

Global Economic and Health Benefits of Tobacco Control: Part 1

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Although the risks of tobacco smoking have been known for decades, the pandemic of tobacco use continues. There are an estimated 1.3 billion smokers worldwide, along with millions more using various oral tobacco products. Recent global estimates place the mortality burden from tobacco use at over 6 million annually, with nearly two-thirds of these deaths occurring in developing countries. If current patterns persist, there will be an estimated 1 billion deaths from tobacco during the twenty-first century. Part 1 of this two-part paper provides an overview of the tobacco pandemic, the scope of the pandemic, and its economic and health consequences. Part 2 reviews the history of tobacco control to date and addresses the current global strategy, based on the World Health Organization's (WHO's) Framework Convention on Tobacco Control and the MPOWER package of interventions. Part 2 ends with a consideration of scenarios for the future of the pandemic.

INTRODUCTION

Although the risks of tobacco smoking have been known for decades, the pandemic of tobacco use continues. There are now an estimated 1.3 billion smokers worldwide, along with millions more who use various oral tobacco products.¹ The cigarette industry is now consolidated within a few multinational corporations, along with China National Tobacco, leading to aggressive marketing and promotion in developing nations as markets in developed countries decline. The disease burden attributable to smoking is already enormous—about 6 million premature deaths worldwide each year—and projected to grow substantially across the century without an end to the pandemic.²

Although the global epidemic of tobacco use is growing, great progress has been made in tobacco control, primarily in the more developed countries of North America and Western Europe. In these countries, smoking rates have dropped by ~50% over the past four decades; mortality rates from several smoking-induced diseases, including lung cancer and coronary heart disease (CHD), are declining; and, in many countries, smoke-free initiatives are protecting nonsmokers from inhaling secondhand smoke (SHS). This progress has been achieved through domestic initiatives, often involving scientists, activists, advocates, and public health agencies within governments.

Currently, there is a global public health treaty that addresses the tobacco epidemic—the World Health Organization's (WHO's) Framework Convention on Tobacco Control.³ The Framework's

components incorporate the strategies that have proved effective in controlling tobacco use; the more than 160 nations that have ratified the Framework are committed to implementing a range of comprehensive tobacco-control measures, including tobacco-product health warnings, tobacco-advertising bans, and restrictions on smoking in public places. Funding for global tobacco-control efforts has increased substantially, largely because of donations by the Bloomberg Philanthropies and the Gates Family Foundation, that have together pledged \$500 million toward global efforts to reduce tobacco use.

This two-part paper provides an overview of the current status of tobacco control globally. The first part covers the scope of the pandemic and its economic and health consequences. The second part reviews the history of tobacco control up to the present, and addresses the current global strategy, based on the Framework Convention on Tobacco Control³ and on the WHO's MPOWER package of interventions.⁴ We end with a consideration of scenarios for the future of the epidemic. We can only briefly consider the many elements of this broad topic; for more in-depth coverage, we recommend the following resources: the historical perspectives provided by Kluger and Brandt in their books,^{5,6} the comprehensive reviews of health effects provided in the US Surgeon General's reports^{7,8} (a), the monograph series published by the National Cancer Institute (b), and publications of the WHO's Tobacco Free Initiative (c), including the MPOWER report.⁴ (The references cited as a–hh are listed as

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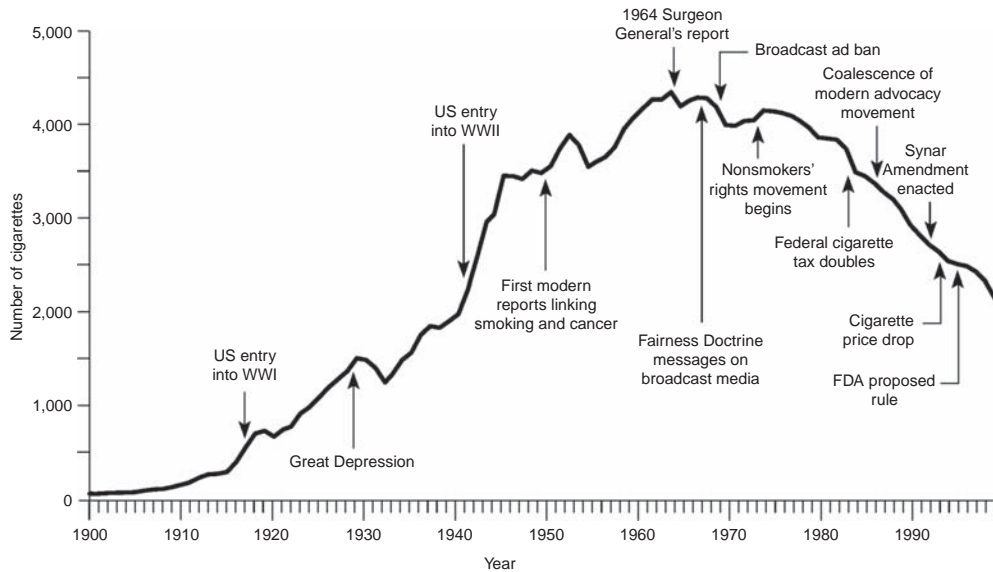


Figure 1 Adult per capita cigarette consumption and major smoking and health events in the United States from 1900 to 1999. FDA, Food and Drug Administration. Reprinted from The US Surgeon General's Report for the Year 2000 (ff).

