduces the risks of death from other diseases. Although cessation has become common in high-income countries, it is still rare in most low- and middle-income countries.
- Countries such as France that have aggressively used higher taxes to curb smoking have reduced consumption much faster than countries that have not aggressively increased tobacco taxation.
- In low- and middle-income countries, a 10% higher tobacco price reduces consumption by around 8%, which is twice the effect seen in high-income countries. Health information, counter-advertising, restrictions on smoking and cessation therapies are also highly effective at reducing smoking.
- A 70% higher street price of cigarettes (corresponding to around a 2–3-fold higher tax) would avoid 115 million deaths or one-quarter of expected tobacco deaths over the next few decades. Of the avoided deaths, approximately 25 million would be from cancer and 50 million from vascular disease.

yet confirmed[16]. A notable exception to the increases of smokers in low- and middle-income countries is Brazil, which has recorded decreases in the prevalence of adult smokers[17].

***Smoking cessation.*** The smoking prevalence in a population comprises the current smokers, ex-smokers and individuals who have never smoked. The prevalence of ex-smokers is a good measure of cessation at a population level[1,13]. Cessation, together with an increasing proportion of individuals who have never smoked, has reduced the adult (aged >30 years) smoking prevalence in the United Kingdom between 1950 and 2005 from 70% to 25% in men and 40% to 20% in women[14]. There are now twice as many ex-smokers as smokers in the United Kingdom who are currently aged 50 years or over[18]. Similar increases in cessation have been reported in most high-income countries[13,19]. By contrast, the prevalence of male ex-smokers in most low- and middle-income countries is low: <10% in China[20] and Vietnam[21], and <2% in India[22,23]. Even these low figures might be falsely high because they include people who have stopped smoking as a result of being too ill to continue or as a result of the diagnosis of early symptoms of illnesses attributable to smoking tobacco[24], such as respiratory disease.

***Importance of prolonged smoking for disease risks.*** Most of the current smokers worldwide are between the ages of 20 and 40 years[13]. For these individuals, a proper understanding of the hazards of continued smoking and the corresponding benefits of cessation must take into account the long delay between the cause and the full effects of smoking[25,26]. The full effects of smoking can take 50 years to measure in individuals and up to 100 years to measure in populations. Among British doctors who were born between 1900 and 1930 and followed between 1951 and 2001, the death rates were three times higher in doctors who smoked than in those who did not[27]. The differences in the risk of death between smokers and non-smokers became more extreme in 1981–2001 than they were in 1951–1980 (REF. 28). Those who smoked over a prolonged period lost around 10 years of life compared with non-smokers. Most, but not all, of the absolute excess in death from all causes among smokers was due to smoking, as there were no material differences between smokers, non-smokers and ex-smokers in education, drinking and obesity. Similarly, the main increase in cigarette smoking in the United States occurred in 1920–1940, and consumption peaked at approximately 10 cigarettes per adult per day around 1960 (REFS 14,29). However, the rates of lung cancer, almost all of which are due to smoking, peaked only around 30 years later[6,29–31] (FIG. 2).

***Effects of cessation on lung cancer and total deaths.*** Widespread cessation of smoking in high-income countries has afforded the opportunity to study the impact of stopping smoking at various ages on the risk of death from tobacco-attributable diseases. United Kingdom doctors who stopped smoking before the onset of major disease avoided most of the hazards of smoking. Compared with individuals who continued smoking, the life expectancy gained by stopping smoking around 60, 50, 40 or 30 years of age was approximately 3, 6, 9 years or almost the full 10 years, respectively[27].

Cessation before middle age (defined as around 30 years) avoids more than 90% of the lung cancer mortality attributable to smoking, and individuals who stop smoking show a similar pattern of survival to that of individuals who have never smoked. In the United Kingdom, among those who stopped smoking, the risk of lung cancer fell steeply with time since cessation[18]; for men who stopped at ages 50, 40 and 30 years, the cumulative risks of lung cancer mortality by age 75 years were 6%, 3% and 2%, respectively, in contrast to the risk of 16% for individuals who continued to smoke. Similar reductions in the risk of death from lung cancer have occurred in the United States in men (FIG. 3) and women[29]. The absolute reduction in mortality due to cessation of smoking might be even greater for other diseases, particularly vascular diseases, than for lung cancer in the first decade or two after stopping smoking[27].

## Current and future disease risks from smoking

Currently, approximately 70% of the 40 million deaths among adults over the age of 30 years worldwide are due to cancer, vascular and respiratory diseases and tuberculosis[32]; the incidence of each of these diseases increases with smoking[8–11]. Smoking caused around 5–6 million deaths worldwide from all causes[2] and approximately 850,000 deaths from cancer[3] around 2001. Approximately 50% of all deaths due to smoking occur in low-income countries. The following section examines the current cancer and total mortality that reflects past exposure to smoking.

