## Section 2
## Situation Analysis/Mapping

# Chapter 3
# The Economic Costs of Tobacco Use, With a Focus on Low- and Middle-Income Countries

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The costs of tobacco use include illness, disability, premature death, and forgone consumption and investment. This chapter examines the estimation of the costs of tobacco use by:

- Reviewing the economic framework for cost estimation of tobacco use
- Examining cost estimates for individual low- and middle-income countries (LMICs) by World Health Organization Region
- Analyzing recent cost estimates for high-income countries (HICs) in the Region of the Americas, European Region, and Western Pacific Region
- Offering recommendations for addressing current gaps in data and areas for further study.

Significant obstacles to calculating comprehensive estimates of the costs of tobacco use still exist in many countries, particularly in LMICs, where markets in many economic sectors do not function well. Estimates from HICs consistently show that considerable economic costs, for both health care and lost productivity, result from tobacco use and from exposure to secondhand smoke among nonsmokers. Where sufficient data exist, they demonstrate that tobacco-related health care costs for LMICs are comparable to those for HICs when considered as a percentage of total health care costs.

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## Introduction

Tobacco use produces the fourth highest burden of premature morbidity and mortality, accounting for approximately 4% of the total disease burden worldwide—behind only childhood underweight, unsafe sex, and high blood pressure.[1] Tobacco use also is the second leading cause of death globally, accounting for around 6 million deaths annually.[2]

The costs of tobacco use are global, affecting low- and middle-income countries (LMICs) as well as high-income countries (HICs). Many LMICs are in the early-to-middle stages of the tobacco epidemic that has affected HICs for many decades.[3,4] Therefore, the already high burden of tobacco use in LMICs will grow significantly if trends continue. By 2030, tobacco use is forecast to produce the largest burden of premature mortality and disability in the world compared with other health risk factors.[5]

Tobacco products in many LMICs are more diverse than those in HICs and have different profiles of uptake and prevalence by age and gender[6,7]; tobacco products in LMICs may also be associated with different health effects[8,9] (see chapter 2). Use of smokeless tobacco and forms of smoked tobacco other than cigarettes (e.g., hookahs, bidis) is more frequent in many LMICs than in HICs.[8,10] Although research on the economic costs of tobacco use in LMICs has increased significantly during the past decade, fewer studies have estimated the economic costs of tobacco use in LMICs than in HICs[11]—hence, this review.

This chapter first briefly reviews the economic framework for estimating the costs of tobacco use. Next, the chapter examines cost estimates for individual countries by World Health Organization (WHO) Region. The principal outcome measures are direct costs of tobacco use, costs as a proportion of total national health care expenditures, and total cost (including direct and indirect costs) of tobacco use as a proportion of gross domestic product (GDP). This chapter then reviews estimates of the economic costs of tobacco use in LMICs across all regions, followed by costs in HICs. Finally, the chapter summarizes results and suggests areas for further research.

## Framework for Estimating the Costs of Tobacco Use

The information presented in this chapter is intended to provide a general understanding of the economic framework for estimating the costs of tobacco use. More formal discussions of methods for applying economic approaches to estimating the costs of tobacco use can be found in the existing literature.[11–20] WHO provides a "toolkit" for estimating the economic costs of tobacco use which is particularly useful for researchers in LMICs, where key data are often less available.[21]

Accurately estimating the cost of tobacco use is more difficult in LMICs than in HICs. For example, many dwellings in LMICs use solid fuels for cooking and heating, which results in indoor air pollution, and the health effects of indoor air pollution can be difficult to differentiate from those of secondhand smoke (SHS).[22] Also, the tobacco use epidemic is developing simultaneously with modern private and public health care and insurance delivery systems in LMICs.[1,23–25] Thus, the methods used to estimate costs in HICs, which have fully developed health care systems, may not be appropriate for estimating such costs in LMICs.[11] Furthermore, economic evaluations using assumptions appropriate for HICs may not accurately estimate the indirect costs of death and disability in LMICs.

## Cost Concepts

### *Basic Definition of Cost*

For any good or service, *economic cost* is defined by opportunity cost—that is, the value of resources forgone to produce or consume another unit of that good or service. For example, the opportunity cost of an hour of a doctor's time consists of the output the doctor could have produced if he or she had been doing something else. The opportunity cost of a tobacco user's time away from work due to disease caused by smoking would be the market price of the lost labor, usually the market wage, or the monetary value of the total wages and fringe benefits that he or she was receiving. Applied to consumption of tobacco, the opportunity cost of buying and consuming tobacco products is the alternative consumption that would have occurred if such products had not been purchased and consumed.

In most cases of ordinary goods and services, which are either not addictive or much less addictive and have far fewer harmful effects than tobacco, the opportunity cost is measured by market price. Thus, the hourly wage of a doctor is used to measure the opportunity cost of an hour of a doctor's time. The dollar value represents the cost of all production (which is also a person's consumption) forgone because of the use of a doctor's time in one activity rather than another. As discussed later in this chapter, the definition of cost used in tobacco control follows the cost-of-illness framework that uses this basic definition of economic cost but in a different way.

### *Marginal, Total, and Average Costs*

*Marginal cost* is defined as the cost to produce the last additional increment of a specified good or service, assuming production is efficient. *Total cost* is defined as the cost of the total production of a specified good or service. *Average cost* is defined as the total cost divided by the number of units of a good or service.

Using the example of a particular day at a hospital, if an accident requires an unexpected additional surgery, then the marginal cost of that surgery would be the value of the additional health professionals' time, medical supplies, equipment, and services required for the additional surgery. The total cost of surgery is the total sum of the costs of all surgeries for that day. The average cost is the total cost of surgeries for that day divided by the number of surgeries. Of note, marginal cost is usually not equal to average cost. For example, an additional operation in a busy hospital operating at capacity may require payment of overtime for personnel and additional costs for rush delivery of prescription drugs. Therefore, the marginal cost of the last unit produced or consumed may exceed the average cost.

Average costs, or alternatively, observed average expenditures for individual treatment episodes, often are used to estimate health care costs because marginal costs, such as those associated with surgery, are often unavailable, even in HICs.

### *Direct Costs and Indirect Costs*

In the health care field, *direct cost* is defined as the cost incurred by the consumption of health care services. Examples of direct health care costs include the costs of the physician's time, medical supplies, and the value of equipment services for a visit to the physician. In HICs with well-developed survey systems, most services provided in the formal health care field are included as direct costs, such as inpatient acute care, convalescent hospital, and ambulatory clinic services; health professional services; prescription drugs and over-the-counter medications; and medical supplies. *Indirect cost* is defined as

any additional cost (e.g., the cost of traveling to a doctor's office) incurred as a result of consuming health care services.

Use of such terminology is inconsistent, as indirect cost may be included with direct cost. Indirect cost of morbidity typically includes lost productivity (measured by compensation) due to disease-related work absence and premature disability. Indirect cost of mortality includes mainly lost productivity due to premature death.

Many of the direct and indirect costs of tobacco use show up in GDP calculations as income due to goods and services sold in the economy. However, these costs would not be incurred in the absence of tobacco-induced illnesses that reduce welfare through ill health. Thus, the overall economic balance without tobacco-induced illnesses would be more welfare-enhancing.

### *Cross-Sectional and Longitudinal Costs*

Estimates of total cost can include the cost of all current and past tobacco use or only the cost of current tobacco use. For example, the cost of current tobacco use per user (e.g., the cost of smoking per current smoker) is often of interest for policy reasons because many of the costs of former smoking may be fixed. Because consumption of tobacco shortens a smoker's expected life span, the question arises whether the cost should be adjusted for the difference in the life expectancy of smokers versus never smokers.

*Cross-sectional cost* is defined as a cost that does not adjust for different life expectancies. Cross-sectional cost also may be called prevalence-based cost or gross cost and often includes the cost of current and past smoking.[19,26] Conceptually, cross-sectional health care costs are the flows of health-related costs incurred by a living person over a given period of time, rather than the expected present value of smoking-related costs over a person's life span.

Cross-sectional estimates also exist for the indirect costs of morbidity and mortality. Cross-sectional estimates of the morbidity costs of lost productivity from smoking can be interpreted similarly to cross-sectional direct health care costs. Estimates of the indirect cost of mortality, which estimate total production lost in a given year, are sometimes reported. However, longitudinal costs usually are used for this purpose, so indirect cost estimates should be interpreted carefully when reading published estimates.

*Longitudinal cost* is defined as the discounted present value of expected annual flows of cross-sectional costs, using reasonable assumptions about life expectancy and an appropriate discount rate for expenditures in the future (usually 2–3% per year). Longitudinal cost also may be called net cost[19] or life-cycle or incidence-based cost.

The difference between cross-sectional and longitudinal costs can be misinterpreted because they have different dimensions and measure different things. Longitudinal costs are incidence based—that is, they allocate cost of incident disease in a current year, usually in a current smoker compared with a never smoker. Smokers often die at an earlier age than never smokers, and therefore have fewer years of health care costs, which affects the present value of the future stream of costs but not the flow of costs per living smoker.

For some purposes, the different expected life spans of current smokers and never smokers must be taken into account. The most straightforward way to do this is to estimate the longitudinal cost of a typical smoker. For example, the longitudinal direct health care cost of smoking for a 22-year-old male smoker would be estimated by calculating the difference between his discounted present value of future direct health costs and that of an identical 22-year-old never smoker.

### *Measures of Indirect Mortality Cost: Value of Production Versus Value of a Statistical Life and Willingness to Pay*

Estimating the indirect costs of mortality is difficult because life does not have a market price. Three approaches can be used to measure the value of years of life lost due to premature death: The *value of production* approach is based on market losses, and the *value of a statistical life* (VSL) and *willingness-to-pay* (WTP) approaches are based on the subjective value placed on avoiding premature death.

