Section I
Tobacco use and its consequences

2
Global patterns of smoking and smoking-attributable mortality

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This chapter reviews the global data on the prevalence of smoking and its incidence (or uptake), on consumption trends, and on smoking-attributable deaths. The vast majority of the world's 1.1 billion smokers in 1995 lived in low-income and middle-income countries. Cigarette consumption has risen over the past two decades in these countries, in contrast to declines in overall consumption in high-income countries. Most smokers start in youth, and there is some evidence that the average age of smoking uptake is falling. Because of the long delay between the age at which people take up smoking and their death from tobacco-related disease, current mortality patterns largely reflect past smoking patterns, and future mortality depends on current and future smoking. Currently, tobacco deaths number about 4 million per year worldwide, about one in ten of all adult deaths. For the twentieth century, the cumulative number of tobacco deaths is estimated to have been about 100 million, with about 60 million of these in the high-income countries and the former socialist countries. Projections are difficult to make with precision, but on current smoking trends it is plausible that there will be 10 million tobacco deaths per year, about one in six of all adult deaths, by 2030. About seven in ten of these deaths will be in low-income countries. The variations in the tobacco epidemic over time, sex, age group, and region, attest to the importance of conducting further reliable long-term epidemiological studies. If current patterns of smoking continue, about 0.5 billion of the world's population alive today will be killed by smoking, half of them in middle age (defined as ages 35–69). Over the twenty-first century as a whole, about 1 billion tobacco deaths are projected. Much of the projected mortality increase over the next fifty years could be avoided if adults quit smoking. However, quitting remains rare in low-income and middle-income countries.

2.1 Introduction

The use of non-manufactured tobacco is a habit of antiquity. The Chinese record that they cultivated and smoked it before the first millennium, and it can be reliably traced to at least the Middle Ages among native populations of the Americas. When Columbus landed in the New World on 11 October 1492, he was offered dried tobacco leaves at the House of the Arawaks. In the middle of the sixteenth century, tobacco was introduced into Europe and subsequently brought to Africa and Asia (Corti 1931). The use of manufactured tobacco is much more recent: the first manufactured cigarette appeared in the mid-nineteenth century. Today, cigarettes, both manufactured and

various hand-rolled forms, including *bidis*—popular in India and South-east Asia—and clove cigarettes, account for about 65–85% of all tobacco produced worldwide. (WHO 1997). This review will focus on the use of manufactured cigarettes and, to a lesser extent, on the use of *bidis* (see Box 2.1). These forms of tobacco appear to pose the greatest health risks, since their combustion products are absorbed though the pulmonary and vascular systems. Manufactured cigarettes are gradually replacing other forms of tobacco.

This chapter is in six sections. First, we describe regional patterns of smoking in 1995.[1] Second, we discuss trends in cigarette consumption over recent decades. Third, we summarize the evidence on current and projected smoking-attributable mortality. The reader may find more detailed reviews elsewhere on mortality patterns and on other aspects of health and smoking, and these reviews are cited in the appropriate section of the chapter. Fourth, we describe the patterns of smoking cessation and its health consequences. Fifth, we briefly discuss research priorities for monitoring smoking and smoking-attributable disease. Finally, we summarize the key findings.

Box 2.1 Types of tobacco use other than manufactured cigarettes

In addition to cigarettes, various other types of tobacco use are common, but their health impacts and economics are poorly studied. The *bidi* is a hand-rolled cigarette common to South-east Asia and India. A *bidi* consists of 0.2–0.3 g of sun-cured tobacco loosely packed and rolled in a rectangular piece of dried leaf and tied with cotton thread. *Bidis* may allow two or three times as many puffs as an ordinary cigarette. Because of the low porosity of their wrappers and their poor combustibility, *bidis* must be puffed continuously to be kept alight and so they probably deliver a relatively higher dose of tar to the smoker (IARC 1986).

Other cigarettes include clove cigarettes, made from shredded clove buds and tobacco, which are manufactured in Indonesia, and herbal cigarettes, which consist of tobacco blended with herbs, and are common in China.

The oldest recorded form of smoking is probably pipe smoking: the habit has different names in different regions. In South-east Asia, clay pipes known as *sulpa*, *chilum*, and *hookli* are used. In Asia, Egypt, and other middle-eastern countries, water-pipe smoking is common. The tobacco is covered with pieces of

[1] The World Bank regions are as defined in World Development Indicators (1999) and are reproduced in Appendix 3. High-income countries are those with a 1995 gross national product (GNP) per capita of $9386 or more. Low-income and middle-income countries (which are sometimes referred to as developing countries) have 1995 GNPs per capita of $765 or less, and $766–$9385, respectively. Low-income and middle-income countries are further divided by geographic region: East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and Caribbean (LAC), Middle East and North Africa (MNA), South Asia (SSA), and Sub-Saharan Africa (SSA).

Note that wherever possible we present data by World Bank region. However, some data are presented according to an earlier classification used by some sources. This classification, based on regional groupings, is as follows: China (CHN), Established Market Economies (EME), Former Socialist Economies of Europe (FSE), India (IND), Latin America and Caribbean (LAC), Middle East Crescent (MEC), Other Asia and Islands (OAI) and Sub-Saharan Africa (SSA).

glowing charcoal and kept burning on the head of the pipe, and the smoke is drawn through a long tube; smoke bubbles through water before reaching the mouth. The tobacco is cured or fermented in molasses, honey, or fruit juices. In Bangladesh in the 1970s, the majority of smokers used water pipes; today, they are more likely to smoke *bidis*.

Smokeless tobacco is most common in the United States and South Asia. In India, tobacco-chewing is picked up as a traditional habit from parents and at work. Tobacco is chewed alone or with *quid*, which consists of betel leaf, a leaf of the vine *Piper betel* (*Piperaceae*), small pieces of areca nut of the tree *Areca catechu* (*Palmaceae*), and a pinch of aqueous lime (calcium hydroxide). Throughout South-east Asia and in many North African and Eastern Mediterranean countries, tobacco is chewed with flavorings. Among other forms of smokeless tobacco, nasal snuff is a dry finely powdered tobacco that is inhaled through nostrils. Oral snuff is a moist coarsely ground tobacco that is applied to the gums.

2.2 Smoking patterns worldwide

2.2.1 Smoking prevalence

We provide estimates of the numbers of smokers, and cigarettes consumed, for each of the seven different World Bank regions. The estimates were made by following the steps described below.

Methodology

Step 1. Population by region, gender, and age category

World Bank population figures for each of the Bank's seven regions were used as defined in Appendix 3. Population figures for 1995 were used throughout the analysis. Age categories (ages 15–19, 20–29, 30–39, 40–49, 50–59, 60+) were chosen to coincide with the categories most commonly used in smoking prevalence studies.

Step 2. Smoking prevalence by region and gender

The results of 89 studies were used to estimate smoking prevalence, by gender, for each of the seven regions (see Appendix 2). Most of these studies were compiled by the World Health Organization (WHO), and were judged to be 'methodologically sound and to provide reasonably reliable and comparable results' (WHO 1997). Other studies were found from literature searches. Most countries that carried out prevalence surveys reported daily smoking and this is the basic prevalence indicator that has been used here. Country-specific data are combined to estimate regional prevalence values by weighting country estimates by the adult population (>15 years of age) of those countries. Country-specific population figures for 1995 are drawn from a World Bank database (World Bank 1999). The resulting weighted average smoking prevalences are assumed to apply to the entire region, including those countries for which smoking prevalence is not known.