***Smoking and cancer deaths.*** In 2001, cancer caused approximately 2.2 million male deaths and 1.6 million female deaths worldwide for people between the ages of

30 and 69 years (FIG. 4), or approximately 30% of the 13 million adult deaths from non-communicable diseases[32]. At these ages, smoking is estimated to cause around 31% and 6% of all cancer deaths in men and women, respectively (TABLE 1). There was a marked drop in the rates of male smoking deaths from cancer and all other causes between 1975 and 2005 in the United Kingdom and the United States[30,31]. The deaths in men in 1975 reflected the men who began to smoke around 1920–1940, which was during a sharp increase in the incidence of male smoking in both countries, with few men stopping smoking. By 1975, smoking therefore accounted for more than 50% of all male deaths from cancer and 34–44% of deaths from all causes in middle age. By 2005, the percentage of male deaths from cancer due to smoking fell to 23–26% and smoking-associated deaths from all causes also decreased. This decline was because of the much lower proportion of men who began to smoke in 1950–1970, of which a substantial proportion have since stopped smoking. The death rates from cancer and all causes due to smoking in females in the United Kingdom and United States peaked only around 1995, but have since declined.

Where they have been reliably measured, currently there also seems to be a substantial proportion of cancer deaths that are due to smoking in low- and middle-income countries[22,33,34]. In China, smoking caused approximately 28% of cancer deaths in men and 6% in women aged >40 years in 2000 (REF. 33). In India, around 32% of cancer deaths in men and 6% of cancer deaths in women aged 30–69 years are caused by smoking[22]. In addition, smoking seems to synergise with chronic viral infections that cause liver and cervical cancers[35,36,37].

***Smoking and deaths from other diseases.*** Smoking causes approximately four times as many deaths from causes other than cancer than it does from cancer. Cardiovascular disease is the leading cause of smoking-attributable deaths worldwide, accounting for around 1.5 million such deaths annually, of which 0.8 million deaths are caused by acute heart attacks[2,32]. Smoking is a significant risk factor for both fatal and non-fatal heart attacks and strokes[9,11,38,39]. In high-income countries, approximately half of the male and one-third of the female deaths from chronic lung disease are due to smoking[31]. In China, chronic lung disease accounted for nearly half of all tobacco deaths among men aged 30–69 years[34]. In India, among those who are aged 30–69 years, over 30% of deaths among men and 10% of deaths among women from chronic lung disease are due to smoking[22]. In both settings, smoking seems to increase the high background rates of chronic lung disease caused by indoor (not ambient) air pollution[40].

Richard Doll observed an association of smoking with tuberculosis in the 1950s[41] in the United Kingdom, but widespread treatment resulted in tuberculosis becoming too rare to study in high-income countries. The association between tuberculosis and smoking was therefore largely forgotten[8]. More recently, increased risks of tuberculosis death and non-fatal tuberculosis among smokers have been observed in countries in which tuberculosis remains common[34,42,43], most notably in India[22,44,45]. In India, smoking accounts for nearly 40% of tuberculosis deaths among middle-aged males (around 120,000 deaths)[22]. Subclinical infection with *Mycobacterium tuberculosis* is widespread and smoking seems to facilitate progression from a silent form to the active clinical disease[22,44,46,47]. Smoking might therefore contribute to the spread of tuberculosis infection.

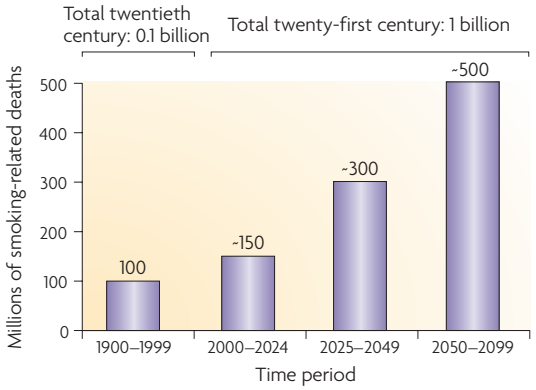


Figure 1 | **Projected numbers of deaths from tobacco smoking during the twenty-first century.** Approximately 100 million people per year reach adult life worldwide. Current smoking uptake patterns suggest that there are approximately 30 million new smokers per year (that is, approximately 50% of young males and 10% of young females)[92]. Most of these individuals will continue smoking, as cessation is currently uncommon outside high-income countries[13]. Even assuming that a large number cease smoking — for example, if one-third of the 30 million stop smoking (or if the risks of eventual death are 'only' 1 in 3 versus 1 in 2), then eventually 10 million people per year will be killed by smoking. The worldwide tobacco mortality will increase to approximately 10 million per year or 100 million per decade around 2030, with some further increases in later decades[5]. During the 25-year period of 2000–2025, there will be approximately 150 million tobacco-related deaths or 6 million deaths per year on average; in 2025–2050, there will be approximately 300 million tobacco-related deaths or 12 million deaths per year. Further estimations are more uncertain but on the basis of the current initiation and cessation rates and the projected population growth, in 2050–2100 there will be, conservatively, 500 million tobacco-related deaths (that is, an average of 10 million deaths per year). Of the estimated 1 billion smoking-attributable deaths in this century, most will occur in low- and middle-income countries. By contrast, there were 'only' 100 million tobacco deaths in the twentieth century, mostly in high-income and eastern European countries that started smoking *en masse* generally before or around the Second World War. Similar projections for the next three to four decades have been made by others[1,93], and these projections are consistent with emerging epidemiological studies in China[33,34,49] and India[22].