The value of production approach (also called the human capital approach) values lost years of life by estimating the market value of the flow of lost production due to premature death in a given year. This value can be estimated by using average labor compensation, which is appropriate for the majority of the population who are wage earners. This is a convenient measure that is appropriate for macroeconomic analysis and analyses for financial planning, but it has some drawbacks when used to compare losses between populations. Most workers in LMICs earn lower average money wages and fringe benefits than those in HICs. Because of arbitrary economic circumstances, the value of production approach produces lower cost estimates for the loss of a life in LMICs than in HICs. The value of production approach also undervalues the lives of people who are not working for reasons other than smoking—such as those who care for young children at home, youth in school, the elderly, and the disabled.

Some estimates that use the value of production approach only use the years of productive life lost, thus the calculations are truncated at the average age of retirement. The reasoning behind this adjustment is that years of life lost after retirement do not contribute to a country's GDP. This variation to the value of production approach is consistent with analyses that use measured economic production as the outcome measure. Using the entire remaining life expectancy is more appropriate as a measure of economic welfare given that it provides some measure of the value of life after retirement, but suffers from the drawbacks of using the value of production as a proxy measure of well-being.

Conversely, limiting the lost productivity to the working years reduces (a) the rate of return to education in a full employment situation and (b) the personal return to investments in education and other human capital. From a social point of view, in many societies a replacement worker often can be found easily if unemployment is present. Some estimates use the "friction cost" method to account for this, producing estimates that are considerably lower than those produced using the human capital approach.[27] However, in LMICs, the true costs must balance the skills a former worker acquired through on-the-job experience versus the increasing human capital of potentially inexperienced new workers. For practical purposes this issue has not been explored in most human capital studies in LMICs.

The VSL and WTP approaches attempt to avoid the limitations of the value of production approach by measuring the subjective evaluation that a person puts on his or her life.[28,29] VSL represents the economic value of preventing the risk of a single premature death. WTP measures what a person is willing to pay to avoid a specific risk, such as the health consequences of smoking addiction.

The VSL approach assumes that a person's welfare is a function of the present value of the flow of his or her expected monetary and nonmonetary benefits over time. Increases in the annual probability of death over a given time period reduce the person's perceived welfare. The VSL approach values life by estimating the value of a small change in the probability of death. Empirical methods to assess value of life can be used to analyze variations in acceptance of wage levels for increases in the objective probability of fatality without any knowledge of subjective probability at which the wage was accepted.[30] An associated empirical method for WTP would be to ask directly what monetary tradeoffs a person would accept to decrease the probability of death in a likely scenario with which he or she is familiar, tailoring the likely scenario to the particular setting involved as necessary.[31] The inferred value of life estimates is highly dependent on personal characteristics.

The WTP approach can assess the amount a person is willing to pay to be indifferent between two alternative states, instead of asking questions about probabilities.[32] As an example of the WTP approach, if the loss of expected life span is the sole concern of an addicted smoker, and the smoker is indifferent both to staying addicted and to paying 500,000 U.S. dollars (US$) to have the addiction removed, then the value of life would be US$ 500,000. WTP is conceptually equal to VSL whether people are purely selfish or altruistic toward the welfare of others, but WTP may differ when policymaking reflects paternalistic concerns that ignore individual preferences.[33] WTP also is usually measured through surveys that attempt to elicit direct revelation of preferences instead of through statistical analyses of market behavior.[34]

The VSL and WTP approaches attempt—directly or indirectly—to ask people about their own valuations; these approaches do not rely solely on the value of their market production. VSL estimates of the value of life vary widely. For example, VSL estimates in LMICs range from approximately US$ 300,000 to several million U.S. dollars, usually far higher than production-based measures for the average resident of a given country.[35]

The VSL approach to measuring the value of a life shares some of the flaws of production-based approaches. Theoretically and empirically, VSL estimates rise with increasing wealth, similar to the value of production approach. VSL estimates also vary by age and several other sociodemographic factors.[35,36]

A straightforward and theoretically sound approach incorporates aspects of VSL and WTP, capturing a person's willingness to trade years of life for consumption of some amount of goods constrained by the ability to earn income. Using this approach, Becker and colleagues[37] note that since the 1960s, at least some LMICs have placed greater importance on gains in life expectancies alongside higher incomes. A theoretically fuller account would incorporate the value others place on one's life.[38] Although these approaches are more theoretically sound than the value of production approach, they have not yet been integrated into the literature assessing the costs of tobacco use.

### *Internal Versus External Costs of Consumption*

Another important cost concept is the distinction between internal and external costs. *Internal costs of consumption* are defined as those costs that fall on or are borne by the consumer. *External costs of consumption* are those that fall on others in society. For example, internal costs are the health care costs of smoking incurred by the smoker, and external costs are the health care costs of those sickened by exposure to SHS from the smoker as well as the publicly financed health care costs of treating smokers.

In economic analyses, external costs weigh more than internal costs, because external costs are considered to be involuntary burdens. For example, if smoking is permitted in workplaces and public areas, a nonsmoker who wishes to be employed or attend public meetings will be involuntarily exposed to SHS. Some analyses include quasi-external costs for costs incurred by nonsmokers in a smoker's household. The idea is that members of the same household make decisions through a group process, and costs incurred by nonsmokers cannot be considered involuntary to the same degree as those incurred by nonfamily members.[39] The external costs of smoking are important to consider because, as discussed in chapter 2, SHS exposure has many significant adverse health consequences for both adults and children.[40,41] Similarly, the external costs of medical care for smokers will reflect the role of government in providing health care, and these external costs will be substantial in countries where all or most health care is publicly funded.

### *Perspective of Analysis*

The *perspective of analysis* is defined as the economic unit that ultimately bears a particular set of costs in an analysis. The perspective of analysis determines which costs are included in a cost analysis. For example, if the perspective of analysis is a private patient in a hospital, then such a cost analysis would examine out-of-pocket and insurance payments incurred by the patient. In this case, any costs of care subsidized by the government or paid by private insurance would not be counted as cost. However, from a social perspective, all costs would be included in a cost analysis.

## Estimation Techniques

### *Epidemiological and Regression Approaches*

Most estimates of direct health care costs are based on cross-sectional cost estimates because longitudinal datasets are few and of insufficient duration to observe differential mortality by smoking status. Most of the studies highlighted in this chapter use the epidemiological (also called attributable fraction) approach to estimate direct health care costs.

The epidemiological approach, as applied to direct health care costs, uses the concept of population-attributable risk, which, when applied to tobacco control, is often called the smoking-attributable fraction (SAF). The SAF is the proportion of the total for a given outcome (i.e., health care costs, health services utilization, deaths or other health outcome measures) that is attributable to current and past tobacco use. The SAF takes into account prevalence of tobacco use and the relative risk of incurring costs as a result of tobacco use, compared to the risk faced by never smokers. When the SAF has been determined, it can be multiplied by another health outcome measure to arrive at the part of that measure that is attributable to tobacco use. For example, the cost of treating heart attacks can be multiplied by the SAF to find the part of heart attack treatment costs that is attributable to smoking.

The SAF is expressed in Equation 1, where for a given smoking-related disease $j$, $p$ is the prevalence of ever smoking, and $R_j$ is the relative risk of health care cost for treating disease $j$ for ever smokers (including both current and former smokers) compared with never smokers. The proportion of the cost of the disease attributable to smoking equals $SAF_j$:

$$SAF_j = \frac{p\,(R_j - 1)}{((1 - p) + pR_j)} \qquad (1)$$

The total cost of smoking in a country can be found by summing the smoking-attributable costs over all diseases that are attributable to smoking. For more accurate estimates, Equation 1 also may be stratified by smoking status (current versus former), age group, and gender.

Rice and colleagues[42] produced the earliest well-documented estimates of the cost of smoking for the United States, using the relative risks of health care utilization to derive the SAFs. Later research by Tanuseputro and colleagues[43] provided modifications for multiple risk factors and imperfect linkages between exposure measures (e.g., prevalence of smoking) and resulting adverse health effects.

An alternative method is the Smoking Impact Ratio (SIR) developed by Peto, Lopez, and colleagues,[44] which captures the accumulated risks from smoking and defines these risks in terms of lung cancer mortality rates within a study population. The SIR is the ratio of (1) the study population's lung cancer mortality that exceeds lung cancer mortality among never smokers to (2) the excess lung cancer mortality for a known reference population's smokers (adjusted to account for differences in never smokers' lung cancer mortality rates between the study population and the reference population).[21] According to Ezzati and Lopez,[4] SIR can be calculated using the formula (Equation 2):

$$SIR = \frac{C_{LC} - N_{LC}}{S_{LC}^* - N_{LC}^*} \times \frac{N_{LC}^*}{N_{LC}} \qquad (2)$$

where $C_{LC}$ is the (age-/gender-specific) lung cancer mortality rate of all individuals in the study population; $N_{LC}$ is the (age-/gender-specific) lung cancer mortality rate of never smokers in the same population as $C_{LC}$; $S_{LC}$* is the lung cancer mortality rate for smokers; and $N_{LC}$* the lung cancer mortality rate for never smokers in the reference population (both are age- and gender-specific).

Conceptually, the SIR converts smokers in the study population who may have different smoking histories into equivalent smokers in the reference population, where the relative risks for different diseases have been measured. Most studies that use the SIR employ the American Cancer Society's Cancer Prevention Study II for the reference population, given that: (1) this is one of the largest smoking and mortality studies ever conducted, (2) it provides separate relative risk estimates for different causes of death, and (3) most smokers studied were lifelong cigarette smokers, which allowed the full effects of the smoking epidemic to be captured.

The SIR method has mainly been used to estimate smoking-attributable mortality rather than the direct health care costs of smoking. More detailed discussions about using SIR as a measure of exposure to accumulated smoking hazards particularly in LMICs are available in the WHO toolkit on assessing economic costs[21] and elsewhere.[4,45,46]

Regression estimates that require nationally representative survey information on health risks, health status, and health care utilization and costs are often used in cost estimation. Regression techniques have been developed to estimate relative risks and attributable fractions.[47–49] These techniques use a multi-equation framework to examine the impact of smoking on health status and health care expenditures and to control for other risk factors and the preferences of individuals for consuming health care services. A first regression analysis is used to model the probability of individual health care utilization over a reference time period as a function of smoking status and demographic, sociodemographic, and other health risk factors. A second regression analysis derives estimates of expected health care expenditures that are conditional on positive utilization, a function of smoking status, and other variables. The cost of

smoking is estimated by using the estimated regressions for two simulations. One simulation estimates the expected costs in a population with observed smoking, and a second simulation estimates the expected costs in a population with no smoking (achieved by setting all smoking indicator variables to zero). The cost of smoking is the difference between the expected costs for these two populations.