Step 3. Prevalence of cigarette versus bidi *smoking in South Asia*

In all regions, with the exception of South Asia, cigarettes constitute the major form of smoked tobacco. In the countries of South Asia, however, many people smoke *bidis*. All calculations for South Asia are conducted separately for cigarettes and *bidis*. Data from three studies (two from India and one from Sri Lanka) suggest that 47–51% of male smokers and 52–95% of female smokers smoke *bidis* (Gupta 1996; Venkat Narayan 1996; WHO 1997, p. 427). In this analysis, it is assumed that 50% of male and 80% of female smokers smoke *bidis*, with the remainder smoking cigarettes.

Step 4. Smoking prevalence by age category

An attempt has been made to find one large-scale study of smoking prevalence by age category for each of the seven regions. China is used as the model country for East Asia and Pacific (Gong 1995), Hungary for Europe and Central Asia (Hungary Central Statistics Office 1994), Argentina for Latin America and the Caribbean (Pan American Health Organization 1992, p. 17), India for South Asia (Goa Cancer Society 1992), and Germany for high-income countries (MarketFile 1998). Data for Sub-Saharan Africa (SSA), the Middle East and North Africa (MNA) were particularly scarce. For SSA, the age distribution amongst 'Africans' in South Africa (i.e. excluding white, Asian, and mixed-race populations) was extrapolated to the entire region (Yach *et al.* 1992). For MNA, the age distribution amongst a group of male Egyptians was extrapolated to both males and females throughout the region (Hassan, personal communication). The age categories used in some of the primary studies do not correspond to the categories being used in this analysis (for example, the study in Argentina provided prevalence values by 10-year age categories starting 15–24, 25–34, etc.). Prevalence values are estimated for the age categories being used in this analysis based on the assumption that the prevalence of smoking is uniform within each age category used in the primary studies (for example, it was assumed that in Argentina, the prevalence of smoking amongst the 1.2 million men of ages 25–29 is the same as amongst the 1.1 million men of ages 30–34, at 57%). Ratios of smoking prevalence amongst older age categories compared to 15–19 year-olds were calculated. These ratios were applied to the entire region, including those countries for which the age ratios of smoking prevalence are not known. A simplified example is shown below.

Argentina is used as the model country for Latin America and the Caribbean. The primary study, which finds an age-weighted male prevalence of smoking of 43% (PAHO 1992) provides the following age breakdown:

Age category	Prevalence (%)	Prevalence ratio
15–19	31	1.0
20–59	49	1.6
60+	16	0.5

From the data collected in steps 1 and 2, the total number of male smokers in Latin America and the Caribbean is estimated to be 62 million (a prevalence of

40% in a population of 156 million). Given the total population for each age category, the age-specific prevalence of 15–19 year-olds for this region can be calculated as follows:

1. $\text{Prev}_{15-19} \times \text{Pop}_{15-19} + \text{Prev}_{20-59} \times \text{Pop}_{20-59} + \text{Prev}_{60+} \times \text{Pop}_{60+} = \text{total smokers}.$
2. $\text{Prev}_{15-19} \times 25\,\text{m} + \text{Prev}_{20-59} \times 114\,\text{m} + \text{Prev}_{60+} \times 17\,\text{m} = 62\,\text{m}.$
3. $\text{Prev}_{15-19} \times 25\,\text{m} + 1.6/(\text{Prev}_{15-19}) \times 114\,\text{m} + 0.5/(\text{Prev}_{15-19}) + \times 17\,\text{m} = 62\,\text{m}.$
4. $\text{Prev}_{15-19} = 62\,\text{m}/(25\,\text{m} + 1.6 \times 114\,\text{m} + 0.5 \times 17\,\text{m}).$
5. $\text{Prev}_{15-19} = 29\%.$

Prevalence values for the other age categories are calculated by multiplying Prev_{15-19} by the appropriate prevalence ratio.

Step 5. Total number of smokers by region, gender, and age

Number of smokers is calculated by multiplying 'population' by 'smoking prevalence'.

Step 6. Number of cigarettes smoked per day per smoker by region and gender

From the WHO database (WHO 1997), and published epidemiological studies, data were collected on the number of cigarettes smoked per smoker per day. For many countries, gender-specific values are not available. For these countries, it was assumed that the number is the same for male and female smokers. For many countries, more than one estimate of the number of cigarettes smoked per smoker per day was available; in these cases, the flat average of available values was used. National-level estimates are weighted by the adult population (defined as those over 15 years of age) of those countries to estimate regional values. The resulting weighted averages were then assumed to apply to the entire region, including those countries for which data are not available.

Step 7. Number of cigarettes smoked per day per smoker by age category

National data on the number of cigarettes smoked per day per smoker by age category (gender-specific) are available for a number of high-income countries (Nicolaides-Bouman *et al.* 1993); similar data for low-income countries are scarce. In this analysis, national-level data were combined by weighting national estimates by the adult population (>15 years of age) of those countries. Age-specific values were then adjusted to correspond to the age-categories being used in this analysis. Finally, the ratios of cigarettes smoked per smoker per day amongst older age categories relative to 15–19 year-olds were calculated. These ratios were applied to all regions, including those for which no data are available.

Step 8. Total number of cigarettes smoked per year by gender, age, and region

For each region, the total number of cigarettes smoked by each age and gender category was calculated by multiplying 'population' by 'smoking prevalence' by 'number

of cigarettes smoked per day per smoker' by 365.25 (assuming that a year has 365 whole days and one quarter day).

Results

Our estimates reveal variations in smoking prevalence across regions, gender and age, and variations in smoking amount. First, globally in 1995, 29% of the population aged 15 years and over smoked daily (Table 2.1). Low-income and middle-income countries, whose populations account for four-fifths of the global adult population, accounted for

Table 2.1 Prevalence of smoking among adults aged 15 and over, by World Bank region, 1995

World Bank region	Smoking prevalence (%)			Total smokers	
	Males	Females	Overall	(millions)	(% of all smokers)
East Asia and Pacific	61	4	33	413	36
Europe and Central Asia	57	26	40	145	13
Latin America and Caribbean	40	21	30	95	8
Middle East and North Africa	44	5	25	40	3
South Asia (cigarettes)	21	1	11	88	8
South Asia (*bidis*)	21	4	13	99	9
Sub-Saharan Africa	29	9	18	59	5
Low-income & Middle-income	49	9	29	939	82
High-income	38	21	29	205	18
World	47	11	29	1143	100

Source: authors' calculations.

Table 2.2 Global prevalence of smoking, by age, 1995

Age categories	Males		Females		Total		
	Prevalence (%)	Number of smokers (millions)	Prevalence (%)	Number of smokers (millions)	Prevalence (%)	Number of smokers (millions)	% Total
15–19	33	86	5	12	19	98	9
20–29	42	213	11	54	27	267	23
30–39	57	235	15	58	36	293	26
40–49	58	182	14	44	37	225	20
50–59	51	108	11	23	31	131	11
60+	41	101	9	28	24	129	11
TOTAL	47	925	11	218	29	1143	100
% of total		81		19		100	

Source: authors' calculations.

82% of the world's smokers. East Asia and the Pacific, which includes China, accounted for 36% (413 million) of all smokers, but only 32% of the population aged 15 years and over. Overall, smoking prevalence was highest in Europe and Central Asia at 40%, and lowest in Sub-Saharan Africa at 18%.