***Overall current risks.*** Provided that the long delay between the onset of smoking and disease is allowed for, consistent quantitative estimates of risk emerge: approximately one in two of all long-term smokers worldwide are killed by their addiction[6,8,22,25,27,30,31,33,34,48,49]. It is already apparent that a substantial fraction of tobacco-associated deaths worldwide occur in middle age (50% in the

United States and United Kingdom[6], 50% in China[33,34] and a surprisingly high 70% in India[22]). Overall, the average smoker loses at least two decades of life expectancy compared with that of a non-smoker[6]. Currently, around 80% of the deaths due to smoking worldwide occur in men[2], but this is chiefly because men who died recently smoked more commonly and more intensively when they were young than female smokers. The emerging proportional increase in United States female death rates seems to be as great as that for males[29]. The eventual risks of premature death and the corresponding benefits of cessation are therefore likely to be similar for women and men. Additionally, the consequences of smoking vary by socio-economic group: in high-income countries and in Poland, smoking deaths account for at least half of the differences in the risk of death in middle age between rich or educated men and poorer or less-educated men[50].

***Future risks from smoking.*** The future risks of smoking in men in low- and middle-income countries and women worldwide will depend on the duration of smoking in the population (and cessation) and on variation in the prevalence of diseases that occur more commonly with smoking, the types of smoked tobacco and patterns of smoking. First, the full effects of smoking will only become apparent when the death rates from smoking in middle age, among those who have started smoking as young adults, increase 30–40 years later. Death rates from smoking at an older age will increase only around 20 years after this[26]. For example, of all United States male deaths at ages 35–69, the proportion attributable to tobacco in 1950 was only 12%, rising to 33% in 1990, when the increase in United States male tobacco deaths had been completed (around 3 decades after peak tobacco consumption)[6]. Currently, there is variation in the percentage of male smokers that die. It was 'only' 25% in China in 2000 (REFS 33,34) but is approximately 40% in India in 2009 (REF. 22). The higher risks among Indian males might reflect the fact that tuberculosis is more common in India than in China, as well as the more prolonged period of smoking in Indian males (the smoking prevalence is higher among Chinese males but they have begun smoking more recently than their Indian counterparts). The risks of smoking in China are likely to rise when the smokers who have been smoking from early adult life reach middle age. Second, greater risks are seen for cigarette than for bidi smoking in India[22], therefore a shift to cigarette consumption[15] would increase the overall hazards among smokers. Third, the average daily consumption of cigarettes or bidi is generally lower in low- and middle-income countries than in high-income countries[1,13,51] and the age of starting to smoke is generally later. However, Chinese men have begun to start smoking at a similar age to young men in the United States[20]. If similar shifts in smoking at younger ages occur in India and other populations, the hazards of smoking will be greater.

Plausible projections of future smoking deaths rely on smoking prevalence and uptake (cessation is minimal in low- and middle-income countries), growth in population and growth in the age-specific tobacco-attributable

