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ECONOMICS OF TOBACCO TOOLKIT

Assessment of the Economic Costs of Smoking

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I. Introduction

Tobacco use is the leading preventable cause of death in high-income countries, and increasingly in low- and middle-income countries. Today, tobacco use causes more than five million deaths per year among adults worldwide (Mathers and Loncar, 2006). By 2030, tobacco's annual death toll will rise to more than eight million per year and more than 80% of the world's tobacco-related deaths will be in low- and middle-income countries (Mathers and Loncar, 2006; Murray and Lopez, 1997; World Health Organization, 2008).

In addition to mortality, tobacco use also causes preventable diseases, poor health, and disability. Numerous epidemiological and laboratory research studies have revealed scientific evidence linking smoking and disease. The 2004 U.S. Surgeon General's Report concluded that cigarette smoking harms nearly every organ of the body (US DHHS, 2004). One efficient way to assess the adverse health effects of smoking on a society is to translate smoking-caused illnesses, premature mortality, and productivity losses into economic terms, a universal marker for measuring the adverse effects of smoking.

Most studies of the economic burden of cigarette smoking have been conducted in the United States and other high-income countries. It was found that annual smoking-attributable healthcare costs account for 6-15% of national healthcare expenditures in the United States and other high-income countries (Warner and Hodgson et al., 1999; World Bank, 1999). Considering both the smoking-attributable healthcare costs and the value of lost productivity caused by smoking-attributable deaths and disability, a review article by Lightwood and Collins et al. (2000) concluded that the total economic costs of smoking represent a significant loss for the whole economy, reaching 2.1%–3.4% of gross domestic product (GDP) in Australia, 1.3%–2.2% of GDP in Canada, and 1.4%–1.6% of GDP in the United States.

The cost of smoking in low- and middle-income countries is rarely documented. Chen et al. (1995) estimated that smoking-attributable medical costs in China were about 4.7% of the national health expenditures in 1988. Jin et al. (1995) estimated that total smoking-attributable direct medical costs and indirect morbidity and mortality costs led to a 1.5% decline in GDP in 1989. A more recent study from China by Sung et al. (2006)

estimated that the smoking-attributable healthcare cost accounted for 3.1% of national health expenditures, and that the total economic cost of smoking was approximately 0.5% of GDP in 2000. Ross et al. (2007) estimated the inpatient healthcare cost caused by smoking represented 4.3% of Vietnam's total health expenditures and 0.22% of GDP in 2005.

The scant evidence from low- and middle-income countries suggests that the economic costs of smoking are lower in low- and middle-income countries compared to high-income countries. It is possible that the full effect of smoking on social costs is not yet evident, because the tobacco epidemic is at an earlier stage (World Bank, 1999) and because the morbidity and mortality effects are only felt after prolonged periods of smoking. It is also possible that limited access and quality of medical care in low-income and middle-income countries lead to the underestimation of true smoking costs (Ross et al., 2007). Although smoking prevalence has been declining recently in developed countries, smoking prevalence and cigarette consumption has been increasing rapidly in developing countries.

Conversely, many developing nations such as China and India are experiencing economic growth that will improve the quality of healthcare services and increase their healthcare spending. Thus, developing countries will face a substantially higher economic burden of healthcare expenditures attributable to tobacco use in the future if they do not adopt tobacco control initiatives. It is important that these countries begin to assess the economic burden of adverse health effects caused by tobacco use as a benchmark, so that policymakers can monitor the health-related economic impact of the escalating tobacco epidemic. Due to differences in healthcare systems and patterns of smoking-related diseases, the economic burden of tobacco use studies must be tailored to country-specific situations. However, there is a lack of country-specific research on the economic costs of tobacco use in low- and middle-income countries.

Purpose of this Toolkit

The main purpose of this toolkit is to assist research initiatives to estimate the economic costs of the health effects of cigarette smoking. It will provide step by step guidance on different techniques to estimate smoking-attributable mortality, morbidity, and healthcare expenditures in the framework of the cost-of-illness methodology. Due to lack of data in many developing countries, we are aiming to provide as many alternative estimation techniques as possible, so that countries with various levels of data can adopt one of these techniques to estimate their country-specific smoking-attributable mortality, morbidity, and healthcare costs.

Who Should Use this Toolkit

This toolkit attempts to explain the process of estimating the health-related economic costs of smoking. It includes discussions of basic issues and economic measures surrounding the economic costs of smoking (written for non-specialists such as policy makers and analysts) and more advanced technical points and data requirements (intended for use by the economists and econometricians who will undertake the actual cost of smoking estimation). This toolkit will focus on the economic burden due to smoking-attributable adverse health effects on the society as a whole.

How to Use this Toolkit

Although this toolkit will focus on addressing the process of estimating the economic costs attributable to cigarette smoking, the estimation techniques presented here may be applicable to the estimation of the economic costs attributable to other types of tobacco products in both smoked forms (e.g., hand-rolled tobacco, pipe tobacco, cigars, bidis, kreteks, etc.) and smokeless forms (such as snuff and chewing tobacco). Some caveats will be discussed in the next chapter.

Chapter II will review the economic framework of cost estimation and discuss the general issues relating to the cost of smoking analysis such as the typical classification of the economic costs of cigarette smoking and the definition of smoking-related diseases. Chapter III will discuss various methodological approaches that have been used in prior research to estimate the costs of smoking, and the measures that economists have used to define the cost of smoking. Chapter IV will compare the previous epidemiological and econometric studies for estimating the smoking-attributable fraction (SAF) of healthcare costs. Chapters V through VII will provide the technical details, step by step, for estimating the direct healthcare costs of smoking, indirect morbidity costs of smoking, and indirect mortality costs of smoking, respectively. Case studies from China will be used to illustrate the process. Chapter VIII will illustrate an approach – the Autopsy Method -- to determine the cause of death for population-based, disease-specific mortality studies. Finally, Chapter IX will describe common formats for presenting the final estimates for meaningful policy interpretation and international comparison.

II. Define the Objectives of the Cost of Smoking Estimation

Reasons for Estimating the Economic Costs of Smoking

Smoking imposes an enormous economic burden on society. It can lead to illness in both smokers and nonsmokers exposed to secondhand smoke. The resulting smoking-related illnesses lead to the need for healthcare services and result in costs incurred in obtaining them. Smoking causes people to lose time from their regular activities and results in premature deaths. Understanding the economic burden of smoking both in terms of monetary costs and in terms of lost time and lives can be helpful for determining how to reduce the impact on society.

The costs of smoking have been estimated in a number of developed countries, including the United States (Rice and Hodgson et al., 1986; Miller and Zhang et al., 1998a; Miller and Ernst et al., 1999; CDC, 2002), Canada (Collishaw and Myers, 1984; Kaiserman,1997), Australia (Collins and Lapsley, 2008), and Germany (Neubauer and Welte et al, 2006). These estimates have proven to be exceedingly helpful for tobacco control efforts. Far fewer studies of smoking-related costs have been conducted in the developing world, though some research has been conducted, including studies in China (Jin et al., 1995, Sung et al., 2006,, India (John et al., 2009), Vietnam (Ross et al., 2007), and South Africa (Yach et al., 1992). These studies are limited by the availability of data and resources to conduct such analyses. It is likely that estimates of the cost of smoking will prove equally useful in helping motivate and guide efforts to reduce the harmful effects of tobacco in developing countries as they have in the developed world.

Potential Uses of the Estimated Costs

Measures of the cost of smoking translate the adverse health effects of smoking into monetary terms. These estimates are useful for a number of purposes:

- To measure the impact of smoking on healthcare delivery and financing, and the productivity of the population
- To inform the adoption of economic interventions, such as increases in cigarette taxes and financial incentives for not smoking
- To determine damages in smoking-related litigation
- To guide health policy and health planning for tobacco control initiatives
- To inform national and local legislators and policymakers
- To provide an economic framework for tobacco control program evaluation

Economic Framework of Cost Estimation

In this section, we briefly review the economic framework of cost estimation based on a recently published World Health Organization Guide to identifying the economic consequences of disease and injury (WHO, 2009; Chisholm and Stanciole et al., 2010)

Perspective

Cost studies may focus on microeconomic perspective by analyzing the impact of disease on economic agents – households, firms, or government. On the other hand, from a macroeconomic perspective, cost studies may focus on the societal assessment by aggregating the impact of disease across all economic agents.

Scope

Welfare economists define the consequences of disease broadly by arguing that individual's welfare or utility is determined by his/her state of health, consumption of non-health goods and services , and amount of leisure time. Goods and services can be further divided into those that are marketed and non-marketed. Marketed goods and services are those that are paid for, such as the salaries of employees and financial investments. Non-market goods and services refer to unpaid but economically valuable goods and services, such as housework, and informal care-giving. Thus, the scope of cost studies to assess the consequences of disease may include three components: (1) the direct effect of poorer health on welfare (the intrinsic value of losses in health status), (2) the effect on leisure time, and (3) the effect on consumption opportunities that are not related to health. The scope of the study determines which of these components would be quantified.

Cost of Illness Approach

The majority of the cost of smoking studies and most of the economic consequences of disease and injury studies undertaken to date adopt the cost of illness approach, which was developed by Dorothy Rice and colleagues (Rice 1966, 1967, 2000; Cooper and Rice, 1976; Rice, Hodgson and Kopstein, 1985). This approach analyzes the impact of illness from a macroeconomic perspective by aggregate impact across all economic agents to derive a societal assessment. The scope of this approach is to capture the foregone consumption (some of which is resulted from foregone production) opportunities. Using this approach, the economic consequences of illness are divided into direct costs – the expenses incurred because of the illness, and indirect costs – the value of lost production because of reduced working time.

The cost of illness approach does not consider the impact on welfare and leisure time. It does not capture the long-term dynamic impact of disease on changes in demographic composition, and reduced resources for investing in financial and human capital formation. Therefore, it provides a static and partial estimate of the full macroeconomic impact of disease.

Other Macroeconomic Approaches

Other macroeconomic approaches were developed to assess the societal impact of disease by considering the long-term dynamic impact on changes in demographic composition, and reduced resources for investing in financial and human capital formation disease, and the interactions of economic activity between different economic agents through a comprehensive 'flow of income' frameworkThe scope of these approaches is to capture the impact of disease on welfare or national income. These approaches include the economic growth model, calibration model, computable general equilibrium (CGE) simulation model, and full income model. The first three models estimate the impact of disease on national income or GDP. The fourth model estimates the impact of disease on welfare based on the willingness-to-pay methodology. These models have their own limitations including the complexity of model estimation and the comprehensive requirement for data elements. The details of these models are available elsewhere (WHO, 2009) and will not be elaborated on here. These macroeconomic approaches have rarely been adopted in the cost of smoking literature except for the mortality burden of disease studies conducted by the World Health Organization. However, the reader should be aware of the existence of these models.

Approach Used in this Toolkit

This toolkit will adopt the cost of illness approach, which has been used in the majority of cost of smoking studies in the literature.

Components of the Economic Costs of Smoking

Smoking imposes an adverse impact on society, both through the loss of life and productive years and through the financial burden borne by smokers, their families, their healthcare providers and insurers, and their employers. The term 'costs of smoking' is defined as the difference between healthcare or other costs that actually occur due to smoking and the costs that would have occurred had there been no smoking. That is, the cost of smoking is based on an excess cost approach. Based on the conventional cost of illness approach, the economic costs of smoking distinguish between direct and indirect costs. Direct costs consist of goods or services which involve a monetary exchange in the marketplace. Indirect costs represent losses for which no money exchanges hands, but nonetheless involve a loss of resources. Indirect costs include the value of time lost from activities due to illness and disability, and the value of lives lost prematurely from smoking-related illnesses. .

Direct Costs of Smoking

Direct costs represent the monetary value of goods and services consumed as a result of smoking and smoking-related illness, and for which a payment is made. Some direct costs result from the use of healthcare services, while other are related to non-healthcare costs. Note that there are two approaches which can be used to estimate the direct costs of smoking – annual cost approach and lifetime cost approach. Details of these two approaches will be described in the next chapter.

Healthcare Costs

Healthcare costs include hospitalizations, physician services, nursing home care, home healthcare, medications, and services of other healthcare providers due to the treatment of smoking-related diseases. Also included might be costs for herbal treatments, complementary and alternative medicine, and traditional healers. Other related costs include medical supplies and equipment.

Non-Healthcare Costs

Non-healthcare costs of smoking include those for transportation to health providers, caregiving by non-health providers such as family members provided to sick smokers, property losses from fires caused by smoking, cleaning clothes and air of smoke, business expenses to hire and train replacements for sick smokers, and insurance premiums for fire and accident insurance.

Indirect Costs of Smoking

Morbidity Costs

Morbidity costs are an indirect cost representing the value of lost productivity by persons who are ill or disabled from smoking-related disease. An ill person may be unable to work at their usual job or perform their usual housekeeping and childcare activities. Morbidity costs are estimated by determining what a person would have been able to earn performing paid labor, and also by estimating an imputed value for lost household production services.

Mortality Costs

Smokers have an increased probability of dying from a number of diseases that have been causally linked to smoking. The value of the lives lost is known as the mortality cost. One measure of the value of life is based on assigning a monetary value to a life. This can be done using the human capital approach, which values life according to what an individual produces, or the willingness-to-pay approach, which values life according to what someone would pay to avoid illness or death. Both approaches will be discussed in more detail in the next chapter.

Another measure of the value of lives lost prematurely is the number of years of potential life lost (YPLL). YPLL denotes the number of years an individual would have lived had they not died of a smoking-attributable disease. The YPLL is determined by the number of years of life expectancy remaining at the age of death.

Disability Adjusted Life Years

Disability adjusted life years (DALYs) incorporate both the impact of smoking-related illness on disability and premature death, i.e., the qualitative and quantitative aspects of illness, by combining them into one measure. The DALY was first conceptualized by Murray and Lopez in work carried out with the World Health Organization and the World Bank (Murray and Lopez, 1996). Years of life lost due to living with a disability is the product of number of incident cases of disease, duration of each case, and a disability weight which reflects the degree of disability. Disability weights to be used with years lived with a specific illness have been developed, and years of life lost from premature death are determined by comparing age at death with the greatest life expectancy – that of Japanese women. The mortality component of the DALYs is similar to the YPLLs. Disability weights for specific illnesses are found in the Global Burden of Disease Study (Murray and Lopez, 1997).

Definition of Affected Population and Age Selection

People of all ages are affected by smoking, but different groups are impacted in different ways. Adult smokers suffer the health and productivity-related impact of exposure to the ingredients of active tobacco smoke. Nonsmoking spouses of smokers may be exposed to secondhand smoke at home, and employed people may be exposed to co-workers' smoke in the workplace. Children may suffer from exposure to secondhand smoke at home and in other settings. Unborn children may be exposed through their mother's smoking behavior while pregnant. Because the health effects of smoking result from many years of exposure, most cost-of-smoking studies focus on adults aged 35 and older. Men and women are usually studied separately, because the health impacts have been found to differ by gender. The relative risk of dying from a smoking-related disease, for example, is lower for women than for men in the United States for most diseases (Schultz et al., 1991) and some conditions such as breast and cervical cancer effect only women (U.S. DHHS, 1989). It is important that a cost-of-smoking study identify the population of interest during the planning phase because it will help determine what diseases should be included.

Definition of Relevant Smoking-Related Diseases

A number of diseases have been causally linked to smoking over the years. The landmark 25th Anniversary Report of the U.S. Surgeon General (US DHHS, 1989) identified 26 diseases for which a causal link to smoking can be established for mortality. This was based on a review of the literature and a 4-year follow-up analysis of the American Cancer Society Cancer Prevention Study II (CPS-II) data. This review was updated in a later U.S. Surgeon General Report (US DHHS, 2004) based on a more recent literature review. The 2004 Report identifies a substantial number of diseases found to be caused by smoking that were not previously identified to be causally associated with smoking: cancers of the stomach, uterine, cervix, pancreas, and kidney; acute myeloid leukemia; pneumonia; abdominal aortic aneurysm; cataracts; and periodontitis. Those diseases whose incidence or mortality have been identified as being causally linked with cigarette smoking are shown below in Table 2.1. Some of these diseases have been shown to result from smoking only in individuals of a certain age.

While the table below contains conditions for which smoking results in death, other conditions may result from smoking but be nonfatal, such as gum disease and nasal irritation. The pediatric conditions are those that result from exposure in utero due to maternal smoking during pregnancy. The list of conditions for which there is scientifically valid evidence of being caused by smoking continues to grow. For example, an international panel in Canada recently concluded that the scientific evidence was adequate to link breast cancer in pre-menopausal women with both active and passive smoking (Collishaw et al., 2009). They concluded that the relationship for post-menopausal women was strong, but not yet conclusive. Thus, the population of interest and the purpose of the study (e.g. the cost of active vs. passive smoking) will help determine what diseases should be included.

Table 2.1. Smoking-Related Causes of Death (US DHHS, 2004)

Disease	ICD-9 Codes	ICD-10 Codes
Malignant Neoplasms:		
Lip, oral cavity, pharynx	140-141, 143-149	C00-C14
Esophagus	150	C15
Stomach (gastric)	151	C16
Pancreas	157	C25
Larynx	161	C32
Trachea, lung, bronchus	162	C33-c34
Cervix, uteri	180	C53
Kidney and renal pelvis	189	C64-C65
Urinary bladder	188	C67
Acute myeloid leukemia	205.0	C92.0
Cardiovascular Diseases:		
Ischemic heart disease	410-414, 429.2	I20-I25
Cerebrovascular disease (stroke)	430-438	I60-I69
Atherosclerosis	440	I70
Aortic aneurysm	441	I71
Peripheral vascular disease	443.1-443.9	I73
Arterial embolism and thrombosis	444	I74
Respiratory Diseases:		
Chronic bronchitis, emphysema	491-492	J41-J43
Chronic airways obstruction	496	J44
Reproductive Effects:		
Low birth weight	765	P07
Respiratory distress syndrome – newborn	769	P22
Other respiratory conditions – newborn	770	P23-P28
Sudden Infant Death Syndrome	798.0	R95

Other Considerations

The most common form of tobacco exposure in much of the world is cigarettes (including kreteks), bidis, cigarillos, pipe tobacco, and cigars. However, other types of tobacco products (e.g. smokeless tobacco) are consumed, particularly in the developing world. Many non-smokers are exposed to the harmful products of tobacco through secondhand smoke exposure. And tobacco can cause illness and injury through smoking-related fires. These considerations are discussed next.

Other Types of Tobacco Use

In addition to cigarettes, tobacco is consumed in other forms, both smoked and smokeless, around the world. The most common form of tobacco used in India, the bidi, is also found in other areas of Southeast Asia, and is exported worldwide. These hand-rolled flavored cigarettes consist of tobacco wrapped in a tendu or temburni leaf, which is then hand-tied. Flavors are often added. Cigars are widely available in most countries, with cheroots and stumpen consumed in western and central Europe and dhumtis consumed in India. Clove-flavored cigarettes known as kreteks are commonly consumed in Indonesia. They contain tobacco, cloves, and other additives.

Pipes are used to consume a blended version of tobacco. Clay pipes are common in Southeast Asia, while wooden pipes are common in other areas. Hookahs, or water pipes, are popular in North Africa, the Mediterranean, the Middle East, and areas of Asia. Water pipes also go by the names nargeela, shisha, okka, kalian, ghelyoon, or hubble bubble.

Smokeless tobacco is commonly consumed as chewing tobacco and snuff. Chewing tobacco is found in loose form, while snuff can be packaged into small pouches for ease of consumption. Chewing tobacco is commonly used in many former Soviet Republics, by Indian women and elderly Vietnamese women, and by western athletes. In many parts of the world, particularly in Asia, betel nut is a popular item, and it is often mixed with tobacco, wrapped in a leaf, and chewed in the form of paan, pan masala, betel quid, or gutkha.

All these forms of tobacco consumption have been linked to health risks. In some cases the way the tobacco is consumed, often without any filtration, may lead to greater risk of some types of illness than the risk from smoking cigarettes. Thus it is important to understand the forms of tobacco consumed in the area of the world of interest, in order to do a comprehensive cost-of-smoking study. However, caution should be exercised in using methods developed for one form of tobacco consumption (e.g. cigarette smoking) and applying them to other forms of consumption (e.g. smokeless tobacco). While the general methodological approach would be similar, some measures such as the relative risks need to be specific to the form in which tobacco is consumed.

Secondhand Smoke Attributable Costs

Secondhand smoke (SHS) exposure has been shown to cause a number of illnesses. Its negative health effects impact people of all ages, including children exposed to their parents' smoking at home, workers exposed to the secondhand smoke of coworkers at work, and adolescents exposed at home or at work (Max and Sung et al., 2009). Specific health effects that have been documented include respiratory effects in children (Jinot and Bayard, 1996; Mannino et al., 2001), and adult effects on lung cancer (Hackshaw and Law et al., 1997), heart disease (Barnoya and Glantz, 2005; Thun and Henley et al., 1999; Steenland, 1999), and respiratory disease (US DHHS, 2006; California Environmental Protection Agency, 2005). Breast cancer in pre-menopausal women has recently been added to the list of cancers caused by SHS exposure (California Environmental Protection Agency, 2005). Because of the challenges in measuring population exposure rates to SHS, very few studies have estimated costs associated with this exposure. However, in countries where smoking prevalence is high and people are frequently exposed to high levels of SHS, the costs associated with SHS exposure could be substantial.

Cigarette-Caused Fire Morbidity and Deaths

Cigarette smoking is the leading cause of fire-related death worldwide (Leistikow et al., 2000). A smoker might leave a burning cigarette unattended or fall asleep while smoking, and the structure might catch on fire. Nonfatal burns can result in severe injury and disfigurement, leading to substantial medical care and rehabilitation needs. Fatal fires may lead to medical costs and lost productivity from premature death. These costs should be considered for inclusion in a cost-of-smoking study.

Summary and Recommendations

This chapter reviewed the basic framework for developing a cost-of-smoking study. The biggest challenge for designing such a study in developing countries is often obtaining the needed data. A number of questions should be addressed before undertaking a study of the costs of smoking, with issues that should be considered and clarified during the planning phase so that an appropriate and useful study can be designed.

- What is the purpose of the study?

- Who is the appropriate audience for the results?
- How will the results be used?
- What is the population of interest and what are their tobacco-consuming habits?
- Whose costs are of interest? Smokers and their families? The healthcare system? Public sector costs? All social costs?
- What are the relevant costs that should be included?
- Are data available to estimate the costs of interest, or is there a published study or some other basis that can be used for estimating the costs of smoking?

III. Methodological Issues of Cost of Smoking Estimation

Annual Cost Approach versus Lifetime Cost Approach

The costs of smoking can be tallied over the course of one time period, typically a year, or over the course of an individual's lifetime. Depending on the course of time to be tallied, the costs of smoking can be estimated by either the annual cost approach or the lifetime cost approach.

Annual Cost Approach

The annual cost approach sums the excess costs of smoking-related diseases and deaths incurred by current smokers and former smokers compared to never smokers in a year. These costs are incurred as a result of smoking-related illnesses manifested during that year (i.e., prevalent illnesses) but caused by cumulative exposure to tobacco over many years in the past. Thus, the annual cost approach is also called the prevalence-based approach. In this approach, the economic costs of smoking are calculated for those with newly diagnosed smoking-related illness, those in advanced stages of smoking-related illness, and those who die of smoking-related illness in that year, regardless of when they may have started or stopped smoking.

The calculation of excess costs incurred by smokers compared to never smokers for the treatment of smoking-related diseases in a given year does not consider the the impact of differing life expectancy on costs between the two groups. In contrast to the "net costs" as explained below, some economists refer to the excess costs estimated by this approach as "gross costs" (Warner and Hodgson et al., 1999; Max 2001; Miller and Max et al., 2010).

The annual costs of smoking are estimated by using cross-sectional data. Therefore, this approach is also called the cross-sectional approach. The majority of cost-of-smoking studies have been conducted using the annual cost approach. (Rice and Hodgson et al., 1986; Schultz et al., 1991; Jin and Lu et al., 1995; Miller and Zhang et al., 1998a, Miller and Zhang et al., 1998b;

Zhang and Miller et al., 1999; Miller and Ernst et al., 1999; CDC, 2002; Max and Rice et al, 2004; Max and Sung et al., 2010).