For both males and females, there was wide variation in smoking prevalence between regions. The prevalence of smoking amongst males was highest in East Asia and the Pacific, and in Europe and Central Asia, at about 60% in each case, and lowest in Sub-Saharan Africa at 29%. Among females, the prevalence of smoking was highest in Europe and Central Asia at 26% and lowest in South Asia at 5% (for cigarettes and *bidis* combined) and Middle East and North Africa at 6%.

Second, the prevalence of daily smoking was higher overall for men (47%) than for women (11%). WHO data at country level suggest that the proportion of men who smoke is well above 50% in many low-income and middle-income countries: 82% in Indonesia, 78% in the Philippines, 75% in Cuba, 72% in Colombia, 70% in Bangladesh, 68% in Romania and Poland, and 62% in China (WHO 1997). Globally, males account for four in five of all smokers (Table 2.2).

Third, the prevalence of smoking is highest for people aged 30–49 years (36–37%, Table 2.2). The prevalence of daily smoking is lowest amongst youth aged 15–19 years (19%), and is also relatively low among people aged 60 and older (24%). These trends in age-specific smoking prevalence are similar for both males and females.

2.2.2 Cigarette and *bidi* consumption levels

On average, the world's smokers consume 14 cigarettes (or *bidis*) each per day (Fig. 2.1). Daily consumption per smoker is highest in high-income countries, where both males and females smoke on average 20 cigarettes a day, and lowest in Latin America and the Caribbean.

Almost 6 trillion units (cigarettes and *bidis*) were smoked in 1995. Three-quarters of these were consumed in low-income countries, with one-third consumed in East Asia and the Pacific alone (Table 2.3).

The limitations of these estimates are obvious. First, definitions of current smoking vary across the 89 studies on which we based our estimates. Second, we assumed that the smoking pattern for a country did not change between the year of the survey and 1995. Thus recent increases in smoking may not be captured in our estimates. Recent decreases are unlikely, given that rates of quitting are low in developing countries. Third, while the overall smoking prevalence data are likely to be plausible, given that they are derived from direct studies in various countries, our indirect estimates of age- and gender-specific patterns are less likely to be robust. Finally, there is great variation in smoking prevalence even within countries. For example, the prevalence among males in cities usually exceeds that of rural males (WHO 1997). Despite these limitations, the prevalence estimates are internally consistent because the totals do not exceed total global smoking prevalence. These estimates are also consistent with other reports of smoking prevalence (WHO 1997), manufacturing reports (Marketfile 1998), and agricultural, import, and export data (USDA 1998).

Some points are noteworthy. Low-income and middle-income countries have a similar aggregate smoking prevalence to that of high-income countries; they account

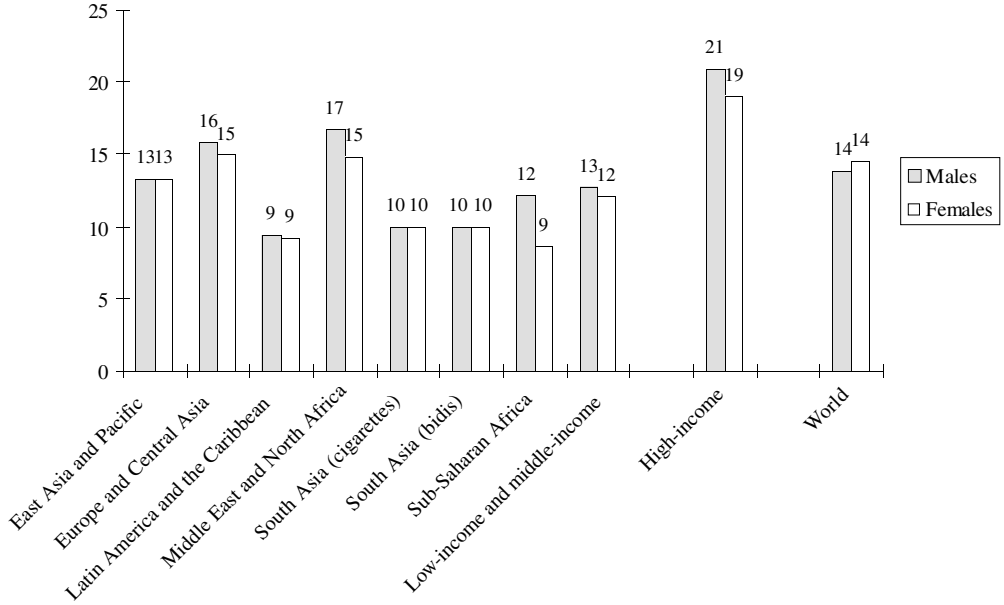

Fig. 2.1 Number of cigarettes smoked per day per daily smoker, by region.

Table 2.3 Estimated number of cigarettes and *bidis* smoked per year, by World Bank region, 1995

World Bank Region	Number (billions)	% Total
East Asia and Pacific	2003	34
Europe and Central Asia	822	14
Latin America and Caribbean	325	6
Middle East and North Africa	242	4
South Asia (cigarettes)	323	6
South Asia (*bidis*)	361	6
Sub-Saharan Africa	244	4
Low-income & middle-income	4319	74
High-income	1508	26
World	5827	100

Source: authors' calculations.

for the majority (82%) of the world's smokers; and they consume three-quarters of the cigarettes and *bidis* smoked worldwide. Males in low-income countries have a higher prevalence of daily smoking (49%) than do males in high-income countries (38%), while the reverse is true for females (9% in low-income countries and 21% in high-income countries).

2.2.3 Smoking incidence

The majority of epidemiological studies suggest that individuals who avoid starting to smoke in adolescence or young adulthood are unlikely ever to become smokers. Nowadays, most smokers start before age 25, often in childhood or adolescence (see Fig. 2.2). In the high-income countries, eight out of ten begin in their teens. In middle-income and low-income countries, for which data are available, it appears that most smokers start by their early twenties, but the trend is towards younger ages. For example, in China between 1984 and 1996, there was a significant increase in the number of young men aged between 15 and 19 years who took up smoking. This resulted in the average age of initiation dropping from 23 in 1984 to 20 by 1996 (Chinese Academy of Preventive Medicine 1997). A similar decline in the average age of starting has been observed over this century in the United States (USDHHS 1989; and Fig. 2.2).

In order to obtain a broad estimate of the number of young people who take up smoking every day worldwide, the following method was used. We used:

(1) World Bank data on the number of young people, male and female, who reached age 20 in 1995, for each World Bank region; and
(2) the above prevalence estimates based on WHO data to estimate the number of smokers in all age groups up to age30 in each of these regions.

For an upper estimate, we assumed that the number of young people who take up smoking every day is a product of (1) multiplied by (2) per region, for each gender.