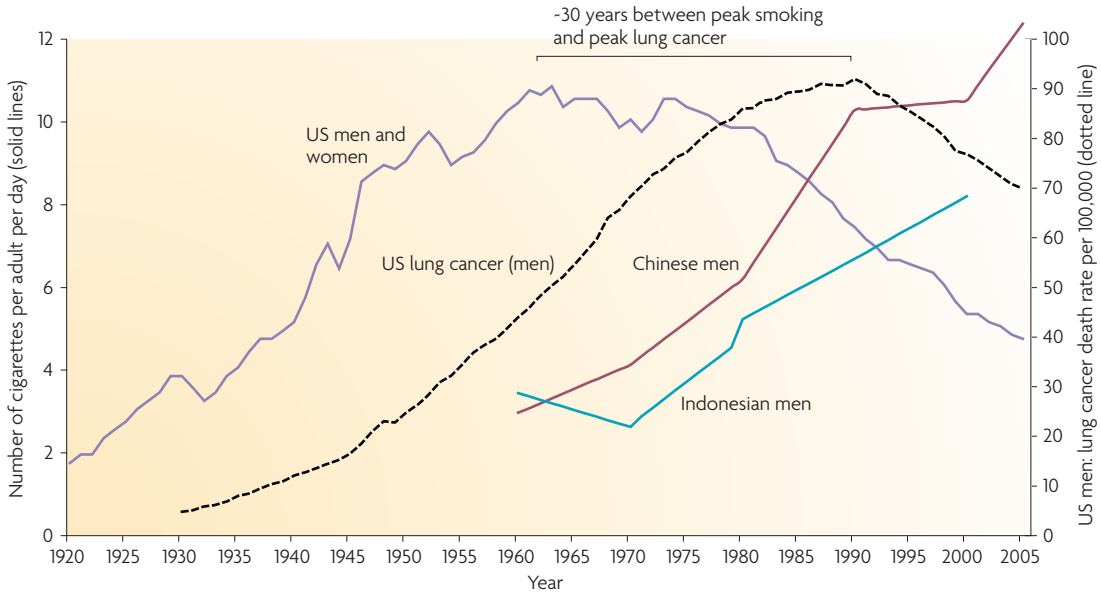


Figure 2 | **Trends in cigarette consumption and male lung cancer rates, 1920–2005.** The number of cigarettes consumed per adult (males are used as the appropriate denominator for cigarette smoking as few females currently smoke in Asia) and the age-standardized lung cancer rates over time by country. The widespread automation of cigarette production in the early twentieth century turned cigarettes into a global commodity[94]. Lung cancer was a rare disease before the Second World War, and the large increase in lung cancer rates lagged behind consumption by three or more decades. The mean consumptions in Chinese men were 1, 4 and 10 cigarettes per day in 1952, 1972 and 1992, respectively, which were similar to the increases in cigarette consumption that were reported 40 years earlier in the United States (US)[34,49]. China has reported a marked increase in cigarette production since 2000. Increases in exposure to smoking at very young ages, combined with prolonged exposure, would be likely to increase the age-specific death rates in the future in China, Indonesia and other countries.

death rates (FIG. 1). Richard Peto estimates[5] that the number of annual tobacco deaths will reach an average of approximately 6 million in 2000–2024, and will be twice this number in 2025–2049. The annual tobacco deaths in China are projected to rise to 2 million by 2025 (REFS 34,49), when the current young adult smokers reach middle age. Similarly, at current risks, India will have 1 million annual deaths during the 2010s[22], and this number will rise with population growth. Similar growth in other populations in Asia, eastern Europe, Latin America, the Middle East and, less certainly, sub-Saharan Africa suggest that the estimate made by Peto of approximately 450 million tobacco-attributable deaths over the next 5 decades is plausible. Indeed, the chief uncertainty is not whether tobacco deaths will reach approximately 10 million per year, but when this will happen, with the most likely scenario being that this total will be reached around 2030. Almost all deaths from smoking over the next few decades will be among current smokers.

## Rapidly increasing cessation rates worldwide

Cessation by current smokers is the only practical way to avoid a substantial proportion of tobacco deaths worldwide before 2050. Halving the per capita adult consumption of tobacco by 2020 (akin to the declines in adult smoking in the United Kingdom over the past 3 decades) would avoid approximately 160–180 million tobacco-related deaths over the next few decades. By contrast, halving the percentage of children who become prolonged smokers (from around 30% to 15% over 2 decades) would prevent approximately 20 million deaths over the next few decades, but its main effect would be to lower mortality rates in 2050 and beyond[1,5].

Aggressive taxation is the key strategy for low- and middle-income countries to reduce smoking at a rate faster than that achieved by high-income countries. Powerful policy interventions to tax and regulate consumption and to inform consumers have reduced consumption in most high-income countries[14,19,52]. The United States and United Kingdom each took approximately 35 years and Canada 25 years to halve cigarette consumption per adult (from around 10 per adult per day to 5 (REF. 14)). However, France took only 15 years to halve cigarette consumption per adult[53]. The uptake of smoking in France chiefly occurred after the Second World War and the prevalence of smoking increased until the mid 1980s. From 1990 to 2005, the cigarette consumption per adult per day decreased from approximately 6 to 3 (REF. 14) (FIG. 5). This was attributed to a sharp increase in tobacco taxation starting in 1990, which increased the inflation-adjusted price three-fold. Among men, the corresponding lung cancer rates at ages 35–44 fell sharply from 1997 onwards[6]. The decline in lung cancer was also attributed, more controversially, to the replacement of high-tar cigarettes with lower-tar cigarettes[54].

The following section briefly reviews the effectiveness of interventions to reduce tobacco use at the population level. More detailed reviews have already been published[1,52,55].

***Tobacco taxation.*** Higher taxation is the single most important intervention to raise smoking cessation globally. Tobacco taxes and consumption are strongly inversely related worldwide[56–58]. Over 100 studies worldwide show that increases in taxes on cigarettes and other tobacco products lead to significant reductions in tobacco use[52,55–58]. Studies from high-income countries estimate a 10% increase in cigarette prices will reduce overall smoking by 2.5% to 5% in the medium term[56,58,59], and perhaps by twice this amount in the longer term[56]. The fewer studies from low- and middle-income countries suggest that increasing taxation will have an effect twice as great: a 10% increase in price will reduce smoking by 8% in the medium term[58,59]. Higher taxes reduce relapse and decrease consumption in individuals who continue to smoke. Half or more of the effect of price on cigarette demand results from reducing the number of current smokers[60,61]. Higher taxes increase the number of attempts at stopping smoking and the success of those attempts; a 10% increase in price results in 11% to 13% shorter smoking duration, or a 3% higher probability of cessation[62]. Higher cigarette prices are particularly effective in preventing young smokers from moving beyond experimentation into regular, addicted smoking[63–64], and are also effective in less educated or lower-income individuals[65,66].