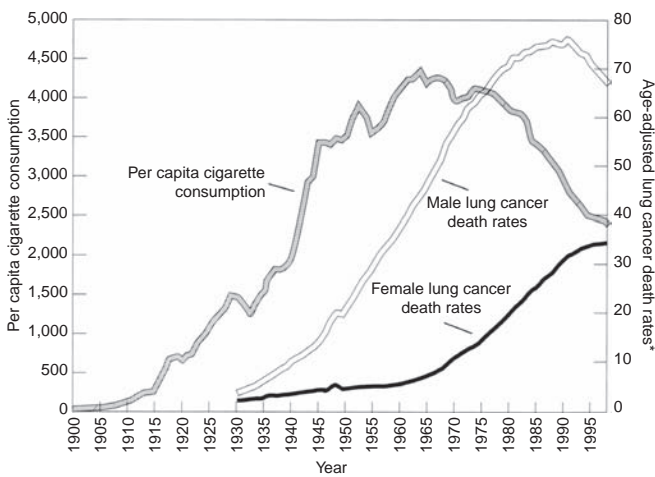


Figure 2 Tobacco use and lung cancer mortality in the United States from 1900 to 1997, per 100,000 and age-adjusted to 1970 US standard population. Reprinted from Hecht, S.S. & Samet, J.M. Cigarette smoking. In *Environmental and Occupational Medicine* 4th edn (ed. Rom, W.M.) (Lippincott Williams & Wilkins, 2007) (gg).

Supplementary References in the online version of the paper at <http://www.nature.com/cpt>.) The journal *Tobacco Control* provides up-to-date coverage.

PATTERNS OF TOBACCO USE

Patterns and practices of tobacco use vary around the globe. In the following section we describe tobacco-use patterns in developed and developing countries; among men, women, and youth; and across socioeconomic groups. The patterns of use over time determined the course of the inevitable epidemic of tobacco-caused disease (Figure 1). Figure 1 shows schematically the parallel, although lagged, courses of smoking and smoking-induced disease. Many developed countries have moved to the phase in which smoking has dropped and disease rates are

declining. By contrast, rates of smoking are still rising in many developing countries, and a goal of tobacco control for these countries is to avoid the predicted rise in tobacco-related disease over the course of this century.

Developed and developing countries

Little more than 400 years ago, tobacco use was limited to Native Americans, who used it exclusively for medicinal and ceremonial purposes. Europeans first encountered tobacco when Columbus brought back a few leaves and seeds from his first voyage to America in 1492 (ref. 6). On the wave of exploration and discovery thereafter, tobacco spread at an incredible speed. Within 100 years, tobacco could be found growing and traded in all of the major regions of the world. However, until the early 1900s, tobacco consumption was almost entirely confined to chewing, the use of snuff, and pipe smoking by men.

Cigarette use first began to rise in developed countries in the early 1900s after the newly industrialized tobacco industry instituted highly effective marketing methods. In 1913, for example, R.J. Reynolds launched a massive, months-long campaign before introducing its Camel cigarettes to the US population. This was the first modern cigarette campaign with national marketing and advertising, and by 1923 Camel cigarettes controlled 43% of the US market (d). Taking both sexes together, the average cigarette consumption per adult in the United States was 1, 4, and 10 per day in 1910, 1930, and 1950, respectively, after which it remained relatively constant for some decades before declining progressively.⁹ By 1960, 50% of adult men in the United States were smoking cigarettes (Figure 2).¹⁰ Similarly, in Great Britain, tobacco consumption doubled in the first half of the twentieth century, from 4.1 g per adult per day in 1905 to 8.8 g in 1945 (one cigarette contains a gram of tobacco).¹¹ Smoking prevalence among men in Great Britain reached 82% in 1948 (ref. 12).