Lifetime Cost Approach

The lifetime cost approach estimates the excess costs expected to occur as a result of smoking-related illness in a group of current smokers compared to never smokers over their lifetimes. The economic costs of smoking are the excess lifetime costs per smoker compared to a never smokerdue to smoking-related diseases if he/she continues to smoke throughout life at the same level as present (i.e., incidence of current smoking) (Sloan et al., 2004). Thus, the lifetime cost approach is also called the incidence-based approach. In this approach, the expected lifetime costs require discounting to convert future values into present values and summing up a series of the discounted annual excess costs over the future lifetime.

The calculation of excess lifetime costs for smokers compared to never smokers takes into account the impact of differing life expectancy on costs between the two groups. There exists a possible tradeoff between higher-than-average annual healthcare expenditures for smokers and the additional years of healthcare expenditure for never smokers due to longer life expectancy (Leu and Schaub 1983, 1985; Hodgson, 1992; Barendregt et al., 1997). To the extent that smokers die prematurely, higher healthcare expenditures for smoking-related illness during a smoker's lifetime are likely offset to a certain degree by expenditures that would be incurred in future years if he/she did not smoke and enjoyed longer life (Institute of Medicine 1981). The potential saving from premature death has been called the “death benefit”. Cost of smoking estimates that take into consideration the expenditures net of the death benefit are referred to as “net costs” (Warner and Hodgson et al., 1999; Max 2001; Miller and Max et al., 2010). Some net costs of smoking studies have even broadened the cost measures to include social security and pension plan programs (Manning and Keeler et al., 1989). The “death benefit” issue in such studies has several complications. Smokers who die earlier do not pay into these pension systems for as many years, and the death benefit to the programs may be overestimated. It is also the case in some countries, such as the former socialist countries, that spouses or other family members can collect pension benefits of deceased relatives. However, if they die prematurely from smoking-related illness, they may not accumulate large enough pension benefits to support their survivors.

The lifetime costs of smoking are estimated by using longitudinal data on healthcare costs for smokers and never smokers over their lifetimes, as well as their survival rates. Therefore, this approach is also called the longitudinal approach. This approach has not been used very often in the cost of smoking literature due to the difficulty in getting the needed longitudinal data to track costs over time.

Which Approach to Use?

The approach to be used is determined by the purpose of the study. If the study is designed to determine how to allocate national budgets, to understand the economic impact of smoking on a particular payer in a given year, or to evaluate the short-term impact of a potential policy, the annual cost (i.e., prevalence-based, gross cost, or cross-sectional) approach is called for. If instead the purpose is to look at the cost-effectiveness of alternative tobacco control strategies over a long time horizon, the lifetime cost (i.e., incidence-based, net cost, or longitudinal) approach would be appropriate.

Due to the challenges in getting the needed longitudinal data to track costs over time, lifetime costs of smoking are more difficult to estimate. Thus the majority of cost-of-smoking studies have used the annual cost approach, and that is what we focus on in this toolkit.

Alternative Economic Measures of the Costs of Smoking

Smoking-related costs can be broken down in several ways, depending upon the goals of the study.

Internal versus External Costs

For policy purposes, it may be useful to know who bears the costs of smoking. Economists distinguish between costs that are internalized, that is, borne by the smoker, and those that impose uncompensated burdens or externalities on others. The internal costs borne by smokers would include their purchase price of tobacco products, medical care costs, and any costs resulting from changes in productivity. The increased healthcare costs that might result from the second-hand smoke exposure of a nonsmoker would be an example of external costs that are not borne or compensated for by the smoker. In addition, if the healthcare costs of smokers are subsidized by nonsmokers through insurance payments or monies spent on public programs, these would also be external costs, i.e. costs not borne by the smokers themselves. It has been suggested by some that only the external costs of smoking should be taken into account in policy debates, because smokers can make their own decisions regarding their behavior. However, if smokers have been misled as to the outcome of their smoking behavior, or if they are unable to quit smoking due to factors beyond their control (including the addictive nature of nicotine), then both internal and external costs can be considered relevant for policy purposes.

Tangible versus Intangible Costs

Some of the economic costs resulting from smoking are tangible, or measurable and easily identifiable. Included are healthcare costs, time lost from productive activities, and years of life lost due to smoking-related illness. Other costs are intangible and are more difficult to quantify, including the pain and suffering of sick smokers and their families, and the negative impact of smoking odors on others. Although pain and suffering can be assessed by using the willingness-to-pay approach as described in the section below, intangible costs in general have rarely been estimated in the previous cost-of-smoking studies.

Avoidable versus Unavoidable Costs

Whether a smoking-related cost is avoidable or not is determined by the time frame. Smoking is the leading cause of preventable death, and given enough time all smoking-related costs would be avoidable if all smokers quit. This is because if there were no current or former smokers, there would be no ill health effects of smoking. However, this would require several generations and would require that anyone ever exposed to smoking in any way be no longer living. In the shorter term, smoking cessation can reduce and even reverse some of the negative effects of smoking and thereby reduce smoking-related costs. The costs that could be eliminated in any time period due to reduced smoking prevalence can be considered to be avoidable costs.

Additive versus Subtractive Approach

Costs can be determined using an additive or a subtractive approach. In the additive approach, the costs incurred by smokers are summed over different smoking-related diseases. Because smoking is a behavior and not a diagnosis, it is necessary to first determine healthcare costs for each disease that might result from smoking, and then to determine what proportion of those costs can be attributed to smoking. In the subtractive approach, expenditures of smokers and a hypothetical group of "nonsmoking smokers" – people who have the same demographics and risk factors as those of smokers except that they have never smoked – are compared. Smoking-attributable costs are calculated as the excess costs of smokers compared to "nonsmoking smokers". Both approaches have been used in the literature to estimate smoking-related costs.

Indirect Cost Measures for the Value of Life: Human Capital versus Willingness-to-Pay Approach

Smoking results in premature deaths and the loss of life years, which should be valued in considering the economic impact. There are two distinct methodologies to measure the value of life: the human capital approach and willing-to-pay approaches. The value of life is often measured using the human capital approach, which values lost productivity using foregone market earnings (Landefeld and Seskin, 1982; Sung et al., 2006) and an imputed value for foregone household production (Rice, 1967; Rice and Hodgson et al., 1986; Max and Rice et al. 2002b). In this approach, a person is seen as producing a stream of future output that is valued at market earnings and the value of life is the discounted future earnings stream. Because it values life using market earnings, it yields low values of mortality costs for children, the retired elderly, and anyone not working in the paid labor market. It also undervalues mortality if labor market imperfections exist and wages do not reflect true productivities. In addition, intangible psychosocial costs, such as pain and suffering, are components of the burden of illness omitted from the human capital computation of indirect costs.

In he willingness-to-pay (WTP) approach, the value of life is based on what a person is willing to pay to avoid illness or death (Acton, 1973; Kniesner and Leeth, 1991; Gerking et al., 1988; Krupnick et al. 2002). It includes a person's intangible quality of life rather than just his/her productivity or market earnings. Thus, the WTP approach produces much larger estimates of the value of life than the human capital approach. Earlier WTP studies used the value of life ranging from $3 million to $7 million per life year (Viscusi, 1993). A recent lifetime cost of smoking study valued the life at $100,000 per year (Sloan et al., 2004). The relative merits of these two methodologies have been debated (Robinson, 1986). The WTP approach is often used when the goal of a study is to derive social preferences regarding public policy, or to assess the burden of illness on pain and suffering.

Summary and Recommendations

This chapter reviewed a number of methodological approaches relevant to the cost of smoking research. Studies can be designed using many methods, depending on the purpose of the study and the concerns to be addressed. It is important that the objective of the study be clarified during the planning phase, as described in chapter I. This should guide the choice of methodological approaches taken.

Annual or prevalence-based studies have simpler data requirements, but even these data may be challenging to obtain in many developing nations. To the extent that prior work has been done in the country of interest, we recommend that researchers build upon existing research and review carefully the methodologies used to see if they are relevant to the study at hand.

IV. Estimation Techniques for Smoking-Attributable Fraction

One of the most important steps in estimating the economic costs of smoking is to determine the smoking-attributable fraction (SAF). The purpose of this chapter is to describe the concept of the SAF and the overview of the techniques that have been used to estimate the SAF in the literature. More details about the data elements needed for estimating the SAF and how to estimate the SAF will be discussed in the next three chapters.

What is the Smoking-Attributable Fraction (SAF)?

The SAF is the proportion of health services utilization, healthcare costs, deaths, or other health outcome measures that can be attributable to smoking. The SAF is also known as the population attributable risk (PAR), Once the SAF is determined, it can be multiplied by the corresponding total measure of interest to derive the smoking-attributable measure. For example, the product of the SAF and total number of inpatient days in a country is the smoking-attributable inpatient days; the product of the SAF and total national outpatient cost is the smoking-attributable outpatient cost. Similarly, the product of the SAF for lung cancer deaths and the total number of lung cancer deaths gives the smoking-attributable lung cancer deaths.

In general, studies estimating the SAF can be classified into two categories according to the estimation techniques: those based on an epidemiological approach and those based on an econometric approach. They differ from each other in terms of estimation methodologies.

- Epidemiological studies use the additive approach to estimate the SAF. Before estimating the SAF, these studies first determine a list of smoking-related diseases. Then they determine the fraction of deaths or healthcare costs for each particular smoking-related disease that can be attributed to smoking according to an epidemiological formula (to be explained in the next section). Therefore, in epidemiological studies, the SAF is calculated for each particular smoking-related disease of interest. The product of the SAF for a particular disease and the national healthcare cost corresponding to that disease is the smoking-attributable healthcare cost for that disease. Finally, summing up the smoking-attributable healthcare cost for each smoking-related disease gives the total healthcare costs of smoking in the country. The epidemiological approach of estimating the SAF is popular because it can be done with aggregate data and therefore can be used when detailed health survey data are not available.

- In contrast, econometric studies use the subtractive approach to estimate the SAF. Through econometric modeling, these studies predict each individual's total annual healthcare costs for all diseases regardless of whether they are smoking-related or not. Then, they determine the excess healthcare costs for smokers by subtracting the predicted total healthcare costs for a hypothetical group of "nonsmoking smokers" (see Chapter III for definition) from the predicted total healthcare costs for smokers. Finally, the SAF is calculated by dividing the excess costs for smokers by the sum of predicted healthcare costs for all individuals. Therefore, in econometric studies, the calculation of the SAF is not confined to certain smoking-related diseases.

  Econometric studies of SAFs consider confounding factors other than smoking status when comparing the healthcare costs (or other health outcome measures) between smokers and "nonsmoking smokers". These factors include sociodemographic characteristics and other risk behaviors such as alcohol drinking and obesity. The econometric approach is often used where national health surveys exist with adequate data on individual's health status, risk factors, and when it is plausible to assume that their coverage is nationally representative.

Epidemiological Studies of SAF

Data

To calculate the SAF in an epidemiological study, two fundamental data elements need to be estimated first: (1) smoking prevalence or smoking impact ratio, and (2) relative risk.

Smoking Prevalence

Smoking prevalence is the percentage of smokers in the total population. Smokers can be categorized as current, former, and ever smokers. In the United States and many developed countries, adult current smokers are defined as those who report smoking at least 100 cigarettes in their lifetime and who smoke cigarettes every day or some days at the time of the survey. A former smoker is someone who has smoked 100 cigarettes in their lifetime but does not smoke cigarettes at the time of the survey. An ever smoker is someone who is either a current smoker or a former smoker. Never smokers are those who have not smoked 100 cigarettes during their lifetime. However, in many developing countries, other types of tobacco products, such as *bidis*, cigarillos, cigars, pipes, rolled tobacco, and chewing tobacco, may constitute a large proportion of total tobacco consumption. For these countries, rather than focusing on cigarette smoking alone, a more comprehensive measure of smoking prevalence needs to include the use of other tobacco products.

Smoking prevalence (P_s) is calculated by:

$P_s = N_s$ / (total persons) x 100% ……(Eq IV.1)

where N_s = number of smokers (i.e., current, former, or ever smokers)

Depending on data availability and the study goal, smoking prevalence may needed to be calculated separately for different population subgroups such as by gender, age, race, ethnicity, socioeconomic status, and geographic region.

Example: A nationally representative survey of smoking behaviors collected the responses of 1000 men and 1200 women. The survey results indicated that there were 600 male current smokers and 80 female current smokers. Based on this survey, the following smoking prevalence can be calculated:

Male current smoking prevalence = (600 / 1000) x 100% = 60%

Female current smoking prevalence = (80 / 1200) x 100% = 6.7%

Total current smoking prevalence = (600 + 80) / (1000 + 1200) x 100% = 30.9%

Because of sampling design and non-response rates, sampling weights are usually provided for each respondent in the survey. Sampling weights indicate how many people are represented by a particular survey respondent. In this case, smoking prevalence is calculated as a weighted sum of current smokers divided by a weighted sum of the sampled population to reflect the actual population composition in the country or a population subgroup.

Smoking Impact Ratio

The accumulated hazards of smoking depend on factors such as the age of smoking initiation or quitting, duration of smoking, smoking intensity, and degree of inhalation. Because these factors may change over time due to changes in economic development and tobacco control policies, current smoking prevalence is not sufficient to capture the accumulated hazard of smoking. The smoking impact ratio (SIR) is a measure developed by Peto and Lopez et al (1992) to capture the accumulated hazard of smoking.

SIR is defined as a ratio of study population's lung cancer mortality in excess of their never smokers to 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. According to Ezzati and Lopez (2003a), SIR can be calculated by:

$$SIR = \frac{C_{LC} - N_{LC}}{S_{LC}^{*} - N_{LC}^{*}} \times \frac{N_{LC}^{*}}{N_{LC}} \qquad \text{……(Eq IV.2)}$$

where C_{LC} is age and gender specific lung cancer mortality rate of all persons in the study population, N_{LC} is age and gender specific lung cancer mortality rate of never smokers in the same population as C_{LC}, S_{LC}^{*} and N_{LC}^{*} are age and gender specific lung cancer mortality rates for smokers and never-smokers, respectively, in the reference population.

Conceptually, SIR converts the smokers in the study population, who may have different smoking histories, into equivalent smokers in the reference population, where relative risks for different diseases have been measured. Most SIR studies used the American Cancer Society's Cancer Prevention Study II (CPS- II) for the reference population because it was one of the largest smoking and mortality studies, the data provided separate relative risk estimates for different causes of death, and most of the smokers were lifelong cigarette smokers so that the full effects of the smoking epidemic could be captured.

The SIR method has been mainly used in studies to estimate the smoking-attributable mortality for developed and developing countries with the standard smoking-attributable fraction formula (see Equation IV.4). This measure has not been used to estimate the direct healthcare costs of smoking. A detailed description about the use of SIR as a measure of exposure to accumulated smoking hazards with emphasis on developing countries is available elsewhere (Ezzati and Lopez, 2003a, 2003b; Ezzati, Henley, and Thun et al., 2005; Ezzati and Henley et al., 2005). More description about SIR and the CPS-II data is also provided in Chapter VII regarding the estimation of the indirect mortality costs of smoking.

Relative Risk

Relative risk is used to measure the strength of the association between the risk of developing a disease or having an event and exposure to a given factor (Cornfield, 1951; Lilienfeld and Stolley, 1994). In the case of smoking studies, an "event" may refer to health outcomes such as deaths, health services utilization, healthcare expenditures, or disability days while "exposure" means tobacco use. The unexposed group often refers to never smokers and the exposed group refers to smokers (i.e., current smokers, former smokers, or ever smokers). The relative risk of developing a disease i or having an event i for smokers is defined as the ratio of the disease i's incidence rate or the event i's incidence rate for smokers relative to that for never smokers as specified below:

$$RR_i = \frac{(\text{disease i's incidence rate or event i's incidence rate})_{\text{smokers}}}{(\text{disease i's incidence rate or event i's incidence rate})_{\text{never smokers}}}$$

$$= \frac{(\text{incident cases for disease i or event i})_{\text{smokers}} / N_s}{(\text{incident cases for disease i or event i})_{\text{never smokers}} / N_n}$$

….. (Eq IV.3)

where N_s = number of smokers

N_n = number of never smokers

The relative risk for developing a disease i or having an event i may be estimated separately by gender, age, race, ethnicity, socioeconomic status, and geographic region depending upon data availability.

Example: If the incidence rate of lung cancer was 20 cases per 1000 persons for current smokers and was 1 case per 1000 persons for never smokers, then the relative risk of lung cancer for current smokers compared to never smoker would be:

$$RR_{\text{lung cancer}} = \frac{(20/1000)}{(1/1000)} = 20.0$$

This value of the relative risk means that a current smoker is 20 times as likely to develop lung cancer as a never smoker.

Formula to Calculate the SAF

Once the data for smoking prevalence or smoking impact ratio (SIR) as well as relative risk are obtained, the smoking-attributable fraction (SAF), also known as the population attributable risk (PAR), can be calculated. The SAF was originally derived by Levin (1953) to examine the proportion of lung cancer cases attributable to smoking using the following epidemiological formula [Lilienfeld and Stolley, 1994]:

$$SAF_i = \frac{P_e * (RR_{ie} - 1)}{P_e * (RR_{ie} - 1) + 1} \text{ x } 100\%$$

$$= \frac{[P_n + P_e * RR_{ie})] - 1}{[P_n + P_e * RR_{ie}]} \text{ x } 100\%$$

……… (Eq IV.4)

where the subscript i = lung cancer or a particular tobacco-related disease i

P_e = percentage of ever smokers (current plus former smokers) or the smoking impact ratio (SIR)

P_n = percentage of never smokers, which equals (1 – P_e)

RR_{ie} = relative risk of developing lung cancer or a particular tobacco-related disease i or having an event i (such as incurring disability days) for ever smokers compared to never smokers

In countries where the smoking prevalence and relative risk data are available separately for current smokers and former smokers, the SAF for a disease i or an event i is calculated by using an adaptation of the above formula for two levels of exposure (Walter 1976):

$$SAF_i = \frac{P_c * (RR_{ic} - 1) + P_f * (RR_{if} - 1)}{P_c * (RR_{ic} - 1) + P_f * (RR_{if} - 1) + 1} \text{ x } 100\%$$

$$= \frac{[P_n + P_c * RR_{ic} + P_f * RR_{if}] - 1}{[P_n + P_c * RR_{ic} + P_f * RR_{if}]} \text{ x } 100\%$$

……… (Eq IV.5)

where P_c = prevalence of current smokers

P_f = prevalence of former smokers

P_n = percentage of never smokers, which equals (1 – P_e – P_f)

RR_{ic} = relative risk of developing a particular tobacco-related disease i (such as lung cancer) or occurring an event i (such as incurring disability days) for current smokers compared to never smokers

RR_{if} = relative risk of developing a particular tobacco-related disease i such as lung cancer or occurring an event i (such as incurring disability days) for former smokers compared to never smokers

The SAF expressed in Equation (IV.5) can be further decomposed into two components: one for current smokers (SAF_{ic}) and the other for former smokers (SAF_{if}) as specified below.

$$SAF_i = SAF_{ic} + SAF_{if} \qquad \text{……… (Eq IV.5.a)}$$

$$SAF_{ic} = \frac{P_c * (RR_{ic} - 1)}{P_c * (RR_{ic} - 1) + P_f * (RR_{if} - 1) + 1} \text{ x } 100\%$$

……… (Eq IV.5.b)

$$SAF_{if} = \frac{P_f * (RR_{if} - 1)}{P_c * (RR_{ic} - 1) + P_f * (RR_{if} - 1) + 1} \text{ x } 100\%$$

……… (Eq IV.5.c)

Example: Among all male adults aged 35 and older, the smoking prevalence is 35% for current smokers and 20% for former smokers. Suppose that the relative risk of dying from lung cancer for current smokers compared to never smokers is 27.48, and the relative risk of lung cancer death for former smokers compared to never smokers is 8.8. We would calculate the following SAF estimates:

Total $SAF_{\text{lung cancer death}}$ = [0.35 (27.48 – 1) + 0.2 (8.8 – 1)] / [0.35 (27.48 – 1) + 0.2 (8.8 – 1) +1] = 91.5%

Current smokers' $SAF_{\text{lung cancer death}}$ = [0.35 x (27.48 – 1)] / [0.35 (27.48 – 1) + 0.2 (8.8 – 1) +1] = 78.4%

Former smokers' $SAF_{\text{lung cancer death}}$ = [0.2 x (8.8 – 1)] / (0.45 + 0.35 x 27.48 + 0.2 x 8.8) = 13.2%

Criticism of Epidemiological Studies

Smokers differ from never smokers in many ways other than smoking status. It is possible that a smokers' healthcare cost differs from that of a never smoker for reasons unrelated to smoking status per se. For example, smokers' risk-taking personalities might lead them to utilize less preventive care services than comparably healthy never smokers (Miller et al., 1998a; Warner and Hodgson, 1999). Current smokers might be more likely than never smokers to have other risk behaviors such as alcohol drinking or obesity that may also contribute to higher healthcare costs. One would not want to attribute to smoking any differences in healthcare expenditures resulting solely from consumers' risk-taking personalities and/or other risk behaviors. In traditional epidemiological studies, such aspects are not usually taken into consideration except for age and gender adjustment (e.g., US DHHS 1989; Thun and Day-Lally et al.,1997; Liu and Peto et al., 1998); therefore, the estimated SAF might be subject to some upward bias. However, several recent epidemiological studies examining the relative risk of smoking on mortality had adjusted for more risk factors such as education, marital status, employment, fruit and vegetable intake, vitamin use, alcohol use, aspirin use, body weight status, physical activity, and dietary fat consumption (Ezzati, Henley, and Thun et al., 2005; Ezzati and Henley et al., 2005; Gu and Kelly et al.,2009).

Econometric Studies of SAF

Data

The estimation of the SAF in an econometric study requires extensive nationally representative data that contain detailed information on each respondent's smoking history, sociodemographic characteristics, employment status, other health risk behaviors, health status, medical conditions, annual healthcare expenditures by type of healthcare services (such as inpatient hospitalizations and outpatient visits), and annual work-loss or disability days.

Econometric Approach for Estimating the SAF?

Several tobacco economics researchers in the United States have developed multi-equation econometric models to estimate the SAF and the direct healthcare costs of smoking, by using individual-level survey data and controlling for many sociodemographic characteristics as well as other risk behaviors such as alcohol drinking.

Two Forms of Econometric Models

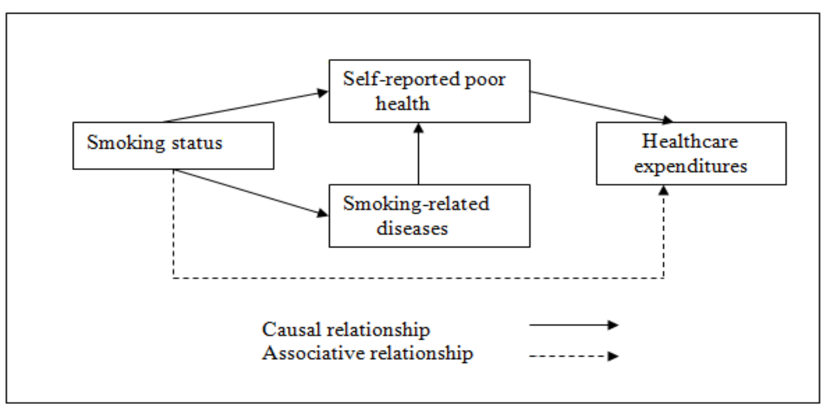
There are two forms of econometric models that have been used in the healthcare cost of smoking literature to estimate the SAF: structural-form models and reduced-form models.