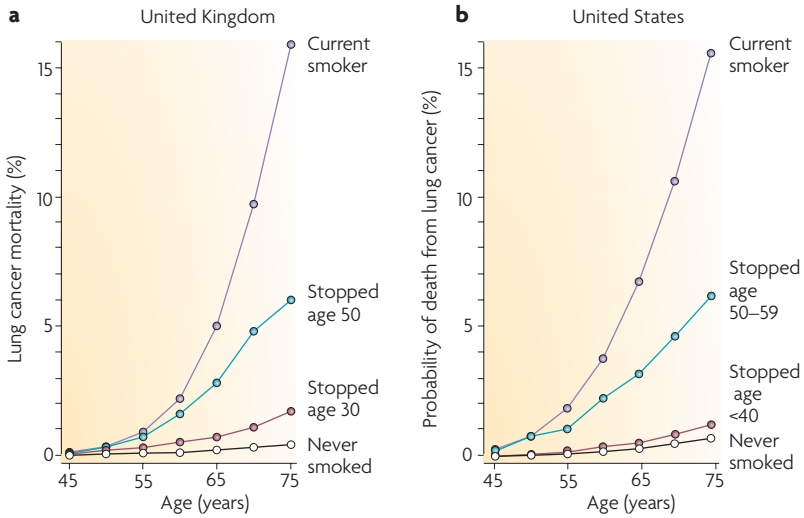


Figure 3 | **Risk of death from lung cancer in smokers and ex-smokers.** The age-specific probability of death from lung cancer for the United Kingdom and United States, stratified by continued smoking or cessation at various ages. The United Kingdom data (**a**) are from retrospective studies[18], courtesy of R. Peto and J. Boreham. For each age, the relative risks match those in a case–control study of smoking, and an appropriately weighted average of the absolute risks matches the national lung cancer death rates. The United States data (**b**) are from the American Cancer Society prospective study of 1.2 million subjects during the first 10 years of follow up, courtesy of M. Thun[29]. These data omit the earlier years of follow up (1981–1983). The same study showed that few of those who stop would restart smoking. In both of these studies, those who stopped smoking did so within 5 years of the stated age, and almost all smokers had used cigarettes. Similar results on reductions in lung cancer risk in ex-smokers are seen in Poland[18,95]. The excess lung cancer mortality avoided in men who stopped smoking by age 40 was 91% in Germany and 80% in Italy[96]. A minority of lung cancers are not due to smoking, and the United States rates of lung cancer that are not due to smoking have changed little from the 1960s to 1990s[6,48,97]. A range of genetic factors has recently been suggested that modestly predicts lung cancer risk in smokers and non-smokers[98]. However, it is improbable that marked shifts in genetic susceptibility have occurred and, even if they had, such shifts would be unlikely to explain the dramatic changes in lung cancer that have been seen over a few years or decades[26,29].