Modifications to Equation 1 may be required because relative risks are often available only for mortality, but relative risk for morbidity is a more appropriate entity to estimate the direct costs of health care. The prevalence of ever smoking may not be available in some countries, so the prevalence of current smoking may be used instead. Using the prevalence of current smoking may produce unbiased estimates of the SAF only when the prevalence of past smoking is zero. Cost data may not be sufficient to estimate an SAF for costs. Instead, a population-attributable risk can be estimated for utilization of health care services, and a separate cost estimate can be developed to apportion costs as a function of utilization. This modification may present a problem in LMICs, where the required estimates of relative risk may not exist or the relationship between tobacco use and disease may differ from estimates borrowed from HICs (e.g., for tuberculosis).[50,51] The methods used for each study should be read carefully to ensure proper interpretation of results.

Estimation of indirect morbidity and mortality costs requires estimates of the annual flow of work loss, premature disability, and mortality attributable to tobacco use. The present value of the effects of changes in annual morbidity and mortality in future years must be simulated because adequate longitudinal data are almost never available.

The epidemiological approach is popular because simple estimates can be calculated using only aggregate data and therefore can be used when detailed health survey data are not available. Warner and colleagues[19] and Max[16] have published reviews of smoking studies that use the epidemiological approach to derive the SAF.

Other types of cost estimates use large longitudinal datasets to make direct regression estimates of the difference, or ratio, of costs between current and former smokers and never smokers. Still other cost estimates use survey data that focus on household expenditures. These methods usually are not used to estimate the total economic cost of smoking to society. For summary analyses of large populations and regions, estimation methods have been developed that (a) can be used for both direct health care costs and indirect costs of tobacco use and (b) combine the relative risk approach and regression analyses that use aggregate population-level data (e.g., WHO's Burden of Disease Project).[1,52–55] When data on smoking status are not available, the indirect method of prevalence measurement, or the Peto method, can be used. In this method, a sentinel disease that is known to be a specific indicator of smoking, such as lung cancer, is used in place of smoking prevalence to measure cumulative smoking exposure.[54,56,57]

Estimating the costs of exposure to SHS is similar to estimating the costs of smoking. However, the specific health effects causally associated with SHS exposure are somewhat different from those caused by direct smoking. SHS exposure in adults causes such health effects as coronary heart disease, lung cancer, and stroke; SHS exposure in children causes middle ear disease, impaired lung function, lower respiratory illness, and sudden infant death syndrome.[41]

### *Statistical Adjustment*

Tobacco use is often associated with other health risk factors, including alcohol consumption and low levels of physical exercise. Many smoking-related diseases are related to other risk factors that are

independent of tobacco use. Therefore, the simple formula for SAF in Equation 1 predicts the reduction in the cost of tobacco use when comparing two populations with identical sociodemographic characteristics and risk factors, except for tobacco use. Adjusted attributable fractions can be used to calculate SAFs that are applicable in more general settings,[4,58] and regression techniques can be used to account for correlated health risks and multiple risk factors. Adjustment methods that work well with one set of data or in one country may fail in other settings. Therefore, whenever possible, estimation methods should be modified for the conditions of each country.

Whether cost estimates should be adjusted for other health risk behaviors related to tobacco use is a contentious issue. Some adjustment for these factors is usually done when sufficient data are available. Some evidence suggests that (a) nicotine addiction and other specific risk behaviors associated with tobacco use evolve together[59–62] and (b) people who initiate tobacco use may differ in their risk-taking behaviors from those who do not.[63] However, many other factors in the individual or surrounding environment may influence health behavior, including family and peer influences, socioeconomic status, or exposure to tobacco industry marketing. Therefore, the proper degree of adjustment is unclear.

## Estimates for Individual Countries

This section and Tables 3.1 and 3.2 present cost estimates for individual countries from the late 1990s to 2011. Estimates are given first for LMICs, where data are more limited and the methods used are generally less sophisticated, then for HICs, where more comprehensive data are available and more sophisticated methods are employed. All English-language studies that could be located, including those from both peer-reviewed and gray literature, are included to give as complete a review as possible of work done in different regions. Details are provided for the most recent studies or those that were judged of the highest quality. The cost concept (cross-sectional or longitudinal), types of costs (direct health care, indirect productivity), method and scope of estimate, and relevant period for the estimate are described. Studies that exclude the costs of nonsmokers' exposure to tobacco smoke are noted.

All costs have been converted into U.S. dollars using the average annual market exchange rates from the World Bank. Although converting all currencies to U.S. dollars allows these costs to be more comparable, fluctuations in the exchange rate from year to year can substantially change the U.S. dollar equivalent. When possible, these costs are expressed as a percentage of total health expenditures and GDP, as appropriate. Unless otherwise specified, the percentage of tobacco-attributable health care costs was calculated using national health care expenditure data obtained from the WHO Statistical Information System, and GDP calculations used GDP data from the World Bank.[64,65] Tables 3.1 (LMICs) and 3.2 (HICs) show the results of recent studies that produced estimated costs which can be interpreted as proportions of total direct health care expenditures and GDP in a national accounts framework. Only studies in this section for which there are sufficient data and details on methodology are included in these tables. Direct regression estimates of the difference in, or ratio of, direct health care cost by smoking status and estimates that focus on household expenditure patterns are beyond the scope of this review but will be discussed when appropriate.

## Table 3.1 Summary of Cost Estimations of Smoking for Low- and Middle-Income Countries

| Country and area | Study author(s) and publication year | Year of estimate | Estimation method | | Indirect costs included in cost of premature mortality | Estimate includes SHS exposure | Direct costs | | | Smoking-attributable direct cost as % of total direct health care costs | Estimated costs as % of GDP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direct costs | Indirect costs | | | Diseases included | Services included | Sector included | | |
| **Region of the Americas** | | | | | | | | | | | |
| Mexico | Reynales-Shigematsu et al. 2006[76] | 2004 | AF-R | — | — | No | E, Is, L, S | H, O | S | 1.4 | 0.1 |
| **Eastern Mediterranean Region** | | | | | | | | | | | |
| Lebanon | Chaaban et al. 2010[79] | 2008 | AF-R | AF-R | Yes | No | C, Lr, M, R | H, M, O | A | 6.6 | 1.1 |
| **European Region** | | | | | | | | | | | |
| Czech Republic | Sovinová et al. 2007[81] | 2002 | AF | — | — | No | C, E, H, Is, Lr, M, P, R, S | H | S | 2.7 | 0.2 |
| Estonia | Taal et al. 2004[86] | 1998 | I | I | No | No | C, Lr, M, R, X | A | S | 6.5* | 1.4 |
| Hungary | Barta 2000[87] | 1998 | I | I | Yes | No | C, E, Lr, M | H, M, O | A | 3.5 | 2.5 |
| Uzbekistan | Usmanova et al. 2007[89] | 2005 | AF | AF | Yes | No | C, E, G, H, Is, Lr, M, R, S | H, M, O | A | 2.7 | 0.6 |
| **South-East Asia Region** | | | | | | | | | | | |
| Bangladesh | World Health Organization 2007[91] | 2004 | AF-R | AF-R | Yes | Yes | E, Is, Lr, O, R, S | H, O | A | 19.8† | 1.5 |
| India | Ministry of Health and Family Welfare 2014[92] | 2011 | AF | AF | Yes | No | C, Lr, M, R | H | A | 4.9 | 1.2 |
| Myanmar | Kyaing 2003[97] | 1999 | AF | — | — | No | H, Is, Lr, M, R, S | H, M, O‡ | § | — | 0.2 |
| Thailand | Leartsakulpanitch et al. 2007[98] | 2006 | AF | — | — | No | E, C, L | \|\| | A | 3.6 | 0.1 |

## Table 3.1 continued

| Country and area | Study author(s) and publication year | Year of estimate | Estimation method | | Indirect costs included in cost of premature mortality | Estimate includes SHS exposure | Direct costs | | | Smoking-attributable direct cost as % of total direct health care costs | Estimated costs as % of GDP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direct costs | Indirect costs | | | Diseases included | Services included | Sector included | | |
| **Western Pacific Region** | | | | | | | | | | | |
| China | Yang et al. 2011[101] | 2008 | AF | AF | Yes | No | C, E, H, Is, Lr, M, R, S | H, O | A | 3.0 | 0.6 |
| China, Hong Kong SAR | McGhee et al. 2006[105] | 1998 | AF-R | AF-R | Yes | Yes | C, G, Is, Lr, M, R, S | A | A | 6.4 | 0.4 |
| Lao People's Democratic Republic | Chu et al. 2009[107] | 2006-2007 | AF-R | AF-R | Yes | No | E, L, S | H, M, O | A | 0.2 | 0.1 |
| Malaysia | Al-Junid 2007[108] | 2004 | AF | — | — | No | Is, E, L | A | A | 16.8 | 0.6 |
| Philippines | World Health Organization 2008[109] | 2003 | AF | AF | Yes | No | C, E, L, S | A | A | — | 7.2 |
| Viet Nam | Ross et al. 2007[111] | 2005 | AF-R | — | — | No | E, Is, L | H¶, M | A | 2.4 | 0.1 |

*Percentage of government Sick Fund costs.
†Proportion of direct health care costs in formal sector only, assuming 25% of patients seek care.
‡Variable costs of treatment, prescription drugs, and equipment only.
§Out-of-pocket costs at government institutions only.
||Out-of-pocket expenditures for all utilization.
¶Includes hospital-associated outpatient treatment.
*Direct and indirect costs:* AF = epidemiological approach using attributable fractions; AF-R = epidemiological approach using attributable fractions with relative risks estimated on relevant population; I = indirect method (Peto).
*Diseases included:* A = all diseases for which relative risk estimates exist; C = cardiovascular disease; E = chronic obstructive pulmonary disease; G = gastrointestinal disease; H = hypertension; Is = ischemic heart disease; L = lung cancer; Lr = lung cancer and upper aerodigestive cancer; M = other malignant neoplasms; O = other diseases; P = maternal and/or perinatal complications; R = nonmalignant respiratory disease; S = cerebrovascular disease; X = fires and/or accidents.
*Services included:* A = all; H = hospital; L = long-term care; M = drugs; O = outpatient care; P = physicians' fees for outpatient care; R = rehabilitation.
*Sector included:* A = all; P = private; S = public.
*Note:* SHS = secondhand smoke. SAR = special administrative region.