Structural-Form Econometric Models

The structural-form econometric models of the SAF was developed by Miller and his colleagues (Bartlett and Miller et al., 1994; Miller and Zhang et al., 1998a, Miller and Zhang et al., 1998b; Zhang and Miller et al., 1999; Max and Rice et al, 2004; Max and Sung et al., 2010). These models relate smoking to healthcare expenditures in terms of both the "biological effect" of smoking (expenditures as a function of self-reported health status) and the "non-biological effect" associated with smokers. The rationale of the "biological effect" is that smokers have higher health expenditures because they are more likely to have smoking-related diseases and, consequently, have poorer health status. The rationale of the "non-biological effect" is that smokers may have higher and lower healthcare expenditures for reasons not directly related to health status. For example, pregnant women don't generally describe themselves as being in poor health; yet, pregnant smokers and their newborns often have higher healthcare expenditures than their nonsmoking counterparts (Adams and Solanki et al., 1995). On the other hand, smokers might have lower healthcare expenditures due to their risk-taking personalities and a resulting lower demand preference for seeking preventive care (Warner and Hodgson et al., 1999).

The structural-form econometric models capture both the "biological effect" and "non-biological effect" by using several equations to describe the causal relationship between smoking and healthcare expenditures and the associative relationship between smoking and healthcare expenditures.

Figure 4.1. Conceptive framework of causal and associative relationships between smoking and healthcare expenditures



Causal relationship between smoking and healthcare expenditures. The solid lines in Figure 4.1 depict the conceptual framework of the causal relationship of how a person's smoking status (current smoker, former smoker, never smoker) influences his/her likelihood of having smoking-related diseases, the causal relationship of how a person's smoking status and history of smoking-related diseases influence his/her self-reported health status, and the causal relationship of a person's health status influences his/her healthcare expenditures.

Associative relationship between smoking and healthcare expenditures. The dotted line in Figure 4.1 depicts the conceptual framework of the associative relationship between smoking and healthcare expenditures. This associative relationship reflects the "non-biological effect" of smoking, after controlling for self-reported health status.

Model specification and estimation. Based on the above conceptual framework, the structural-form econometric models of the SAF consist of four basic equations:

$D_j = f_1 (S_j, X_j, Y_j)$ ……… (Eq IV.6)
$H_j = f_2 (S_j, X_j, Y_j, D_j^*)$ ……… (Eq IV.7)
$Prob(X_{jk}>0) = f_3 (S_j, X_j, Y_j, Z_j, H_j^*)$ ……… (Eq IV.8)
$Log(X_{jk}|X_{jk}>0) = f_4 (S_j, X_j, Y_j, Z_j, H_j^*)$ ……… (Eq IV.9)

where
D_j = person j's probability of ever having any smoking-related diseases
H_j = person j's probability of having poor, fair, good, very good, or excellent health status
X_{jk} = person j's annual expenditures for healthcare services type k (such as inpatient hospitalizations, outpatient visits, and medications) in a given year for all kinds of diseases, including smoking-related diseases and other diseases
Log = logarithmic transformation
S_j = person j's smoking status
X_j = person j's sociodemographic characteristics (such as age, race, ethnicity, geographic region, marital status, education, and family income)
Y_j = person j's other risk behaviors (such as alcohol drinking and obesity)
Z_j = person j's health insurance coverage
D_j^* = predicted probability of ever having any smoking-related diseases for person j
H_j^* = predicted probability of having poor, fair, good, very good, or excellent health status for person j

In Equation (IV.6), the dependent variable is the probability of having ever been diagnosed with tobacco-related diseases. The independent variables include smoking history, sociodemographic factors, and other risk behaviors. Equation (IV.6) is estimated by a probit or logit model.

In Equation (IV.7), the dependent variable is the probability of having poor, fair, good, very good, or excellent health. The independent variables include smoking history, sociodemographic factors, other risk behaviors, and the predicted probability of having smoking-related diseases which is derived from Equation (IV.6). Equation (IV.7) is estimated by an ordered probit or multinomial logit model.

Equations (IV.8)-(IV.9) form a pair of two-part model for healthcare expenditures. The two-part model was pioneered by Duan et al. (1983) to model annual healthcare expenditures, because the distribution of healthcare expenditures among the general population is often skewed to the right due to a small number of persons spending a large amount of healthcare expenditures and a large number of persons spending zero expenditure. It has become a widely used approach in the health services research literature (Robinson et al. (1991). In the first equation of the two-part model (Equation IV.8), the dependent variable is the probability of having positive annual expenditures regardless of whether they resulted from smoking related diseases or not in a given year. In the second equation of the two-part model (Equation IV.9), the dependent variable is the logarithm of annual expenditures for those persons with positive expenditures.

Both equations of the two-part model contain the same independent variables: smoking history, sociodemographic factors, other risk behaviors, health insurance coverage, and the predicted probability of having poor, fair, good, very good, or excellent health status, which is derived from Equation (IV.7). The first-part equation is estimated by a probit or logit model. The second-part equation is estimated by the ordinary least squares method.

The coefficients of the smoking variable in Equations (IV.6)-(IV.7), and the coefficients of the predicted health status variable in Equations (IV.8)-(IV.9) together measure the "biological effect" of smoking on healthcare expenditures (i.e., causal relationship). The coefficients of the smoking variable in Equations (IV.8)-(IV.9) measure the "non-biological effect" of smoking on healthcare expenditures (i.e., associative relationship). It has been found that about 80-90 percent of the combined "biological effect" and "non-biological effect" of smoking result from the "biological effect" (Max and Rice et al, 2004). Some of the econometric studies do not include the "non-biological effect" in the calculation of excess costs of smoking and the SAF (Max and Rice et al, 2004), while other studies do (Miller and Zhang et al., 1998a).

Reduced-Form Econometric Models

An alternative econometric approach to estimate the SAF is the "reduced-form" models (Miller and Ernst et al., 1999), which contain only one dependent variable — the healthcare expenditures. The reduced-form model is a simplified system of the structural-form models wherein the two endogenous variables from Equations (IV.6)-(IV.9) — the probability of having any smoking-related diseases, and the probability of having poor, fair, good, very good, or excellent health status — are expressed in terms of exogenous variables. Afterwards, the reduced-form econometric models of the SAF only consist of two basic equations:

$Prob(X_{jk}>0) = f_1 (S_j, X_j, Y_j, Z_j)$ …… (Eq IV.10)
$Log(X_{jk}|X_{jk}>0) = f_2 (S_j, X_j, Y_j, Z_j)$ …… (Eq IV.11)

where
X_{jk} = person j's annual expenditures for healthcare service type k (such as inpatient hospitalizations, outpatient visits, and medications) in a given year for all kinds of diseases, including smoking-related diseases and other diseases
Log = logarithmic transformation
S_j = person j's smoking status
X_j = person j's sociodemographic characteristics (such as age, race, ethnicity, geographic region, marital status, education, and family income)
Y_j = person j's other risk behaviors (such as alcohol drinking and obesity)
Z_j = person j's health insurance coverage

Equations (IV.10)-(IV.11) form the two-part model for healthcare expenditures. In Equation (IV.10), the dependent variable is the probability of having positive annual expenditures in a given year. In Equation (IV.11), the dependent variable is the logarithm of the annual expenditures for those persons with positive expenditures. Both equations of the two-part model contain the same independent variables: smoking history, sociodemographic factors, other risk behaviors, and health insurance coverage. The first equation is estimated by a probit or logit model. The second equation is estimated by the ordinary least squares method.

Equations (IV.10)-(IV.11) of the reduced-form models look very similar to the last two equations of the structural-form models (i.e., Equations (IV.8)-(IV.9)) except that health status is not included as an independent variable in the reduced-form models. The structural-form models offer a richer understanding of the causal pathways leading from smoking to healthcare expenditure, whereas the reduced-form models examine the overall effect of smoking on healthcare expenditures in a simpler way without distinguishing the causal relationship between smoking and healthcare expenditures from the associative relationship between them.

Formula to Calculate the SAF

Once the econometric models are estimated, the predicted annual healthcare expenditures can be derived for all individuals including current smokers, former smokers, and never smokers.

Another set of predictions can also be derived for a hypothetical group of "nonsmoking current (or former) smokers" who are identical to current (or former) smokers except that they are assumed to be never smokers. The difference in predicted annual expenditures between smokers and the hypothetical group of "nonsmoking smokers" gives the excess costs for all smokers. Finally, the SAF is calculated by dividing the excess costs for all smokers by the sum of predicted costs of all individuals (smokers plus never smokers) following the mathematical formula below (Max and Rice et al., 2002):

$$SAF = \frac{\sum_{c=1}^{Nc}(EXP_c - EXP_{c\rightarrow n}) + \sum_{f=1}^{Nf}(EXP_f - EXP_{f\rightarrow n})}{\sum_{n=1}^{Nn}(EXP_n) + \sum_{c=1}^{Nc}(EXP_c) + \sum_{f=1}^{Nf}(EXP_f)} \times 100\%$$

….(Eq IV.12)

where

EXP_n = predicted expenditures for a never smoker n

EXP_c = predicted expenditures for a current smoker c

EXP_f = predicted expenditures for a former smoker f

$EXP_{c\rightarrow n}$ = predicted expenditures for a hypothetical "nonsmoking current smoker" c who has the identical characteristics of a current smoker except that he/she is assumed to be a never smoker

$EXP_{f\rightarrow n}$ = predicted expenditures for a hypothetical "nonsmoking former smoker" f who has the identical characteristics of a former smoker except that he/she is assumed to be a never smoker

N_n = total number of never smokers

N_c = total number of current smokers

N_f = total number of former smokers

The SAF expressed in Equation (IV.12) can be decomposed into two components: the SAF for current smokers (SAF_c), and the SAF for former smokers (SAF_f) as specified below.

$$SAF = SAF_c + SAF_f$$ ………(Eq IV.13)

$$SAF_c = \frac{\sum_{c=1}^{Nc}(EXP_c - EXP_{c\rightarrow n})}{\sum_{n=1}^{Nn}(EXP_n) + \sum_{c=1}^{Nc}(EXP_c) + \sum_{f=1}^{Nf}(EXP_f)} \times 100\%$$

……(Eq IV.14)

$$SAF_f = \frac{\sum_{f=1}^{Nf}(EXP_f - EXP_{f\rightarrow n})}{\sum_{n=1}^{Nn}(EXP_n) + \sum_{c=1}^{Nc}(EXP_c) + \sum_{f=1}^{Nf}(EXP_f)} \times 100\%$$

...…(Eq IV.15)

Limitations of Econometric Studies

The econometric studies have mainly estimated the direct healthcare costs of smoking. The approach has not been used to estimate the indirect costs of smoking. A review paper that compared different studies estimating the direct healthcare costs of smoking and the SAF concluded that the econometric approach is a better approach and will become the norm in cost of smoking studies in the future (Warner and Hodgson et al., 1999). However, the primary challenge of the econometric approach is that it requires comprehensive data that contain detailed information on each individual's smoking history, sociodemographic characteristics, employment status, other health risk behaviors, self-reported health status, medical conditions, and annual healthcare expenditures by type of healthcare services. While clinical data or medical records may contain patients' medical condition histories, medical encounters (e.g., hospital admission), some demographic information such as age and gender, and health insurance coverage, they rarely contain patients' medical expenditures. While claims data or health plan administrative data contains such medical expenditures and health services utilization, neither source contains data such as smoking status, other risk behaviors, and key sociodemographic predictors for healthcare expenditures such as income and employment status. One way to obtain such comprehensive data is to conduct a nationally representative survey.

Even in developed countries, such survey data are not commonly available. For example, in the United States, almost all of the published econometric studies of the SAF for the direct costs of smoking were analyzed using the same dataset– the 1987 National Medical Expenditures Survey (NMES-2), which contained a cohort of 35,000 persons selected for face-to-face interviews four times between February 1987 and May 1988. Respondents provided information about their sociodemographic characteristics, health insurance coverage, healthcare utilization and expenditures for different types of health services, health status, history of medical conditions, smoking history, and other health risk behaviors such as seat belt use. Most importantly, respondents' self-reported healthcare expenditures were validated by contacting medical providers through a supplemental survey to ensure the data reliability. It was not until 1996 when a new dataset – the Medical Expenditure Panel Survey (MEPS), linked with the same individuals from the National Health Interview Survey (NHIS) – became available on an annual basis. This new dataset allows for monitoring the change in the SAF and costs of smoking for the United States in recent years (Max and Sung et al., 2010).

Most developing countries lack nationally representative survey data that contain reliable person-level smoking history, annual health expenditures, health status, history of medical conditions, and health risk behaviors for the same group of individuals. Therefore, conducting econometric studies is challenging at the present time for most countries. Other data issues of using the econometric approach include the reliability of self-report health status and the underdiagnosis of medical conditions due to lack of effective health coverage. However, these issues are only relevant for the structural-form econometric studies. The reduced-form econometric studies and epidemiological studies do not require the use of health status and medical conditions, thus they do not have these issues.

Summary and Recommendations

This chapter introduced the concept of the SAF and reviewed the two approaches used to estimate the SAF. If appropriate data are available, the econometric approach is better because it controls for other factors which may also affect healthcare costs, and it is not limited to particular smoking-related diseases. Because the epidemiological approach usually does not control for other confounding factors, the estimated SAF might be subject to some upward bias. Because the epidemiological approach needs to first determine the relevant smoking-related diseases and then estimate the SAF for each particular disease, the estimated total costs of smoking might be downward-biased if such list is not comprehensive enough to capture the true health effects of smoking for the residents of a particular country.

Given data limitations, it is more feasible to adopt the epidemiological approach to estimate the costs of smoking for most countries. As a result, the rest of this toolkit will be devoted to presenting the more detailed steps for estimating the SAF and costs of smoking using the epidemiological approach.

For researchers who have access to the appropriate data and are interested in estimating the costs of smoking using the econometric approach, the information conveyed in the corresponding section of this chapter should provide a clear road map.

V. Estimate the Direct Healthcare Costs of Smoking

Introduction

This chapter presents the detailed steps for estimating the direct healthcare costs of smoking using the epidemiological approach. A major focus of this chapter is to describe how to estimate the smoking-attributable fraction (SAF) for healthcare costs as shown in a subsequent section.

Definition of the Direct Costs of Smoking

The direct costs of smoking, also called smoking-attributable healthcare expenditures (SAE), are those healthcare expenditures resulting from the treatment of smoking-related diseases. As mentioned in Chapter IV, the key step in estimating the costs of smoking is to determine the SAF. Once the SAF is determined, the product of the SAF and the total measure of interest gives the smoking-attributable measure. Therefore, the product of the SAF and total national healthcare expenditures is the smoking-attributable healthcare expenditures.

In the epidemiological approach, the SAF is calculated for each smoking-related disease of interest; therefore, the smoking-attributable healthcare expenditures need to be estimated for each particular smoking-related disease. The smoking-attributable expenditures are often estimated by type of healthcare services and population groups (e.g., gender, age, race, ethnicity, socioeconomic status, and geographic region). Depending on each country's healthcare system, the type of healthcare services used for treating smoking-related diseases varies. For most countries, these services include inpatient hospitalizations, outpatient visits, and medications. For some countries, these services may also include home health care, nursing home care, and other professional services. Finally, based on the additive approach, the sum of the smoking-attributable healthcare cost for each smoking-related disease, each type of healthcare services, and each population subgroup gives the total healthcare costs of smoking in the country.

Formula

The formula to calculate the smoking-attributable healthcare expenditures for treating disease i using healthcare service type k among population subgroup j (SAE_{kij}) is specified as:

$$SAE_{ikj} = SAF_{ikj} \times THE_{ikj} \qquad \text{……… (Eq V.1)}$$

where SAF_{ikj} = smoking-attributable fraction for treating disease i using healthcare service type k among population subgroup j
THE_{ikj} = total national annual expenditures in the country for treating disease i using healthcare service type k among population subgroup j

If the SAF estimates are not available by type of healthcare services, the above formula is approximated to be:

$$SAE_{ikj} = SAF_{ij} \times THE_{ikj} \qquad \text{……… (Eq V.2)}$$

where SAF_{ij} = smoking-attributable fraction for disease i among population subgroup j

Example: National statistics in a country show that the national outpatient expenditures for treating lung cancer amounted to $30,000,000 for females in a given year. An epidemiological study estimated the SAF for lung cancer among females in this country to be 40%. Based on this data, we can calculate the following:

Smoking-attributable outpatient costs for lung cancer for females = ($30,000,000) x 40% = $12,000,000

Steps to Estimate the Smoking-Attributable Healthcare Expenditures (SAE): An Example

Estimating the SAE consists of four steps:

1. Determine the smoking-related diseases, the types of healthcare services to be included, and the appropriate classification of population subgroups
2. Estimate the SAF of healthcare expenditures using the epidemiological approach
3. Estimate total national healthcare expenditures (THE) by population groups

4. Estimate the SAE as the product of the SAF and the THE according to Equation (V.1)

Step 1: Determine Smoking-Related Diseases, Types of Healthcare Costs and Population Subgroups

We have already discussed the definition of smoking-related diseases, the types of healthcare services, and potential ways to classify population subgroups in Chapters II and IV. Here we only assume a simple scenario with:

- two smoking-related diseases: heart disease (HD) and chronic obstructive pulmonary disease (COPD)
- two types of healthcare services: inpatient care and outpatient visits
- two population subgroups classified by gender (males and females)

Given this scenario, eight sets of SAE estimates need to be calculated for the eight combinations classified by two types of healthcare services, two smoking-related diseases, and two population subgroups (see the first column in Table 5.1). Table 5.1 also shows a template of the steps to estimate the smoking-attributable expenditures (SAE) based on this scenario.

Table 5.1. Template of the steps to estimate the smoking-attributable expenditures (SAE) given an example with two smoking-related diseases, two types of healthcare services, and two population subgroups

Disease, Health Care Types, Population Sub-Groups	Estimate SAF					Estimate THE	Estimate SAE ((=SAF x THE)
	Smoking Prevalence		Relative Risk		SAF (from Eq IV.5)		
	current smoking P_c	former smoking P_f	current smoking RR_c	former smoking RR_f			
HD/Inp/male	$P_{c,male}$	$P_{f,male}$					
HD/Inp/female	$P_{c,female}$	$P_{f,female}$					
HD/Outp/male	$P_{c,male}$	$P_{f,male}$					
HD/Outp/female	$P_{c,female}$	$P_{f,female}$					
COPD/Inp/male	$P_{c,male}$	$P_{f,male}$					
COPD/Inp/female	$P_{c,female}$	$P_{f,female}$					
COPD/Outp/male	$P_{c,male}$	$P_{f,male}$					
COPD/Outp/female	$P_{c,female}$	$P_{f,female}$					

Note: “Inp” denotes inpatient care, “Outp” denotes outpatient visits, “HD” denotes heart disease, and “COPD” denotes chronic obstructive pulmonary disease.

Step 2: Estimate the SAF of Healthcare Expenditures

To estimate the SAF with the epidemiological approach, two data elements are needed –smoking prevalence rates and relative risk of healthcare expenditures.

Estimate Smoking Prevalence

Estimating the prevalence rates of current smokers and former smokers, P_c and P_f, requires individual-level data which contain respondent's history of smoking behaviors and demographic characteristics for a nationally representative sample. Note that the smoking prevalence rate should be estimated among all persons within each population sub-group stratified by demographic characteristics, regardless of whether or not these persons have a particular smoking-related disease and which type of healthcare services is examined. In this example, only two sets of smoking prevalence rates need to be estimated -- one for males ($P_{c,male}$ and $P_{f,male}$) and one for female ($P_{c,female}$ and $P_{f,female}$). Given the appropriate data, smoking prevalence rate can be estimated according to Equation (IV.1). Here we simply assume the prevalence rates of current smokers, former smokers, and never smokers are 55%, 11%, and 34% for males, and 19%, 4%, and 77% for females, respectively.

Four Methods to Estimate the SAF of Healthcare Expenditures

There are four different approaches used to estimate the SAF depending on what relative risk data are available or how relative risk is estimated.

- Medical cost ratio approach – the RR is calculated by using medical cost data. This approach requires data on disease-specific annual treatment cost per person stratified by smoking status. Thus, appropriate data which contains each individual's smoking history and disease-specific healthcare expenditures (including both out-of-pocket and insurance paid expenses) are necessary.
- Utilization ratio approach – the RR is calculated by using healthcare utilization data. This approach requires data on disease-specific annual healthcare utilization per person stratified by smoking status. Thus, appropriate data which contain each individual's smoking history and disease-specific healthcare utilization are necessary.
- Disease incidence ratio approach – the RR is calculated by using disease incidence data. This approach requires data on separate disease incidence rates for smokers and never smokers.
- Mortality ratio approach – the RR is calculated by using mortality data. This approach requires data on separate

population death rates by underlying cause of death for smokers and never smokers.

Medical Cost Ratio Approach

In this approach, the SAF of "healthcare cost" for treating a disease i is calculated directly by using the RR of "healthcare cost" for treating this disease.

RR of medical cost for disease i =
(average annual medical cost per smoker for disease i) / (average annual cost per never smoker for disease i)
…. (Eq V.3)

Note that both the numerator and denominator are based on per person cost for all people (including healthy and ill persons) rather than just those who have the disease of interest.

Table 5.2. An example of average annual healthcare cost per male for treating heart disease by smoking status

	Inpatient Cost per person per year	Outpatient Cost per person per year
Current smoker	$120	$38
Former smoker	$110	$43
Never smoker	$98	$29

Then, the following RR estimates can be calculated.

RR of inpatient cost for current smokers = 120 / 98 = 1.22

RR of inpatient cost for former smokers = 110 / 98 = 1.12

RR of outpatient cost for current smokers = 38 / 29 = 1.31

RR of outpatient cost for former smokers = 43 / 29 = 1.48

Based on Equations (IV.5)-(IV.5c) and the above assumed smoking prevalence rates, the SAF of inpatient care costs for treating heart disease can be calculated by:

Total SAF of inpatient cost for ever smokers = [(0.34 + 0.55 x 1.22 + 0.11 x 1.12) – 1] / [(0.34 + 0.55 x 1.22 + 0.11 x 1.12)] = 11.8%

SAF of inpatient cost for current smokers = [0.55 x (1.22 – 1)] / [(0.34 + 0.55 x 1.22 + 0.11 x 1.12)] = 10.7%

SAF of inpatient cost for former smokers = [0.11 x (1.12 – 1)] / [(0.34 + 0.55 x 1.22 + 0.11 x 1.12)] = 1.1%

Therefore, among males, 11.8% of the national annual inpatient expenditures for treating heart disease are attributable to smoking, including 10.7% attributable to current smokers and 1.1% attributable to former smokers. This approach allows for differential RR and SAF estimates by type of healthcare services.

Utilization Ratio Approach

In this approach, the calculation of the SAF of "healthcare cost" for treating a disease i is based on the RR of "healthcare utilization" for treating this disease. This approach was originally developed by Rice and Hodgson (1986), who estimated the RR of healthcare utilization for smokers and then applied it to the calculation of the SAFs for medical cost. This approach was adopted by a software package called SAMMEC II (Smoking-Attributable Mortality, Morbidity and Economic Costs (Schultz et al., 1990; Schultz et al., 1991), that has been distributed by the U.S. Centers for Disease Control and Prevention. The RR of healthcare utilization for treating a disease i is calculated as:

RR of healthcare utilization for disease i =
(average annual utilization per smoker for disease i) / (average annual utilization per never smoker for disease i)
…. (Eq V.4)

Note that both the numerator and denominator are based on per person utilization for all people (including healthy and ill persons) rather than just those who have the disease of interest.

Table 5.3. An example of average annual healthcare utilization per male for treating heart disease by smoking status

	Hospital Days per person per year	Outpatient Visits per person per year
Current smoker	0.77	4.18
Former smoker	0.78	4.32
Never smoker	0.56	3.86

Then, the following RR estimates can be calculated.