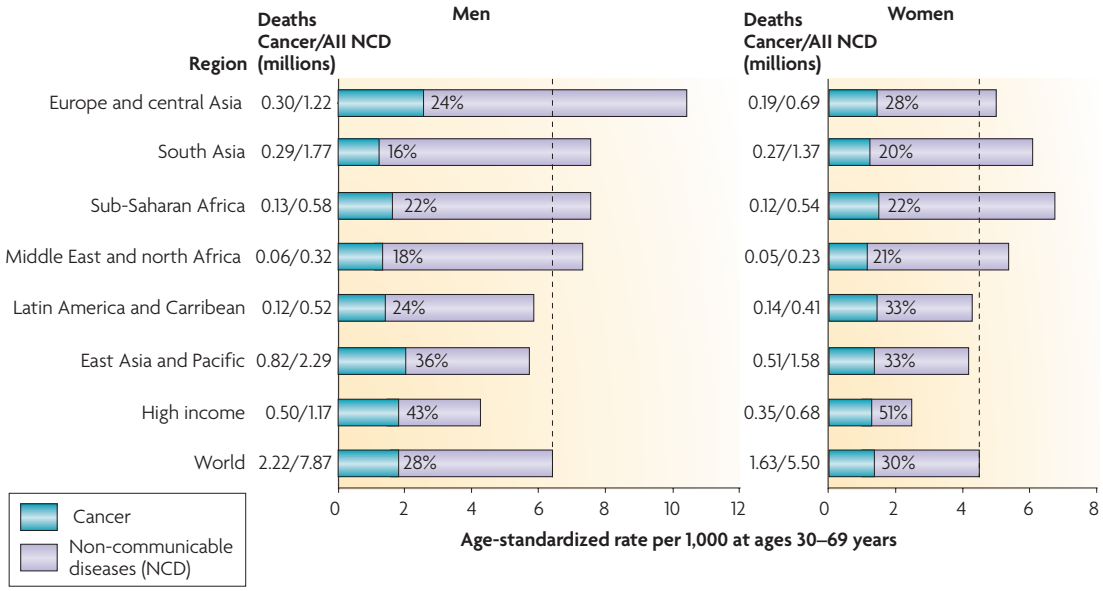


Figure 4 | **Death rates in middle-age from cancer and non-communicable disease by region, 2001.** The 2001 death rates are directly standardized to the world population for the same year. Regions are grouped as per the World Bank regional classification[99]. The figure shows the age-standardized death rate for adults aged 30–69 years across various regions from non-communicable diseases (NCD; total bar), and the proportion of these deaths that were due to cancer (blue portion of bar). The proportions of cancer deaths to total deaths from NCD vary across regions, in part owing to differences in the specific types of cancer, competing deaths from non-cancer risks and the effects of smoking. Of note, the death rates at ages 30–69 years from these causes in sub-Saharan Africa exceed the corresponding death rates in high-income countries by over 50%. Even more extreme death rates are seen in the former Socialist economies. In all regions, a significant minority of the total deaths in middle age are caused by cancer; it causes an average of 28% of all male deaths and 30% of all female deaths. The proportion of cancer to total deaths ranges from 16% in males and 20% in females in south Asia up to 43% in males and 51% in females in high-income countries.

An increase in cigarette taxes of 10% globally would raise cigarette tax revenues by nearly 7%, as the fall in demand is less than proportional to the price increase in most countries[55]. However, taxes are underused in most developing countries[67,68]. Taxes tend to be higher and account for a greater share of the retail price (71% as of 2006) in high-income countries. In low- and middle-income countries, taxes account for 54% of the final price of cigarettes[55]. In South Africa, tax as a percentage of tobacco retail price fell to approximately 20% around 1990, but has subsequently risen to nearly 40%[59]. As a result, consumption decreased from around four cigarettes per adult per day to two over a decade[59] and adult lung cancer rates may be falling[69]. The recent tax increases in Poland have doubled the consumer price of cigarettes[70] and reduced consumption.

***Health information and counter-advertising.*** There is a widespread misconception that smoking risks are well known. In many countries, there continues to be substantial ignorance of the health risks of smoking. For example, a national survey in China in 1996 found that 61% of smokers thought that tobacco did them 'little or no harm' (REF. 20). In high-income countries, smokers are more aware of the risks, but few smokers judge the size of these risks to be larger and more established than non-smokers, and most smokers minimize the personal relevance of these risks[71]. Decreases in smoking prevalence were largest in high-income countries in which the public is constantly and consistently reminded of the dangers of smoking by extensive coverage of issues that are related to tobacco in the media[1,19,72]. For example, the 1962 report by the British Royal College of Physicians[73] and the 1964 United States Surgeon General's report[74] and the publicity that followed reduced cigarette consumption by 4% to 9% initially, and by 15% to 30% in the longer term[72,75]. Counter-advertising efforts, including focused mass publicity, are therefore likely to be effective in low- and middle-income countries[72]. Prominent, rotating pictorial warning labels on tobacco products are also effective at portraying risks to smokers[76], and would be particularly relevant in countries in which illiteracy is high (half of the smoking deaths in India occur among uneducated individuals[22]).

***Restrictions on smoking in public places.*** Restrictions on smoking in public places are intended chiefly to reduce the exposure of non-smokers to passive tobacco smoke and also to create non-smoking social norms. However, comprehensive restrictions also increase attempts to stop smoking, so that overall consumption falls by 3–4%[77–79]. Admissions to hospital for acute heart attack have fallen in several high-income countries that have introduced restrictions on public smoking[38]. Smoking bans in workplaces can reduce prevalence rates by up to 20% and reduce the quantity of cigarettes smoked among

Table 1 | **Deaths in middle-aged adults from cancer and all causes (in thousands), attributed to smoking**

| Country or region | Year | Age group | Number of smoking-related cancer deaths/total number of cancer deaths (men) | Cancer deaths due to smoking (%) (men) | Number of smoking-related deaths from all causes/ total number of deaths from all causes (men) | Deaths from all causes due to smoking (%) (men) | Number of smoking-related cancer deaths/total number of cancer deaths (women) | Cancer deaths due to smoking (%) (women) | Number of smoking-related deaths from all causes/total number of deaths from all causes (women) | Deaths from all causes due to smoking (%) (women) | Refs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| World | 2001 | 30–69 | 749/2429 | 31 | 2309/12263 | 19 | 108/1741 | 6 | 489/8088 | 6 | 2 |
| *High-income** | | | | | | | | | | | |
| United Kingdom | 1975 | 35–69 | 23/39 | 57 | 62/142 | 44 | 5/31 | 15 | 15/85 | 18 | 6 |
| United Kingdom | 2005 | 35–69 | 10/28 | 34 | 18/78 | 23 | 5/25 | 19 | 11/51 | 21 | 6 |
| United States | 1975 | 35–69 | 54/107 | 51 | 157/457 | 34 | 13/88 | 14 | 40/262 | 15 | 6 |
| United States | 2005 | 35–69 | 50/121 | 42 | 113/432 | 26 | 28/106 | 26 | 73/284 | 26 | 6 |
| *Low or middle-income* | | | | | | | | | | | |
| China‡ | 2000 | >40 | 240/859 | 28 | 538/4172 | 13 | 28/488 | 6 | 135/4348 | 3 | 33 |
| India§ | 2010 | 30–69 | 67/134 | 32 | 579/2882 | 20 | 3/120 | 6 | 93/2002 | 5 | 22 |