## Table 3.2 Summary of Cost Estimations of Smoking for High-Income Countries

| Country and area | Study author(s), publication year | Year of estimate | Estimation method | | Indirect costs included in the cost of premature mortality | Estimate includes SHS exposure | Direct costs | | | Smoking-attributable direct cost as % of total direct health care costs | Smoking-attributable direct and indirect costs as % of GDP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direct costs | Indirect costs | | | Diseases included | Services included | Sector included | | |
| **Region of the Americas** | | | | | | | | | | | |
| Canada | Rehm et al. 2007[112] | 2002 | AF | AF | Yes | Yes | A | H, M, O, P | A | 3.9 | 1.5 |
| United States | CDC 2008[116] | 2000-2004 | AF-R | AF-R | Yes* | Yes | A | A | A | 5.8† | 1.8† |
| **European Region** | | | | | | | | | | | |
| Denmark | Rasmussen et al. 2004,[125] 2005[126] | 1999 | AF-R | AF-R | Yes | No | A | H, M, O, R | A | 8.9 | 2.0 |
| Germany | Neubauer et al. 2006[128] | 2003 | AF | AF | Yes | No | C, E, Lr, M, P, R, S | H, M, O, R | A | 3.2 | 1.0 |
| Israel | Ginsberg et al. 2010[131] | 2008 | AF | — | — | No | C, E, G, H, Is, Lr, M, R, S | H‡, O, L, M, R | A | 1.5–3.1‡ | 0.1–0.2‡ |
| Netherlands | van Genugten et al. 2003[132] | 1999 | AF | — | — | No | C, E, L, S | A | A | 8.6 | 0.7 |
| Sweden | Bolin et al. 2011[133] | 2007 | AF | AF | Yes | No | C, E, Is, Lr, M, P, R, S | H, M, O | A | 1.2 | 0.3 |
| Switzerland | Weiser 2009[135] | 2007 | AF | AF | Yes | No | unknown | H, M, O | A | 3.1 | 1.8 |
| United Kingdom | Callum et al. 2011[111] | 2006 | AF | — | — | No | A | H, M, O, P | S | 2.4 | 0.2 |

## Table 3.2 continued

| Country and area | Study author(s), publication year | Year of estimate | Estimation method | | Indirect costs included in the cost of premature mortality | Estimate includes SHS exposure | Direct costs | | | Smoking-attributable direct cost as % of total direct health care costs | Smoking-attributable direct and indirect costs as % of GDP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direct costs | Indirect costs | | | Diseases included | Services included | Sector included | | |
| **Western Pacific Region** | | | | | | | | | | | |
| Australia | Collins and Lapsley 2008[142] | 2004-2005 | AF-R | AF-R | No | Yes | A | A | A | 2.2 | 0.9 |
| New Zealand | Easton 1997[145] | 1990 | AF | AF | No | No | A | H, M, O | A | — | 1.0 |
| Republic of Korea | Oh et al. 2012[147] | 2008 | AF | AF | Yes | No | L, M§ | H,O | A | 1.4 | 0.3 |
| Singapore | Quah et al. 2002[151] | 1997 | AF | AF | Yes | No | C, Is, Lr, M, S | H | S | 1.8 | 0.4–0.5 |

*Household production included in estimate.
†Average percentage of health care expenditures and GDP across all four years.
‡Lower estimate includes only hosptial care; higher estimate includes rough estimates of the cost of outpatient, home and nursing care, medications, and rehabilitation.
§Nonmedical care costs (transportation and caregivers' expenses) were also included as part of the direct health care cost.
*Direct and indirect costs:* AF = attributable fraction; AF-R = attributable fraction with relative risks estimated on relevant population.
*Diseases included:* A = all diseases for which relative risk estimates exist; C = cardiovascular disease; E = chronic obstructive pulmonary disease; G = gastrointestinal disease; H = hypertension; Is = ischemic heart disease; L = lung cancer; Lr = lung cancer and upper aerodigestive cancer; M = other malignant neoplasms; P = maternal and/or perinatal complications; R = nonmalignant respiratory disease; S = cerebrovascular disease.
*Services included:* A = all; H = hospital; L = long-term care; M = prescription drugs; O = outpatient care; P = physicians' fees for outpatient care; R = rehabilitation.
*Sector included:* A = all; P = private; S = public.
*Note*: SHS = secondhand smoke.

## Estimates for Individual Low- and Middle-Income Countries

### *African Region*

Recent estimates of the costs of smoking are not available for countries in the African Region. Many countries in this region have high mortality from infectious disease and low mortality from chronic disease caused by tobacco use.[66] This region is still in the early stages of the tobacco epidemic,[67] and studies of the cost of smoking may have been viewed as a lower priority for these countries. However, the prevalence of smoking in some countries in the region now approaches that of some higher income countries, so the cost of smoking is probably increasing.[68,69]

Estimates of the cost of smoking in South Africa in the late 1970s to 1980s found that the direct health care cost of smoking was between US$ 20.2 million and US$ 127.4 million (17.6–289.6 million South African rand).[11,70–72] In 1988, the total estimated direct and indirect cost of smoking was as high as US$ 1.1 billion (2.5 billion rand), or 0.9% of GDP. A study by Groenewald and colleagues[73] updated previous estimates of the health burden of tobacco use in South Africa. Using the SAFs developed from country data, this study found a higher prevalence of smoking and higher attributable fractions of smoking-related disease and smoking-related disease burden than earlier studies.

### *Region of the Americas*

Relatively few studies provide estimates of the economic costs of tobacco use in Latin American and Caribbean countries.

***Barbados.*** A study by Lwegaba[74] did not estimate the cost of tobacco use in Barbados but did estimate the relative direct health care cost for current smokers, finding that direct health care costs were higher among current smokers than nonsmokers.

***Brazil.*** Iglesias and colleagues[75] reported cross-sectional estimates of the cost of smoking for Brazil. Using the epidemiological approach and data from 1996 to 2005, the study estimated the direct health care cost—defined as hospital costs for malignant neoplasm, ischemic heart disease, pneumonia, and influenza, but omitting some costs of care due to chemotherapy and radiation therapy associated with hospital admissions. Iglesias and colleagues reported total costs for a 10-year period of analysis (1996–2005). The annual inpatient hospital cost of smoking was US$ 451.9 million (1.1 billion Brazilian reals) in 2005 figures, which accounted for approximately 0.6% of national health care costs. The distribution of costs by disease category was 49% for ischemic heart disease, 38% for influenza and pneumonia, and 12% for cancer. The distribution of costs by gender was 69% for men and 31% for women. The prevalence of hospitalization due to ischemic heart disease and cancers of the lung, larynx, and esophagus increased between 1999 and 2005, indicating that tobacco-attributable costs may rise for these disease types.

***Mexico.*** A study by Reynales-Shigematsu and colleagues[76] used the epidemiological approach to estimate the direct health care cost of smoking in 2004 and estimated the cumulative effects of smoking among current, former, and never smokers age 35 years and older. Estimated direct cost of smoking was US$ 629.1 million (7.1 billion Mexican pesos), or 4.3% of operating expenditures for the Mexican Social Security Institute (IMSS) in 2004. This estimate was significantly lower than a previous estimate of 7.3% of total IMSS health care costs for the state of Morelos only, but that estimate did not use a nationally representative population or a more aggregate approach to estimating the SAFs.[77] The cost of

smoking to the IMSS alone accounted for 0.08% of GDP. The distribution of costs of smoking by disease was 61% for heart attack, 24% for stroke, 14% for chronic obstructive pulmonary disease (COPD), and 1% for lung cancer.

### *Eastern Mediterranean Region*

There are very few published studies estimating the cost of smoking for individual countries in the Middle East and North Africa.

***Egypt.*** A study described in a report by Nassar[78] estimated cross-sectional, tobacco-attributable direct health care costs and the present value of lost years of life due to tobacco use in Egypt in 1989. The combined estimated cost of direct health care and indirect mortality was US$ 218.1 million (189 million Egyptian pounds), or 0.6% of GDP.

***Lebanon.*** Chaaban and colleagues[79] estimated the direct and indirect costs for cancers and cardiovascular and respiratory diseases caused by tobacco among adults age 30 years and older in 2008. They used the epidemiological approach and calculated SAFs for former and current smokers using data from Lebanon. Health care costs were estimated to be US$ 146.7 million (6.6% of national health care costs). Indirect costs totaled US$ 180.4 million, including US$ 13.6 million in environmental costs (fires and collecting smoking-related waste), and US$ 102.2 million and US$ 64.6 million in lost productivity due to morbidity and mortality, respectively. The total cost estimate was US$ 327.1 million, or 1.1% of GDP.

### *European Region*

Only a few estimates are available for the cost of smoking in LMICs in the European Region, although many countries in this region have high smoking prevalence and heavy burdens of disease due to tobacco use.[80]

***Czech Republic.*** Sovinová and colleagues[81] published a study on direct health care costs attributable to smoking in the Czech Republic for 2002. This study used the epidemiological approach to assess the cost of hospital care for current and former smokers above age 35. The cost of direct health care was estimated to be US$ 144.4 million (4.7 billion Czech koruna [CZK]), which accounts for 2.7% of national health care expenditures and 0.2% of GDP.