Table 1 Prevalence of tobacco smoking in any form among adult men and women in selected developing countries

Country	Adjusted prevalence, % (95% confidence interval)			
	Male adults	Female adults	Male youth	Female youth
Bangladesh	44.5 (36.1–53.0)	2.9 (1.7–4.0)	5.9 (4.4–7.7)	4.7 (3.4–6.4)
Brazil	16.8 (11.5–22.0)	9.5 (5.7–13.3)	17.2 (14.0–21.0)	15.7 (12.3–19.8)
China	60.8 (48.8–72.8)	4.2 (3.5–4.9)	7.1 (5.2–9.4)	4.1 (2.3–7.0)
Egypt	26.0 (23.8–28.1)	4.1 (3.0–5.2)	16.0 (13.0–19.6)	7.6 (6.1–9.3)
India	30.8 (24.9–36.8)	2.8 (1.9–3.7)	17.3 (14.5–20.4)	9.7 (7.2–12.8)
Indonesia	65.3 (57.3–73.2)	4.2 (3.7–4.7)	24.1 (19.0–30.1)	4.0 (3.0–5.4)
Mexico	37.6 (30.2–45.0)	12.4 (8.9–15.9)	29.4 (25.0–34.1)	24.8 (18.8–32.1)
Pakistan	31.7 (25.6–37.7)	5.2 (3.4–7.1)	12.4 (9.2–16.5)	7.5 (5.4–10.2)
Philippines	40.7 (35.6–45.8)	9.1 (8.2–9.9)	21.4 (17.5–26.0)	11.8 (9.4–14.8)
Poland	44.0 (35.3–52.7)	25.6 (17.0–34.2)	21.4 (16.6–27.0)	17.3 (14.5–20.6)
Russia	70.2 (59.2–81.3)	23.2 (16.7–29.7)	30.1 (26.6–33.8)	24.4 (21.5–27.6)
Thailand	39.9 (35.1–44.7)	3.4 (3.3–3.5)	21.7 (19.4–24.2)	8.4 (6.9–10.2)
Turkey	53.3 (45.5–61.0)	20.5 (8.4–32.5)	11.1 (9.8–12.5)	4.4 (3.7–5.3)
Ukraine	63.3 (53.2–73.5)	19.3 (14.0–24.6)	29.8 (25.0–35.1)	22.2 (18.3–26.6)
Vietnam	44.4 (38.5–50.3)	2.1 (1.5–2.8)	29.8 (25.0–35.1)	22.2 (18.3–26.6)

Reprinted from ref. 4.

Fortunately, the peak of tobacco consumption has passed in most developed countries, where smoking prevalence rates in both men and women have been declining for several decades. In 2008, the percentage of Americans who smoked cigarettes fell to <20%, and teen smoking fell to the lowest levels in over 15 years.¹³ Similarly, smoking prevalence rates in the United Kingdom fell to 22% in 2008 and are on track to meet the government's goal of 21% by 2010 (ref. 14). In many Northern, Southern, and Western European countries as well, the prevalence of smoking in men has fallen over the past 25 years.¹⁵

Tobacco-use patterns in developing countries have lagged ~40 years behind those of developed countries. In China, for example, cigarette consumption among men averaged 1, 4, and 10 per day in 1952, 1972, and 1992, respectively, without any further increase thereafter.¹⁵ The rise in tobacco prevalence in developing countries was largely the result of the complete transformation and globalization of the tobacco industry between 1970 and 1998. Because of industry penetration and aggressive marketing, smoking prevalence rates among men in many developing countries now approach and exceed 50% (Table 1).

Globally, 40% of smokers live in just four countries; China, India, Indonesia, and Russia. China, with 20% of the world's population, produces and consumes about 30% of the world's cigarettes. A majority of all young men in China become persistent smokers¹⁶ (c–f). In India, ~51% of men and 10% of women currently use some form of tobacco, totaling an estimated 250 million tobacco users.¹⁷

Women and youth

In developed countries, very few women smoked until after 1920. In an effort to make smoking more socially acceptable to women, an early marketing strategy for the tobacco industry was to link cigarette smoking to the liberation of women and the

women's rights movement. In 1924, for example, Marlboro was launched as a brand for women.⁶ By 1974 over 40% of women in the United States and Great Britain were smokers.¹⁸ The prevalence of smoking in women in developed countries has fallen over the past 25 years. However, in many countries where there has been a decline in the prevalence of smoking, this decline has been less marked among women. For example, between 1980 and 2005, in Sweden, the prevalence of smoking in men fell by nearly 60% but fell in women by just 35%. In some Central, Eastern, and Southern European countries, the prevalence of smoking is still rising among women. Consequent to these trends, the difference in smoking prevalence between men and women in developed countries has narrowed in recent years.¹⁹

Unfortunately, women are still a specific target of marketing by the tobacco industry, especially in developing countries where women smoke far less than their male counterparts (Table 1). In many Asian and African countries, smoking prevalence among women remains at <5%. However, data from the Global Youth Tobacco Survey show that, in many countries where smoking rates among women have stayed at <10%, the smoking prevalence rates among boys and girls are now growing increasingly similar (g).

Youth are also a target for the tobacco industry, as they represent replacement smokers for those who quit or die. The Global Youth Tobacco Survey found that nearly two of every 10 students worldwide between 13 and 15 years of age currently use a tobacco product, and that there is no statistically significant difference between the proportion of those reporting cigarette smoking (8.9%) and those reporting other tobacco use (11.2%).²⁰ Among youth, the prevalence rates for using any tobacco product range from 3.3 to 62.8%, with nearly 25% of student smokers having smoked their first cigarette before they were 10 years of age.