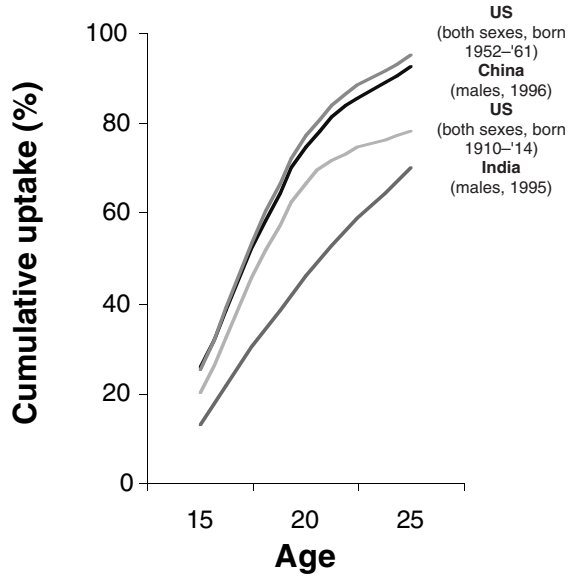

Fig. 2.2 Smoking initiation age in China, India and the United States. Source: Gupta 1996; USDHHS 1989 and 1994; Chinese Academy of Preventive Medicine 1997.

Table 2.4 Estimated number of 20-year-olds who become long-term smokers each day, by World Bank Region, 1995

	Number per day (in thousands)	
	Lower estimate	Upper estimate
East Asia Pacific	29	31
Eastern Europe and Central Asia	9	12
Latin America	9	11
Middle East and North Africa	4	6
South Asia	11	17
Sub-Saharan Africa	7	8
Low-income & middle-income	68	84
High-income	13	14
World total	81	98

Source: authors' calculations.

For a lower estimate, we reduced the prevalence value used by region-specific estimates for the proportion of smokers who start after the age of 30. We added three conservative assumptions. First, that there have been minimal changes over time in the average age of uptake. In fact, as we have shown, there have been recent downward trends in the age of uptake in young Chinese men, but our assumption of little change means that, if anything, our figures are underestimates. Second, we focused on regular smokers, excluding the much larger number of children who would try smoking but not become regular smokers. Third, we assumed that, among more established adolescent smokers, quitting before adulthood is rare. In high-income countries, quitting is common, but in low-income and middle-income countries it is currently very rare.

With these assumptions, we calculated that the number of children and young people taking up smoking ranges from 13000 to 14000 per day in the high-income countries as a whole. For middle-income and low-income countries, the estimated numbers range from 68000 to 84000 (Table 2.4). This means that every day worldwide there are between 81000 and 98000 young people becoming long-term smokers. These figures are consistent with existing estimates for individual high-income countries, such as for the United States (Pierce *et al.* 1989).

2.2.4 Past trends in smoking patterns

Smoking patterns vary over time according to income level, population size, age, gender, and the presence of control policies. In this section, we briefly review trends in consumption over the past few decades and attempt to project patterns for the next

few decades. Detailed age- and sex-specific trends data are not available. Thus we concentrate on aggregate smoking trends at the level of countries.

From about 1970 to the mid-1990s, annual world cigarette and *bidi* consumption increased from about 3 trillion to 6 trillion sticks However, consumption per capita has remained flat since about 1970, stabilizing at about 1650 cigarettes per adult annually from 1980–82 to 1990–92 (Fig. 2.3). This is because developed countries are consuming less, and developing countries are consuming more.

Tobacco consumption fell over the past 20 years in most high-income countries, such as Australia, Britain, Canada, New Zealand, the United States, and most northern European countries. Consumption among men peaked around 1970 in many countries but patterns among women are more uncertain. In the United States, about 55% of males smoked at the peak of consumption in the 1950s, but the proportion had fallen to 28% by the mid-1990s. However, among certain groups, such as teenagers and young women, the proportion of those who smoke increased in the 1990s.

In contrast to overall declines in the high-income countries, tobacco consumption increased in middle-income and low-income countries by about 3.4% per annum between 1970 and 1990 (Fig. 2.3 and Table 2.5).

Overall, the ratio of average cigarette consumption per adult between developed and developing countries has narrowed from 3.3 in the early 1970s to 1.8 in the early 1990s. According to WHO data for 111 countries, there are 30 countries where annual cigarette consumption per capita has increased by at least one tertile from 1970 to 1990. Of these 30 countries, 25 are low-income and middle-income countries.

In China, among men, the new popularity of smoking appears to be particularly pronounced. The first national smoking survey of more than half a million individuals was conducted in China in 1984 (Weng 1988). The results of the survey showed that 61% of males older than age 15 in China smoked, and the prevalence of smoking in

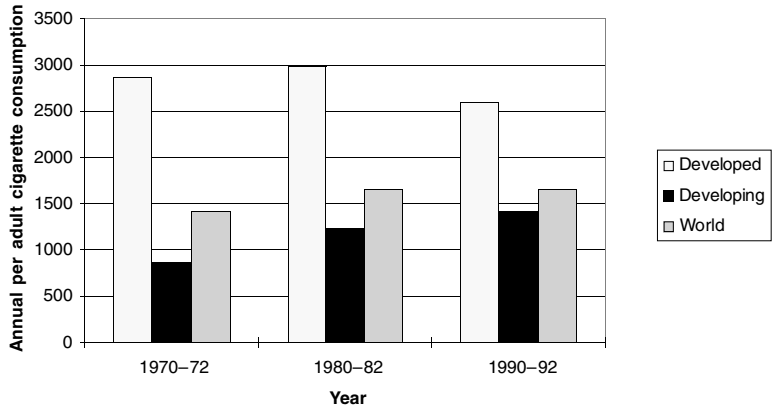

Fig. 2.3 Trends in per capita cigarette consumption in developed and developing countries. Source: WHO 1997.

Table 2.5 Cigarette consumption per adult aged 15 years and over: selected countries 1970–72 to 1990–92

Income group	Country	Cigarette consumption per adult 1970–90	
		Relative increase over 1970–72 levels (%)	Absolute Increase since 1970–72 (sticks)
Low-income	Nepal	241	410
	Haiti	241	410
	Cameroon	174	470
	China	160	1170
	Senegal	144	620
	Bangladesh	94	480
	Sierra Leone	76	350
	Yemen, Rep.	72	340
	Madagascar	70	190
	Myanmar	67	60
	Malawi	65	130
	Niger	55	60
	Ethiopia	50	30
	India	36	360
	Cambodia	30	280
Lower-middle	Indonesia	136	680
	Syria	111	1050
	Algeria	68	650
	Egypt, Arab Rep.	66	480
	Jordan	65	660
	Suriname	61	710
	Fiji	38	440
	Morocco	35	240
	Ecuador	34	220
	Thailand	30	240
Upper-middle	Saudi Arabia	75	910
	Mauritius	40	520
High-income	Cyprus	41	890
	Portugal	40	570
	Greece	36	950

Source: WHO 1997.

all occupational groups was higher than for the corresponding groups in the United States. By 1996 the prevalence of smoking in Chinese men had risen further, to 63% (Chinese Academy of Preventive Medicine 1997). The average consumption of cigarettes per Chinese man per day was 1 in 1952, 4 in 1972, 10 in 1992, and 11 in 1996 (Weng 1988, 1990; Mackay 1995; Chinese Academy of Preventive Medicine 1997; WHO 1997).

2.3 Smoking-attributable mortality

It is well established that prolonged smoking is an important cause of chronic disease. Here we summarize the literature on mortality from chronic diseases attributable to smoking. We begin by discussing the long delay between the onset of smoking and chronic disease, given that this key feature of smoking is important to individual choices and the perception of risk, and to public policy. We then describe current smoking mortality in developed and developing populations, including differences by gender, duration of exposure, and age. Finally, we review projections of tobacco deaths into the twenty-first century.