An older study commissioned by Phillip Morris Czech Republic estimated the cost of smoking to the Czech government for 1999.[82] This study used the epidemiological approach to estimate that the direct health care costs for treating smoking-attributable diseases and fires were US$ 329.8 million (CZK 11.4 billion), or 8.4% of total health care costs. The indirect costs of morbidity were estimated at US$ 49.2 million (CZK 1.7 billion). Additional smoking-attributable costs to the government due to fires, lost income taxes, and exposure to SHS were US$ 75.2 million (CZK 2.6 billion). These researchers also estimated that the total benefit of tobacco to the government, including tobacco tax revenues and savings in elderly care, pensions, and health care costs due to premature mortality, was US$ 621.9 million (CZK 21.5 billion), concluding that smoking saved the Czech government US$ 167.8 million (CZK 5.8 billion).[82] This study attracted a great deal of attention because of its conclusion that the Czech government benefited from the premature deaths caused by smoking.

Ross's[83] critical review of the Philip Morris Czech Republic study highlighted numerous methodological problems, including inconsistent treatment of state tax and income losses due to smoking-related morbidity, a mix of cash flow and net present value analyses in annual cost accounting, neglect of the effect of premature mortality on the future productivity of the Czech economy, and inconsistent analyses of current health care costs of living among smokers and future health care costs that would have been incurred by longer-lived nonsmokers. Also, most of the tobacco excise tax revenue would have been replaced by tax revenue on the production and sales of other products had there been no tobacco sales. After correcting for these issues, Ross[83] estimated smoking costs the Czech government at least US$ 373 million annually, almost 0.8% of Czech GDP. A simpler critique of the Philip Morris Czech Republic study similarly assumed that lost tobacco tax revenues would have been replaced by other commerce and that the cost of tobacco outweighed the benefits by a factor of 13.[84] Philip Morris Czech Republic eventually apologized for the study, stating that "we understand the outrage that has been expressed and we sincerely regret this extraordinarily unfortunate incident. All of us at Philip Morris Czech Republic are extremely sorry. No one benefits from the very real, serious, and significant diseases caused by smoking."[85]

***Estonia.*** Taal and colleagues[86] estimated the direct health care and indirect morbidity and mortality costs of smoking among Estonian adults age 35 years and older in 1998. This study used the Peto approach[56] to estimate the direct health care cost to the national health insurance program, which covers 95% of the population. Direct costs included smoking-attributable fires, lung and other cancers, COPD and other respiratory diseases, and cardiovascular disease. The estimated direct health care cost of tobacco use in 1998 was US$ 13.7 million (193 million Estonian kroon [EEK]), or 6.5% of national health insurance costs, according to the authors. The indirect costs of morbidity and mortality were US$ 48.8 million (EEK 687 million) and US$ 16.1 million (EEK 226 million), respectively. Total estimated costs were 1.4% of GDP.

***Hungary.*** Barta and GKI Economic Research Ltd.[87] estimated the cost of smoking in Hungary for 1995, 1996, and 1998 among individuals age 35 years and older. These researchers used the Peto method[56] to estimate the direct cost of health care and the indirect cost of morbidity, and used the production value approach to estimate the value of years of life lost. Estimated direct health care costs rose from US$ 95.5 million (12 billion Hungarian forints [HUF]) in 1995 to US$ 121.3 million (HUF 26 billion) in 1998, or from 2.9% to 3.5% of total national health expenditures. The estimated indirect cost of morbidity went from US$ 111.4 million (HUF 14 billion) in 1995 to US$ 88.6–93.3 million (HUF 20 billion) in 1998. (Note that while costs measured in Hungarian forints rose during this period, the U.S. dollar equivalent declined due to substantial currency exchange fluctuations.) Estimated indirect mortality costs went from US$ 1.2 billion (HUF 150 billion) in 1995 to US$ 1.0 billion (HUF 217 billion) in 1998. The estimated costs of smoking in Hungary amounted to 3.1% and 2.6% of GDP in 1995 and 1998, respectively.

***Russian Federation.*** An informal analysis of mortality-related productivity losses in the Russian Federation in 2006 used a population-based simulation model to estimate that the indirect mortality costs were US$ 24.7 billion, or 3.2% of GDP.[88]

***Uzbekistan.*** Using the epidemiological approach, Usmanova and colleagues[89] estimated direct health care costs and indirect costs of smoking by males in Uzbekistan age 35 years and older in 2005. The

health care cost estimates included government expenditures for inpatient and outpatient hospital care and out-of-pocket spending to treat smoking-related diseases for which relative risk estimates were available. The estimated direct health care costs of smoking were US$ 17.3 million (20.4 billion Uzbekistani soums [UZS]), or 2.7% of health care expenditures. The indirect cost of smoking to society was US$ 75.2 million (UZS 88.5 billion); 3% of this loss was due to premature mortality, 74% due to disability, and 23% due to sickness. Total estimated costs of smoking were 0.6% of GDP.

### *South-East Asia Region*

National estimates of the costs of tobacco use are available for several countries in this region, including two of the most populous, Bangladesh and India.

***Bangladesh.*** Two major studies have examined the costs of tobacco use in Bangladesh. A 2001 study by Efroymson and colleagues[90] found that tobacco use accounted for a significant proportion of household expenditures, resulting in lower expenditures for food and education in low-income households.

WHO[91] estimated the direct health care cost of smoking and indirect costs of productivity loss due to tobacco-related morbidity (i.e., income lost to temporary work absence and premature disability) and mortality for 2004. This study used the epidemiological approach to examine current and past tobacco use by those age 30 years and older. The study reported that in households that used tobacco, approximately 5.5% of expenditures were for tobacco-attributable illness, which accounted for 41% of these households' direct expenditures on health care. Among those older than 30 years of age, approximately 50% of men and 3% of women were current smokers, and 22% of men and 39% of women were current users of smokeless tobacco. The study did not estimate the actual direct health care cost because of the difficulty of determining actual utilization rates of inpatient care services; the summary reported costs that assumed a baseline utilization rate of 25%.

Total direct and indirect costs of tobacco in Bangladesh were estimated as US$ 855.3 million (50.9 billion Bangladeshi takas [BDT]). Of this amount, US$ 346.1 million (BDT 20.6 billion) was spent on direct health care and US$ 411.7 million (BDT 24.5 billion) on indirect morbidity and mortality from tobacco use. This cost also included US$ 97.5 million (BDT 5.8 billion) on direct and indirect costs of exposure to SHS. The total cost (US$ 855.3 million; BDT 50.9 billion) exceeded the total tax revenue and wage labor earned from tobacco production and consumption (US$ 438.6 million; BDT 26.1 billion). Total estimated cost was distributed as follows: 41% for direct health care costs, 24% for indirect mortality costs, 24% for indirect morbidity costs, and 11% for treating the effects of SHS exposure. Estimated direct health care cost of smoking was 19.8% of total direct health care costs, and the total cost of smoking was 1.5% of GDP.[91]

***India.*** Three studies have assessed the cost of smoking-attributable disease in India. A study published by the government of India[92] estimated the costs of direct health care and indirect morbidity and mortality. The epidemiological approach was used to assess the tobacco-attributable cost of cardiovascular diseases, cancers, respiratory diseases, and tuberculosis in adults ages 35–69. The researchers calculated separate estimates for males and females and by type of tobacco use (e.g., smokeless, smoked). They found that the estimated cost of tobacco-attributable diseases in 2011 totaled US$ 22.4 billion (104,500 crore rupees [Rs]), or 1.2% of GDP. The cost of medical treatment was US$ 3.6 billion (4.9% of national medical expenditures). Indirect costs totaled US$ 18.8 billion (Rs 87,700 crore) with indirect morbidity costs of US$ 3.1 billion (Rs 14,700 crore) and indirect

mortality costs of US$ 15.6 billion (Rs 73,000 crore). Men accounted for 91% of the estimated costs of tobacco use.

An earlier study by John and colleagues[93] estimated the direct health care cost and indirect cost of morbidity (but not mortality) for 2004 using the epidemiological approach with cross-sectional data for people age 35 years and older. This study estimated that the direct health care cost attributable to tobacco was US$ 1.2 billion (3.7% of national health care expenditures), and the indirect cost of morbidity for lost work was US$ 502 million, for a total of US$ 1.7 billion (0.2% of GDP). John and colleagues noted that the cost of smoking in 2004 was greater than the annual total of tobacco control programs and revenue from tobacco taxes. The cost of smoking-related tuberculosis was US$ 311 million, which exceeded the total expenditures on tuberculosis control in 2006.

In a related study, John[94] estimated household expenditures for 1999-2000 and found that tobacco use in the household displaces expenditures for such basic needs as food and education.

***Indonesia.*** Kosen[95] used a variation of the Peto method[56] that was developed as part of the Global Burden of Disease Project[1,55,96] to estimate the cross-sectional direct health costs for 11 tobacco-related diseases, indirect morbidity, and the present value of indirect mortality from smoking in Indonesia for 2005. Estimated direct health care cost was US$ 221.0 million, or 2.7% of total national health care expenditures. Estimated indirect morbidity and mortality costs were US$ 1.9 billion and US$ 4.9 billion, respectively, for a total indirect cost of US$ 6.8 billion. Direct and indirect costs were estimated to total US$ 7.0 billion, or 2.4% of GDP. Including the cost of cigarette purchases, the total cost was US$ 20.9 billion, or 7.3% of GDP.

***Myanmar.*** Kyaing[97] used the epidemiological approach to estimate direct health care costs for 1999. She estimated the cost of smoking for 1999 at between US$ 19.6 million (123 million Myanmar kyats [MMK]) and US$ 24.8 million (MMK 156 million), which was 0.2–0.3% of GDP. Outpatient costs included nonmalignant respiratory illness and hypertension treatment, totaling US$ 11.3 million (MMK 71 million). Inpatient care accounted for US$ 13.5 million (MMK 85 million), or between 55% and 70% of the total cost. The distribution of inpatient costs by disease category was tuberculosis, 53.4%; ischemic heart disease, 14%; stroke, 8%; hypertension, 6.7%; head and neck cancer, 5.7%; lung cancer, 4.9%; other nonmalignant respiratory disease, 4.5%; and COPD, 2.8%.