Worldwide, >40% of men smoke tobacco, as compared to only ~12% of women. This tobacco-use profile implies that women and children are the primary victims of exposure to SHS. The Global Youth Tobacco Survey found that ~44% of youth were exposed to tobacco smoke at home, and that 47% had at least one parent who smoked. A study conducted in 2005 and 2006 in homes with smokers in 31 developing countries found that 88% of smokers smoke inside the home, and 82% indicated that they smoke in the vicinity of their children.²¹ In contrast, >70% of homes in the United States with a smoker report that they have a “no smoking” policy within the home.²² Between 1988 and 2002, the majority of US nonsmokers went from having a detectable to a nondetectable serum cotinine (a biomarker for nicotine) level. The large decrease observed in serum cotinine concentrations suggests a substantial reduction in the exposure of the US population to SHS during the 1990s (ref. 23).

Socioeconomic determinants

Socioeconomic factors influence tobacco-use patterns in all countries. In developed countries, the poorest and least educated have the highest smoking rates. In the United Kingdom, for instance, only 16% of the women and 18% of the men in the highest socioeconomic group are smokers; in the lowest socioeconomic groups the corresponding figures are 29 and 32%, respectively.²⁴ The same inverse relationship is found between education levels and smoking. In 2008, Americans who had only a general education development certificate had the highest smoking prevalence rate—44%, 11.4% in those with a college degree, and 6.2% in those with a graduate degree. Smoking rates also vary among ethnic groups. Among men living in the United Kingdom, smoking rates ranged from 20% (among Indians) to 40% (among Bangladeshis), as compared to the national average of 24%. Among women, the rates ranged from 2% (among Bangladeshis) to 26% (among the Irish), as compared to the national average of 23% (ref. 25).

Studies of smoking prevalence by socioeconomic group in developing countries are fewer, with mixed results depending on the type of population studied. In some low- and middle-income countries, smoking was reported to be more prevalent among the more affluent, contrasting with the gradient in high-income countries.²⁶ However, many studies in low-income countries, particularly in more recent years, have found a social gradient similar to that in Western countries. Tobacco use is now more prevalent among the poor in a number of developing countries, including India, China, Brazil, Mexico, Vietnam, Guatemala, Poland, Hungary, South Africa, and Costa Rica.²⁶

THE HEALTH CONSEQUENCES OF ACTIVE AND PASSIVE SMOKING

Active smoking

The body of research evidence that constitutes the foundation of recognizing tobacco as a cause of disease dates to approximately the mid-twentieth century. The rise in the rates of diseases that had once been uncommon, such as lung cancer (Figure 2) and CHD, was noticed early in the twentieth century. This finding led to clinical and pathological studies to determine whether

the increases were “real” or an artifact of changes in detection of these diseases. By mid-century, it had become clear that the increases in these disease rates were real, and the focus of research shifted to finding the causes of the new epidemics of chronic diseases such as lung cancer and CHD.

By the 1940s there was substantial evidence suggesting that smoking caused disease and premature death. Astute clinicians, such as surgeons Ochsner and DeBakey (h) had noted the preponderance of smokers among persons receiving treatment for certain diseases, including lung cancer, and postulated a causal role for cigarette smoking. Based on a follow-up study among families living in Baltimore, Pearl reported in 1938 that smokers did not live as long as nonsmokers (i).

There have been many landmark investigations of smoking and disease—the early case-control studies of lung cancer (j-l) and cohort studies such as the Framingham study (m), the British physicians study (n), and the studies initiated by the American Cancer Society, two of which involved 1 million Americans each (o). These initial observations led to complementary laboratory studies on the mechanisms by which tobacco smoking causes disease. By 1953, for example, Wynder and colleagues (p) had shown that painting the shaved skin of mice with cigarette smoke condensate causes tumors. By the late 1950s and early 1960s, the mounting evidence received formal review and evaluation by government committees, leading to definitive conclusions in the 1960s. In the United Kingdom, the 1962 report of the Royal College of Physicians²⁷ concluded that smoking was a cause of lung cancer and bronchitis, and a contributing factor to CHD. In the United States, the 1964 report of the Advisory Committee to the Surgeon General concluded that smoking was a cause of chronic bronchitis and, in men, lung cancer.²⁸

Subsequent reports have led to a progressively lengthier list of diseases caused by smoking (Table 2). The list now includes specific diseases of most organ systems, as well as diminished health in general (Table 2). The diseases caused by smoking include diseases affecting sites directly reached by inhaled smoke and also sites affected by circulating or excreted tobacco-smoke components or metabolites. It is obvious that smoking causes diseases throughout the respiratory tract. It has also been causally linked to the major cardiovascular diseases, except for hypertension. Table 2 includes diverse additional effects of smoking. The relative risks for developing these diseases in smokers as compared to those who have never smoked (referred to here as “never smokers”) are quite high, particularly for diseases such as chronic obstructive pulmonary disease and lung cancer, for which smoking is a predominant cause (Table 3). For some diseases, such as CHD, even though the relative risk for smokers is more modest, the numbers of deaths attributable to smoking are high because of the high baseline rates of mortality.