Tobacco contains nicotine, a substance that is recognized to be addictive by WHO and several other international medical organizations (see, for example: USDHHS 1988; WHO 1992). There is increasing evidence that nicotine addiction is central to consumer choices (see Chapter 5, for a discussion of the economics of addiction, and Chapter 12, for a discussion on nicotine replacement therapies). We refer the reader to several key references for a more comprehensive discussion on smoking and addiction (USDHHS 1988, 1994). Similarly, we refer the reader elsewhere for comprehensive reviews of maternal smoking (Naeye 1980; Taylor 1989; Groff *et al.* 1997; Horta *et al.* 1997; Eriksson *et al.* 1998; Ventura *et al.* 1998) or environmental tobacco smoke (Trichopoulos 1981, 1983; Hirayama 1983, 1984; USDHHS 1986; Glantz and Parmley 1991; EPA 1992; OEHHA 1997).

2.3.1 The long delay between the onset of smoking and death

There is no longer doubt about the causal connection between tobacco use and chronic disease. Prolonged smoking causes many diseases in addition to lung cancer, notably other cancers and chronic respiratory and cardiovascular diseases. Smokers are at greater risk than non-smokers for malignancies, both of organs that are in direct contact with smoke, such as the oral cavity, oropharynx, esophagus, larynx, and lung, and in organs and tissues not in direct contact with smoke, such as the pancreas, urinary track, kidney, stomach, and hemotopoietic tissues.

Past and current misunderstandings about the hazards of smoking are due in large part to the long delay between the onset of smoking and the occurrence of tobacco-related disease in individuals, and to the long delay between an increase in smoking rates within a population and a full increase in that population's death rates from tobacco-related diseases. For example,in the United States, per capita tobacco consumption increased 44% between 1920 and 1950, mostly due to smoking by young men. Lung cancer rates increased three-fold during that time. After 1950, per capita tobacco consumption stabilized but lung cancer rates increased by greater than 11-fold (Peto *et al.* 1992; USDA 1998; Table 2.6). The stabilization of lung cancer rates in men in the United States since about 1985 reflects a decline in the prevalence of smoking in males over the past few decades.

Similar evidence of the long delay between an increase in smoking and an increase in death rates is found in other countries with reliable ascertainment of both consumption and deaths, such as Japan, Finland, Norway, and the United Kingdom (Peto and Zaridze 1986). In Japan, smoking markedly increased in males after the Second

Table 2.6 Trends in tobacco consumption and lung cancer in the United States

Year	Percentage increase in per capita tobacco consumption in pounds weight (increase over 1920–29 average baseline)	Percentage increase in age-adjusted lung cancer rates per 100 000 (average of 1930–34 as baseline)
1940–45	19	104
1950–55	42	300
1960–65	34	528
1970–75	9	837
1980–85	–16	1103

Source: USDA 1998; Doll and Peto 1981.

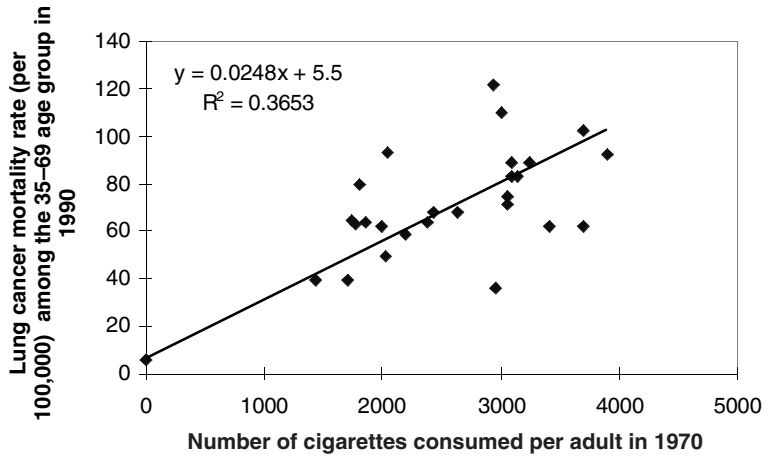

Fig. 2.4 Cigarette smoking in 1970 and lung cancer in 1990. Source: author's calculations, based on Peto *et al*. 1994 and USDA 1998.

World War, peaked in the 1960s, and then started to decline. However, tobacco-attributable mortality continues to increase to this day. Moreover, sub-populations without marked increases in smoking, such as young males living in Japan during the Second World War, do not have marked increases in lung cancer rates 20 years later (Tominaga 1986). Across the populations of the industrialized countries with a history of prolonged smoking, past consumption predicts current tobacco-attributable mortality remarkably with a lag of about 20 years (Fig. 2.4).

The long delay between smoking and disease has several implications, the most important of which is to lead smokers to underestimate their risk of disease (see Chapter 8). Smokers may be aware of the findings of epidemiological studies, but such studies conducted at the earlier stages of a tobacco epidemic may seriously mislead or underestimate the true long-term hazards from tobacco use. In the British Doctors'

Table 2.7 Annual deaths by cause in smokers and non-smokers: British Doctors' Study 1951–91

Cause of death	Annual death rate per 100 000 men			
	1951–71		1971–91	
	Non-smokers	Cigarette smokers	Non-smokers	Cigarette smokers
All neoplastic causes	382	743	394	993
Lung cancer	17	264	17	314
All respiratory causes	165	384	121	466
Chronic obstructive lung disease	7	151	15	208
Other respiratory diseases	156	253	106	258
All vascular causes	1626	2416	1153	2003
Cerebrovascular disease	401	516	276	501
Cardiovascular disease	1225	1900	857	1502
Other diseases	258	370	198	388
Trauma and poisoning	94	119	74	156
All causes	2523	4077	1954	4026

Source: Doll *et al.* 1994. Reproduced with permission of the BMJ Publishing Group.

Table 2.8 Lung cancer deaths, United States: two million-person prospective studies

Period	Males		Females	
	Death rate /100 000 Non-smokers	Death rate ratios Smoker : non-smoker	Death rate /100 000 Non-smokers	Death rate ratios Smoker : non-smoker
1960s	6	12	4	3
1980s	6	22	5	11

Source: Peto *et al.* 1994; USDHHS 1989.

study (Doll *et al.* 1994), the mortality among middle-aged smokers was two times that of non-smokers during the first 20-year follow-up period, and three times that of non-smokers during the second 20-year follow-up period. This implies that half of deaths in middle age among the smokers in the first 20-year follow-up period, and two-thirds of those deaths in the second 20-year period, were caused by tobacco. Thus, in the British Doctors' study, the excess mortality among middle-aged smokers was substantially higher during the second follow-up period than it was during the first (Table 2.7).