***Thailand.*** Leartsakulpanitch and colleagues[98] examined the out-of-pocket smoking-attributable cost (i.e., the patient's perspective) of direct health care for lung cancer, COPD, and coronary heart disease in 2006. The estimated direct out-of-pocket cost of these diseases was US$ 261.3 million (9.9 billion Thai baht), or 3.6% of national health care costs, which accounted for 0.1% of GDP. The distribution of costs by disease was 78% for COPD, 18% for coronary heart disease, and 4% for lung cancer.

Sarntisart[99] also conducted an economic analysis of tobacco use in Thailand, estimating the direct health care cost and indirect cost of smoking using a smaller base of diseases and arriving at smaller estimates compared with those of Leartsakulpanitch and colleagues. Sarntisart estimated that the direct and indirect health care cost of treating lung cancer and COPD associated with tobacco use in 1999 was US$ 6.0 million, or 0.1% of Thailand's total health care expenditure.

### *Western Pacific Region*

***The People's Republic of China.*** China presents a challenge for tobacco control in the region and worldwide. China is both the largest consumer and producer of tobacco and includes 27.3% of the world's smokers.[100] Four studies of tobacco-attributable costs were found for China. Yang and colleagues[101] assessed the cost of ever smoking among adults age 35 and older in China over three years: 2000, 2003, and 2008. The epidemiological approach was used to calculate direct and indirect costs of cancer and cardiovascular and respiratory diseases. Between 2000 and 2008, estimated direct health care costs ranged from US$ 2.4 billion to US$ 6.2 billion (3.0–5.3% of national health care costs), and estimated indirect costs ranged from US$ 4.8 billion to US$ 22.7 billion. The total cost was approximately US$ 7.2–22.7 billion (0.6–1.0% of GDP).

Also using the epidemiological approach, Sung and colleagues[102] estimated the direct and indirect cross-sectional costs of cigarette smoking in 2000 among Chinese adults age 35 years and older. They estimated that the direct health care cost in China in 2000 was US$ 1.7 billion, which accounted for 3.1% of total health care costs. The indirect cost of morbidity was US$ 0.4 billion, and the present value of future potential years of life lost was US$ 2.9 billion. The total estimated cost was US$ 5 billion, which was approximately 0.4% of GDP.

In addition, two household expenditure studies found that tobacco use in the household reduces expenditures on such other basic needs as education and medical care.[103,104] Xin and colleagues[104] found that current smokers and former smokers have higher medical care expenditures than never smokers and that exposure to SHS in the household is associated with increased medical expenditures.

***China, Hong Kong Special Administrative Region (SAR).*** McGhee and colleagues[105] estimated the direct and indirect costs of smoking for 1998 among all age groups in China, Hong Kong SAR. Using the epidemiological approach to examine the effects of smoking and exposure to SHS, these researchers estimated that the direct health care cost in 1998 was US$ 459 million, of which 28% was due to exposure to SHS. The productivity cost of morbidity and mortality was estimated to be US$ 230 million.[105]

Total health care expenditures in China, Hong Kong SAR were approximately US$ 7.2 billion (59,661 million Hong Kong dollars).[106] The direct health care cost of smoking was 6.4% of total health care expenditures. The estimated direct health care and indirect productivity costs of smoking totaled US$ 688 million,[105] or 0.4% of GDP in China, Hong Kong SAR.

***Lao People's Democratic Republic.*** Chu and colleagues[107] calculated direct health care costs and the indirect cost of morbidity and mortality in Lao People's Democratic Republic in 2006-2007. Using the epidemiological approach, they calculated attributable fractions using relative risk data from past and current Lao smokers. The estimated health care cost of lung cancer, COPD, and stroke totaled more than US$ 309,000 (3.1 billion Lao kip [LAK]), or 0.2% of total health care costs. Total costs including the cost of morbidity and mortality were estimated to be US$ 2.9 million (LAK 28.5 billion), or 0.1% of GDP.

***Malaysia.*** Al-Junid and the Southeast Asia Tobacco Control Alliance[108] used the epidemiological approach to assess direct health care costs for former and current smokers over the age of 18 years in Malaysia in 2004. Estimated cost of health care totaled US$ 769.7 million (2.9 billion Malaysian ringgit). This accounts for approximately 16.8% of national health care costs and 0.6% of GDP.

***Philippines.*** WHO[109] estimated the direct health care and indirect morbidity and mortality smoking-attributable costs in the Philippines from lung cancer, coronary artery disease, stroke, and COPD in 2003. Two epidemiological approaches were used to provide plausible ranges of estimates: the Peto method[56] of estimating cumulative exposure to tobacco use and the software program Smoking-Attributable Mortality, Morbidity, and Economic Costs (SAMMEC) developed by the Centers for Disease Control and Prevention (CDC), an agency of the U.S. Department of Health and Human Services.[110]

WHO estimated that between US$ 501 million and US$ 858 million was spent in 2003 to treat the four major diseases caused by smoking. Using SAMMEC, they estimated that the annual indirect productivity cost of mortality was as much as US$ 5 billion (US$ 2.2 billion using Peto estimates), with as much as another US$ 185 million in lost productivity from smoking-attributable morbidity (US$ 121 million using Peto estimates). The total cost of smoking in 2003 was estimated as US$ 6.0 billion, or 7.2% of GDP according to SAMMEC (using Peto estimates, US$ 2.9 billion, or 3.4% of GDP).[109]

***Viet Nam.*** A study by Ross and colleagues[111] estimated the direct health care cost of ever smoking for inpatient treatment in Viet Nam in 2005. Using the epidemiological approach, the researchers examined the costs to all payers (individual, government, and private insurance companies) for lung cancer, ischemic heart disease, and COPD. They estimated that the inpatient cost of smoking was US$ 73.2 million (1.16 billion Viet Nam dongs) in 2005, which was 2.4% of national health care expenditures and 0.1% of GDP. Of the smoking-attributable inpatient care costs, 51% were paid by government services, 34% by patients, and 15% by private insurance companies. The distribution of costs by smoking-attributable disease was 89% for COPD, 7% for lung cancer, and 4% for ischemic heart disease.[111]

### Estimates for Individual High-Income Countries

Many cost of smoking studies have been conducted in HICs using the various approaches described above. This section reviews the research conducted since 2000; for a comprehensive discussion of older studies from HICs, see the review by Lightwood and colleagues.[11]

#### *Region of the Americas*

***Canada.*** Rehm and colleagues[112] used the epidemiological approach to estimate Canada's costs of direct health care and indirect mortality and morbidity in 2002 for all diseases with estimated relative risks due to tobacco use. Estimated direct health care cost from smoking was US$ 2.8 billion (4.4 billion Canadian dollars [C$]), or 3.9% of national health care expenditures. The total estimated indirect productivity cost was US$ 7.9 billion (C$ 12.5 billion): US$ 6.7 billion (C$ 10.5 billion) for indirect morbidity, and US$ 1.2 billion (C$ 1.9 billion) for premature mortality. The cost of tobacco-attributable fires was US$ 55.1 million (C$ 86.5 million). The total estimated cost of tobacco use was US$ 10.8 billion (C$ 17.0 billion), or 1.5% of GDP.

***United States.*** Many studies have estimated the cost of smoking in the United States.[42,47–49,113] Several earlier studies are reported or discussed in previous reviews.[11,15,16,19] Estimates from the 2014 Surgeon General's report[41] and the CDC[114–116] are discussed here.

The 2014 Surgeon General's report, *The Health Consequences of Smoking—50 Years of Progress*,[41] included three separate analyses to assess the direct health care costs of smoking and one analysis of productivity loss due to premature mortality (but excluding productivity losses due to morbidity). The first analysis was based on an approach used by Miller and colleagues,[49] which provides estimates by type of medical service, using SAMMEC's expenditure SAFs. Estimated health care cost for adults age 19 and older in 2009 was US$ 132.5 billion, which was 5.4% of national health care expenditures and 1.0% of GDP.

The second analysis was based on an approach by Solberg and colleagues,[117] who calculated the health care cost for adults age 35 years and older by age, gender, and smoking status. Estimated health care cost of current and former smoking for 2012 was US$ 175.9 billion, or 6.3% of national health care expenditures and 1.1% of GDP.

The third analysis discussed in the 2014 Surgeon General's report[41] was completed by Xu and colleagues.[118] A regression analysis was used to estimate 2010 health care costs of past and current smokers age 19 years and older by source of funding. Using this method, estimated health care costs were similar to the two other analyses discussed in the 2014 Surgeon General's report: Health care cost was US$ 170.6 billion, or 6.7% of national health care expenditures and 1.2% of GDP.

The 2014 Surgeon General's report calculated productivity losses due to smoking-related mortality for the years 2005–2009. SAMMEC was used to derive cost estimates for 19 smoking-related diseases among adults over the age of 35. The average annual cost of lost productivity attributable to mortality was US$ 150.7 billion, or about 1.1% of GDP.

Studies by the CDC use SAMMEC[110,119] for all smoking-related diseases with sufficient data to estimate relative risks, as reported in several studies.[120–122] The average annual direct health care costs for smoking-attributable disease was US$ 96 billion for the years 2001–2004[116] and US$ 75.5 billion for 1995–1999.[114] The estimated direct health care cost attributable to tobacco use ranged from 5.2% to 7.6% of total national direct health care costs between 1995 and 2004.[114,116] Lost productivity costs for the years 1995–2004 ranged from US$ 81.9 billion to US$ 97.0 billion.[114–116] The direct and indirect cost of smoking between 2001 and 2004 totaled US$ 193 billion per year, which was approximately 1.6% to 1.9% of GDP.[116]

Using the epidemiological approach, Max and colleagues[123] estimated the cost to the U.S. economy of lost productivity due to premature mortality from SHS alone at US$ 6.6 billion.