*In 2005 smoking accounted for 34% of all cancer deaths at ages 35–69 years in men in the United Kingdom and 42% of all cancer deaths at these ages in men in the United States[6]. However, these percentages are substantially lower than those in 1975 (REF. 31). In high-income countries, the major tobacco-attributable cancers are lung cancer and upper aero-digestive cancers (mouth, oesophagus, pharynx and larynx)[6]. ‡Nearly three-quarters of all male cancer deaths in China arise from cancer of the lung, oesophagus, stomach or liver, all of which are more common among smokers[33,34]. Smoking is also associated with the five 'minor' cancer sites, namely the mouth, pharynx, larynx, pancreas and bladder. §In India, most of the smoking-associated cancer deaths arise from cancers of the mouth, throat, lung, oesophagus and stomach, with a small excess of liver cancer[44]. The absolute rates of lung cancer are lower in India than in China or high-income countries, for reasons that are not yet clear.

continuing smokers by 5% to 25%[78,80]. These policies are most effective when strong social norms against smoking help to make smoking restrictions self-enforcing[81].

***Bans on advertising and promotion.*** Cigarettes are among the most heavily advertised and promoted products worldwide. In 2005, cigarette companies spent US$13.1 billion on advertising and promotion in the United States alone, the highest spending level reported to date[82]. In high-income countries, comprehensive bans reduce consumption by approximately 7%, taking into account differences in price and non-price control interventions[83], and might be twice as effective in low- and middle-income countries[84]. However, partial bans have little effect, given that the tobacco industry shifts to other media or to promotions.

***Smoking cessation treatments.*** Pharmacological treatments, including nicotine replacement therapies, such as bupropion and varenicline, significantly improve the likelihood of cessation, with success rates two to three times those when pharmaceutical treatments are not used[85]. In addition, over-the-counter access to such medications increases access and decreases cost[86,87].

***Supply-side interventions.*** In contrast to the effective interventions to reduce demand, there is little evidence that restricting supply is effective, including efforts to limit youth access, trade restrictions, crop substitution and diversification[52,55,57]. However, a key intervention on the supply side is the control of smuggling. Of the cigarettes consumed globally, perhaps 6–8% are smuggled[88]. The tobacco industry contributes to smuggling to reduce taxes and capture market share[89,90]. Aside from harmonizing prices between countries, effective measures to counteract smuggling include prominent tax stamps and warning labels in local languages, better methods for tracking cigarettes through the distribution chain, aggressive enforcement of anti-smuggling laws, and stronger penalties[90,91]. Even in the presence of smuggling, tax increases will reduce consumption and increase revenue[88].

## Quantifying avoidable tobacco deaths

FIGURE 6 summarizes the potential effect of a 70% price increase and a 10% reduction of consumption achieved through non-price interventions, such as bans on public smoking or information measures, among the cohort of 1.1 billion smokers who were alive in 2000. Among this group, conservatively, over 440 million are expected to die in the next few decades owing to smoking. Price increases have the greatest effect on future tobacco mortality: a 70% higher price would avoid 115 million deaths or one-quarter of all expected premature deaths from tobacco. Of the avoidable deaths, approximately 25 million would be expected to occur from cancer and 50 million would be expected to occur from vascular disease. Non-price interventions would avoid 35 million deaths from all causes. The

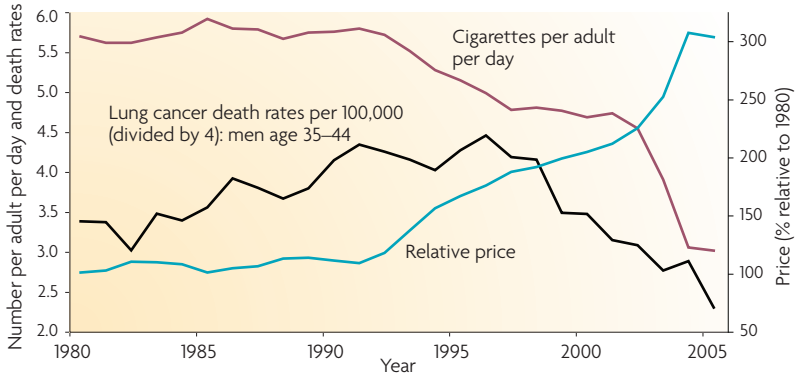


Figure 5 | **France: smoking, tax and lung cancer rates in young males, 1980–2004.** The per capita cigarette consumption, lung cancer death rates and relative price of cigarettes over time. The lung cancer death rates per 100,000 are divided by 4, allowing them to be displayed on the same scale as the amount of smoking per day. Female lung cancer rates peaked later than the male lung cancer rates, but their increase has been halted since 2002 (REF. 6). The stabilization of the prevalence of smoking in 1980–1990 is due in part to the smaller earlier tax increases and to restrictions on advertising. Further decreases in smoking in France were reported after 2008, when bans on public smoking appeared. Data on the amount of smoking per person per day and relative prices are from REF. 53.

greatest effect of these tobacco control interventions would occur after 2015. By 2030, the expected annual toll of 10 million deaths would be reduced to around 7 million.