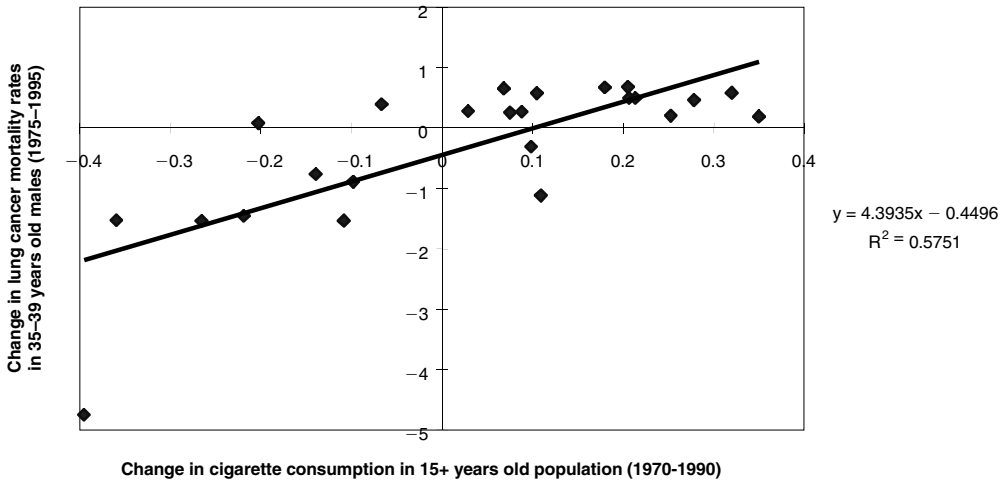

Fig. 2.5 Changes in cigarette consumption and changes in lung cancer mortality rates in 35–39 year-old males (1975–95), selected countries. Source: authors' calculations from Peto *et al*. 1994 and WHO 1997.

A comparable pattern has emerged in the United States. Table 2.8 shows change over time in the ratio of deaths from lung cancer for smokers versus non-smokers. The death rate from this disease among non-smokers did not change appreciably in 20 years, whereas the death rate among smokers increased substantially in in both sexes between the 1960s and the 1980s (Peto *et al.* 1994).

Despite the long lag between smoking and its full impact, *recent* changes in lung cancer rates in *young* men and women are a very sensitive indicator of recent changes in tobacco consumption. This is because lung cancer in young adults is easier to diagnose than at older ages. Across high-income countries, changes in total cigarette consumption in the past 20 years have predicted changes in lung cancer rates in young males (Figure 2.5).

2.3.2 Current estimates of tobacco-attributable mortality worldwide

The WHO has produced estimates of global mortality from smoking (WHO 1999),[2] using a method known as the *smoking impact ratio*, which indexes various causes of death to lung cancer (Peto *et al.* 1994). The method has been applied to low-income and middle-income countries. The results are shown in Table 2.9.

How plausible are these estimates? Given the long delay between onset of smoking and disease, the most reliable estimates are for men in the established market economies and the former socialist economies. In these countries, men took up

[2] WHO also provide estimates of the disability-adjusted life years (DALYs) attributable to tobacco. For a full explanation of how this measure of disease burden is calculated see Murray and Lopez (1996). In brief, total DALYs from tobacco in 1998 were 49 288 000 or about 3.6% of all DALYs.

Table 2.9 Estimates of tobacco-attributable mortality, by region, in thousands, during 1998

Region or country	Males	Females	Total
Established market economies	840	400	1240
China	783	130	913
Formerly socialist economies of Europe	595	88	683
India	332	51	383
Other Asia and islands	242	34	276
Middle Eastern Crescent	210	28	238
Latin America	130	38	168
Sub-Saharan Africa	109	13	122
World	3241	782	4023
% of worldwide deaths	11.4	3.1	7.5

Source: WHO (1999) with adaptation to the regional classification used in Murray and Lopez (1996).

Table 2.10 Smoking and death among males aged 35–69 in the United States

Cause of death	Mean[a] annual mortality rate per 100 000 males aged 35–69		
	Nonsmokers	Current cigarette smokers	Excess rate in smokers
Lung cancer	8	196	441
Upper aerodigestive cancer[b]	5	28	23
Other cancers	109	188	79
Respiratory	9	62	53
Vascular	176	446	270
Cirrhosis	5	19	14
Other medical	39	81	42
Non-medical (suicide, homicide, accident, etc.)	31	62	31
All causes	382	1083	701

[a] Average of rates by each cause for seven age groups: 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, and 65–69.
[b] Cancers of the mouth, oesophagus, pharynx and larynx.

Source: Peto *et al.* 1994.

smoking in large numbers 30–60 years ago and deaths today from various causes are reliably measured, as shown, for example, in the American Cancer Society's Cancer Prevention Study (CPS-II) (USDHHS 1990) (Table 2.10).

Based on the CPS-II, Peto and colleagues have derived a novel approach of using the absolute age- and sex-specific lung cancer rates, minus USA non-smoker lung cancer rates from the CPS-II, to approximate the proportions of deaths from various

other diseases that can be attributed to tobacco. This methodology was applied to routinely collected mortality data in high-income western countries and former socialist countries (Peto *et al*. 1994). It indicated that in 1990, tobacco was responsible for 17% of total deaths or 2.1 million deaths per year in these countries (Table 2.11). Throughout Europe in 1990, tobacco smoking caused three-quarters of a million deaths in middle age. In the countries of Central and Eastern Europe, including the former Soviet Union, there were 441 200 deaths in middle-aged men and 42 100 deaths in women. The highest burdens of tobacco-attributable mortality were in Eastern Europe. Retrospective application of this method indicates that tobacco-attributable mortality has risen in most developed countries over the past 40 years, but that non-tobacco-attributable mortality is generally falling. From 1950 to 2000, according to this method, tobacco caused about 60 million deaths in developed countries, or 20% of total male deaths and 4% of total female deaths. Of these 60 million deaths, about 40 million were in middle age and 20 million in old age. On the basis of newer data from China and India (see below), it is plausible that between 20 million and 30 million tobacco deaths have occurred since 1950 in low-income and middle-income countries. These deaths, combined with an estimated several million deaths between 1900 and 1950, suggest that the twentieth century has seen a total of about 100 million tobacco deaths (Peto and Lopez in press).

Cardiovascular disease—in particular ischemic heart disease—is the most common smoking-related cause of death in developed countries. By calculating the smoking impact ratio, researchers have attributed a significant proportion of deaths from cancer, vascular disease, and chronic obstructive pulmonary disease to tobacco (Table 2.11; Peto *et al.* 1994; WHO 1997).

The strengths and weaknesses of this indirect methodology have been reviewed previously (Peto *et al.* 1994). Most importantly, these methods are indirect and may under- or over-estimate smoking-attributable mortality. The method may be less reliable in estimating deaths from cardiovascular disease in Eastern Europe (Murray and Bobadilla 1997). Ongoing epidemiological studies in Poland and Russia should help to validate these indirect estimates, particularly for Eastern European populations.

Countries in South and East Asia, Africa and Latin America are at earlier stages in

Table 2.11 Percentage of deaths in middle age attributed to smoking, by cause, in high-income countries and former socialist countries during 1995

Sex	All causes	All cancer	Lung cancer	Upper aerodigestive cancer	Chronic obstructive pulmonary disease	Vascular disease
Males	36	50	94	70	82	35
Females	13	13	71	34	55	12
Both sexes	28	35	89	65	73	28

Source: Peto *et al*. 1994.

the pattern of cigarette consumption seen in developed countries. Because it is only those who start smoking in early adult life who are at really high risk of death from tobacco in middle and old age, there will generally be a delay of about half a century between the time of the main increase in smoking by young adults and the time of main increase in death from tobacco in later life. Hence, the peak of the epidemic of tobacco-related morbidity and mortality is yet to be seen in many developing countries. In addition, these countries have few direct or indirect studies of tobacco-attributable mortality. One important exception, however, is China. A large retrospective Chinese study, conducted in 98 geographically defined areas, revealed that one smoker in four has already been killed by tobacco. However, the proportion of all deaths caused by tobacco is currently lower than that in the West (Table 2.12; Liu *et al.* 1998), partly because the full effects of the large recent increases in male cigarette consumption are not yet evident. Even at this early stage, however, China has more tobacco deaths than the USA or Russia. In 1990, tobacco-attributed deaths numbered 0.6 million (0.5 million males and 0.1 million females). By 2000, tobacco deaths are expected to reach at least 0.8 million (0.7 million of them in males). Half of these deaths will occur in middle age (defined as ages 35–69) and half in old age.