### *European Region*

***Denmark.*** A series of studies[124–126] assessed the costs of past and current smoking in Denmark, using the epidemiological approach to estimate direct health care costs and indirect costs of morbidity and mortality among adults ages 35–89 years. All smoked tobacco products were included in the analysis. Estimated health care costs in Denmark in 1999 were US$ 1.4 billion (9.7 billion Danish kroner [DKK]), or 8.9% of total direct health care costs. These studies estimated the indirect costs of morbidity and mortality at US$ 2.0 billion (DKK 13.9 billion). Total estimated costs were US$ 3.4 billion

(DKK 23.7 billion), or 2.0% of GDP.[125] Among moderate smokers who quit smoking at age 35, lifetime health care cost savings were estimated at US$ 8,100 (7,600 euros [€]) for men and US$ 13,000 (€12,200) for women. Total direct and indirect cost savings were estimated at US$ 26,400 (€24,800) for men and US$ 36,200 (€34,000) for women.[126] These researchers concluded that lifetime health care costs were higher for ever smokers than for never smokers, with the ratio of costs for ever smokers to never smokers ranging from 1.63 to 1.82.[125]

***Finland.*** Kiiskinen and colleagues[127] estimated the direct health care and indirect productivity costs attributable to smoking in Finland, using data from a cohort of 25- to 59-year-old men followed from 1972 to 1991. Direct health care costs included hospital stays and major drug use, and indirect costs were defined as permanent or temporary work absences of one or more weeks. Compared with never smokers, the discounted costs of hospitalization (at rates of 0% and 5% to the baseline year of 1972) for current smokers over the 19-year study period were approximately 56% greater, and total costs were about 85% greater. The difference in estimated discounted health care costs per person between current smokers and never smokers was US$ 1,900 (€1,800) due to hospitalization, US$ 18,600 (€17,500) due to premature morbidity, and US$ 19,800 (€18,600) due to premature mortality—for a total difference of US$ 40,300 (€37,800) per person.

***Germany.*** Neubauer and colleagues[128] used the epidemiological approach to estimate the direct and indirect costs attributable to current and former smoking in Germany in 2003. They focused on more than 30 smoking-related diseases and included hospital, outpatient, and ambulatory care; rehabilitation; and prescription drugs. Indirect productivity costs included morbidity due to illness, permanent disability, and premature mortality. Estimated health care costs were US$ 8.5 billion (€7.5 billion), or 3.2% of total health care costs. Estimated indirect costs were US$ 9.9 billion (€8.8 billion) for morbidity and US$ 5.3 billion (€4.7 billion) for mortality. Total estimated costs were 1.0% of GDP.

Similar estimates of the total cost of smoking in Germany were produced by Ruff and colleagues[129] in their study using the attributable risk method. Prenzler and colleagues[130] also used the attributable risk method and estimated that the indirect costs of smoking in Germany in 2005 were US$ 11.9 billion (€9.6 billion), or 0.4% of the GDP.

***Israel.*** Ginsberg and colleagues[131] used the epidemiological approach to estimate the direct health care cost of past and current smoking in Israel in 2008. Their main analysis only included the cost of hospitalization of various smoking-related diseases (cancers; cardiovascular, cerebrovascular, respiratory, digestive diseases; burns; etc.), but additional rough estimates were also provided for more extensive services including outpatient service, home and nursing care, medication, and rehabilitation. The estimated cost of inpatient hospital care was US$ 236.1 million ($847 million new shekels [ILS]), which accounts for 1.5% of national heath expense and 0.1% of GDP. Including the rough estimates for additional medical expenses, Ginsberg and colleagues estimated that smoking could cost US$ 486.9 million (ILS 1.7 billion), or 3.1% of national health care costs and 0.2% of GDP.

***Netherlands.*** Van Genugten and colleagues[132] constructed a dynamic population simulation model to estimate and forecast the relative savings of alternative long-term tobacco control programs and estimate the direct health care cost attributable to smoking for 1999, with a focus on lung cancer, COPD,

coronary heart disease, and stroke. Estimated smoking-attributable health care cost was US$ 2.9 billion (€2.7 billion), or 8.6% of total direct health care expenditures (0.7% of GDP).

***Sweden.*** Bolin and colleagues[133] estimated the cost of former and current smoking among adults age 35 and older in Sweden for 2007. They used the epidemiological approach to estimate health care costs and the indirect cost of smoking-related morbidity and mortality. Estimated health care cost was US$ 479.5 million (1.2% of national health care expenditures), and the total estimated cost was US$ 1.6 billion (0.3% of GDP).

In an earlier study, Bolin and Lindgren[134] used the epidemiological approach to estimate the cost of cigarette smoking among 35- to 84-year-old smokers in Sweden for 2001. Estimated direct health care cost of smoking was US$ 212 million, or 1.0% of national health care expenditures. The total indirect cost of smoking was US$ 592 million—US$ 169 million for indirect morbidity and US$ 423 million for indirect mortality. Total cost of smoking was US$ 804 million, or 0.4% of GDP.

***Switzerland.*** Weiser[135] estimated the cost of health care and indirect morbidity and mortality due to smoking in Switzerland for 2007. Hospital, outpatient care, and prescription drug costs were estimated at US$ 1.4 billion (1.7 billion Swiss francs [CHF]), or 3.1% of national health care expenditures. Estimated indirect costs totaled US$ 6.8 billion (CHF 8.3 billion)—US$ 2.2 billion (CHF 2.7 billion) due to morbidity, US$ 1.0 billion (CHF 1.3 billion) due to mortality, and US$ 3.6 billion (CHF 4.3 billion) for other intangibles (such as quality of life and health due to illness or disability). Direct and indirect costs totaled US$ 8.3 billion (CHF 9.9 billion), or 1.8% of GDP.

Priez and colleagues[136] and Vitale and others[137] used the epidemiological approach to estimate the direct health care and indirect productivity costs of smoking in Switzerland for 1995. In a supplemental analysis, the willingness-to-pay approach was used to estimate the production value of household services and intangible losses due to mortality. Estimated direct health care cost of smoking was US$ 1.0 billion (CHF 1.2 billion), or 3.4% of national health care costs.[137] Estimated indirect productivity cost of smoking was US$ 2.4 billion (CHF 2.8 billion), which consisted of US$ 847.5 million (CHF 1.0 billion) for mortality and US$ 1.5 billion (CHF 1.8 billion) for morbidity in the form of both temporary and permanent incapacitation. The total cost of smoking was US$ 3.4 billion (CHF 4.0 billion), or 1.0% of GDP. The total value of lost household production (not included in the definition of GDP) was US$ 1.4 billion (CHF 1.6 billion)—US$ 701.9 million (CHF 830 million) for mortality and US$ 659.6 million (CHF 780 million) for morbidity. The WTP to avoid the health consequences of smoking was US$ 4.3 billion (CHF 5.0 billion).

Hauri and colleagues[138] studied the direct and indirect costs of SHS, which other Swiss studies did not include in their estimates. They used the epidemiological approach to assess the cost of treating the following tobacco-attributable diseases among people age 15 years and older in 2006: ischemic heart disease, stroke, lung and nasal cancer, COPD, asthma, respiratory diseases, and pre-term delivery. Estimated health care costs totaled US$ 51.0 million (CHF 63.9 million), or 0.1% of national health care expenditures. Including indirect costs of morbidity and mortality, total cost of smoking was estimated to be US$ 262.9 billion (CHF 329.7 billion), or less than 0.1% of GDP.

***The United Kingdom of Great Britain and Northern Ireland.*** Three studies have assessed the direct health care cost of smoking in the United Kingdom; none of these studies assessed the indirect cost.

Scarborough and colleagues[139] used the epidemiological approach to assess health care costs of COPD, cancers, and cardiovascular, gastrointestinal, and respiratory disease for 2006-2007. Estimated health care cost was US$ 6.3 billion (3 billion British pounds [£]), which was 2.8% of national health care expenditures and 0.2% of GDP.

Allender and colleagues[140] also used the epidemiological approach to study health care costs for fiscal year 2005-2006. This study was similar to the Scarborough study and assessed the same diseases. Estimated cost of health care was US$ 9.5 billion (£5.2 billion), or 4.8% of national health care expenditures and 0.4% of GDP.

Callum and colleagues[141] used the epidemiological approach to estimate the health care cost of past and current smoking among people age 15 years and older in 2006. This study assessed the cost of hospitalization, outpatient visits, consultations, and prescriptions associated with tobacco-related diseases. Estimated health care costs totaled US$ 5.0 billion (£2.7 billion), or 2.4% of national health care costs and 0.2% of GDP.

### *Western Pacific Region*

***Australia.*** Using the epidemiological approach, Collins and Lapsley[142] conducted a study of direct health care costs and indirect mortality and morbidity costs attributable to current and former smoking in Australia for 2004 and 2005.

The total gross (as opposed to net) direct health care cost of smoking was US$ 1.4 billion (1.8 billion Australian dollars [A$]), 2.2% of total direct health care expenditures. The total gross indirect cost was US$ 4.3 billion (A$ 5.7 billion), which included US$ 584 million (A$ 780 million) for morbidity and US$ 3.7 billion (A$ 5.0 billion) for mortality. The cost of smoking-attributable fires was US$ 47.2 million (A$ 63 million). The total cost of tobacco use was US$ 5.7 billion (A$ 7.6 billion) or 0.9% of GDP.[142]

The estimated net direct health care cost, which accounted for the fact that smokers die younger, was US$ 238.3 million (A$ 318 million). Indirect cost estimates of household production (which are not included in the official GDP statistics) were US$ 514.8 million (A$ 687 million) due to morbidity and US$ 6.9 billion (A$ 9.2 billion) due to mortality. Estimated indirect workforce and household indirect productivity costs totaled US$ 11.7 billion (A$ 15.6 billion).[142]

***Japan.*** The epidemiological approach has not been used to estimate the total direct health care or indirect productivity costs for Japan. A literature review by Shimada and colleagues[143] found that most studies have focused on estimating changes in health care costs due to changes in tobacco control policy or direct regression estimates based on longitudinal data. Although not exhaustive, this review provides evidence that tobacco use increases direct health care costs among the elderly in Japan. A study by Kuriyama and colleagues[144] found that ever smoking increases direct health care costs in individuals when combined with other health risk behaviors, but the analysis did not include estimates of total national costs.