RR of hospital days for current smokers = 0.77 / 0.56 = 1.38

RR of hospital days for former smokers = 0.78 / 0.56 = 1.39

RR of outpatient visits for current smokers = 4.18 / 3.86 = 1.08

RR of outpatient visits for former smokers = 4.32 / 3.86 = 1.12

Based on Equations (IV.5)-(IV.5c) and the above assumed smoking prevalence rates, the SAF of inpatient care costs for treating heart diseases is equal to the SAF of hospital days for treating heart diseases, which can calculated by:

Total SAF of hospital days for ever smokers = [(0.34 + 0.55 x 1.38 + 0.11 x 1.39) – 1] / [(0.34 + 0.55 x 1.38 + 0.11 x 1.39)] = 20.1%

SAF of hospital days for current smokers = [0.55 x (1.38 – 1)] / [(0.34 + 0.55 x 1.38 + 0.11 x 1.39)] = 16.7%

SAF of hospital days for former smokers = [0.11 x (1.39 – 1)] / [(0.34 + 0.55 x 1.38 + 0.11 x 1.39)] = 3.4%

According to the assumption of the utilization ratio approach, since 20.1% of hospital days for treating heart disease are attributable to smoking, 20.1% of inpatient expenditures for treating heart disease are also attributable to smoking, including 16.7% attributable to current smokers and 3.4% attributable to former smokers. This approach allows for differential RR and SAF estimates by type of healthcare services.

Disease Incidence Ratio Approach

In this approach, the calculation of the SAF of “healthcare cost” for treating a disease i is based on the RR of “disease incidence rate” for smokers relative to never smokers. The RR of developing a disease i for smokers is calculated by:

RR of developing a disease i =
(incidence rate for disease i among smokers) / (incidence rate for a disease i among never smokers)
…. (Eq V.5)

Table 5.4. An example of heart disease incidence rates among males by smoking status

	Disease Incidence Rate per 1,000 persons
Current smoker	2.72
Former smoker	1.98
Never smoker	1.51

Then, the following RR estimates can be calculated.

RR of heart disease incidence for current smokers = 2.72 / 1.51 = 1.80

RR of heart disease incidence for former smokers = 1.98 / 1.51 = 1.31

Based on Equations (IV.5)-(IV.5c) and the above assumed smoking prevalence rates, the SAF of inpatient costs (or other health care costs such as outpatient costs) for treating heart disease is equal to the SAF of disease incidence for heart disease, which can calculated by:

Total SAF of heart disease incidence for ever smokers = [(0.34 + 0.55 x 1.80 + 0.11 x 1.31) – 1] / [(0.34 + 0.55 x 1.80 + 0.11 x 1.31)] = 32.1%

SAF of heart disease incidence for current smokers = [0.55 x (1.80 – 1)] / [(0.34 + 0.55 x 1.80 + 0.11 x 1.31)] = 29.8%

SAF of heart disease incidence for former smokers = [0.11 x (1.31 – 1)] / [(0.34 + 0.55 x 1.80 + 0.11 x 1.31)] = 2.3%

According to the assumption of the disease incidence approach, since 32.1% of the heart disease incidence cases are attributable to smoking, 32.1% of inpatient expenditures (or other health care expenditures such as outpatient expenditures) for treating heart disease are also attributable to smoking, including 29.8% attributable to current smokers and 2.3% attributable to former smokers. This approach does not allow for differential RR and SAF estimates by type of healthcare services.

The disease prevalence ratio approach requires separate disease incidence data for smokers and never smokers. General health surveys have been undertaken by many developed and developing countries to collect information on respondent's health and medical conditions to estimate the population's incidence or prevalence for particular diseases. For example, the National Health Interview Survey of the United States asked each respondent: "During the past 12 months, have you been told by a doctor that you have congestive heart failure?" The answer to this question can be used to estimate the population's 12-month incidence rate of congestive heart failure in the United States. A National Health Research Survey of Indonesia asked each respondent: "In the past one month, have you ever been diagnosed with pneumonia by health personnel including doctors, nurses and midwife?" The answer to this question can be used to estimate the population's one-month incidence rate of pneumonia in Indonesia. However, in addition to such health condition questions, the questionnaire also needs to ask smoking status questions for each respondent so that separate disease incidence rates can be derived for smokers and never smokers.

Mortality Ratio Approach

In the mortality ratio approach, the calculation of the SAF of "healthcare cost" for treating a disease i is based on the RR of "mortality" caused by this disease for smokers relative to never smokers. The former Congressional Office of Technology Assessment (OTA, 1985) of the United States conducted the first study which used the mortality ratio approach to estimate the SAF of medical costs. Using the RR estimates derived from the American Cancer Society's Cancer Prevention Study (US DHHS, 1989), OTA derived age-specific and gender-specific SAF estimates for deaths.

The RR of dying from a disease i for smokers is calculated by:

RR of mortality caused by disease i =
(death rate of disease i among smokers) / (death rate of disease i among never smokers)
…. (Eq V.6)

Table 5.5. An example of population death rates of heart disease among males by smoking status

	Death Rates per 100,000 persons
Current smoker	222.4
Former smoker	171.9
Never smoker	138.5

Then, the RR estimates can be calculated by:

RR of dying from heart disease for current smokers = 222.4 / 138.5 = 1.61

RR of dying from heart disease for former smokers = 171.9 / 138.5 = 1.24

Based on Equations (IV.5)-(IV.5c) and the above assumed smoking prevalence rates, the SAF of inpatient costs (or other health care costs such as outpatient costs) for treating heart disease is equal to the SAF of deaths from heart disease, which can calculated by:

Total SAF of heart disease deaths for ever smokers = [(0.34 + 0.55 x 1.61 + 0.11 x 1.24) – 1] / [(0.34 + 0.55 x 1.61 + 0.11 x 1.24)] = 26.5%

SAF of heart disease deaths for current smokers = [0.55 x (1.61 – 1)] / [(0.34 + 0.55 x 1.61 + 0.11 x 1.24)] = 24.6%

SAF of heart disease deaths for former smokers = [0.11 x (1.24 – 1)] / [(0.34 + 0.55 x 1.61 + 0.11 x 1.24)] = 1.9%

According to the assumption of the mortality ratio approach, since 26.5% of heart disease deaths are attributable to smoking, 26.5% of inpatient expenditures (or other health care expenditures such as outpatient expenditures) for treating heart disease are also assumed to be attributable to smoking, including 24.6% attributable to current smokers and 1.9% attributable to former smokers. This approach does not allow for differential RR and SAF estimates by type of healthcare services.

The mortality ratio approach requires comparing the population death rates by underlying cause of death between smokers and never smokers. While death rates by cause of death may be available for the general population through vital statistics or vital registration monitoring systems, separate death rates for smokers and never smokers are not available in such systems. To compare the death rates between smokers and never smokers, several kinds of studies have been conducted: (1) retrospective cohort studies of smoking and mortality, (2) prospective cohort studies of smoking and mortality, and (3) case-control studies of smoking and mortality. More details about these studies and the mortality ratio approach will be described in Chapter VII.

Which Approach to Choose?

- If the appropriate data are available, the preferred choice is the medical cost ratio approach because it directly compares average medical costs per person (including both healthy and ill persons) for treating a particular disease between smokers and never smokers.
- The next preferred choice is the utilization ratio approach because it compares average healthcare utilization per person (including both healthy and ill persons) for treating a particular disease between smokers and never smokers. Although it does not directly compare average healthcare cost, it is related to one of the components in the average health cost per person because the latter can be derived by the product of average healthcare utilization per person (including both healthy and ill persons) and unit cost per utilization. The utilization ratio approach only examines the first component. If the unit cost per utilization is similar between smokers and nonsmokers, these two approaches will yield similar SAF estimates.
- The third preferred choice is the disease incidence ratio approach because it compares the disease incidence rates between smokers and never smokers. Although it does not directly compare average healthcare cost, it is related to one of the components in the average health cost per person because the latter can be derived as the product of disease incidence rate, the average healthcare utilization per ill person with that disease, and the unit cost per utilization.

The disease prevalence ratio approach only examines the first component and does not consider differential access to health insurance and behavioral risk factors between smokers and never smokers. Therefore, it is possible that the disease incidence ratio approach may yield biased SAF estimates compared with the first two approaches.

- If the data necessary for conducting the above three approaches are not available but the RR estimates of mortality rates for smokers relative to never smokers are available, then the mortality ratio approach becomes the only choice. Whether or not the RR of mortality serves as a good proxy for morbidity is important yet understudied. The only exception is the study by Rice and Hodgson (1986), in which they found empirical evidence that using the RR of mortality as a proxy seems to result in an underestimated and conservative proxy for the SAF for medical cost.
- Due to data limitations, it may be the case that none of the four approaches can be employed. In this case, the empirical RR estimates of mortality rates from another country with similar tobacco use patterns and economic environment may be used as a proxy. In Chapter VII and Appendices A-D, we will include several tables of RR estimates for the United States and other countries.

Step 3: Estimate Total Healthcare Expenditures

If a country's total healthcare expenditures are available by type of health services, by smoking-related diseases, and by population subgroups, then the product of these numbers and the corresponding SAF estimates gives the direct cost of smoking or SAE according to Equations (V.1-V-2). While many countries may have national health accounts classified by type of health services such as inpatient care and outpatient care, disease-specific total national healthcare expenditures are usually not available.

Alternatively, national healthcare expenditure for treating a disease i on healthcare service type k among population subgroup j can be estimated by the following expression:

$$THE_{ikj} = POP_j \times Q_{ikj} \times UCOST_{ik} \qquad \text{……… (Eq V.7)}$$

where
POP_j = population size for population subgroup j
Q_{ikj} = average annual healthcare utilization per person for treating a disease i on healthcare service type k among population subgroup j
$UCOST_{ik}$ = average expenditure per unit of utilization for treating a disease i on healthcare service type k

Population Size

The best data source for population is the Population Census or Population Survey data that allows for a tally of the total population in a country broken down by demographic subgroups such as gender, age, race, ethnicity, socioeconomic status, and geographic region. For example, given the scenario assumed earlier in this chapter for Step 1 of estimating the SAE, two population estimates are needed: total male population and total female population.

Average Annual Healthcare Utilization per Person

The most common utilization measures include average number of hospitalizations per person in 12 months, average number of inpatient days per person in 12 months, and average number of outpatient visits per person in 12 months for treating a particular disease. These measures require data on disease-specific annual healthcare utilization per person (including healthy and ill persons) regardless of smoking status. The best data source is national survey data or claims data that contain each individual's disease-specific healthcare utilization and demographic characteristics. Compared with the data required for the utilization ratio approach, these data are relatively easier to obtain because they do not require smoking history information. If the utilization measures in the survey data are expressed by a 2-week or 6-month time frame, they need to be annualized by multiplying by 26 or 2.

Average Expenditure per Unit of Utilization

The most common "unit cost" measures include average expenditure per inpatient hospitalization and average expenditure per outpatient visit for treating a particular disease. Data sources include published estimates, and nationally representative survey or claims data that contain disease-specific treatment cost.

Step 4: Estimate Smoking-Attributable Healthcare Expenditures (SAE)

Once the SAF and THE are estimated, the smoking-attributable health care expenditure (SAE) can be calculated according to the formula in Equations (V.1)-(V.2).

Case Study: China

This case study is based on a published paper, "Economic Burden of Smoking in China, 2000" (Sung et al., 2006).

Step 1: Determine Smoking-Related Diseases, Types of Healthcare Costs and Population Subgroups

In the original paper, the authors combined current and former smokers into one category as "ever smokers" to compare with never smokers. They considered:

- three major categories of smoking-related diseases were considered: cancer (all types of malignant neoplasm), cardiovascular diseases (stroke, ischemic heart disease, rheumatic heart disease), and respiratory diseases (chronic obstructive pulmonary disease, respiratory tuberculosis, pulmonary heart disease)
- three types of healthcare services (inpatient hospitalizations, outpatient visits, self-medications)
- gender (males, females)
- two age groups (35-64, 65+)
- two districts (rural, urban)

For easier illustration, we made the following simplification by considering:

- two diseases -- cancer and respiratory diseases
- two types of healthcare services -- inpatient hospitalizations and outpatient visits
- gender -- males and females
- one age group (35-64)
- one district (urban)

Thus, there are eight combinations of sub-classification groups as illustrated in Table 5.6.

Table 5.6. A case study: estimation of the smoking-attributable expenditures (SAE) by smoking-related diseases, types of healthcare services, and gender among adults aged 35-64 in urban areas, China, 2000

Sub-Groups	Estimate SAF			Estimate THE (US $1,000,000)	SAE ((=SAF x THE) (US $1,000,000)
	Smoking Prevalence (ever smokers)	Relative Risk* (ever smoker)	SAF (from Eq IV.4)		
	P_e (%)	RR_e	%		
CA/Inp/male	65.5	1.62	28.9	$212.1	$61.3
CA/Inp/female	6.1	1.67	3.9	$354.4	$13.8
CA/Outp/male	65.5	1.62	28.9	$129.00	$37.3
CA/Outp/female	6.1	1.67	3.9	$61.5	$2.4
RD/Inp/male	65.5	1.48	23.9	$185.4	$44.3
RD/Inp/female	6.1	2.28	7.2	$134.2	$9.7
RD/Outp/male	65.5	1.48	23.9	$724.8	$173.2
RD/Outp/female	6.1	2.28	7.2	$688.4	$49.6

Source: Sung, Want and et al., 2006
* Liu, Peto and et al., 1998
Note: "Inp" denotes inpatient care, "Outp" denotes outpatient visits, "CA" denotes cancer, and "RD" denotes respiratory diseases.

Step 2: Estimate the SAF of Healthcare Expenditure

- The mortality ratio approach was adopted.
- **Smoking Prevalence for Ever Smokers (P_e).** Because this case study only includes two demographic subgroups: males and females, smoking prevalence rates need to be calculated only by gender. According to China's 1998 National Health Services Survey data, 65.5% of the males aged 35-64 were ever smokers. The corresponding smoking rate for females was 6.1%.
- **Relative Risk for Ever Smokers** (RR_e). Because this case study was based on the mortality ratio approach, the data on the RR of death by disease and gender are needed. The RR estimate does not need to differentiate by type of healthcare services. From a published retrospective mortality study of one million deaths in China by Liu, Peto, et al. (1998), the RR estimates of mortality for ever smokers were obtained.
- **SAF.** Based on the mortality ratio approach, the SAF of deaths from a disease is assumed to be the SAF of inpatient expenditure for treating this disease and also the SAF of outpatient expenditure for treating this disease. According to Equation (IV.4), the following SAF estimates for deaths from cancer (CA) and from respiratory diseases (RD) are calculated. The results are also shown in Column 4 of Table 5.6.

SAF of deaths from CA for males = (0.345 + 0.655 x 1.62 – 1) / (0.345 + 0.655 x 1.62) = 28.9%

SAF of deaths from CA for females = (0.939 + 0.061 x 1.67 – 1) / (0.939 + 0.061 x 1.67) = 3.9%

SAF of deaths from RD for males = (0.345 + 0.655 x 1.48 – 1) / (0.345 + 0.655 x 1.48) = 23.9%

SAF of deaths from RD for females = (0.939 + 0.061 x 2.28 – 1) / (0.939 + 0.061 x 2.28) = 7.2%

Step 3: Estimate Total Healthcare Expenditures (THE)

Population Size for each demographic subgroup. Based on the 2000 Population Census, there were 84.07 million males and 78.96 million females of ages 35-64 in urban areas.

Average Annual Healthcare Utilization per Person and Average Expenditure per Unit of Utilization. From China's 1998 National Health Services Survey data, these measures were obtained by disease category, type of health services and gender as shown below. Note that the unit cost estimates had been adjusted by multiplying a factor of 0.948 so that the self-reported health expenditures from the 1998 NHSS data sum up to China's national health care expenditures in 2000 at $44.5 billion.

Table 5.7. A case study: annual number of hospitalizations and outpatient visits per person, and unit cost per hospitalization and per outpatient visit

Sub-Groups	Inpatient Hospitalization		Outpatient Visits	
	# of hospitalization per person per year	Unit cost per hospitalization (US$1)	# of visits per person per year	Unit cost per visit (US$1)
CA/male	0.001141	$2,211.4	0.025108	$61.1
CA/female	0.001188	$3,777.8	0.017657	$44.1
RD/male	0.004565	$483.2	1.214292	$7.1
RD/female	0.003735	$455.1	1.503056	$5.8

Source: 1998 National Health Services Survey, China

THE. The product of population size, annul number of hospitalizations per person, and the unit cost per hospitalization derives the THE for inpatient care. Likewise, the product of annual number of outpatient visits and the unit cost per visit derives the THE for outpatient care. The results are shown in Column 5 of Table 5.6.

Step 4: Estimate the Smoking-Attributable Health Care Expenditures (SAE)

Given the SAF and THE estimates described above, the smoking-attributable expenditure can be calculated by their product as shown in the last column of Table 5.6.

VI. Estimate the Indirect Morbidity Costs of Smoking

Introduction

This chapter presents the detailed steps for estimating the indirect morbidity costs of smoking using the epidemiological approach. These steps include how to estimate the smoking-attributable fraction (SAF) of indirect morbidity costs. Once the SAF is determined, the product of the SAF and the total measure gives the smoking-attributable measure.

Definition of Indirect Morbidity Costs of Smoking

The indirect morbidity costs of smoking, also called smoking-attributable indirect morbidity costs (SAI), are the economic value of lost productivity by persons who are sick or disabled due to smoking-related diseases. The lost productivity is measured by work-loss days and/or disability days. Some cost-of-smoking studies estimated the indirect morbidity costs by also including the "non-healthcare direct costs" such as those paid to caregivers and for transportation to an inpatient hospitalization or outpatient visit due to smoking-related diseases (Sung et al., 2006; John et al., 2009). Therefore, the smoking-attributable indirect morbidity costs may include two components: those resulting from the productivity losses due to illness (SAI1), and those resulting from non-healthcare payments for caregivers and transportation to healthcare providers (SAI2).

In the epidemiological approach, the SAF is calculated for each smoking-related disease of interest; therefore, the smoking-attributable indirect morbidity costs need to be estimated for each particular smoking-related disease. The smoking-attributable indirect morbidity costs are often estimated by population groups (e.g., gender, age, race, ethnicity, socioeconomic status, and geographic region). Also, those resulting from non-healthcare payments (SAI2) are often estimated by type of healthcare services, while those resulting from productivity losses (SAI1) are not. Finally, based on the additive approach, the sum of the smoking-attributable indirect morbidity cost for each smoking-related disease, each type of healthcare services, and each population subgroup gives the total indirect morbidity costs of smoking in the country.

Formula

The formula to calculate the smoking-attributable indirect morbidity costs (SAI) for disease i among population subgroup j is expressed as:

$$SAI_{ikj} = SAI1_{ij} + \sum_{n=1}^{Nn} (SAI2_{ikj})$$
$$= SAF_{ij} \text{ x } TWLD_{ij} \text{ x } ERN_j + \sum_{n=1}^{Nn} (SAF_{ikj} \text{ x } TNHC_{ikj})$$

……… (Eq VI.1)

where
$SAI1_{ij}$ = smoking-attributable indirect morbidity costs resulting from the productivity losses due to disease i among population subgroup j
$SAI2_{ikj}$ = smoking-attributable indirect morbidity costs resulting from non-healthcare payments to caregivers and for transportation related to the utilization of healthcare service type k due to disease i among population subgroup j
SAF_{ikj} = smoking-attributable fraction of indirect morbidity costs for disease i using healthcare service type k among population subgroup j
$TWLD_{ij}$ = total yearly work-loss days in a country due to disease i among population subgroup j
ERN_j = mean daily earnings or salary for population subgroup j
$TNHC_{ikj}$ = total yearly non-healthcare costs (such as payments to caregivers and for transportation to healthcare providers) in a country related to the utilization of healthcare service type k due to disease i among population subgroup j
N_k = total types of healthcare services

Steps to Estimate the Smoking-Attributable Indirect Morbidity Costs (SAI): An Example

Estimating the SAI comprises five steps:

1. Determine the smoking-related diseases, the type of healthcare services to be included, and the appropriate classification of population subgroups
2. Estimate the SAF of work-loss days and non-healthcare costs using the epidemiological approach
3. Estimate total national work-loss days (TWLD) and total national non-healthcare costs (TNHC) by population groups
4. Estimate the mean daily earnings or salary
5. Estimate the SAI by adding the product of the SAF, TWLD, and mean daily earnings to the product of the SAF and the TNHC for each type of healthcare services.

Note that the estimation for the second component of the SAI — those resulting from non-healthcare payments to caregivers and for transportation (SAI2) — resembles the estimation for smoking-attributable healthcare expenditures (SAE). Therefore, the steps described in the previous chapter are applicable to the estimation of the SAI2 except that the average expenditure per unit of utilization in Equation (V.7) needs to be replaced by the average payments to caregiver and for transportation per unit of utilization. Thus, we will focus from here on describing the estimation steps for the estimation of the first component of the SAI, those resulting from the productivity losses due to illness (SAI1).

Step 1: Determine Smoking-Related Diseases, Types of Healthcare Costs and Population Subgroups

We have already discussed the definition of smoking-related diseases, the type of healthcare services, and potential ways to classify population subgroups in Chapters II and IV. Here we only assume a simple scenario with:

- one smoking-related disease: heart disease
- no differentiation of healthcare services
- four population subgroups classified by gender (males and females), and age (35-64, 65+).

Given this scenario, four sets of SAI estimates need to be calculated for the four combinations of population subgroups (see the first column in Table 6.1). Table 6.1 also shows a template of the steps to estimate the SAI1 based on this scenario.

Table 6.1. Template of the steps to estimate the smoking-attributable indirect morbidity costs resulting from the productivity losses (SAI1) due to heart disease by gender and age

Sub-Groups	Estimate SAF					Estimate TWLD	Estimate ERN	Estimate SAI1 (=SAF x TWLD x ERN)
	Smoking Prevalence		Relative Risk		SAF			
	current smoking P_c	former smoking P_f	current smoking RR_c	Former smoking RR_f	(from Eq IV.5)			
M 35-64	$P_{c,M35-64}$	$P_{f, M35-64}$						
M 65+	$P_{c,M65+}$	$P_{f, M65+}$						
F 35-64	$P_{c,F35-64}$	$P_{f, F35-64}$						
F 65+	$P_{c,F65+}$	$P_{f, F65+}$						

Note: "M" denotes males; "F" denotes females.

Step 2: Estimate the SAF of Indirect Morbidity Costs

To estimate the SAF with the epidemiological approach, two data elements are needed – smoking prevalence rates and relative risk of indirect morbidity costs.

Estimate Smoking Prevalence

We have described how to estimate smoking prevalence in the previous two chapters. Here we simply assume that the prevalence rates of current smokers, former smokers, and never smokers are 55%, 11%, and 34% for males aged 35-64, and are 31%, 29%, and 39% for males aged 65 and older. For females, the corresponding prevalence rates are 19%, 4%, and 77% for those aged 35-64, and 13%, 5%, and 82% for those aged 35-64.

Three Methods to Estimate the SAF of Productivity Losses

There are three approaches to estimate the SAF for productivity losses depending on what relative risk data are available.

Work-loss ratio approach – the RR is calculated by using work-loss days data. This approach requires data on disease-specific annual work-loss days per person stratified by smoking status among employed persons.

Disease incidence ratio approach – the RR is calculated by using disease incidence data. This approach requires data on separate disease incidence rates for smokers and never smokers.

Mortality ratio approach – the RR is calculated by using mortality data. This approach requires data on separate population death rates by underlying cause of death for smokers and never smokers.

Since the disease incidence ration approach and the mortality ratio approach have been described in the previous chapter, we will only describe the work-loss ratio approach below.

Work-Loss Ratio Approach

In this approach, the SAF of the "work-loss days" due to illness from disease i is calculated directly by using the RR of "work-loss days" for this disease.

RR of work-loss days for disease i =
(average annual work-loss days per employed smoker for disease i) /
(average annual work-loss days per employed never smoker for disease i)

…. (Eq VI.2)

Note that both the numerator and denominator are based on per person work-loss days for all people (including healthy and ill persons) rather than just those who have the disease of interest.

Table 6.2. An example of average annual work-loss days per employed male and female aged 35-64 due to illness from heart disease by smoking status

	Annual work-loss days per employed male	Annual work-loss days per employed female
Current smoker	345	431
Former smoker	283	393
Never smoker	237	315

Then, the following RR estimates can be calculated.