For all of the smoking-induced diseases, successful cessation of smoking is followed by a reduction in disease risk. The topic of cessation was the focus of the 1990 Surgeon General’s report (q), and the 2004 report provides an update.⁷ The 1990 report documents that cessation is beneficial in lowering

Table 2 Diseases caused by smoking, as first identified by major health reports

Major disease category	Disease
Cancer	Bladder
	Cervical
	Esophageal
	Kidney
	Laryngeal
	Leukemia
	Lung
	Oral
	Pancreatic
	Stomach
Cardiovascular diseases	Abdominal aortic aneurysm
	Atherosclerosis
	Cerebrovascular disease
	Coronary heart disease
Respiratory diseases	Chronic obstructive pulmonary disease
	Pneumonia
	Respiratory effects <i>in utero</i>
	Respiratory effects in childhood and adolescence
	Respiratory effects in adulthood
Reproductive outcomes	Fetal death and stillbirths
	Fertility
	Low birth weight
	Pregnancy complications
Other health effects	Cataracts
	Diminished health status/morbidity
	Hip fractures
	Peptic ulcer disease

Reprinted from Hecht, S.S. & Samet, J.M. Cigarette smoking. In *Environmental and Occupational Medicine* 4th edn (ed. Rom, W.M.) (Lippincott Williams & Wilkins, 2007) (gg).

mortality at any age. The patterns of change in risk vary among the different diseases. For cardiovascular diseases, there is a relatively immediate decline in the excess risk, lowering it by about 50% within the first year of quitting, followed by a further decline to the approximate risk applicable to never smokers over the next 5 years. The lung damage in chronic obstructive pulmonary disease is largely irreversible, and for those with advanced disease cessation of smoking is of little benefit. In fact, the relative risk for dying from chronic obstructive pulmonary disease is typically higher in recent quitters than in current smokers because some smokers quit on receiving a diagnosis of the disease. For the various cancers caused by smoking, risk declines after quitting, but even decades after successful cessation, it does not reach that of never smokers. For lung cancer, the absolute risk appears to remain fixed after cessation, and the relative risk never declines back to unity.⁷

SHS

The issue of passive smoking and health has a briefer history. Some of the first epidemiological studies on SHS or environmental tobacco smoke and health were reported in the late 1960s (r–t). These initial investigations focused on the association between parental smoking and lower respiratory tract illnesses in infants; studies of lung function and respiratory symptoms in children soon followed (u,v). The 1972 report of the Surgeon General was the first to call attention to passive smoking (w). The first major studies on passive smoking and lung cancer in nonsmokers were reported in 1981 (refs. 29,30), and by 1986 the evidence supported the conclusion that passive smoking was a cause of lung cancer in nonsmokers, a conclusion reached by the International Agency for Research on Cancer, the US Surgeon General, and the US National Research Council.^{31–33} The evidence on child health and passive smoking was also reviewed in 1986 by the US Surgeon General and the US National Research Council. A now-substantial body of evidence has continued to identify new diseases and other adverse effects of passive smoking, including increased risk for CHD (u,x–z). The 2006 Report of the Surgeon General provides the most recent comprehensive review of the topic (**Table 4**).⁸

THE BURDEN OF SMOKING

Global health burden

When smoking came to be recognized as the cause of lung cancer, epidemiologists turned to quantifying the risk and burden of disease associated with cigarette smoking. Levin, who carried out one of the earliest epidemiological studies on lung cancer and smoking (k), also proposed the attributable risk statistic that is now widely used to estimate the avoidable burden of disease caused by a risk factor (aa). He showed that the disease burden depended on the prevalence of exposure and on the relative risk associated with that exposure. For smoking, the burden is calculated in comparison with a hypothetical condition, “the counterfactual,” in which there is an assumption of no smoking; i.e., the prevalence was zero. This concept underlies the estimates offered by the US Surgeon General and the Centers for Disease Control⁷ as well as the WHO’s Global Burden of Disease estimates.³⁴ The US Centers for Disease Control and Prevention have developed a software system, Smoking Attributable Mortality, Morbidity, and Economic Costs, that provides national and state-specific estimates.⁷

The most recent global estimates are for 2002 (ref. 35). This updated set of projections places the mortality burden at over 6 million annually (**Table 5**). Lung cancer deaths exceed 1 million, but the largest contributors to smoking-related mortality are cardiovascular and respiratory diseases. By region, tobacco kills over 1 million persons annually in East Asia and the Pacific; 897,000 in Europe and Central Asia; 250,000 in Latin America; 121,000 in the Middle East and North Africa; 879,000 in South Asia; and 135,000 in Sub-Saharan Africa. In 2005, in China, for example, a total of 673,000 deaths were attributable to smoking: 268,000 from cancer; 146,200 from