***New Zealand.*** Easton[145] used the epidemiological approach to estimate direct health care and indirect productivity costs for New Zealand for 1990. The study also used the WTP approach to estimate the cost of premature mortality. All smoking-related diseases for which relative risk estimates were available

were included, using attributable fraction estimates from Australia. In 1990, the total estimated cost of smoking in New Zealand was US$ 456.4 million (765 million New Zealand dollars [NZ$]). This total included US$ 122.3 million (NZ$ 205 million) in direct health care costs, US$ 238.6 million (NZ$ 400 million) in production losses to mortality, US$ 86.5 million (NZ$ 145 million) in losses from morbidity due to tobacco use, and US$ 8.9 million (NZ$ 15 million) due to tobacco-related fires. These costs were approximately 1.0% of GDP.

In addition, a study by Thomson and colleagues[146] found that tobacco expenditures displace expenditures for other goods and services in lower income households.

***Republic of Korea.*** Four studies have assessed the cost of smoking in the Republic of Korea. Oh and colleagues[147] used the epidemiological approach to assess direct and indirect costs of past and current smoking among adults age 35 years and older in 2008. They studied 10 types of smoking-related cancers. Estimated health care costs totaled more than US$ 831.6 million (1.4% of national health care expenditures) with men accounting for 70% of the cost. Estimated cost of morbidity and mortality was US$ 2.3 billion. Total direct and indirect costs in the Republic of Korea were US$ 3.1 billion, or 0.3% of GDP.

Kang and colleagues[148] used two different methods to estimate the cost of smoking for adults age 35 and older in 1998: the epidemiological approach, using data on commonly recognized smoking-related diseases, and an "all-cause" direct regression approach that used longitudinal data to compare all health expenditures by smoking status. Costs were estimated for adults age 35 and older by current and former smoking status.

Using the epidemiological approach, Kang and colleagues estimated the medical cost of smoking as US$ 130.3 million for current smokers and US$ 64.0 million for former smokers, totaling US$ 194.3 million in 1998, or 1.3% of national health care expenditures. The estimated indirect morbidity cost of ever smoking was US$ 84.7 million, about two-thirds of which was due to current smoking. Estimated indirect cost of mortality ranged from US$ 2.0 billion to US$ 2.7 billion, almost 80% of which was due to current smoking. The total cost of smoking ranged from US$ 2.3 billion to US$ 3.0 billion (0.6% to 0.8% of GDP).[148]

According to direct regression estimates using all medical care utilization, Kang and colleagues[148] found that current tobacco use reduced direct health care cost, and former smoking did not affect cost. In an earlier study which used a different dataset but a similar method, Jee and colleagues[149] found that tobacco use increased the cost of medical care; they also estimated the cost of smoking using a direct regression approach in the context of multiple modifiable health risk factors. Lee and colleagues[150] used the epidemiological approach to estimate hospital costs attributable to tobacco use, finding that tobacco use increased hospital costs.

***Singapore.*** A 2002 study by Quah and colleagues[151] used the epidemiological approach to estimate the direct health care cost and indirect morbidity and mortality costs of smoking among those age 30 years and older. For 1997, the total estimated cost of smoking ranged from US$ 453.3 million (673 million Singapore dollars [S$]) to US$ 565.1 million (S$ 839 million), or 0.4–0.5% of GDP. The estimated inpatient cost of health care ranged from US$ 49.8 million to US$ 50.1 million (S$ 74 million to S$ 75 million), or 1.8% of national health care expenditures. The indirect cost of

morbidity was approximately US$ 2.2 million (S$ 3.3 million) for both the low- and high-cost cases. The indirect cost of mortality ranged from US$ 401.4 million to US$ 512.5 million (S$ 596 million to S$ 761 million). The costs for women were about 57.6% of those for men for direct costs and 10% of those for men for indirect morbidity and mortality costs.

## Global Estimates

Goodchild and colleagues[152] conducted analyses assessing the total economic cost of smoking-attributable diseases in 152 countries, representing 97% of the world's smokers. To estimate direct health care costs attributable to smoking in 2012, Goodchild and colleagues first completed a literature review to identify any studies on the health care cost of smoking published between 1990 and 2015. A total of 33 studies covering 44 countries were identified, and the SAFs were extracted. Regression analyses were conducted to estimate SAFs for the remaining 108 countries, which together account for only 14% of global health expenditures. The value of production approach was used to measure indirect costs of lost productivity from smoking-attributable morbidity and mortality among smokers ages 15–69. Indirect costs for all WHO Member States were calculated using WHO estimates on smoking-attributable death, disability-adjusted life-years, and smoking-attributable years lost to disability. These estimates do not include costs associated with SHS or smokeless tobacco.[152]

Goodchild and colleagues estimated that the worldwide health care cost of smoking in 2012 was US$ 422 billion, accounting for 5.7% of global health expenditures. Higher proportions of direct health care costs of smoking were seen in HICs (6.5%), the Region of the Americas (6.7%), and the European Region (6.6%) than in others countries/regions. Estimated indirect costs totaled US$ 357 billion for morbidity and US$ 657 billion for mortality. Goodchild and colleagues estimated that the total economic cost of smoking was US$ 1.4 trillion, or 1.8% of the world's annual GDP. HICs and countries in the European and Americas Regions spent the highest amounts proportionally on smoking-attributable disease (2.2%, 2.5%, and 2.4% of GDP, respectively). The direct and indirect cost of smoking-attributable diseases in LMICs make up approximately 40% of the global economic cost of smoking. The cost of smoking is proportionally lowest in the African and the Eastern Mediterranean Regions, which in part reflects the lower smoking prevalence and intensity of smoking in these regions relative to regions with higher levels of tobacco use, such as Eastern Europe.[152]

## Summary

Progress has been made during the past 15 years on estimating the costs of smoking. These estimates are useful in documenting the economic burden of tobacco use, designing tobacco control programs, and identifying the health care needs of vulnerable populations, and, where such studies exist, they have at times motivated policymakers to implement strong tobacco control policies. Reliable cost estimates are lacking for many countries, especially LMICs. Where sufficient data exist for these estimates, they show that the direct cost of tobacco-related disease in LMICs is comparable to that in HICs—that is, the direct health care cost of smoking is similar in terms of the percentage of total health care expenditures. The indirect cost of mortality is also high, at least in countries for which such cost can be measured. Substantial economic resources are lost to other uses because of tobacco-related illnesses, premature disability, and death. These losses are especially harmful in LMICs, where economic resources are urgently needed for economic and social investment.

In countries with underdeveloped formal health care and social insurance systems, the estimated costs of smoking vary widely among studies, most likely because (a) the formal health care system is not fully developed or is changing rapidly and (b) data on utilization and cost of treatment are incomplete or of poor quality.

Similarly, the indirect cost of smoking may be much higher than measured in existing studies. Evidence from household expenditure surveys in several LMICs and HICs shows that tobacco use displaces household expenditures on education and medical care, which are important investments to improve economic well-being. In countries with poorly developed social insurance sectors and large burdens of poverty on households, other expenditures displaced by tobacco use may have very large long-term costs.[153]

Many estimates of the cost of direct health care attributable to smoking have some limitations. For example, cost estimates may be lacking for maternal tobacco use during pregnancy and for exposure to secondhand smoke on perinatal, infant, child, and adult health. Estimates do not always cover the full range of tobacco-related diseases, especially in LMICs, where direct cost estimates focus on only the most prominent diseases (e.g., lung cancer, COPD, and ischemic heart disease) linked to smoking. Furthermore, estimates do not always account for all of the health care costs of tobacco use[154] and often use attributable or relative risk estimates from other countries that may not be applicable to the country under study. Finally, relatively few studies distinguish between internal and external costs of tobacco use. External costs are of particular interest and can vary considerably across countries given the differences in nonsmokers' exposure to secondhand smoke and the extent of the governments' role in providing health care.

## Research Needs

Many of the studies profiled in this chapter lack data in one or more of the following areas:

- Epidemiological data on the incidence or prevalence of many tobacco-related diseases
- Adjusted country-specific estimates of relative risk and attributable fractions of mortality, health care costs, or disability due to tobacco use
- Total utilization and expenditures for treatment, including disease-specific costs
- Insurance, labor force participation, and earnings data that can provide market-based estimates of the productivity costs of death and disability.

Several studies in this review illustrate approaches that can be used to remedy these problems.

Comprehensive estimates of the cost of smoking at the country, region, and global levels should be a high priority. These estimates are important for documenting the economic burden of tobacco use, designing effective tobacco control programs, and identifying the health care needs of vulnerable populations. Even in countries where data are limited, estimates using the available data that can be done at relatively low cost, such as those described in the WHO toolkit on assessing economic costs,[21] can be useful in advancing tobacco control efforts.

## Conclusions

1. The economic costs of tobacco use are substantial and include significant health care costs for treating the diseases caused by tobacco use and the lost productivity that results from tobacco-attributable morbidity and mortality.
2. In high-income countries, lifetime health care costs are greater for smokers than for nonsmokers, even after accounting for the shorter lives of smokers.
3. Evidence on the economic costs of tobacco use in low- and middle-income countries is limited but growing; the comprehensiveness of these studies varies greatly within and across countries, as do the existing cost estimates.
4. Past and current trends in tobacco use, together with improvements in health care systems and access to health care, suggest that the economic costs of tobacco use in low- and middle-income countries are likely to increase considerably in coming years.
5. The public's share of tobacco-attributable economic costs varies significantly among countries, reflecting differences in the role of government in providing health care.

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