RR of work-loss days for current smokers among males aged 35-64 = 345 / 237 = 1.46

RR of work-loss days for former smokers among males aged 35-64 = 283 / 237 = 1.19

RR of work-loss days for current smokers among females aged 35-64 = 431 / 315 = 1.37

RR of work-loss days for former smokers among females aged 35-64 = 393 / 315 = 1.25

Based on Equations (IV.5)-(IV.5c) and the above assumed smoking prevalence rates, the SAF of work-loss days due to illness from heart disease for employed males aged 35-64 can be calculated by:

Total SAF of work-loss days for ever smokers = [(0.34 + 0.55 x 1.46 + 0.11 x 1.19) – 1] / [(0.34 + 0.55 x 1.46 + 0.11 x 1.19)] = 21.5%

SAF of work-loss days for current smokers = [0.55 x (1.46 – 1)] / [(0.34 + 0.55 x 1.46 + 0.11 x 1.19)] = 19.9%

SAF of work-loss days for former smokers = [0.11 x (1.19 – 1)] / [(0.34 + 0.55 x 1.46 + 0.11 x 1.19)] = 1.6%

Therefore, among all males aged 35-64, 21.5% of the national annual work-loss days are attributable to smoking, including

19.9% attributable to current smokers and 1.6% attributable to former smokers.

Which Approach to Choose?

- If the appropriate data are available, the preferred choice is the work-loss ratio approach because it directly compares the average work-loss days per person (including both healthy and ill persons) for a particular disease between smokers and never smokers.
- The next preferred choice is the disease incidence ratio approach because it compares the disease incidence rates between smokers and never smokers. Although it does not directly compare the average work-loss days, it is related to one of the components in the average work-loss days per employed person because the latter can be derived by the product of disease incidence rate and the average work-loss days per ill person with that disease. The disease prevalence ratio approach only examines the first component and does not consider differential work-loss days between sick smokers with a disease and sick never smokers with that disease. Therefore, it is possible that the disease incidence ratio approach may yield biased SAF estimates compared to the first approach.
- If the data necessary for conducting the above two approaches are not available but the RR estimates of mortality rates for smokers relative to never smokers are available, then the mortality ratio approach becomes the only choice.
- If none of the data required for these three approaches exist, then the empirical RR estimates of mortality rates from another country with similar tobacco use patterns and economic environment may be used as a proxy. In Chapter VII and Appendices A-D, we will include several tables of RR estimates for the United States and other countries.

Step 3: Estimate Total National Work-Loss Days

A country's total number of work-loss days due to disease i among population subgroup j can be estimated by the following expression:

$$TWLD_{ij} = POP_j \times EMPLOY_j \times QW_{ij} \quad \text{......... (Eq VI.9)}$$

where

POP_j = population size for population subgroup j

$EMPLOY_j$ = labor force participation rate, which is defined as the proportion of the total population who are currently employed, for population subgroup j

QW_{ik} = average number of work-loss days per employed person per year due to disease i among population subgroup j

Population Size

See the description in the previous chapter.

Labor Force Participation Rate

Data sources include published national estimates, and nationally representative survey data which contain each individual's employment status.

Average Annual Work-Loss Days per Employed Person

The best data source is national surveys which contain each respondent's employment status, work-loss days, and the medical conditions which caused these work-loss days, and demographic characteristics. If work-loss days are not available in the survey data, the total number of hospitalization days may be used as a proxy measure for work-loss days. If the work-loss days are expressed by a 2-week or 1-month time frame, they need to be annualized by multiplying by 26 or 12.

Step 4: Estimate the Mean Daily Earnings

Mean daily earnings are derived by dividing the average annual salary or wages by 356. Some studies also derive mean daily earnings by dividing per capita Gross National Product (GNP) by 365 (Jin and Lu et al., 1995).

Step 5: Estimate the Smoking-attributable Indirect Morbidity Costs

Once the SAF, TWLD, and mean daily earnings are estimated, their product derives the smoking-attributable indirect morbidity costs resulting from the productivity losses due to illness (SAI1) according to the formula in Equation (VI.1).

Case Study: China

This case study is drawn from a published paper, "Economic Burden of Smoking in China, 2000" (Sung et al., 2006).

Step 1: Determine Smoking-Related Diseases, Types of Healthcare Costs and Population Subgroups

In the original paper, the authors combined current and former smokers into ever smokers to compare with never smokers. They only considered the productivity losses due to smoking-related illness, and did not include non-healthcare payments to caregivers and for transportation to visit healthcare providers. Other considerations include:

- three major categories of smoking-related diseases: cancer, cardiovascular diseases, and respiratory diseases
- gender (males, females)
- two age groups (35-64, 65+)
- two districts (rural, urban)

For easier illustration, we focus on a simplified consideration:

- three major categories of smoking-related diseases: cancer, cardiovascular diseases, and respiratory diseases
- only females
- two age groups (35-64, 65+)
- one district (urban)

Thus, there are six combinations of sub-classification groups as illustrated in Table 6.3.

Table 6.3. A case study: estimate the smoking-attributable indirect morbidity costs resulting from work-loss days due to illness (SAI1) by smoking-related diseases and age among female adults in urban areas, China, 2000

Sub-Groups	Estimate SAF			Estimate TWLD	Estimate ERN	Estimate SAI1 (=SAF x TWLD x ERN)
	Prevalence of ever smokers	Relative Risk* (ever smokers)	SAF (from Eq. IV.4)			
	P_e (%)	RR_e	%	1,000,000 days	US$1	US$1,000
CA,35-64	5.3	1.21	1.1	10.3	1.13	128
CA,65+	10.3	1.21	2.1	5.8	1.13	138
CVD,35-64	5.3	0.92	0.0#	255.2	1.13	0
CVD,65+	10.3	0.92	0.0#	71.0	1.13	0
RD,35-64	5.3	1.43	2.2	604.2	1.13	15,020
RD,65+	10.3	1.43	4.2	87.7	1.13	4,162
Total						19,448

Source: Sung and Wang et al. (2006)

Note: "CA" denotes cancer, "CVD" denotes cardiovascular diseases, and "RD" denotes respiratory diseases. * Liu, Peto and et al., 1998. # The SAF was assumed to be zero because the estimated RR was less than one.

Step 2: Estimate the SAF of Work-Loss Days

- The mortality ratio approach was adopted.
- **Smoking Prevalence (P_e).** According to the 1998 National Health Services Survey data, the prevalence rates of ever smokers in the rural areas were 5.3% for females aged 35-64, and 10.3% for females aged 65+, respectively.
- **Relative Risk** (RR_e). According to Liu, Peto et al. (1998), the RRs of dying from cancer, cardiovascular diseases, and respiratory diseases for ever smokers relative to never smokers were 1.21, 0.92, and 1.43, respectively among rural women aged 35-69. Sung et al. (2006) applied these RR estimates to both age groups (35-64, 65+) for rural women.
- **SAF.** Based on the mortality ratio approach, the SAF of death is assumed to be the SAF for work-loss days. According to Equation (IV.4), the following SAF estimates for death from cancer are calculated.

SAF of work-loss days due to cancer for rural women aged 35-64 = (0.947 + 0.053 x 1.21 – 1) / (0.947 + 0.053 x 1.21) = 1.1%

SAF of work-loss days due to cancer for rural women aged 65+ = (0.897 + 0.103 x 1.21 – 1) / (0.897 + 0.103 x 1.21) = 2.1%

Similarly, other SAF estimates are calculated for rural women for work-loss days due to cardiovascular diseases and respiratory diseases as shown in Column 4 of Table 6.6.

Step 3: Estimate Total National Work-Loss Days (TWLD)

- **Population Size** for each demographic subgroup. Based on the 2000 Population Census, there were 127.47 million females aged 35-64 and 31.19 million females aged 65+ in the rural areas.
- **Average Annual Work-Loss Days per Person.** According to China's 1998 National Health Services Survey data, average annual work-loss days per person were estimated by type of smoking-related diseases and age group for rural women as shown in Table 6.4.

Table 6.4. Average number of work-loss days per person per year by smoking-related diseases and age among female adults in urban areas, China, 2000

Sub-Groups	# of work-loss days per person per year
CA,35-64	0.0806
CA,65+	0.1846
CVD,35-64	2.0020

CVD,65+	2.2776
RD,35-64	4.7398
RD,65+	2.8106

Source: 1998 National Health Services Survey, China

Note: “CA” denotes cancer, “CVD” denotes cardiovascular diseases, and “RD” denotes respiratory diseases.

- **Total national Work-Loss Days (TWLD).** The product of population size and average number of work-loss days per person per year derives the total annual work-loss days in the country. The results are shown in Column 5 of Table 6.6.

Step 4: Estimate the Mean Daily Earnings (ERN)

The mean daily earnings for rural women was estimated by the product of per capita annual net income of rural households and the average number of rural residents supported by the rural working population in year 2000, and then divided by 366. The results are shown in Column 6 of Table 6.6.

Step 5: Estimate the Smoking-Attributable Indirect Morbidity Costs

Given the SAF, TWLD, and ERN described above, the smoking-attributable indirect morbidity costs resulting from the productivity losses (SAI1) can be calculated by their product as shown in the last column of Table 6.3.

VII. Estimate the Indirect Mortality Costs of Smoking

Introduction

This chapter presents the detailed steps for estimating the indirect mortality costs of smoking using the epidemiological approach.

Definition of Indirect Mortality Cost of Smoking

The indirect mortality costs of smoking, also called smoking-attributable indirect mortality costs (SAMC), are defined as the value of lives lost due to smoking-caused premature death.

Another way to measure the value of live is in terms of the number of years of potential life lost (YPLL), which indicates how many more years an individual would have lived had they not died prematurely from a smoking-related disease. The YPLL is determined by the number of years of life expectancy remaining at the age of death.

Formula

Based on the human capital approach, the smoking-attributable mortality costs (SAMC) due to dying from disease i among population subgroup j can be estimated according to the following formula:

$$SAMC_{ij} = SAF_{ij} \text{ x } \sum_{a=MINa}^{MAXa} (TDEATH_{ija} \text{ x } PVLE_{ja})$$

……… (Eq VII.1)

where
SAF_{ij} = smoking-attributable fraction of death from disease i for population subgroup j
$TDEATH_{ija}$ = total number of deaths from disease i for population subgroup j (note that death data are usually available only by gender and age) whose age at death is within the 5-year age group "a"
$PVLE_{ja}$ = total discounted present value of lifetime earnings for population subgroup j whose age is within the 5-year age group "a"

MINa = minimum age group
MAXa = maximum age group (e.g., age 85+)

Similarly, the smoking-attributable years of potential life lost (SAYPLL) due to dying from disease i among population subgroup j can be estimated by the following formula:

$$SAYPLL_{ij} = SAF_{ij} \text{ x } \sum_{a=MINa}^{MAXa} (TDEATH_{ija} \text{ x } YLIFE_{ja})$$
……… (Eq VII.2)

where
SAF_{ij} = smoking-attributable fraction of death from disease i for population subgroup j
$TDEATH_{ija}$ = total number of deaths from disease i for population subgroup j whose age at death is within the 5-year age group "a"
$YLIFE_{ja}$ = average number of years of life expectancy remaining at the time of death for population subgroup j (note that life expectancy data are usually available only by gender and age) whose age at death is within the 5-year age group "a"
MINa = minimum age group
MAXa = maximum age group (e.g., age 85+)

Steps to Estimate the Smoking-Attributable Indirect Mortality Costs (SAMC): An Example

Estimating the SAMC and SAYPLL involves six steps:

1. Determine the smoking-related diseases, and the appropriate classification of population subgroups
2. Estimate the SAF of mortality
3. Estimate the total number of deaths in the country for the disease of interest (TDEATH)
4. Estimate the present value of lifetime earnings (PVLE)
5. Determine the years of remaining life expectancy (YLIFE)
6. Estimate the SAMC as the product of the SAF, TDEATH, and PVLE. Similarly, estimate SAYPLL as the product of SAF, TDEATH, and YLIFE.

Step 1: Determine Smoking-Related Diseases and Population Subgroups

As shown in Equations (VII.1)-(VII.2), the estimation of the smoking-attributable mortality costs requires the breakdown of age into 5-year categories. For illustration purpose, we assume a simple scenario with:

- one smoking-related disease: heart disease
- only males 35 years of age or older

Given this scenario, eleven sets of SAMC estimates need to be calculated for eleven 5-year age subgroups from 35-39 till the maximum age group 85+ (see the first column in Table 7.1). Table 7.1 also shows a template of the steps to estimate the SAMC and SAYPLL based on this scenario.

Table 7.1. Template of the steps to estimate the smoking-attributable indirect mortality costs (SAMC) and smoking-attributable years of potential life lost (SAYPLL) for heart disease by age, among males aged 35+

Sub-Groups	Estimate SAF					Estimate TDEATH	Estimate PVLE	D Determine YLIFE	Estimate SAMC (= SAF x TDEATH x PVLE)	Estimate SAYPLL (= SAF x TDEATH x YLIFE)
	Smoking Prevalence		Relative Risk		SAF					
	current smoking P_c	former smoking P_f	current smoking RR_c	former smoking RR_f	(from Eq IV.5)					
35-39										
40-44										
45-49										
50-54										
55-59										
60-64										
65-69										
70-74										
75-59										
80-84										
85+										

Step 2: Estimate the SAF of Mortality

To estimate the SAF of mortality with the epidemiological approach, two data elements are needed: (1) smoking prevalence rates or smoking impact ratio, and (2) the relative risk of mortality.

Estimate Smoking Prevalence or Smoking Impact Ratio (SIR)

We have described how to estimate smoking prevalence in the previous chapters. Here we simply assume that smoking prevalence data are only available for two age groups: 35-64, and 65+ years old. The prevalence rates of current smokers, former smokers, and never smokers are 55%, 11%, and 34% for males aged 35-64, and are 46%, 18%, and 36% for males aged 65+.

The estimation of SIR is described in the end of this section.

Mortality Ratio Approach to Estimate the SAF of Mortality

According to the mortality ratio approach, the calculation of the SAF of mortality caused by a disease is based on the estimated relative risk (RR) of mortality caused by that disease for smokers relative to never smokers.

Assuming the death rates from heart disease among males aged 35+ are 138.5 per 100,000 persons for never smokers, while the corresponding death rates are 222.4 and 171.9 per 100,000 persons for current and former smokers, respectively, as exemplified in Table 5.5 of Chapter V. Following Equation

(V.6), the RR of mortality for current and former smokers is equal to:

RR of heart disease mortality for current smokers = 222.4 / 138.5 = 1.61

RR of heart disease mortality for former smokers = 171.9 / 138.5 = 1.24

Given the RR of mortality estimates and the above assumed smoking prevalence rates, we can use Equations (IV.5)-(IV.5c) to calculate the SAF of heart disease mortality as follows.

Total SAF of mortality from heart disease for male ever smokers aged 35-64 = [(0.34 + 0.55 x 1.61 + 0.11 x 1.24) – 1] / [(0.34 + 0.55 x 1.61 + 0.11 x 1.24)] = 26.5%

SAF of mortality from heart disease for male current smokers aged 35-64 = [0.55 x (1.61 – 1)] / [(0.34 + 0.55 x 1.61 + 0.11 x 1.24)] = 24.6%

SAF of mortality from heart disease for male former smokers aged 35-64 = [0.11 x (1.24 – 1)] / [(0.34 + 0.55 x 1.61 + 0.11 x 1.24)] = 1.9%

Total SAF of mortality from heart disease for male ever smokers aged 65+ = [(0.36 + 0.46 x 1.61 + 0.18 x 1.24) – 1] / [(0.36 + 0.46 x 1.61 + 0.18 x 1.24)] = 24.5%

SAF of mortality from heart disease for male current smokers aged 65+ = [0.46 x (1.61 – 1)] / [(0.36 + 0.46 x 1.61 + 0.18 x 1.24)] = 21.2%

SAF of mortality from heart disease for male former smokers aged 65+ = [0.18 x (1.24 – 1)] / [(0.36 + 0.46 x 1.61 + 0.18 x 1.24)] = 3.3%

Therefore, among males aged 35-64, 26.5% of heart disease deaths are attributable to smoking, including 24.6% attributable to current smokers and 1.9% attributable to former smokers. As for males aged 65+, 24.5% of heart disease deaths are attributable to smoking, including 21.2% attributable to current smokers and 3.3% attributable to former smokers.

How to Estimate Disease-Specific RR of Mortality

As mentioned above, one key element of estimating the SAF of mortality is to determine the RR of mortality for smokers compared to never smokers. Three epidemiologic approaches have been used in the literature to estimate the disease-specific RR of mortality for smoking or tobacco use — (1) prospective cohort studies of smoking and mortality (Garfinkel, 1985; Doll and Peto, 1976; Thun and Day-Lally et al., 1997; Thun and Apicella et al., 2000; Gupta and Pednekar et al., 2005; Gu and Kelly et al., 2009), (2) retrospective case-control studies of smoking and mortality (Gajalakshmi and Peto., 2003; Jha and Jacob et al., 2008), and (3) retrospective proportional mortality studies (Liu and Peto et al., 1998).

Describing how to conduct these epidemiologic studies is beyond the scope of this toolkit. However, a brief description of each approach follows. Generally speaking, a prospective cohort study recruits a cohort representative of the targeted population and the endpoint of the prospective cohort study is mortality. At the time of recruitment, personal interviews are conducted to collect each individual's smoking or tobacco use history, and socio-demographic characteristics. Several years later, follow-up interviews are conducted to ascertain whether the individual is alive or not. For those individuals reported as dead, the date, place, and cause of death are recorded. By using survival analysis regression, relative risks of mortality for smokers compared to never smokers can be estimated.

In a retrospective case-control study of smoking and mortality, cases are adults who died in particular years and whose households could be visited by interviewers to determine from the surviving family members the smoking history or other tobacco use habits, socio-demographic characteristics, and the cause of death of the decedent. Controls are adults living in a household where a family member died in the same years and same areas as cases. Controls' smoking habits and socio-demographic characteristics are also collected by interviewers. By using logistic regression on the association between smoking and the outcome of being dead, relative risks of mortality for smokers compared to never smokers can be estimated.

In a retrospective proportional mortality study, surviving family members of persons who died in particular years are interviewed to determine whether the dead person had been a smoker before a certain year. Because most of the excess mortality among smokers is from cancer, respiratory, and vascular diseases, the smoking habits of adults who had died of these causes are compared with the habits of those who had died of other causes (the reference group). Based on logistic regression, differences between the proportions of smokers in the reference group and in people who died of cancer, respiratory, or vascular causes can be used to calculate the risk ratios of mortality for smokers versus never smokers.

Existing Estimates of Disease-Specific RR of Mortality

Due to the resource intensity involved, nationally representative epidemiologic studies of smoking and mortality are not available for most developed or developing countries. Only a handful of countries have estimated their population-based RRs of mortality for smoking. In the Appendix of this toolkit, we show existing RR estimates from several selected studies of large-scale population-based sample of both males and females for countries including the United States (Appendix Table 1), China (Appendix Table 2-3), India (Appendix Table 4-5), and Taiwan (Appendix Table 6). These estimates may be applied as a proxy to other countries with similar tobacco use patterns, lifestyles, and economic environment.

As for the guidance of how to choose among alternative sources of existing RR estimates, one should use the most recent estimates available for the purpose of the study at hand. For example, Appendix Table 3 shows the latest RR estimates of mortality for cigarette smokers compared to never smokers in China from a nationally representative prospective cohort who were evaluated during 1991-2000. These RRs were estimated by type of diseases and gender, but not by urban and rural areas. Appendix Table 2 also shows the RR estimates of mortality for cigarette smokers compared to never smokers in China. These RRs were available by type of diseases, gender, and urban/rural areas; however, they were estimated from a nationally representative retrospective cohort of one million deaths during earlier years, 1986-1988. Between these two sources of RRs, if the study purpose requires distinguishing urban from rural population, one would choose the RR estimates in Appendix Table 2 even if they were not the latest estimates for China.

Another example is the case for India. Appendix Table 4 shows the latest RR estimates of mortality for cigarette/bidis smokers compared to never smokers in India from a nationally representative retrospective cohort of 152,000 men and women during 2001-2003. These RRs were estimated by type of diseases, gender, and urban/rural areas; however, the risk of mortality for smokeless tobacco use was not examined. On the other hand, Appendix Table 5 shows the RRs of mortality for cigarette/bidis smokers as well as for smokeless tobacco users compared to never tobacco users; however, they were estimated from data in earlier years, 1992-1999, and the study cohort was recruited in Bombay only. Between these two sources of RRs for India, if the study purpose is to estimate the smoking-attributable mortality for smokeless tobacco use, one would choose the RR estimates in Appendix Table 5 even if they were not the latest estimates and not derived from nationally representative sample for India.

Among the existing disease-specific RR estimates of mortality, the mostly widely used are those derived from the American Cancer Society's Cancer Prevention Study II (CPS-II) in the United States. The CPS-II is the largest and most recent prospective study of smoking, diseases, and mortality in the United States, with a cohort of 1.2 million Americans aged 30 years or older when they completed a questionnaire in 1982. The participants were recruited from 50 states, the District of Columbia, Puerto Rico, and Guam, and their vital status was followed up through personal inquiry.

The RR estimates from the 4-year follow-up (1982-1986) of CPS-II have been used to estimate smoking-attributable mortality in the United States (US DHHS, 1989), California (Max and Rice et al., 2002), and other countries including Canada (Tanuseputro and Manuel et al., 2005). They have also have been adopted in a SAMMEC II software (Schultz et al., 1990; Schultz et al., 1991) that has been distributed by the United States Centers for Disease Control and Prevention to estimate smoking-attributable mortality, morbidity and economic costs. The RR estimates from the 6-year follow-up (1982-1986) of CPS-II have been used more recently to estimate smoking-attributable mortality in the United States (CDC, 2002; CDC, 2008) and other countries including Germany (Neubauer and Welte et al., 2005), and they have been adapted in a more recent internet-based version of the SAMMEC software (CDC, 2010) that is available on the United States Centers for Disease Control and Prevention website (https://apps.nccd.cdc.gov/sammec/edit_risk_data.asp)

Smoking Impact Ratio Method to Extrapolate Existing Estimates of Disease-Specific RR of Mortality for One Country to Estimate the SAF of Mortality for Another Country

For countries without their own population-based RR estimates of mortality for smoking, Peto and Lopez et al (1992) developed a smoking impact ratio (SIR) measure and an indirect extrapolation method which applies the estimated age-gender-specific SIRs and the age-gender-specific RRs obtained from the 1984-1988 follow-up of CPS-II tothe smoking-attributable fraction (SAF) formula. They have used this method to estimate smoking-attributable mortality for 44 developed countries (Peto and Lopex et al., 1996). This indirect method can be broken down into three steps.

First, the SIR which captures the accumulated hazard of smoking as defined in Chapter IV is used as a proxy for the “synthetic smoking prevalence”, F, for the study country. This extrapolation method assumes that never smokers' lung cancer death rates obtained from CPS-II population approximate never smokers' lung cancer death rates in the study country, and that the lung cancer mortality rate is composed of the lung cancer mortality rates of smokers and never smokers as described by the following equation:

$$C_{LCj} = F_j \times S_{LC}{}^{*}{}_{j} + (1 - F_j) \times N_{LC}{}^{*}{}_{j} \quad \text{……… (Eq VII.3)}$$

where

C_{LCj} = lung cancer death rate for population subgroup j in the study country

$S_{LC}{}^{*}{}_{j}$ = lung cancer death rate for smokers obtained from CPS-II population

$N_{LC}{}^{*}{}_{j}$ = lung cancer death rate for never smokers obtained from CPS-II population

F_j = synthetic smoking prevalence for population subgroup j in the study country

Second, the synthetic smoking prevalence (or SIR)in the study country can be solved from Equation (VII.3) as”

$$F_j = (C_{LCj} - N_{LC}^*) / (S_{LC}^{*}{}_j - N_{LC}^*) \quad \text{……… (Eq VII.4)}$$

The estimated synthetic smoking prevalence (or SIR) is then applied to the standard SAF formula for lung cancer mortality according to the following formula:

$$SAF_{LCj} = \frac{F_j \text{ x } (RR_{LC} - 1)}{F_j \text{ x } (RR_{LC} - 1) + 1} \text{ x } 100\% \quad \text{……… (Eq VII.5)}$$

where
SAF_{LCj} = SAF of death from lung cancer (LC) for population subgroup j in thestudy country
RR_{LC} = relative risk of mortality from lung cancer (LC) for smokers obtained from CPS-II population

Third, for causes of death other than lung cancer, the excess risk associated with smokers (excess risk = RR -1) is assumed to be halved to compensate for possible confounding factors that were not adjusted in the original RRs estimates from CPS-II data. Thus, the SAF of mortality for other diseases is estimated by:

$$SAF_{kj} = \frac{F_j \text{ x } (RR_k - 1)}{F_j \text{ x } (RR_k - 1) + 2} \text{ x } 100\% \quad \text{……… (Eq VII.6)}$$

where
SAF_{kj} = SAF of death from diseases other than lung cancer (k) for population subgroup j in the study country
RR_k = relative risk of mortality from diseases other than lung cancer (k) for smokers obtained from CPS II population

More details of the abovemethod are described by Bronnum-Hansen and Juel (2000) and Tanuseputro and Manuel et al. (2005). Note that the rationale of halving the excess risk is because the RR estimates derived from the CPS-II by Peto and Lopez et al (1992) were adjusted for age and gender only, but not adjusted for other demographic characteristics and confounding factors such as alcohol consumption. However, halving the excess risk is crude and arbitrary.