Table 3 Age-adjusted relative risks of death from smoking-related diseases from the CPS-I and CPS-II

Disease Category (ICD-9 code)	CPS-I (1959–1965)				CPS-II (1982–1988)			
	Males		Females		Males		Females	
	CS	FS	CS	FS	CS	FS	CS	FS
<i>Neoplasms^a</i>								
Lip, oral cavity, pharynx (140–149)	6.3	2.7	2.0	1.9	10.9	3.4	5.1	2.3
Esophagus (150)	3.6	1.3	1.9	2.2	6.8	4.5	7.8	2.8
Stomach (151)	1.8	1.7	1	1	2	1.5	1.4	1.3
Pancreas (157)	2.3	1.3	1.4	1.4	2.3	1.2	2.3	1.6
Larynx (161)	10	8.6	3.8	3.1	14.6	6.3	13	5.2
Trachea, bronchus, lung (162)	11.4	5	2.7	2.6	23.3	8.7	12.7	4.5
Cervix uteri (180)			1.1	1.3			1.6	1.1
Urinary bladder (188)	2.9	1.8	2.9	2.3	3.3	2.1	2.2	1.9
Kidney, other urinary (189)	1.8	1.8	1.4	1.5	2.7	1.7	1.3	1.1
Acute myeloid leukemia (204–208)	1.6	1.6	1	1	1.9	1.3	1.1	1.4
<i>Cardiovascular diseases^a</i>								
Ischemic heart disease (410–414)								
Aged 35–64 years	2.3	1.6	1.8	1.7	2.8	1.6	3.1	1.3
Aged ≥65 years	1.4	1.3	1.2	1.3	1.5	1.2	1.6	1.2
Other heart disease (390–398, 415–417, 420–429)	1.4	1.1	1.1	1.4	1.8	1.2	1.5	1.1
Cerebrovascular disease (430–438)								
Aged 35–64 years	1.8	1	1.9	1.8	3.3	1	4	1.3
Aged ≥65 years	1.2	1	1	1.1	1.6	1	1.5	1
Atherosclerosis (440)	3.1	2	1.9	1.5	2.4	1.3	1.8	1
Aortic aneurysm (441)	4.1	2.4	4.6	3.7	6.2	3.1	7.1	2.1
Other arterial disease (442–448)	3.1	2	1.9	1.5	2.1	1	2.2	1.1
<i>Respiratory diseases^a</i>								
Pneumonia, influenza (480–487)	1.8	1.6	1	1	1.8	1.4	2.2	1.1
Bronchitis, emphysema (490–492)	8.8	10.2	5.9	5.9	17.1	15.6	12	11.8
Chronic airway obstruction (496)	5.5	9.6	5.1	5.3	10.6	6.8	13.1	6.8
<i>Perinatal conditions</i>								
Shortened gestation/low birth weight (765)			1.8				1.8	
Respiratory distress syndrome (769)			1.8				1.3	
Other respiratory conditions in newborns (770)			1.8				1.4	
Sudden infant death syndrome (798.0)			1.5				2.3	

CPS, Cancer Prevention Study; CS, current smokers; FS, former smokers; ICD-9, International Classification of Diseases, 9th revision.

^aAmong persons aged ≥35 years.

Reprinted from ref. 7.

cardiovascular disease; and 66,800 from respiratory disease.³⁶ The main smoking-induced diseases that kill people prematurely differ across the world because of varying background rates of disease (e.g., tuberculosis). However, regardless of geography, we can expect that ~50% of persistent tobacco smokers will die prematurely as a result of their addiction.¹⁵

The current estimate of 6 million deaths a year caused by tobacco reflects patterns of tobacco use relating to several

decades ago. Because developing countries are still in the early stages of the tobacco epidemic, they have yet to experience the full impact of tobacco-related disease and death already evident in wealthier countries. In China alone, nearly 1 million deaths are already occurring each year as a result of tobacco use, a figure that could double by 2025. If the rise in current smoking patterns persists, there will be an estimated 1 billion deaths from tobacco during the twenty-first century.¹⁵