The tax increases needed to raise the street prices by 70% would be 2- to 2.8-fold increases across countries. The increase would raise the street price from around US$0.70 to $1.30 per pack of 20 cigarettes in low-income countries, from approximately $1.30 to $2.30 in middle-income countries and from $3.70 to $6.30 in high-income countries. Such increases have been achieved in numerous countries, including Canada, France, Poland and South Africa, and in various states in the United States. Indeed, price elasticity studies[61] suggest that the 2.5-fold increase in the United States federal cigarette tax as of 2009 (rising by 62 cents to $1.01 per pack) might cause ~1 million Americans to stop smoking and deter another 2 million young people from starting, therefore saving well over 1 million lives.

## Conclusions

On the basis of current smoking patterns, approximately 1 billion people will be killed in the twenty-first century by smoking. Without widespread cessation, around 450 million people alive today will be killed by smoking in 2000–2050. At least half will die aged 30–69 years, losing decades of productive life, and those who smoke throughout adult life can expect to lose around 1 decade of life compared with non-smokers. Smoking-attributable cancer and total deaths have fallen sharply in high-income countries but will rise globally unless the current smokers, most of whom live in low- and middle-income countries, stop smoking before or during middle age. Tripling taxes on tobacco could rapidly increase cessation rates and deter smoking initiation. Higher taxes, regulations on smoking and information for consumers could avoid at least 115 million smoking deaths in the next few decades, including at least 25 million cancer deaths.

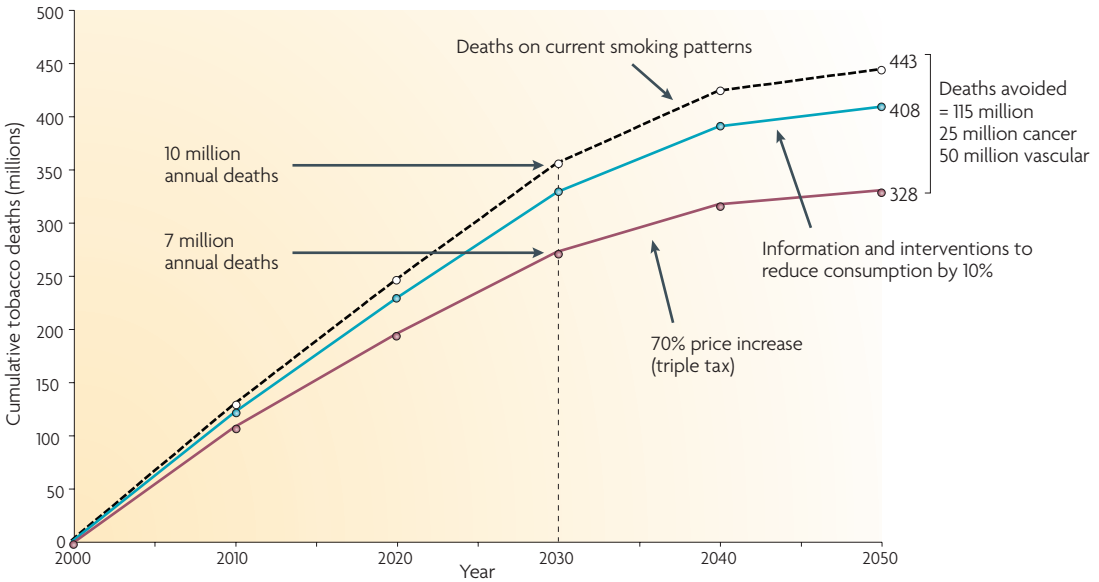


Figure 6 | **Smoking deaths avoided through tax increases and non-price interventions, 2000–2050.** The estimation uses a static compartment model[1] with price increases having a long-term price elasticity of –1.2 for low- and middle-income countries and –0.8 for high-income countries. Low- and middle-income countries account for approximately 90% of the 115 million avoided deaths. East Asia and the Pacific alone will account for approximately 40% of avoided deaths. Around 80% of avoided deaths would be male, reflecting the higher overall prevalence of smoking in men. The greatest relative effect of a price increase and non-price interventions on deaths avoided is in younger cohorts. The model is concerned only with cessation, but higher tax and non-price interventions would substantially reduce initiation, meaning that an even greater reduction in deaths can be expected after 2050.

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## FURTHER INFORMATION

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