These two issues were fixed in more recent SIR studies (Ezzati, Henley, and Thun et al., 2005; Ezzati and Henley et al., 2005). First, they re-estimated the RRs from the 1982-1988 CPS-II data by adjusting for many risk factors including education, marital status, employment, fruit and vegetable intake, vitamin use, alcohol use, aspirin use, body weight status, physical activity, and dietary fat consumption. Second, they modified the SIR formula by including an adjustment factor due to regional or country-specific differences in the background risks of specific cause of death. Background risks vary because of regional or country-specific differences in nutritional, behavioral, and environmental factors and healthcare care systems, all with important population-specific dynamics and potentially different biologic mechanisms. For example, coal is used for household heating and/or cooking in many regions of China and has caused high background mortality from lung cancer (Smith et al., 2004; Florig 1997). The adapted SIR formula is what we have described in Equation (IV.2) but we restate it below.

$$SIR = \frac{C_{LC} - N_{LC}}{S_{LC}^{*} - N_{LC}^{*}} \times \frac{N_{LC}^{*}}{N_{LC}}$$

This SIR is calculated by age and gender. The age groups include 30 to 44, 45 to 59, 60 to 69, 70 to 79, and 80 years and older. The adapted SIR differs from Equation (VII.4) by including the adjustment factor, N_{LC}^{*}/ N_{LC}, and requiring the data of lung cancer mortality rate among never smokers (N_{LC}). While country-specific lung cancer mortality rate for all persons (C_{LC}) can be obtained from the WHO Global Burden of Disease database, the data requirement for lung cancer mortality rate for never smokers (N_{LC}) may be a challenge for some developing countries. Details of using the SIR method to estimate the SAF of mortality can be found elsewhere (Ezzati, Henley, and Thun et al., 2005; Ezzati and Henley et al., 2005). In the Appendix of this toolkit, we show risk-adjusted RRs of mortality re-estimated from the CPS-II data by the authors of these adapted SIR studies (Appendix Table 7).

Step 3: Estimate Total Number of Deaths (TDEATH)

For countries with national vital statistics systems, 5-year age-specific annual number of deaths in the country by cause of death and population subgroups such as gender, race, ethnicity, and geographic region can be easily obtained. Moreover, the World Health Organization (WHO) has routinely published mortality data for all member countries in selected years (Lopez and Ahmad et al., 2002; WHO, 2010a). The WHO mortality data include both total annual number of deaths and death rate per 100,000 population by causes of death, and gender for three age groups (0-14, 15-59, 60+) (WHO, 2010b). However, the WHO mortality data are not reported by 5-year age group.

For countries without any existing sources for mortality data, it will be necessary to collect disease-specific mortality data from a nationally representative sample so as to estimate the population-based mortality rates by cause of death, gender, and 5-year age group. One way to collect such data is to adopt the verbal autopsy approach which will be described in the next chapter. Once the disease-specific mortality rates by age and other population subgroup are estimated for a particular year, they can be applied to the country's census population in that year to derive the annual total disease-specific deaths for each population subgroup.

Step 4: Estimate the Present Value of Lifetime Earnings (PVLE)

The PVLE per person can be estimated by gender and 5-year age group using an approach developed by Max and Rice et al. (2004b). This approach takes into account life expectancy for different gender and age groups, varying rates of labor force participation, changing patterns of earnings at successive ages, and a discount rate to convert a stream of earnings into current worth. It predicts the future pattern of earnings and labor force participation rates by assuming that people will be working and productive during their lifetimes in accordance with the current pattern of earnings and work experience for their gender and age groups. The data elements required include: 1) remaining life expectancy, 2) proportions of the population participating in the labor force by gender and age, and 3) earnings by gender and age. The formula to calculate the PVLE is specified as follows:

$$PVLE_{ag} = \sum_{n=a}^{MAX} (SURV_{ag}(n)) \times [Y_g(n) \times E_g(n)+ YH_g(n) \times EH_g(n)] \times (1+V)^{n-a} / (1+r)^{n-a}$$

where

$PVLE_{ag}$ = present discounted value of lifetime earnings for a person of age a and gender g

$SURV_{ag}(n)$ = the probability that a person of age a and gender g will survive to age n

a = the age of the person at death

MAX = maximum age group (e.g., age 85)

g = the gender of the person

$Y_g(n)$ = the mean annual earnings of an employed person of gender g and age n

$E_g(n)$ = the proportion of the population of gender g and age n that are employed in the labor market

$YH_g(n)$ = the mean annual imputed value of household production for a person of gender g and age n

$EH_g(n)$ = the proportion of the population of gender g and age n that are doing housekeeping

V = the growth rate of labor productivity

r = the discount rate

More details of the PVLE estimation are available in Max and Rice et al. (2004b).

Step 5: Estimate the Remaining Life Expectancy

Life expectancy by 5-year age group and gender is available in the vital statistics of many countries. Beginning with the year 1999, WHO has also produced annual life expectancy tables for all member countries (WHO, 2010a).

Step 6: Estimate the Smoking-Attributable Mortality Costs

Once the SAF, TDEATH, PVLE, and YLIFE are estimated, the product of the SAF, TDEATH, and PVLE in 5-year age groups derives smoking-attributable mortality costs (SAMC) according to Equation (VII.1). Similarly, the product of SAF, TDEATH, and YLIFE in 5-year age groups derives smoking-attributable years of potential life lost (SAYPLL) according to Equation (VII.2).

Case Study: China

This case study is based on the published paper by Sung et al (2006).

Step 1: Determine Smoking-Related Diseases, and Population Subgroups

For illustration purpose, we only focus on:

- one disease category -- cancer (CA)
- one gender -- males
- all ages -- 35+
- one district -- rural

Thus, there are eight sub-classification groups as illustrated in Table 7.2.

Table 7.2 A case study: estimate the smoking-attributable mortality cost (SAMC) of dying from cancer among males aged 35+ in rural areas, China, 2000

Sub-Group	Estimate SAF			Estimate total # of cancer deaths (TDEATH)				Estimate PVLE	Estimate SAMC	
	Prevalence of ever smokers	Relative Risk	SAF (from Eq. 2)	Population	Death rate	Death number	Adjusted death number		SA cancer deaths	SAMC (=SAF x TDEATH x PVLE)
	P_e (%)	RR_e	%		1/1000			US$1		US$1
35-39	73.73	1.48	26.14	32,871,502	0.6037	19,845	24,972	30,042	6,528	196,105
40-44	73.73	1.48	26.14	24,744,004	1.0473	25,914	32,610	22,181	8,524	189,076
45-49	73.73	1.48	26.14	27,694,279	1.9482	53,954	67,894	16,011	17,747	284,155
50-54	73.73	1.48	26.14	21,341,811	2.7314	58,293	73,354	11,207	19,175	214,891
55-59	73.73	1.48	26.14	15,984,347	3.7080	59,270	74,583	7,522	19,496	146,649
60-64	73.73	1.48	26.14	14,155,101	5.8148	82,309	103,575	4,842	27,075	131,095
65-69	63.85	1.48	23.46	11,420,743	8.1426	92,995	117,021	2,981	27,453	81,838
70-74	63.85	1.48	23.46	8,219,961	11.0045	90,457	113,827	1,751	26,704	46,758
75-59	63.85	1.48	23.46	4,884,268	11.7822	57,547	72,415	1,005	16,989	17,074
80-84	63.85	1.48	23.46	2,199,509	11.7579	25,862	32,543	583	7,635	4,451
85+	63.85	1.48	23.46	895,686	10.1150	9,060	11,401	288	2,675	770
Total									179,999	1,312,862

Source: Sung and Wang et al .(2006); Liu and Peto et al. (1998)

Step 2: Estimate the SAF of Mortality

- **Smoking Prevalence (P_e).** From the 1998 National Health Services Survey (NHSS) data, 73.73% of males aged 35-64 were ever smokers. The corresponding smoking rate for males aged 65+ was 63.85%%.
- **Relative Risk** (RR_e). From a published retrospective mortality study of one million deaths in China by Liu, Peto, and et al. (1998), the RR of dying from cancer for ever smokers was 1.48 for men in rural areas.
- **SAF.** The SAF of deaths can be calculated with Equation (IV.4) as follows:

SAF of death from cancer for rural males aged 35-64 = (0.2627 + 0.7373 x 1.48 – 1) / (0.2627 + 0.7373 x 1.48) = 26.14%

SAF of death from cancer for rural males aged 65 and older = (0.3615 + 0.6385 x 1.48 – 1) / (0.3615 + 0.6385 x 1.48) = 23.46%

Step 3: Estimate Total Number of Deaths

- **Population size** for each demographic subgroup. Based on the 2000 Population Census, the male population for urban areas is shown in the Column 5 of Table 7.2.
- **Cancer death rates** per 1000 persons were obtained from the 2000 Vital Registration system monitored by China's Ministry of Health. The cancer death rates for males in

urban areas by 5-year age group are shown in Column 6 of Table 7.2.

- **Total number of cancer deaths.** The product of population size and cancer death rate gives the estimated total number of cancer deaths as shown in Column 7 of Table 7.2.
- **Adjusted total number of cancer deaths.** Total numbers of cancer deaths were rescaled using the Life Tables reported by the World Health Organization (WHO, 2000) as a gold standard. First, total number of deaths from each underlying cause of death, rural/urban, and 5-year age group was calculated for all males aged 0 and older. Second, these numbers of deaths were summed up by cause of death, rural/urban, and all age groups to derive the total male deaths in China. Third, the ratio of total male deaths to the total male population was calculated. This ratio was compared to the ratio of total male deaths to the total male population reported by the WHO (2000). An adjustment factor, 1.25836, was derived by dividing the latter ratio by the former ratio. Multiplying 1.25836 by the total number of cancer deaths derived the adjusted total number of cancer deaths as shown in Column 8 of Table 7.2.

Step 4: Estimate the PVLE

- The PVLE estimates by gender for both urban and rural areas are shown in Table 7.3. The estimates for males aged 35+ in rural areas are also shown in Column 9 of Table 7.2.

Table 7.3 Example of PVLE* in China, 2000, by Urban/Rural District, Gender, and Age. (Unit: US$1)

	Urban		Rural	
Age (years)	Male	Female	Male	Female
<1	238,235	158,620	189,567	185,462
1-4	218,518	145,609	173,878	170,249
5-9	177,523	118,246	141,258	138,256
10-14	140,524	93,525	111,817	109,351
15-19	110,887	73,636	88,027	85,974
20-24	85,897	56,320	68,479	66,757
25-29	64,626	41,330	52,623	51,202
30-34	47,457	29,258	40,011	38,830
35-39	33,848	19,679	30,042	29,042
40-44	23,051	12,136	22,181	21,315
45-49	14,466	6,669	16,011	15,249
50-54	8,050	3,361	11,207	10,543
55-59	3,843	1,718	7,522	6,979
60-64	1,769	972	4,842	4,395
65-69	1,014	575	2,981	2,649
70-74	632	335	1,751	1,548
75-79	382	174	1,005	857
80-84	216	53	583	437
85+	96	0	288	168

Source: Sung and Wang et al. (2006).
Note: * Estimated with 3% discount rate and 8% productivity growth rate, which was approximately the average growth rate of gross domestic product (GDP) in China between 1998 and 2002.

Step 5: Estimate the Smoking-Attributable Mortality Cost (SAMC)

- Given the estimated SAF and adjusted total number of deaths, the smoking-attributable deaths from cancer can be calculated by their product. The product of SAF, adjusted total number of deaths (TDEATH), and PVLE derives the SAMC as shown in the last column of Table 7.2.

VIII. Determine Disease-Specific Mortality Using Verbal Autopsy (VA) Method

Introduction

This chapter presents a verbal autopsy approach that has been used in several developing countries to determine the cause of death for population-based, disease-specific mortality studies (Gajalakshmi and Peto et al., 2003; Jha, Jacob, and Gajalakshmi et al., 2008).

Introduction of Verbal Autopsy

Verbal autopsy (VA) is a systematic retrospective inquiry of family members about the circumstances, events, symptoms and signs of illness prior to death. In developed countries, data on disease-specific mortality by age are readily available from national vital registration. In developing countries, where 80% of the world's deaths occur, estimation of disease-specific mortality is more difficult, not only due to low level of coverage of vital registration and poor reliability of cause of death stated on the death certificate, but also because the underlying cause of death is often unknown for those who die at home without medical attention. VA may be a surrogate for death certificates in obtaining a specific cause of death in many developing countries.

Approaches to Verbal Autopsy

There are two main approaches for conducting a VA.

The first one is a questionnaire approach that is used more commonly for childhood deaths[1] and is of established value in helping to classify the broad patterns of childhood mortality in populations not adequately covered by medical services. The second approach is a narrative approach in which the verbal autopsy report is written (preferably in the local language) with

Experience in India has shown that for adult deaths, compared to the questionnaire approach to VA, the narrative approach has been successful in capturing all relevant information that helps to arrive at the underlying cause of death.

the aid of a list of symptoms and signs to probe the respondent for more details about the circumstances and illness that preceded the event of death.

Both questionnaire and narrative approaches have been used for adult deaths in different population settings (Walker et al. 1986; Fauveau and Koenig, 1988; Kumar et al. 1989; Ronsman et al. 1998; Gajalakshmi, Peto et al. 2002, 2003, 2004; Jha, Gajalakshmi et al. 2006). In India, for deaths that occur in areas covered by the Sample Registration System, VA diagnosis has been based primarily on the narrative part of the VA tool that gives the chronology of events, progression of the disease, duration of symptom(s), treatment details, history of hospital admission, if any, and history of similar episodes in the past. The narrative text is an essential part of VA tool for adult deaths compared with childhood deaths because causes of death are numerous among adults, whereas there are generally only a limited number of underlying causes for childhood deaths.

Methods

The methods described in this section are based on ones developed for adult (≥15 years) deaths by the Epidemiological Research Center in Chennai, India, in collaboration with the University of Oxford, UK and tested among 48,000 adult deaths in an urban area (Chennai, Tamil Nadu, India) and 32,000 adult deaths in a rural area (the Villupuram district of Tamil Nadu ,India) during 1998–2000.[7]

Training: Two different kinds of training need to be organized.

The first training needs to be organized for the field interviewers who interview the spouse, /close associates, or neighbors of the deceased adult in order to collect information on circumstances, events, signs, and symptoms of illness experienced by the deceased prior to death. These interviews employ a check list of signs and symptoms to probe the respondent to for more details on the cause of death. Field interviewers also need to receive training on how to prepare VA reports. The training module for the field interviewers is discussed in detail in the next section.

The second training needs to be organized for the physicians who will review the VA reports. These physicians must learn which code they will need to enter for the underlying cause of death according to the 10th International Classification of Diseases, (ICD-10) Injuries and Causes of Death (WHO, 1994).

Report writing: To enhance the accuracy of the underlying cause of death, the VA report should be written in the local language and contain the following information:

- the chronological order of appearance of signs and
- symptoms along with their duration;

- disease progression with details of treatment received including name of the hospital(s) admitted to,
- history of similar episodes in the past and
- history of any chronic illness.

Judgment of diagnosis of death: When the VA reports are finalized by field interviewers, they should next be given to the physicians in the project to review them and make a judgment on the diagnosis of the underlying cause of death. Physicians should report only one cause of death based on their best judgment.

Validation:

VA reports: A certain percentage (e.g 5%) of VA reports may need to be checked randomly by re-interview, by a different interviewer blind to the results. This re-interviewing needs to be done because knowledge that a re-survey could take place helps to ensure reliable fieldwork at the initial survey, and also helps to check whether there are any systematic defects in the technique of any of the field interviewers (workers).

Diagnosis of deaths: Reviews of the VA reports should be done by physicians independently of each other. At the end, their judgments of the VA reports should be compared. When a discrepancy occurs, physicians should discuss and reach a conclusion on the cause. In the case of the India study, the VA diagnosis arrived at by physician review of the VA report was better than that arrived at by an opinion-based algorithm (Chandramohan et al., 1998).

Training Module for Field Interviewers

Field interviewers should be trained on using verbal autopsy interview techniques, how to use the symptoms/signs checklist, and how to write VA reports. This training module for field interviewers consists of four steps.

Step 1: Anatomy and Interviewing Techniques

First, the field interviewers need to be taught about the anatomy of the human body. Next they need to be trained on interview techniques and how to obtain data on the cause of death as follows:

- **Interviewees**: In order to obtain necessary information to classify the underlying cause of death into medical and non-medical (external) causes of death, the surviving spouse/close associates or relatives of the deceased, as well as other members of the community such as neighbours, need to be interviewed.
- **Medical conditions of the deceased**: For deaths due to a medical cause, data on common past medical conditions

prior to death, such as hypertension, heart attack, any heart disease, stroke, diabetes, tuberculosis, asthma, cancer, HIV/AIDS and any other chronic illness, need to be recorded in the VA report.

- The symptoms/signs list in Appendix IIB for deaths due to medical causes can be used when obtaining the required data from the respondent when a narrative VA report is prepared. These include:

  1. Onset of illness prior to death: sudden or gradual
  2. Symptoms of the illness prior to death. If the respondent is able to give the major symptoms and circumstances leading to death, then additional probing questions can be asked about the associated symptoms using the symptoms/signs checklist (Appendix IIB). A symptom, if present, can be used as a filter to define the questions to be asked.

     For example, breathlessness is the main symptom for 'respiratory illnesses' and is an associated symptom for 'heart attack'. Therefore the interviewer should get the details of this filter symptom and other associated symptoms of respiratory illness and heart attack. Details of these symptoms should be built into the narrative, by prompting if necessary. The onset and duration of major symptom(s) and associated symptom(s) are to be recorded in chronological order.
  3. If the respondent has difficulty in remembering any major symptom, or is not able to give adequate information on the symptoms of the illness prior to death, then the filter symptom/sign of each module in the symptom/sign checklist should be read out. Any positive responses should be recorded, together with full details on the major symptom and associated symptoms.
  4. Next is the progress of the illness, whether it is gradual or rapid. Details on any treatment received prior to death, along with hospitalization details such as name of the hospital or unit of the hospital where admitted for treatment [e.g. tuberculosis hospital, cancer hospital, coronary care unit, intensive care unit etc], duration of hospitalization, status at the time of discharge from the hospital [alive or dead] should be obtained.
  5. Questions should next be asked about any history of similar episodes, as well as any treatment(s) given in the past for these episodes.
  6. Relevant information abstracted from the investigation reports/hospital discharge summary etc. should be noted, if available, for any illness close to the time of death (within 6 months prior to the death). If the cause of death from a death certificate is available, this should be copied to the VA report.

7. For adult deaths with longstanding illness, details that occurred in the month prior to death should be recorded in the section on history of past illness together with any related information.

- For deaths due to external causes, detailed information of the event should be collected using Appendix IIA
- For maternal deaths (deaths that occur during pregnancy, delivery, or within six weeks after delivery), the relevant information should be collected using Appendix III.

This represents an open, interactive process for collecting data on the details of illness prior to death. The respondent takes the lead in providing the information, while the interviewer prompts him or her with the aid of the symptoms/signs checklist to gather as much information as possible on the history of symptoms, signs, events, results of investigations and treatment details for writing the VA report (narrative text). The goal of this process is for sufficient information to be acquired to assign a probable specific underlying cause of death by a medical reviewer.

Step 2: Mock Interviews

In the next two days of training, mock interviews are used to teach field interviewers techniques of probing a respondent by using Appendices II and III to get the necessary data on the cause of death. They should also learn to write a VA report in the local language. After each mock interview, field interviewers should produce a written summary (usually about half a page) of the interview. These can be read to others in the training program to get their views regarding the adequacy of the written information, to help participants improve their interviewing and VA report writing skills.

Step 3: Writing Verbal Autopsy Reports

The third component of this training is a hands-on session on writing VA reports, for three days in the field. The field visit is recommended to be carried out at least six months after the occurrence of the death to reduce the distress to the respondent over the terminal event. These field interviews involve speaking with the surviving spouse and/or close associates or relatives of the deceased, as well as other members of the community such as neighbours, to get sufficient information to write a VA report. Appendices II and III are carried to the field to aid in probing the respondent. Field interviewers should be accompanied by an experienced interviewer to monitor their interview skills, and to extend help if needed.

Each field interviewer's completed VA reports are to be later reviewed independently by two medical doctors, with feedback provided shortly after completion of the field work.

Step 4: Feedback Session

To maximize the quality of VA reports, a feedback session forms the final component of the training module. This session should be attended not only by field interviewers but also by physicians who have reviewed the VA reports. This session reinforces VA report writing skills and the importance of obtaining and recording adequate information on cause of death. This feedback session should mainly focus on reports that did not have a specified underlying cause of death, and reports with insufficient information to arrive at a probable underlying cause of death.

Training Module for Physicians

A three day training can be conducted to teach physicians how to use ICD 9 to code cause of death and to assign a probable underlying cause of death by reviewing a VA report. This should be a hands-on session on arriving at a VA diagnosis by reviewing VA reports, with feedback given to improve the accuracy of VA diagnoses assigned by each physician.

Validity of Verbal Autopsy Tool

The validity of the VA diagnoses assigned by physicians depend to a great extent on the training received by physicians to review VA reports to assign an underlying cause of death, on the quality of the training received by field interviewers to write VA reports, and on how well VA reports are written by the field interviewers. Their validity will also be enhanced by built-in random checking of at least 5% of VA reports by field interviewers.

The VA tools used for childhood deaths (Snow et al., 1992; Kahn et al., 2000; Benara and Singh, 1999; Mobley et al., 1996; Marsh et al., 2003) and maternal deaths (Chandramohan et al. 1998; Fauveau et al. 1988) have been validated by several studies, whereas the VA tool for adult deaths has been validated by only a few studies (Gajalakshmi and Peto, 2003; Kahn et al., 2000; Kumar et al., 2006; Yang et al., 2005). The sensitivity of this tool for cancer diagnosis was also shown to be between 94% and 96% in work by Gajalakshmi, Peto et al. (2002, 2003).

The WHO has recommended a questionnaire approach to conduct a verbal autopsy and developed 3 questionnaires for three age groups based on the age at the time of death : (1) aged under four weeks; (2) four weeks to 14 years; and (3) 15 years and above (Baiden et al., 2007).

The narrative approach, which is not part of the WHO methodology, has also been used in places such as India to conduct verbal autopsies. For example, the Registrar General of India (RGI) has collaborated with epidemiologists in India, Canada and the United Kingdom to develop verbal autopsy forms for three age groups based on the age at the time of death. In all three forms, narrative text is an important component for arriving at the probable underlying cause of death. Physicians review the report and write keywords on which the diagnosis is arrived at; these key words may be used in future to check the reproducibility of the VA diagnoses.