Table 4 Adverse effects of exposure to tobacco smoke

Health effect	SGR 1984	SGR 1986	EPA 1992	Cal/EPA 1997	UK 1998	WHO 1999	IARC 2004	Cal/EPA ^a 2005	SGR 2006
Increased prevalence of chronic respiratory symptoms	Yes/a	Yes/a	Yes/c	Yes/c	Yes/c	Yes/c		Yes/c	Yes/c
Decrement in pulmonary function	Yes/a	Yes/a	Yes/a	Yes/a		Yes/c		Yes/a	Yes/c
Increased occurrence of acute respiratory illnesses	Yes/a	Yes/a	Yes/a	Yes/c		Yes/c		Yes/c	Yes/c
Increased occurrence of middle ear disease		Yes/a	Yes/c	Yes/c	Yes/c	Yes/c		Yes/c	Yes/c
Increased severity of asthma episodes and symptoms			Yes/c	Yes/c		Yes/c		Yes/c	Yes/c
Risk factor for new asthma			Yes/a	Yes/c				Yes/c	Yes/c
Risk factor for SIDS				Yes/c	Yes/a	Yes/c		Yes/c	Yes/c
Risk factor for lung cancer in adults		Yes/c	Yes/c	Yes/c	Yes/c		Yes/c	Yes/c	Yes/c
Risk factor for breast cancer in younger, primarily postmenopausal women								Yes/c	
Risk factor for nasal sinus cancer								Yes/c	
Risk factor for heart disease in adults				Yes/c	Yes/c			Yes/c	Yes/c

Cal/EPA 1997, California Environmental Protection Agency and Office of Environmental Health Hazard Assessment (1997); Cal/EPA 2005, California Environmental Protection Agency and Air Resources Board (2005); EPA 1992, US Environmental Protection Agency (1992); IARC 2004, International Agency for Research on Cancer (2004); SGR 1984, Surgeon General's Report, US Department of Health and Human Services (1984); SGR 1986, Surgeon General's Report, US Department of Health and Human Services (1986); SGR 2006, Surgeon General's Report, US Department of Health and Human Services (2006); SIDS, sudden infant death syndrome; UK 1998, Scientific Committee on Tobacco and Health and HSMO (1998); WHO 1999, World Health Organization (1999); Yes/a, association; Yes/c, cause.

^aOnly effects causally associated with SHS exposure are included.

Reprinted from Samet, J.M., Neta, G.I. & Wang, S.S. Secondhand smoke. In *Environmental Toxicants: Human Exposures and Their Health Effects* 3rd edn (ed. Lippmann, M.) (Wiley, 2009) (hh).

Economic costs of smoking

The economic costs of treating tobacco-related illnesses—and the resulting loss of productivity—are among the leading arguments for tobacco-control policies, particularly in countries where health care is paid for by the government. There are also costs related to illnesses caused by exposure to SHS—costs that are borne by those directly affected and by society in general. The costs of tobacco use fall into two broad categories: (i) the financial consequences of tobacco use in terms of health care, life insurance, pensions, and other collective programs; and (ii) the indirect and intangible psychological costs of pain and suffering arising from smoking-induced disease. Being a major contributor to disability, smoking substantially reduces the quality of life in those who develop a chronic disease caused by smoking.

Cost estimates vary depending on the methodology used. In the United States, direct medical costs for the detection, treatment, and rehabilitation of persons with smoking-attributable clinical diseases have been the primary outcome in the cost models.⁷ These smoking-attributable costs have been consistently estimated at 6–8% of the total annual expenditures for health care, with estimated upper bounds as high as 14% (bb). Other studies have included indirect morbidity and mortality costs, defined as the costs of excess sickness and disability days for smoking-

related illnesses, as well as lost productivity because of premature death caused by smoking (cc). The total direct and indirect costs for 1995–1999 in the United States were estimated at \$157.7 billion, or ~\$3,400 per smoker annually.³⁷ For the 22 billion packs of cigarettes purchased in 1999, the CDC calculated that \$3.45 per pack was spent on medical care costs related to smoking, and a further cost of \$3.73 was incurred in the form of lost productivity because of premature death from smoking, totaling \$7.18 per pack. In 2008, the American Legacy Foundation estimated that its truth campaign, the largest youth smoking prevention campaign in US history, would save \$1.9 billion or more in health-care costs associated with tobacco use because youth who avoided smoking would consequently avoid the negative health consequences associated with tobacco use.³⁸

Whereas the costs of medical treatment for smoking-related illnesses are relatively well documented, the economic impact of SHS on health-care costs has received less attention. A recent study in Minnesota of direct medical treatment costs for conditions for which the 2006 US Surgeon General's report found that there was sufficient evidence to conclude a causal link with exposure to SHS—including lung cancer and CHD—gave a figure of \$228.7 million in 2008 dollars, equivalent to \$44.58 per Minnesota resident.³⁹ A study in New York City calculated annual costs of \$99 million related to infants' developmental delays caused by

Table 5 Projected global tobacco-induced deaths, by cause, 2,015 baseline scenario

Cause	Deaths caused by tobacco	
	Number (millions)	Percentage of total
<i>All causes</i>	6.43	100
Tuberculosis	0.09	1
Lower respiratory infections	0.15	2
<i>Malignant neoplasms</i>	2.12	33
Trachea, bronchus, lung cancers	1.18	18
Mouth and oropharynx cancers	0.18	3
Esophagus cancer	0.17	3
Stomach cancer	0.12	2
Liver cancer	0.10	2
Other malignant neoplasms	0.34	5
Diabetes mellitus	0.13	2
<i>Cardiovascular diseases</i>	1.86	29
Ischemic heart disease	0.93	14
Cerebrovascular disease	0.52	8
Other cardiovascular diseases	0.24	4
<i>Respiratory diseases</i>	1.87	29
Chronic obstructive pulmonary disease	1.76	27
Digestive diseases	0.20	3