The Chinese data also reveal that the causes of tobacco-attributable death may differ between developing and developed countries. Chronic obstructive pulmonary disease (COPD) accounted for almost half the tobacco-attributed deaths in China (three times as great a proportion as in the USA), while ischaemic heart disease accounted for only a relatively small percentage. Smoking appeared to cause about as many deaths from tuberculosis as from ischaemic heart disease in China. In India, earlier studies have shown that the use of tobacco increases the risk of developing lung cancer among tuberculosis patients (Willcox *et al.* 1982). In Egypt, a higher risk of bladder cancer has been seen among smokers infected with the pathogen *Schistosoma haematobium* than among non-smokers (Makhyoun 1974). Moreover, various populations have high underlying vascular mortality, such as India, Malaysia, Mauritius, and Sri Lanka (WHO 1997), and smoking may exacerbate this pattern in the future.

Reliable evidence of tobacco-attributable mortality in other large developing

Table 2.12 Percentage of deaths in middle age attributed to smoking, by cause, in China during 1986–88

Sex	All causes	All cancer	Lung cancer	Oesophagus cancer	Stomach cancer	Chronic obstructive pulmonary disease	Respiratory tuberculosis	Vascular disease
Males	13	24	52	28	18	23	11	9
Females	3	4	19	3	2	9	3	0.2
Both sexes	9	17	42	19	13	17	8	9

Source: Liu *et al.* 1998. Reproduced with permission from the BMJ Publishing Group.

countries is lacking, although several studies are ongoing. In India, 48% of male cancers and 20% of female cancers are tobacco-related (Gajalakshmi *et al.* 1996). Preliminary results from a large retrospective study in Chennai of the smoking habits of 48,000 adults who died recently and of 48,000 live controls suggest that, in middle age, smokers have about twice the age-standardized death rate of non-smokers, i.e., that half of all the male smokers who die in middle age would not have done so at non-smoker death rates. A substantial minority of these tobacco-attributed deaths involve tuberculosis (Gajalakshmi and Peto 1999). If, eventually, the twofold difference in male death rates between smokers and non-smokers at ages 25–69 observed in Chennai is found in many parts of urban and rural India, then about 30% of the male deaths in middle age and about 10% of the male deaths in old age will be attributable to smoking in India.

In all attempts to estimate the burden of tobacco-attributable disease, a major area of uncertainty is the impact of prolonged smoking on women. Table 2.9 notes that less than one in five of all current tobacco deaths are among women. Patterns of tobacco-attributable mortality among men are well established from observations over the past 40 years in populations where mass smoking in men started at various times between 1920 and 1960. In contrast, the pattern for women is less well established, because women took up smoking in mass numbers more recently. If women's smoking patterns approached those of men, then the number of female deaths from tobacco would be expected to rise as high as as those seen among males. In the United States, smoking-attributable mortality in females aged 35–69 has increased from 5% in 1965 to 31% in 1995. In many developed countries, lung cancer had equalled breast cancer, the leading cause of cancer deaths in women, by the mid-1980s (USDHHS 1986). On current smoking patterns, death rates from lung cancer and other tobacco-attributable diseases among women will rise continuously in the twenty-first century.

Another important factor in assessments of the burden of tobacco-attributable disease is the effect of early initiation to smoking. In assessing the risk of disease, the total amount of tobacco smoked appears to be less important than the age of onset and the duration of smoking. The risks are notably higher in individuals who start smoking early and continue for prolonged periods. Starting at age 15 and smoking 10–20 cigarettes a day for 45 years, increases the risk of lung cancer about twice as much as does smoking 21–39 cigarettes per day starting at age 25 (Peto 1986). Differences in the relative hazards of smoking with age have only recently emerged. A large retrospective study of 14 000 myocardial infarction survivors and 32 000 controls found non-fatal myocardial infarction rates are five times as common in smokers as in non-smokers aged 30–49, three times as great at ages 50–59, and twice as great at ages 60–79 (Parish *et al.* 1995). In addition, the risks of tobacco use are more extreme in middle age than in old age. Both the British Doctors' study and studies in the United States showed higher death rates among smokers in middle age compared to those in old age.

2.3.3 Future mortality from smoking

Policy-makers must be concerned not so much by the current mortality from past smoking patterns, but by the much larger death rates that are projected in coming

decades as a result of current smoking, especially for low-income and middle-income countries.

Smoking-attributable deaths are projected to increase for two reasons: first, increases in the susceptible population size; and second, increases in age-specific disease rates. For example, in China, male per capita consumption of manufactured cigarettes rose 10-fold between 1952 and 1992. The incidence of lung cancer in China has increased more than six-fold during the period 1970 to 1980 (Sidel and Sidel 1982), and is likely to increase 7.5-fold in the near future. During the same period, the population that will contract lung cancer will increase four-fold. The net result is that 30 000 lung cancer deaths per year in 1975 will increase to 900 000 per year by 2025 (i.e. $30\,000 \times 7.5 \times 4$).

Using data on previous smoking and mortality patterns, Peto *et al.* (1994) have estimated the magnitude of the tobacco epidemic in developing countries during the next few decades. They conclude that tobacco will cause about 0.5 billion deaths among smokers alive today. At some point in the second decade of the twenty-first century, annual deaths from tobacco will average 10 million a year. This total may appear earlier or later, the researchers conclude, depending on smoking patterns and background rates of tobacco-attributable diseases. On current smoking patterns, there will be about 450 million tobacco deaths between 2000 and 2050 (Peto *et al.* 1999). Projections beyond 2050 are more uncertain. If the proportion of people taking up smoking continues, as at present, to be between one-quarter and one-third of young adults, then, given population growth, an additional 500 billion tobacco deaths are expected in the second half of the twenty-first century. Thus, in the twenty-first century overall, tobacco would be expected, on current patterns, to kill about a billion people, or ten times as many people as in the twentieth century (Peto and Lopez in press).

Direct estimates for China based on retrospective and prospective studies (Liu *et al.* 1998; Niu *et al.* 1998) suggest that, on current patterns, smoking may account for one in three of all adult male deaths in China, or about 100 million of the 300 million Chinese males now aged 0–29. Annual tobacco deaths will rise to 1 million before 2010 and 2 million by 2025, when young adults of today reach old age. Similar preliminary estimates for India based on large retrospective and prospective studies suggest that about 30% of male deaths in middle age are attributable to smoking and about 80 million Indian males currently aged 0–34 years will eventually be killed by tobacco.

Projections of tobacco mortality based on econometric models by Murray and Lopez suggest that there will be 8.3 million tobacco-attributable deaths per year in 2020 (Table 2.13). These researchers have predicted elsewhere that global deaths attributed to tobacco would rise from 6% of all deaths in 1990 to about 12% in 2020 (Murray and Lopez 1997).