Summary and Recommendations

The Verbal Autopsy (VA) approach is useful for understanding broad causes of mortality in different age groups. This information is of use in the planning of public health programmes in countries where death certification data is grossly incomplete. The use of a questionnaire method of VA with or without a narrative section helps to determine probable underlying cause of death for childhood deaths. However, for adult deaths, the narrative section of VA is an essential part of the exercise to arrive at a probable underlying cause of death. The narrative approach has certain advantages over the questionnaire approach because it has information on the chronology of events, and helps to obtain certain details that are difficult to capture through the questionnaire approach unless the questionnaire is exceedingly long. However, more experience is needed in different population settings with both approaches of VA to understand more about their limitations and advantages.

Empirical research has underscored the importance of a formal training methodology for teaching VA skills. In one study in Tamil Nadu, India, a ten day training programme to write VA reports, combined with adequate feedback sessions and random re-interviewing of 5% of the VA reports submitted, resulted in reliable probable underlying causes of death for deaths in early adult life or middle age (25–69 years) However, causes of death were less reliable for adults age 70 and older. The narrative approach of VA reduced unspecified and unknown causes of adult deaths ($\geq$ 25 years) from 54% to 23% ($p < 0.0001$) in urban areas and from 41% to 26% ($p < 0.0001$) in rural areas in this same study (Gajalakshmi and Peto, 2004). VA also reduces misclassification and assigns a cause when none is reported.

IX. Present the Final Results

Introduction

This chapter describes common formats for presenting the final estimates for meaningful policy interpretation and international comparison.

Total Economic Costs of Smoking

The total economic cost of smoking is the sum of the estimated smoking-attributable healthcare expenditures, smoking-attributable indirect morbidity cost, and smoking-attributable mortality cost. For cross-country comparison, the total cost of smoking is often expressed as a percentage of the gross domestic product (GDP). Although this proportion provides convenient comparison for the relative scale of smoking-attributable burden to the society across countries, this proportion does not mean to measure the impact of smoking on the growth of economy.

It is useful to present the estimated total economic cost of smoking in the following ways:

- by the component of the economic costs (e.g., healthcare costs, mortality cost, etc.)
- by type of smoking-related diseases (e.g., heart diseases, cancer, etc.)
- by demographic subgroups (e.g., gender)
- in terms of cost per person or per smoker
- in terms of cost per pack of cigarettes sold

Total Smoking-Attributable Healthcare Costs

For cross-country comparison, the total smoking-attributable healthcare cost is commonly expressed as the percentage of the national total healthcare expenditures.

It is useful to present the estimated total smoking-attributable healthcare cost in the following ways:

- by type of healthcare services (e.g., inpatient hospitalizations, outpatient visits and etc.)
- by type of smoking-related diseases
- by demographic subgroups
- in terms of costs per person or per smoker
- in terms of cost per pack of cigarettes sold

X. Bibliography

Acton JP (1973). *Evaluating Public Programs to Save Lives: The Case of Heart Attacks*. Santa Monica, CA: Rand Corporation, R-950-RC.

Adams EK, Solanki G, Miller LS (1997). Medical care expenditures attributable to cigarette smoking during pregnancy-United States, 1995. *MMWR Morbidity and Mortality Weekly Report*, 46:1048-50.

Anderson RN, Minino AM, Hoyert DL, Rosenberg HM (2001). Comparability of cause of death between ICD-9 and ICD-10: preliminary estimates. *National Vital Statistics Report*, 49(2):1-32.

Baiden F, Bawah A, Biai S, et al. (2007). Setting international standards for verbal autopsy. *Bulletin of the World Health Organization*, 85(8).

Barendregt JJ, Bonneu L, Van Der Mass PJ (1997). The health care costs of smoking. *New England Journal Medicine*, 337:1052–7.

Barnoya J, Glantz SA (2005). Cardiovascular effects of secondhand smoke: nearly as large as smoking. *Circulation*, 111:2684-2698.

Bartlett JC, Miller LS, Rice DP, et al.(1994) . Medical expenditures attributable to cigarette smoking—United States, 1993. *MMWR Morbidity and Mortality Weekly Report*. 43:469–72.

Benara SK, Singh P. (1999). Validity of causes of Infant death by verbal autopsy. *Indian Journal of Pediatrics*, 66:647–50.

Bronnum-Hansen H, Juel K (2000). Estimating mortality due to cigarette smoking: two methods, same result. Epidemiology, 11:422– 426.California Environmental Protection Agency (2005). *Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant*. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment: Sacramento, CA, U.S..

Centers for Disease Control and Prevention (CDC) (2002). Annual smoking-attributable mortality, years of potential life lost, and economic costs--United States, 1995-1999. *MMWR Morbidity and Mortality Weekly Report*, 51:300-303.

Centers for Disease Control and Prevention (CDC) (2008). Smoking-attributable mortality, years of potential life lost, and productivity losses—United States, 2000–2004. *MMWR Morbidity and Mortality Weekly Report*, 57(45):1226–1228.

Centers for Disease Control and Prevention (CDC) (2010). Adult SAMMEC: Smoking-attributable Mortality, Morbidity, and Economic Costs. (Online software). Atlanta, GA: Centers for Disease Control and Prevention. [https://apps.nccd.cdc.gov/sammec/edit_risk_data.asp]

Chandramohan D, Maude GH, Rodrigues LC, Hayes RJ (1998). Verbal autopsies for adult deaths: their development and validation in a multicentre study. *Tropical Medicine and International Health*, 3(6):436-46

Chandramohan D, Rodrigues LC, Maude GH, Hayes RJ (1998). The validity of verbal autopsies for assessing the causes of institutional maternal deaths. *Studies in Family Planning*, 29:414–22.

Chen J, Cao JW, Chen Y, Shao DY (1995). Evaluation of medical cost lost due to smoking in Chinese cities. *Biomedical Environmental Science*, 8(4):335-41.

Chisholm D, Stanciole AE, Edejer TT, Evans DB (2010). Economic impact of disease and injury: counting what matters. BMJ, 340:c924 .

Collins D, Lapsley H (2008). *The Costs of Tobacco, Alcohol and Illicit Drug Abuse to Australian Society in 2004/05*. Canberra: Commonwealth of Australia.

Collishaw NE, Myers G. (1984). Dollar estimates of the consequences of tobacco use in Canada, 1979. *Canadian Journal of Public Health*, 75, 192–9.

Collishaw NE (Chair), Boyd NF, Cantor KP, Hammond SK, Johnson KC, Millar J, Miller AB, Miller M, Palmer JR, Salmon AG, Turcotte F (2009). *Canadian Expert Panel on Tobacco Smoke and Breast Cancer Risk*. Toronto, Canada: Ontario Tobacco Research Unit, OTRU Special Report Series.

Cooper BS, Rice DP (1976). The economic cost of illness revisited. Social Security Bulletin, 39: 21-36.

Cornfield J (1951). A method of estimating comparative rates from clinical data; applications to cancer of the lung, breast, and cervix. *Journal of the National Cancer Institute*, 11(6):1269-75.

Doll R, Peto R (1976). Mortality in relation to smoking: 20 years' observations on male British doctors. *British Medical Journal*, 2: 1525-1536.

Duan N, Manning WG Jr, Morris CN, Newhouse JP (1983). A comparison of alternative models for the demand for medical care. *Journal of Business and Economic Statistics*, 1(2):115-126.

Ezzati M, Lopez AD (2003a). Measuring the accumulated hazards of smoking: global and regional estimates for 2000. Tobacco Control, 12:79–85.

Ezzati M, Lopez AD (2003b). Estimates of global mortality attributable to smoking in 2000. Lancet, 362:847–52.

Ezzati M, Henley SJ, Lopez AD, Thun MJ (2005). Role of smoking in global and regional cancer epidemiology: current patterns and data needs. Int J Cancer, 116(6):963-71.

Ezzati M, Henley SJ, Thun MJ, Lopez AD (2005). Role of smoking in global and regional cardiovascular mortality. Circulation, 112:489-497.Florig HK (1997). China's air pollution risks. Environ Sci Technol, 1:274A–79A.

Gajalakshmi V, Peto R (2003): Verbal autopsy to evaluate completeness of cancer registration in Chennai (formerly Madras), India. *Journal of Registry Management*, 30:4-7.

Gajalakshmi V, Peto R (2004). Verbal autopsy of 80 000 adult deaths in Tamilnadu, South India. *BMC Public Health*, 4:47. [http://www.biomedcentral.com/1471-2458/4/47]

Gajalakshmi V, Peto R, Kanaka S, Balasubramanian S (2002). Verbal autopsy of 48 000 adult deaths to medical causes in Chennai (formerly Madras), India. *BMC Public Health*, 2:7 [http://www.biomedcentral.com/1471-2458/4/47].

Gajalakshmi V, Peto R, Kanaka TS, Jha P (2003). Smoking and mortality from tuberculosis and other diseases in India: retrospective study of 43 000 adult male deaths and 35 000 controls. *Lancet*, 362:507-15.

Garfinkel L (1985). Selection, follow-up and analysis in the American Cancer Society prospective studies. In: Garfinkel, L, Ochs, O, Mushinski, M, eds., *Selection, Follow-up, and Analysis in Prospective Studies: A Workshop*, NCI Monograph 67. National Cancer Institute. NIH Publication No. 85-27 13, 49-52.

Gerking S, de Haan M, Schulze M (1988). The Marginal Value of Job Safety: A Contingent Valuation Study. *Journal of Risk and Uncertainty*, 1(2):185-200.

Gu D, Kelly TN, Wu X, Chen J, Samet JM, et al. (2009). Mortality attributable to smoking in China. *New England Journal of Medicine*, 360(2):150-9.

Gupta PC, Pednekar MS, Parkin D, Sankaranarayanan R (2005). Tobacco associated mortality in Mumbai (Bombay) India. Results of the Bombay Cohort Study. *International Journal of Epidemiology*, 34(6):1395-402.

Hackshaw A, Law M, Wald N (1997). The accumulated evidence on lung cancer and environmental tobacco smoke. *British Medical Journal*, 315:980-999.

He J, Gu D, Wu X, Reynolds K, Duan X, et al. (2005). Major causes of death among men and women in China. *New England Journal of Medicine*, 353(11):1124-34.

Hodgson RA (1992). Cigarette smoking and lifetime medical expenditures. *Milbank Quarterly*, 70: 81-125.

Institute of Medicine (1981). *Costs of Environment-Related Health Effects*. Washington: National Academy Press.

Jha P, Gajalakshmi V, Gupta PC et al. (2006). Prospective study of one million deaths in India. Rationale, design, and validation results. *PLoS Medicine*, 3:e18.

Jha P, Jacob B, Gajalakshmi V, Gupta PC, Dhingra N, Kumar R, et al. (2008). Smoking and mortality among women and men in India: nationally representative case-control study of 74000 deaths and 78000 controls. *New England Journal of Medicine*, 358:1137-1147.

Jin SG, Lu BY, Yan DY, et al. (1995). An evaluation on smoking-induced health costs in China (1988–1989). *Biomedical Environmental Science*, 8:342–9.

Jinot J, Bayard S (1996). Respiratory health effects of exposure to environmental tobacco smoke. *Review of Environmental Health*, 11:89-100.

John R, Sung H-Y, Max W (2009). Economic cost of tobacco use in India, 2004. *Tobacco Control*,18:138-143.

Kahn K, Tollman SM, Garenne M, Gear JS (2000). Validation and application of verbal autopsies in a rural area of South Africa. *Tropical Medicine and International Health*, 5:824–31.

Kaiserman MJ (1997). The cost of smoking in Canada, 1991. *Chronic Diseases in Canada*, 18(1), 13–9.

Kaufman DW, Helmrich SP, Rosenberg L. Miettinen OS, Shapiro S (1983). Nicotine and carbon monoxide content of cigarette smoke and the risk of myocardial infarction in young men. *New England Journal of Medicine*, 308(8):409-413.

Kniesner TJ, Leeth JD (1991). Compensating wage differentials for fatal injury risk in Australia, Japan, and the United States. *Journal of Risk and Uncertainty*, 4(1):75-90.

Krupnick A, Alberini A, Cropper M, Simon N, et al. (2002). Age, health, and the willingness to pay for mortality risk reductions: a contingent valuation survey on Ontario residents. *Journal of Risk and Uncertainty*, 23:161-186.

Kumar R, Sharma AK, Barik S, Kumar V (1989). Maternal mortality enquiry in a rural community of North India. *International Journal of Obstetrics and Gynecology*, 29:313–19.

Kumar R, Thakur JS, Rao BT, Singh MMT, Bhatia SPS (2006). Validity of verbal autopsy in determining causes of adult deaths. *Indian Journal of Public Health*, 50:90–94.

Landefeld JS, Seskin EP (1982). The economic value of life: linking theory to practice. *American Journal of Public Health*, 72(6):555-566.

Leistikow BN, Martin DC, Milano CE (2000). Fire injuries, disasters, and costs from cigarettes and cigarette lights: a global overview. *Preventative Medicine*, 31:91–9.

Leu RE, Schaub T (1983). Does smoking increase medical expenditures? *Social Science and Medicine*, 17:1907–14.

Leu, RE, Schaub, T (1985). More on the impact of smoking on medical care expenditures. *Social Science and Medicine*, 21:825-827.

Levin ML (1953). The occurrence of lung cancer in man. *Acta Unio Int Contra Cancrum*, 9:531-541.

Lightwood J, Collins D, Lapsley H, et al. (2000). Estimating the costs of tobacco use. In: Jha P, Chaloupka FJ, eds. *Tobacco Control in Developing Countries*, Oxford: Oxford University Press, 2000.

Lilienfeld DE, Stolley PD (1994). *Foundations of epidemiology, 3rd ed*. New York: Oxford University Press.

Liu BQ, Peto R, Chen ZM, et al. (1998). Emerging tobacco hazards in China: 1. Retrospective proportional mortality study of one million deaths. *British Medical Journal*, 317:1411–22.

Lopez AD, Ahmad OB, Guillot M, et al. (2002). *World Mortality in 2000: Life Tables for 191 Countries*. Geneva: World Health Organization.

Manning WG, Keeler EB, Newhouse JP, et al. (1989). The taxes of sin: Do smokers and drinkers pay their way? *Journal of the American Medical Association*, 261:1604-9.

Mannino, DM., Moorman, JE, Kingsley, B, Rose, D, Repace, J (2001). Health effects related to environmental tobacco smoke exposure in children in the United States: data from the Third National Health and Nutrition Examination Survey. *Archives of Pediatric and Adolescent Medicine,* 155:36-41.

Marsh DR, Sadruddin S, Fikree FF, Krishnan C, Darmstadt GL (2003). Validation of verbal autopsy to determine the cause of 137 neonatal deaths in Karachi, Pakistan. *Paediatric Perinatal Epidemiology*, 17:132–42.

Mathers CD, Loncar D (2006). Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Medicine*, 3(11):e442.

Max W (2001). The financial impact of smoking on health-related costs: A review of the literature. *American Journal of Health Promotion*, 15(5):321-331.

Max W, Rice DP, Zhang X, Sung HY, Miller L (2002). *The Cost of Smoking in California, 1999*. Sacramento, CA: California State Department of Health Services. [http://www.cdph.ca.gov/programs/tobacco/Documents/CTCPCostOfSmoking1999.pdf]

Max W, Rice DP, Sung HY, Michael M, Bruer W, Zhang X (2002b). The economic burden of prostate cancer , California, 1998. *Cancer*, 94(11):2906-2913.

Max W, Rice DP, Zhang X, Sung H-Y, Miller L (2004). The economic burden of smoking in California. *Tobacco Control*, 13:264–267.

Max W, Rice DP, Sung H-Y, Michel M (2004b). *Valuing Human Life: Estimating the Present Value of Lifetime Earnings.*

University of California, San Francisco, Institute for Health and Aging. [http://repositories.cdlib.org/ctcre/esarm/PVLE2000]

Max W, Sung HY, Shi Y (2009). Who is exposed to secondhand smoke? Self-reported and serum cotinine measured exposure in the U.S., 1999-2006. *International Journal of Environmental Research and Public Health*, 6(5):1633-1648. [http://www.mdpi.com/1660-4601/6/5/1633]

Max W, Sung HY, Tucker LY, Stark B (2010). The Disproportionate Cost of Smoking for African Americans in California. *American Journal of Public Health*, 100(1):152–158.

Miller L, Zhang X, Novotny T, Rice D, Max W (1998a). State estimates of Medicaid expenditures attributable to cigarette smoking, fiscal year 1993. *Public Health Reports*, 113:140-151.

Miller L, Zhang X, Rice D, Max W (1998b). State estimates of total medical expenditures attributable to cigarette smoking, 1993. *Public Health Reports*, 113:447-458.

Miller VP, Ernst C, Collin F (1999). Smoking-attributable medical care costs in the USA. *Social Science and Medicine*, 48:375–91.

Miller LS, Max W, Sung HY, Rice D, Zaretsky M (2010). Evaluation of the economic impact of California's Tobacco Control Program: a dynamic model approach. *Tobacco Control*, 19(Suppl 1): i68-76.

Mobley CC, Boerma JT, Titus S, Lohrke B, Shangula K, Black RE (1996). Validation study of a verbal autopsy method for causes of childhood mortality in Namibia. *Journal of Tropical Pediatrics*, 42:365–69.

Murray JL, Lopez AD, eds. (1996). *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020*. Cambridge: Harvard University Press.

Murray CJL, Lopez AD (1997). Alternative projections of mortality and disability by cause 1990-2020: Global burden of disease study. *Lancet*, 349(9064):1498-15

Neubauer S, Welte R, Beiche A, Koenig H, Buesch K, Leidl R (2006). Mortality, morbidity and costs attributable to smoking in Germany: update and a 10-year comparison. *Tobacco Control*, 15:464-71.

Office of Technology Assessment (OTA), US Congress (1985). Smoking related deaths and financial costs. OTA staff memorandum. Washington, DC: Health Program, OTA.

Peto R, Lopez AD, Boreham J, Thun M, Heath C (1992). Mortality from tobacco in developed countries: indirect estimation from national vital statistics. *Lancet*, 339:1268-1278.

Peto R, Lopez AD, Boreham J, Thun M, Heath C, Doll R (1996). Mortality from smoking worldwide. *British Medical Bulletin*, 52(1):12-21.

Rice DP (1966). Estimating the Cost of Illness. Health Economics Series, No. 6. DHEW Pub. No. (PHS) 947-6. Rockville, MD: U.S. Department of Health, Education and Welfare.

Rice DP (1967). Estimating the costs of illness. *American Journal of Public Health*, 57:424-440.

Rice DP (2000). Cost of illness studies: what is good about them? Injury Prevention, 6: 177-179.

Rice D, Hodgson TA, Sinsheimer P, Browner W and Kopstein AN (1986). The Economic Costs of the Health Effects of Smoking, 1984. *Milbank Quarterly*, 64(4):489-547.

Rice DP, Hodgson TA, Kopstein AN (1985). The economic costs of illness: a replication and update. Health Care Fin Rev 7: 61-80.

Robinson JC (1986). Philosophical origins of the economic value of life. *Milbank Quarterly*, 64:133-55.

Robinson J, Luft HP, Gardner LB, Morrison EM (1991). A method for risk adjusting employer contributions to competing health insurance plans. *Inquiry*, 28:107-116.

Ronsmans C, Vanneste AM, Chakraborty J, Ginneken JV (1998). A comparison of three verbal autopsy methods to ascertain levels and causes of maternal deaths in Matlab, Bangladesh *International Journal of Epidemiology*, 27:660–66.

Rosenberg L, Kaufman DW, Helmrich SP, Shapiro S (1985). The risk of myocardial infarction after quitting smoking in men under 55 years of age. *New England Journal of Medicine*, 313(24):151 I-1514.

Ross H, Trung DV, Phu VX (2007). The costs of smoking in Vietnam: The case of inpatient care. *Tobacco Control,* 16(6):405-9.

Shultz JM, Novotny TE, Rice DP (1990). SAMMEC II: Computer software and documentation. Atlanta, Georgia: Centers for Disease Control, Office on Smoking and Health, 1990.

Schultz JM., Novotny TE, Rice DP (1991). Quantifying the disease impact of cigarette smoking with SAMMEC II software. *Public Health Reports*, 106(3):326-333.

Sloan FA, Ostermann J, Picone G, Conover C, Taylor DH (2004). *The Price of Smoking*. Cambridge, MA: The MIT Press.

Smith KR, Mehta S, Maeusezahl-Feuz M (2004). Indoor air pollution from household solid fuel use. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, eds. Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva: WHO, 2004.1435–93.

Snow RW, Armstrong JRM, Forster D et al. (1992) Childhood deaths in Africa: uses and limitations of verbal autopsies. *Lancet*, 340:351–55.

Steenland, K (1999). Risk assessment for heart disease and workplace secondhand smoke exposure among nonsmokers. *Environmental Health Perspectives*, 107:859-863.

Sung HY, Wang L, Jin S, et al. (2006). Economic burden of smoking in China, 2000. *Tobacco Control*, 15(Suppl 1):i5–11.

Tanuseputro P, Manuel DG, Schultz S, Johansen H, Mustard C (2005). Improving population attributable fraction methods: examining smoking attributable mortality for 87 geographic regions in Canada. *American Journal of Epidemiology*, 161:787–798.

Thun MJ, Day-Lally C, Myers DG, Calle EE, Flanders WD, Zhu BP, Namboodiri MM, Heath CW (1997). Trends in tobacco smoking and mortality from cigarette use in Cancer Prevention Studies I (1959-1965) and II (1982-1988). In: *National Cancer Institute, Smoking and Tobacco Control, Monograph 8: Changes in Cigarette-Related Disease Risks and Their Implication for Prevention and Control*. Washington, DC: National Institutes of Health. NIH Publication No.97-4213, 305-382.

Thun, M, Henley, J, Apicella, L (1999). Epidemiologic studies of fatal and nonfatal cardiovascular disease and secondhand smoke exposure from spousal smoking. *Environmental Health* Perspectives, 107:841-846.

Thun MJ, Apicella LF, Henley SJ (2000). Smoking vs other risk factors as the cause of smoking-attributable deaths: confounding in the courtroom. *Journal of the Americal Medical Association*, 284:706–12.

U.S. Department of Health and Human Services (US DHHS) (1989). *Reducing the Health Consequences of Smoking, 25 Years of Progress: A Report of the Surgeon General*. DHHS Publication No. (CDC) 89-8411. Washington, DC: U.S. Public Health Service, Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Office of Smoking and Health.

US Department of Health and Human Services (US DHHS) (2004). *The Health Consequences of Smoking: A Report of the Surgeon General*. Atlanta, Georgia: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

U.S. Department of Health and Human Services (US DHHS). 2006. *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General*. Washington, D.C., U.S.: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Office of Smoking and Health.

Viscusi WK (1993). The value of risks to life and health. *J Econ Lit,* 31:1912-1946.

Walker GJA, Ashley DEC, McCaw AM, Bernard GW (1986). Maternal mortality in Jamaica. *Lancet*, 327(8479):486–88.

Walter SD (1976). The Estimation and Interpretation of Attributable Risk in Health Research. *Biometrics*, 32:829-49.

Warner KE, Hodgson TA, Carroll CE (1999). Medical costs of smoking in the United States: Estimates, their validity, and their implications. *Tobacco Control*, 8(3):290-300.

Wen CP, Tsai SP, Chen CJ, Cheng TY (2004). The mortality risks of smokers in Taiwan: Part I: cause-specific mortality. *Preventive Medicine*, 39: 528-535.

World Bank (1999). *Curbing the Epidemic: Governments and the Economics of Tobacco Control*. New York: World Bank.

World Health Organization (WHO) (1977). *Manual of International Classification of Diseases, Injuries and Causes of Death (Ninth revision)*. Geneva: World Health Organization.

World Heath Organization (WHO) (2004). Life tables for 191 countries, world mortality in 2000. [http://www.who.int/country/chn/en/]

World Health Organization (WHO) (2008). *Fresh and Alive: Mpower, WHO Report on the Global Tobacco Epidemic, 2008*. Geneva:World Health Organization.

World Health Organization (WHO) (2009). WHO guide to identifying the economic consequences of disease and injury. http://www.who.int/choice/publications/d_economic_impact_guide.pdf

World Heath Organization (WHO) (2010a). Life Tables for WHO Member States. 2010a. [http://apps.who.int/whosis/database/life_tables/life_tables.cfm]

World Heath Organization (WHO) (2010b). Death and DALY estimates for 2004 by cause for WHO Member States. [http://www.who.int/healthinfo/statistics/mortality/en/index.html].