Reprinted from ref. 35.

prenatal exposure to SHS.⁴⁰ A study in Hong Kong found that the total costs associated with SHS—including direct medical costs, long-term care, and productivity losses—were \$156 million in 1998 for a population of 6.5 million.⁴¹

Recently, cost studies using a methodology similar to that used in the United States have been used in developing countries to assess the magnitude of their current cost-of-smoking burden and future burdens, with differences in tobacco-use histories and the availability of treatment for chronic diseases having an effect on country-specific estimates (bb). A study by Sung *et al.*⁴² found that the economic costs of smoking in China in the year 2000 totaled \$5.0 billion, direct costs were \$1.7 billion (34% of the total), indirect morbidity costs were \$0.4 billion (8%), and indirect mortality costs were \$2.9 billion (58%). The direct costs of smoking accounted for 3.1% of China’s national health expenditures. In India, in 2004, the direct medical costs of treating tobacco-related diseases were estimated at \$907 million for smoked tobacco and \$285 million for smokeless tobacco.⁴³ The indirect morbidity costs of tobacco use, which includes the costs of caregivers and the value of work lost due to illness, amounted to \$398 million for smoked tobacco and \$104 for smokeless tobacco. The total economic cost of all tobacco use in India in that year amounted to \$1.7 billion.

One ethically difficult point in relation to cost studies is how to evaluate the shortening of life that results from smoking. The tobacco industry has promoted studies purporting to show that smoking results in economic gains if smokers die prematurely, arguing that there can be a “death benefit” in terms of saved

pension costs. Philip Morris infamously provided a report to Czech legislatures in 2001 arguing that smokers who died early saved the Czech government \$30 million in 1999 (ref. 44). They proposed that these premature deaths caused by smoking constituted a “benefit” because funds would not need to be expended to support, house, and care for these persons in their later years. The report concluded that, because of the tobacco industry, the Czech Republic was better off in 1999. Philip Morris was forced to apologize for the report after its contents were shared with international tobacco-control advocates who subsequently published the report’s contents in newspapers throughout the United States. However, ethical objections aside, studies have shown that these savings are counterbalanced by forgone productivity and increased medical treatment costs while smokers are still alive. In an extensive review by the World Bank,⁴⁵ the gross health-care costs of smoking for high-income countries ranged from 0.10 to 1.1% of the gross domestic product, and most of the net-vs.-gross cost studies showed positive net costs associated with smoking.

Many studies have shown that the poorest households in some low-income countries spend a significant amount of total household expenditure on tobacco, resulting in less money available to spend on basic items such as food, education, and health care. For example, the WHO estimates that, at the household level in Indonesia, a country where smoking is most common among the poor, the lowest-income group spends 15% of its total expenditure on tobacco, while in the poorest 20% of households in Mexico, this figure is nearly 11% (ref. 4). In addition to its direct health effects, tobacco use leads to malnutrition, increased health-care costs, and premature death. Studies by Best and colleagues in Indonesia⁴⁶ and Bangladesh⁴⁷ show an increased risk for malnutrition in households with parental smoking. Tobacco use also contributes to a higher illiteracy rate because money that could have been used for education is spent on tobacco instead (dd). As a consequence, the control of tobacco use is increasingly tied to sustainable development programs and the Millennium Development Goals (ee).

The loss to the world economy as a result of tobacco use is so massive that even a conservative estimate ranks it as exceeding the total current health expenditures in all developing countries combined. Over 15 years ago, a World Bank study estimated that tobacco use resulted in a global net loss of US\$200 billion per year, with half of these losses in developing countries.⁴⁸ Given the continued rise of the global epidemic since that time, this figure must have grown.

However, tobacco-control programs need to address the economic forces that influence tobacco production and consumption, including the role that tobacco plays in employment, tax revenues, and trade balances in some countries. Tobacco is grown in more than 125 countries, and the global value of crop production is ~\$25 billion, which is <1% of the value of agricultural production globally.⁴⁹ However, in some countries, the relative value is considerably higher, and in some localities tobacco dominates the economy. An estimated two-thirds of the workers employed in cigarette production globally work in just three countries—China, India, and Indonesia. The Chinese government, which controls tobacco production through a state monopoly, earns about 240 billion Yuan (\$30 billion) from combined profits and

taxes related to its production.⁴⁹ Independent studies show that, in most countries over the medium and long term, even very stringent tobacco-control policies will have minimal negative impact on economic growth, employment, tax revenues, and foreign trade balances.

SUPPLEMENTARY MATERIAL is linked to the online version of the paper at <http://www.nature.com/cpt>

CONFLICT OF INTEREST

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