2.4 Smoking cessation: patterns and consequences

It is clear that, worldwide, most smoking begins in youth. However, the percentage of adult smokers who quit varies greatly between high-income countries and the rest of the world. The prevalence of ex-smokers is the most reliable estimate of levels of

Table 2.13 Econometric model projections of deaths and disease burden attributable to tobacco, estimates for 1990 and projections for 2020

Region	Total deaths (thousands)		Deaths (% of total)	
	1990	2020	1990	2020
Established market economies	1063	1286	15	15
Former socialist economies	515	1101	14	23
Demographically developing countries[a]	1460	5996	4	11
World	3038	8383	6	12

[a] Other than a few exceptions, low-income and middle-income economies make up the grouping of demographically developing countries in this table. For the listing of countries in this grouping, please see appendix C of WHO (1996).

Source: WHO 1996.

Table 2.14 Prevalence of ex-smokers in selected countries, ranked by per capita GDP

Country	Prevalence (%)	
	Time period 1	Time period 2
High-income		
United States	20 (1965)	30 (1991)
Australia	28 (1986)	32 (1992)
Italy	22 (1990)	28 (1995)
Sweden	20 (1963)	41 (1994)
Spain	17 (1989)	19 (1992)
Middle-income		
South Africa	N/A	06 (1996)
Hungary	15 (1986)	14 (1994)
Poland	18 (1974)	21 (1997)
Low-income		
China	N/A	02 (1993)
India	N/A	05 (1992–94)
Vietnam	N/A	10 (1997)

Sources: Giovino *et al*. 1994; Hill and White 1995; Hill 1998; La Vecchia *et al*. 1994; Pagano *et al*. 1998; Wersall and Eklund 1998; del Rio and Alvarez 1994; Reddy 1999 (unpublished data); Hungary Central Statistics Office 1994; Zatonski 1996; Gong *et al*. 1995; Gupta 1996; Jenkins *et al*. 1997.

quitting within a population. In high-income countries, ex-smoker rates have increased over the past two to three decades, and today about 30% of the male population are former smokers (Table 2.14). In contrast, only 2% of Chinese men surveyed in 1993 had quit; only 5% of Indian men had done so at around the same period; and only 10% of Vietnamese men had quit in 1997. Even these low figures may be misleadingly high because they include those people who quit because of illness.

There is considerable evidence that smoking cessation reduces the risk of death from tobacco-related diseases. A reduction in the risk of lung cancer after smoking cessation has been observed in the United States, Canada, Europe, United Kingdom, Canada, Asia, Latin America, and Sweden. There has been some marked reduction in tobacco-attributable mortality in some countries, largely due to quitting. For example, male deaths in middle age from tobacco-related disease in the United Kingdom have fallen from 69 000 to 28 000 during the period 1965–95 (Peto *et al.* 1994). Around 1970, British men had the worst death rate in the world from tobacco, but with adults quitting, Britain has the world's biggest decrease in tobacco deaths. Data presented by Bobak *et al*. (Chapter 3) also reveal that declines in tobacco-attributable mortality differ by socio-economic group within countries, largely reflecting differences in quitting.

There is as yet unclear evidence from epidemiological studies about the rate at which the risks of morbidity and mortality decline after an individual quits. Former smokers face a lower risk of tobacco-related diseases than current smokers, but their risks remain higher than those of non-smokers. As the time since quitting increases, the risks to former smokers of tobacco-related diseases falls. In studies in the United Kingdom, those who quit smoking before the onset of major disease avoided most of the excess hazard of smoking (Doll *et al.* 1994). The benefits of quitting were largest in those who quit early (between ages 35 and 44) but still significant in those who quit later (between ages 45 and 54). In the United States, former smokers who have quit for 15 years or more have lung cancer mortality rates twice those of non-smokers. This compares with rates 15 times greater than those of non-smokers among continuing smokers who started in their early teens (USDHHS 1983). In Sweden, it was found that men who had ceased smoking for 10 years had no significant excess risk of coronary heart disease over non-smokers, and the results for women were consistent with those for men (Rosenberg *et al.* 1990). In Britain, the relative risk of coronary heart disease among men aged between 30 and 54 years compared to non-smokers was 1.9 for those who had discontinued smoking for less than 5 years, 1.3 for those who had discontinued for between 15 and 5 years, and among men who had quit for more than 15 years, the risks were virtually identical to those of non-smokers (USDHHS 1983).

2.5 Directions for research

The smoking epidemic is not uniform. There is considerable variation in mortality across age groups, by gender, over time, by geography, and by socio-economic group (see Chapter 3). Thus, while the hazards of smoking appear well documented, at least

in high-income countries, the importance of monitoring the epidemic is clear. Three types of key data would be required for an overall strategy for research on tobacco (see Chapter 19 and Baris 1999). First, epidemiologists would need reliable estimates of smoking prevalence and incidence across different populations. Standardized methods of measuring smoking prevalence, akin to the National Health Interview Survey (US National Center for Health Statistics 1999) are required in all countries to monitor the smoking epidemic, as well as the success of interventions and control programs. Second, reliable data on absolute numbers of cigarettes sold in any country would be needed as a proxy indicator of the overall levels of future disease in a population. Third, retrospective 'proportional mortality' studies, which compare the proportions of smokers and non-smokers who have died of tobacco-attributable diseases to calculate the excess in smokers, and 'case-control' studies, which use deceased persons as cases and their surviving spouses/close relatives as controls, would be required to project future mortality patterns. Both proportional mortality and case-control studies involve simple ascertainment by an interviewer of the cause of death, along with a measure of past smoking gathered from living household members. Experience from China (Liu *et al.* 1998) suggest that simple information on death certificates about whether or not the deceased person smoked would permit a robust analysis of proportional mortality. Such an analysis compares the tobacco habits of adults who died of cancers, vascular and respiratory diseases, to those who died of other causes as 'reference groups'. For example, the excess of lung cancer deaths among smokers can be inferred from the excess of smokers among lung cancer deaths. Proportional mortality results in China are comparable to those from an early prospective study (Niu *et al.* 1998). In Chennai, India, a retrospective case-control study to assess the health effects of tobacco use is under way; the smoking and tobacco-chewing habits of those who died in Chennai during 1995–97 are being analyzed by interviewing the surviving spouse/close relatives (Gajalakshmi and Peto 1999). Living women are compared to dead women for the magnitude of risk from exposure to tobacco, and living men are compared to dead men. In this study design, the data on both cases and controls are obtained at the same time. South Africa now obtains past smoking status on all death certificates, and a review of early implementation is under way (Sitas *et al.* 1998). By January 2000, India began to record past tobacco use on all death certificates. Similar efforts are required in other countries to enable effective monitoring of the smoking epidemic.

2.6 Conclusions

The majority of smokers today live in low-income and middle-income countries, where consumption has risen over the last two decades. Most smokers worldwide start their addiction as children, and there is some evidence from China that the average age of smoking onset is falling. Current tobacco-attributable mortality is about 4 million deaths per year, with half of these deaths in low- and middle-income countries. Current risks for prolonged smoking are considerable: one in two long-term smokers will be

killed by tobacco, half of these in middle age. On current smoking trends, there will be 10 million annual deaths (about one in six of all adult deaths) by 2030. About seven in ten of these deaths will be in low-income countries. All told, on current smoking patterns, about 0.5 billion of the world's population alive today will be killed by smoking, half of them in middle age, and the twenty-first century is likely to see about 1 billion tobacco deaths. Evidence from developed countries suggests that quitting can avoid much of the excess risk from smoking, but quitting remains rare in low-income and middle-income countries. Alongside specific action to reduce mortality, further specific research is required to monitor the great epidemic of the twenty-first century.

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