Yach D, McIntyre D, Saloojee Y (1992). Smoking in South Africa: the health and economic impact. *Tobacco Control*, 1:272-280.

Yang G, Rao C, Ma J et al. (2005). Validation of verbal autopsy procedures for adult deaths in China. *International Journal of Epidemiology*, 35:741–48.

Zhang X, Miller LS, Max W, Rice DP (1999). Cost of smoking to the Medicare program, 1993. *Health Care Financing Review*, 20(4):179–196.

XI. Appendix I: Existing Relative Risk (RR) Estimates of Mortality from Selected Countries

Appendix Table 1. Estimated relative risk (RR)* of mortality for current and former cigarette smokers compared to never smokers, aged 35+, 6-year (1982-1988) follow-up of American Cancer Society's Cancer Prevention Study II (CPS-II) of 1.2 million adults, United States

Causes of Death	ICD-9 Code	ICD-10 Code	Male		Female	
			Current Smoker	Former Smoker	Current Smoker	Former Smoker
All causes			2.34	1.58	1.90	1.32
Malignant Neoplasm:						
Lip, oral cavity, pharynx	140-149	C00-C14	10.89	3.40	5.08	2.29
Esophagus	150	C15	6.76	4.46	7.75	2.79
Stomach	151	C16	1.96	1.47	1.36	1.32
Pancreas	157	C25	2.31	1.15	2.25	1.55
Larynx	161	C32	14.60	6.34	13.02	5.16
Trachea, lung, bronchus	162	C33-C34	23.26	8.7	12.69	4.53
Cervix, uterus	180	C53	---	---	1.59	1.14
Urinary bladder	188	C67	3.27	2.09	2.22	1.89
Kidney and Renal Pelvis	189	C64-C65	2.72	1.73	1.29	1.05
Acute Myeloid Leukemia	205.0	C92.0	1.86	1.33	1.13	1.38
Cardiovascular Diseases:						
Ischemic heart disease:	410–414, 429.2	I20–I25				
age 35-64			2.80	1.64	3.08	1.32
age ≥ 65			1.51	1.21	1.60	1.20
Other heart disease (rheumatic, pulmonary, and other forms of heart disease)	390-398, 415-417, 420-429.1, 429.3-429.9	I00–I09, I26–I51	1.78	1.22	1.49	1.14

Cerebrovascular disease:	430-438	I60-I69				
age 35-64			3.27	1.04	4.00	1.30
age ≥ 65			1.63	1.04	1.49	1.03
Other circulatory disease:						
Atherosclerosis	440	I70	2.44	1.33	1.83	1.00
Aortic aneurysm	441	I71	6.21	3.07	7.07	2.07
Other arterial diseases	442-448	I72-I78	2.07	1.01	2.17	1.12
Respiratory Diseases:						
Pneumonia, influenza	480-487	J10-J18	1.75	1.36	2.17	1.10
COPD:						
Bronchitis, emphysema	490-492	J40-J42, J43	17.10	15.64	12.04	11.77
Chronic airways obstruction	496	J44	10.58	6.80	13.08	6.78

Source: CDC (2010); CDC (2008); Thun and Day-Lally et al. (1997); Tanuseputro and Manuel et al. (2005). For the comparability between ICD-9 and ICD-10 codes, see Anderson et al. (2001). *Note:* * RR estimates were adjusted for age.

Appendix Table 2. Estimated relative risk (RR)* of mortality for ever cigarette smokers compared to never smokers, aged 35-69, from a retrospective proportional study of one million deaths during 1986-1988 in 98 nationally representative areas, China

Causes of Death	ICD-9 Code	Urban		Rural	
		Male	Female	Male	Female
All causes		1.29	1.40	1.22	1.14
Malignant Neoplasm (any)	140-208	1.62	1.67	1.48	1.21
Lip, oral cavity, pharynx	140-149,	1.58	1.68	1.48	1.39
Esophagus	150	2.06	1.65	1.57	1.28
Stomach	151	1.36	1.30	1.35	1.13
Liver	155	1.39	1.49	1.41	1.12
Pancreas	157	1.58	1.68	1.48	1.39
Larynx	161	1.58	1.68	1.48	1.39
Lung	162	2.98	3.24	2.57	1.98
Urinary bladder	188	1.58	1.68	1.48	1.39
Other neoplastic		1.16	1.17	1.28	0.95
Cardiovascular Diseases (any)	390-415, 418-459	1.17	1.14	1.14	0.92
Ischemic heart disease	410-414	1.28	1.37	1.28	1.22
Stroke	430-439	1.18	1.11	1.17	0.88
Rheumatic heart disease	416-417	1.00	1.04	0.92	0.88
Other vascular disease	*	1.00	1.04	0.92	0.88
Respiratory Diseases (any)	011,012,018,460-519	1.48	1.28	2.28	1.43
Respiratory tuberculosis	011,012,018	1.42	1.56	1.17	1.25
COPD	490-492,496	1.57	2.51	1.41	1.50
Pulmonary heart disease	416-417	1.57	2.51	1.41	1.50
Other respiratory disease	460-487,493-495,500-519	1.23	1.37	1.03	1.03

Source: Liu and Peto et al. (1998)

Note: COPD = chronic obstructive pulmonary disease. * RR estimates were adjusted for age.

Appendix Table 3. Estimated relative risk (RR) of mortality for ever cigarette smokers compared to never smokers, from a prospective cohort study in a nationally representative sample of 169,871 adults aged 40+, with baseline data collected in 1991 and follow-up evaluation collected in 1999-2000, China**

Causes of Death	ICD-9 Code	Male	Female
All causes		1.21	1.33
Malignant Neoplasm (any)	140-208	1.55	1.62
Esophagus	150	1.34	1.24
Stomach	151	1.52	1.05
Liver	155	1.36	1.44
Colon and rectal	153-154	1.02	1.21
Lung	162	2.44	2.76
Other	*	1.26	1.42
Cardiovascular Diseases (any)	*	1.17	1.21
Coronary heart disease	390-398, 401-429	1.21	1.41
Stroke	430-438	1.17	1.18
Respiratory Diseases (any)	*	1.14	1.43
COPD	490-496	1.19	1.61

Source: Gu and Kelly et al.(2009). ICD-9 codes reported here are based on He and Gu et al. (2005).
Note: COPD = chronic obstructive pulmonary disease; * ICD-9 codes were not provided in the paper by Gu and Kelly et al. (2009). ** RR estimates were adjusted for the age at baseline, educational level, geographic region (north vs. south), urbanization (rural vs. urban), and the presence or absence of hypertension, overweight status or obesity, alcohol consumption, and physical inactivity.

Appendix Table 4. Estimated relative risk (RR)* of mortality for ever cigarette/bidis smokers compared to never smokers, aged 30-69, from a retrospective case-control study of a nationally representative sample of 152,000 men and women during 2001-2003, India

Causes of Death	ICD-10 Code	Male			Female		
		Urban	Rural	All	Urban	Rural	All
All causes		1.9	1.6	1.7	1.9	2.0	2.0
Neoplasm	C00-D48	2.2	2.1	2.1	2.4	2.0	2.1
Cardiovascular Diseases:							
Heart disease	I00-I59, I70-I99, R96	1.7	1.6	1.6	1.8	1.7	1.7
Stroke	G60-G69, G81-G83	1.5	1.6	1.6	1.3	1.7	1.6
Respiratory Diseases	J00-J99	2.5	2.0	2.1	2.6	3.3	3.1
Tuberculosis	A15-A19, B90	2.7	2.3	2.3	3.2	3.2	3.0
Other Diseases:							
Peptic ulcer	K25-K31	2.2	1.8	1.9	1.7	2.9	2.8
Liver disease and alcohol	K70-77, B15-19, F10, R17-18, X45, X65, Y15, Y90-91	1.4	1.7	1.6	1.0	1.7	1.5
Infection	Rest of A-B, G00-09, R50	1.8	1.3	1.3	0.9	1.5	1.5
Other or unspecified disease	Rest of C–N & P–R	1.5	1.2	1.3	1.2	1.9	1.7

Source: Jha and Jacob et al. (2008)

Note: * RR estimates were adjusted for age, educational level, and use of alcohol.

Appendix Table 5. Estimated relative risk (RR)* of mortality for ever cigarette/bidis smokers and ever smokeless tobacco users compared to never tobacco users, from a prospective cohort study in a Bombay sample of 99,570 adults aged 40+, with baseline data collected in 1992-1994 and 5.5-year follow-up evaluation collected in 1997-1999, India

Causes of Death	ICD-10 Code	Ever Smoker[1]		Ever Smokeless Tobacco User[2]	
		Male	Female	Male	Female
All causes		1.55	1.40	1.16	1.25
Malignant Neoplasm (any)	C00-C978	2.60	1.85	1.40	1.57
Oral and pharynx	C00-C14	19.69	N/A	3.72	2.74
Respiratory cancer	C30-C39	4.05	N/A	2.23	N/A
Cardiovascular Diseases (any)	I00-I99	1.21	1.19	0.94	0.84
Ischemic heart disease	I10-I11,I13,I21,I24-I25,I46,I50	1.17	1.24	0.89	0.57
Cerebrovascular disease	I61-64,I66-I67	1.54	1.46	1.32	1.15
Respiratory Diseases (any)	J00-J99	2.12	1.15	1.50	1.04
Pneumonia	J18	2.46	1.26	1.50	1.30
COPD	J42-J46	2.13	1.26	1.42	0.96
Tuberculosis	A15-A19	2.30	5.92	1.46	1.40
Other Diseases:					
Digestive	K00-K93	1.35	N/A	0.93	0.95
Accidents	X00-X99	2.65	N/A	1.71	0.76
Other disease	**	1.26	1.57	1.18	1.26

Source: Gupta and Pednekar et al. (2005)
Note: COPD = chronic obstructive pulmonary disease; * RR estimates were adjusted for age and education level; ** ICD-10 codes were not provided in the paper by Gupta and Pednekar et al. et al (2005).
[1] Ever smokers are defined as those who reported smoking cigarettes or bidis regardless of whether they also used smokeless tobacco products or not.
[2] Ever smokeless tobacco users are those who reported using smokeless tobacco only.
N/A: not available.

Appendix Table 6. Estimated relative risk (RR)* of mortality for current cigarette smokers compared to never smokers, from two prospective cohorts of 86,580 adults aged 35+, with baseline data collected between 1982 and 1992 and vital status followed up as of December 31, 2000, Taiwan

Causes of Death	ICD-9 Code	Male	Female
		Current Smoker	Current Smoker
All causes		1.55	1.89
Malignant Neoplasm (any)	140-208	1.67	2.42
Lip, oral cavity, pharynx	140-149	2.60	--
Nasopharynx	147	1.78	--
Esophagus	150	3.18	15.57
Stomach	151	1.68	--
Rectum	154	2.06	--
Liver/gallbladder	155-156	1.46	5.03
Lung	162	2.73	3.36
Cervix uteri	180	--	5.78
Cardiovascular Diseases (any)	390-459	1.49	1.69
Ischemic heart disease:	410-414		
age 35-64		2.06	3.58
age ≥ 65		1.20#	2.43#
Cardiac arrest/other heart disease	420-429	1.60	2.02#
Cerebrovascular disease:	430-438		
age 35-64		1.65	2.08#
age ≥ 65		0.90#	0.57#
Respiratory Diseases (any)	460-519	1.67	3.04
COPD:			
Chronic bronchitis	491	3.13	--
Emphysema	492	1.12#	--
Asthma	493	1.19#	7.12
Chronic airway obstruction	496	2.65	2.19#
Other Diseases:			
Diabetes mellitus	250	1.51	1.09#
Digestive system diseases (any)	520-579	1.69	1.27#
Peptic ulcer/GI hemorrhage	531-533	3.00	22.28
Liver cirrhosis	571	2.01	0.71#
Kidney disease	580-589	2.23	0.94#
Accidents (any)	800-949	1.66	1.70#
Motor vehicle	810-829	1.87	1.15#
Nonmotor vehicle	850-929	1.40	2.50#
Falls	880-888	1.93	--

Source: Wen and Tsai et al (2004)
Note: COPD = chronic obstructive pulmonary disease. * RR estimates were adjusted for age; # Not statistically significant at p-value=0.05.

Appendix Table 7. Estimated relative risk (RR)* of mortality for cigarette smokers compared to never smokers, aged 30+, 4-year (1982-1988) follow-up of American Cancer Society's Cancer Prevention Study II (CPS-II) of 1.2 million adults, United States

Causes of Death	ICD-9 Code	Male Smoker	Female Smoker
Malignant Neoplasm*:			
Upper aerodigestive track	140-150	8.1	6.0
Stomach	151	2.2	1.5
Colorectal	153-154	1.3	1.4
Liver	155	2.3	1.5
Pancreas	157	2.2	2.2
Trachea, lung, bronchus	162	21.3	12.5
Cervix, uterus	180	---	1.5
Urinary bladder	188	3.0	2.4
Myeloid Leukemia	205	1.89	1.30
Kidney and other urinary	223	2.5	1.5
Ischemic heart disease**:	410–414		
age 30-44		5.49	2.28
age 45-59		3.05	3.77
age 60-69		1.87	2.47
age 70-79		1.40	1.57
age ≥ 80		1.01	1.34
Cerebrovascular disease**:	430-438		
age 35-64		--	--
age 45-59		3.11	4.55
age 60-69		1.85	2.74
age 70-79		1.35	1.85
age ≥ 80		1.01	0.90
Hypertensive disease**	401-405	1.96	2.12
Other cardiovascular diseases**	390-398, 415-429, 440-459	2.11	1.95

Source: Ezzati, Henley, and Thun et al., 2005; Ezzati and Henley et al., 2005
Note: * RR estimates were adjusted for age, race, education, marital status, ''blue-collar'' employment in most recent or current job, weekly consumption of vegetables and citrus fruit and vitamin (A, C and E) use plus additional covariates which vary by cancer cite. ** RR estimates were adjusted for adjusted for age, race, education, marital status, "blue collar" employment in most recent or current job, weekly consumption of vegetables and citrus fruit, vitamin (A, C, and E) use, alcohol use, aspirin use, body mass index, exercise, and dietary fat consumption.

XII. Appendix II: Symptoms/Signs Checklist for Adult Deaths (≥15 Years)

This checklist consists of two sections:
A: deaths attributed to injuries (unnatural deaths/non medical causes)
B: deaths due to illnesses (medical causes). This section has 9 main symptoms or conditions called lead symptoms or filter symptoms.

INJURIES : unintentional or intentional

Road traffic injuries related to any motorized or non-motorized modes of transport
Falls at home or any other pace, fall of objects, burns (including hot objects, vessels or electrical injuries), drowning (include from floods), poisoning (accidental or intentional), bite/sting (mention name of the insect/animal), natural disaster (lightning, sunstroke, flood, earthquake,)
Fracture: write details of where, when, how
Suicide (may need to ask neighbours or others to obtain this history)
Homicide (may need to ask neighbours)
Enter the time interval between the accident and death
Did the person die at the site of accident? If not, for how many days did he/she live?
Type of medical care, and where received
Any chronic conditions/illness in the month prior to injury death?

SYMPTOMS/SIGNS CHECK LIST:

1.Symptom: chest pain

Ask about onset (sudden or gradual), duration of pain (pain lasted for more than 24 hours or less than 24 hours)
Location of pain (chest, upper abdominal, etc)
Spread of pain to any part of the body, e.g., pain in behind the central part of chest (retrosternal), hand, shoulder, back etc.
Whether pain was increased by cough/deep breath, or by touching the area or walking/after eating

Associated symptoms: breathlessness, sweating, vomiting, loss of consciousness
Write history from childhood until death: any history of fever with joint pain and swelling, chest pain or heart attack and any treatment, and medication or treatment in detail, including surgeries.

2. Symptoms: Cough and or Breathlessness

2.1 Cough
Cough: dry, productive (with sputum) or with blood (haemoptysis),
Severe bouts of cough with whoop at the end, cough only at night: enquire when cough was worse (day or night)
Always sitting in bed for relief of cough
Localized pain (pain at the sides of the chest wall increased by cough and/or deep breath)

2.2 Breathlessness
Write details of onset and progression of breathlessness {e.g. breathlessness is initially on exertion (i.e., not present at rest), but progressively worsens to a stage of breathlessness even at rest}
Breathlessness occurring soon after lying flat and relieved by sitting up
Breathlessness at rest, triggered by allergy or chest infection
Episodes or attacks of wheeze and breathlessness of sudden onset (may be triggered by allergy or chest infections)
May be accompanied by swelling of hands and legs, generalized swelling of the body, enlarged abdominal swelling or fluids in chest

2.3 Other Symptoms associated with cough, breathlessness
Weight loss
Hoarseness of voice
Night sweats
Evening rise of temperature
Fever with generalized aches and pains
Vomiting

3. Fever
High grade/low grade fever for how many days?
Continuous with no normal temperature, intermittent (on and off) fever, or occasional
Repeated attacks of fever with chills, rigor (shaking), sweating, myalgia (muscle pain)
High fever followed by skin eruption (rash/blisters) the next day
Fits, confusion, drowsiness, coma
Associated with cold, dry cough, headache, generalized ache
Coated tongue, jaundice, diarrhoea, burning sensation while passing urine, chest pain, neck stiffness, sensitivity to light, sound etc.
Fever for more than 30 days: refer to symptoms for HIV/AIDS

4. Symptom: Paralysis
Was paralyses accompanied by sudden loss of consciousness?
Time of onset: during activity or in sleep?
Progression: over minutes, hours or noticed on waking up with or without vomiting/ headache?
Note if paralysis in any part of the body in the month preceding death

Write affected part of the body: half of the body, one upper limb– right/left side, face, loss of speech, lower limbs
Was it associated with loss of memory, loss of vision, altered speech, loss of urinary control, loss of sensation of any part of body, or other features: convulsions (fits), neck stiffness, giddiness, hypertension

5. Symptom: Seizures/ fits

History of sudden jerky movements of limbs with or without loss of consciousness accompanied by rolling of eye balls and frothing of mouth; with loss of consciousness, loss of memory, awake between convulsions or not, tongue bite, bed wetting, confused
History of head injury
Type and duration of treatment taken, etc.

6. Symptom: difficulty in passing urine or low urine out put

Abrupt onset with puffiness of face or swelling of eyelids in the morning, low urine amount, passing urine with pus, passing urine with blood, localized/generalised swelling of hands and legs, swelling or fluid in the abdomen and/or fluid in the chest
Frequent passage of urine, pain in middle of lower abdomen, intense desire to pass more urine even after the bladder has been emptied
Tenderness in the side of abdomen, sudden onset of pain in one or both loins, spreading to lateral part of lower abdomen and above genital area
Pallor, nausea, vomiting
Become dull, drowsy, coma (unconsciousness) and death
History of kidney transplantation
History of high blood pressure

7. Sign: Oedema (swelling of feet and hands or body)

Did she/he look pale?
Loss of weight
Presence of breathlessness at rest; aggravated by walking (refer symptoms under 2.2)
Fatigue, feeling the heart beat faster, nausea, loss of appetite
Generalized swelling of feet and hands

Symptoms related to abdomen/GI tract

8.1 Symptom: abdominal pain or swelling

Abdominal pain: localized or generalized, type (sharp, dull, throbbing, continuous) and relationship to food intake (pain was more on empty stomach and relieved after taking food or pain increased after taking food)
Abdominal distension: sudden or gradual
Other symptoms: loss of appetite, nausea, constipation, black stools, vomiting with blood, breathlessness and sweating with sudden abdominal pain
History of surgery or trauma or cancer
Lump/mass in abdomen
Difficulty in swallowing solid/liquid food

8.2 Symptom: stomach pain/ulcers

Had peptic ulcer: burning pain, localized to middle part of upper abdomen or extending to chest, recurrent abdominal pain
Typically pain wakes the patient from sleep around 2 AM and is relieved by food, milk, antacids, belching or vomiting

Periodicity: pain occurs in episodes, lasting 1-3 weeks every time, 3-4 times per year
Natural history of spontaneous re-occurrence and freedom from symptoms lasting for decades or even life
Relationship to food: pain occurs on empty stomach (hunger pain) and is relieved by food or antacids
Vomited blood, had been drinking alcohol
Other symptoms: loss of appetite, nausea

8.3. <u>Symptom: diarrhoea/dysentery or blood in stools</u>
Loose/semisolid stools, blood/mucus in stools, watery/rice water-like stools, Painless profuse (large quantity) diarrhoea
How many times a day at worst?
Vomiting, excessive thirst and dehydration (less water in the body: sunken eyes, diminished urine amount, dried tongue) , fever (sudden onset).
Blood in the stool, colour red or black. Any history of cancer?
Did the deceased have food in any party or any gathering few days prior to the event of diarrhoea? If yes, did any other person who had food from the same party also suffer from loose motion?

8.4. <u>Symptom: Jaundice (yellowness in the white part of eyes)</u>
Eye/skin colour change to yellow, urine also dark yellow in colour
Marked swollen, bloated abdomen with swelling of feet and then face and hands
Vomiting blood, history of drinking alcohol regularly
Any history of cancer

8.5. <u>Symptom: Local swelling in the groin/scrotum</u>:

History of reducible swelling in scrotum (used to appear on coughing or straining and then disappeared)
Able to push back the swelling without pain
Became painful, tender and not able to reduce before death

<u>Symptoms/signs of various illnesses:</u>
9.1. HIV/AIDS:
Loss of weight and degree (percentage) of weight loss (this is a key symptom)
Any ulcers or sores in the genital area (sexually transmitted infection or venereal disease)
Fever for more than 30 days
Diarrhoea for more than 30 days
Persistent cough for more than 30 days
Generalised generalized swelling of nodes in arm pits, neck, groin
Generalised itching and skin rash
Did she/he have white sores in mouth (white patches)?
Did she/he have any skin disease?
Had multiple sexual partners?
Had been injecting drugs?
Any test done to confirm HIV/AIDS? If so, write name of the facility and when was it done
Had any one in the family (spouse or parent) has HIV/AIDS?
Had TB? (For symptoms - refer above under respiratory tuberculosis)

Tetanus:
Locked jaw (unable to open mouth), history of stiffness of neck/back of the body and fits
History of open wound, animal bite/sting, burns, fracture, fireworks
Injury, bad wound in limb

Leprosy:
History of unhealed ulcers
Disfigurement

Mental Disorders
History of sudden changes in behaviour, sudden spells of excessive crying, isolation, withdrawn nature
History of aggressive, unusual or violent behaviour
History of excessive talking, incoherent or self talking
Reporting hearing of voices
Passing into sudden bouts of unconsciousness
Loss of memory and difficulty in recalling names of objects or persons

9.5 Diabetes: Also known as sugar disease. May have the history of:

Increased appetite, thirst, increased frequency of urination
Weight loss/weight gain
Unhealed ulcer, amputation
Gangrene (blackening of the skin due to serious and permanent arterial obstruction)
Diabetic coma (unconsciousness)

9.7 Cancer

Loss of weight
Lumps or ulcers rapidly increasing in size over the period
Difficulty in swallowing or breathlessness for more than a month
Prolonged cough
Loss of appetite
Bleeding from various body openings (eg. Bleeding PV)
History of taking treatment for cancer
Write the site of the cancer, type of treatment received and details on spread of cancer, if possible, as stated by the respondent.

XIII. Appendix III: Maternal Deaths

Maternal deaths – include deaths during pregnancy, delivery, or within six weeks (42 days) of delivery or abortion.

Collect the following information on delivery:
Duration of pregnancy, history of antenatal care, type of delivery (normal, caesarean, forceps or vacuum), complications of pregnancy (prolonged labour, difficulty in delivering the placenta, fits, loss of consciousness, hypertension, excessive bleeding (in the beginning of labour pains or during labour or after delivery), history of puerperal infection/sepsis, date of delivery, place of delivery- domiciliary or institutional.

Collect the following information on abortion:
Spontaneous or induced, place of abortion- domiciliary or institutional.
Who attended it? Doctor, midwife/nurse or traditional birth attendant

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