4
Estimating the costs of tobacco use

James Lightwood, David Collins, Helen Lapsley, and Thomas E. Novotny[1]

Reliable estimates of the costs of tobacco use are valuable to policy-makers, particularly in planning health service provision and other items of public expenditure. However, such estimates are difficult to obtain because the methods used by different researchers vary and, in some respects, are controversial. Four types of cost analyses are compared here and the implications of different methods for results are explored. The literature on the healthcare costs of smoking is more extensive than for other types of cost and therefore forms the focus of this chapter. Estimates of the *gross* healthcare costs of smoking (that is, all the expenditures associated with treating diseases attributable to smoking) for high-income countries range between 0.10% and 1.1% of gross domestic product (GDP).The higher estimates occur in countries where healthcare costs account for a relatively large share of GDP. In low-income and middle-income countries, fewer studies have been performed, and often with very limited data, but the existing studies suggest that the gross costs of smoking can be as high as those in high-income countries. Studies of the *net* healthcare costs of smoking—which compare the *lifetime* healthcare costs of smokers and non-smokers and take account of the fact that smokers' lives are usually shorter than non-smokers'—reach more heterogeneous conclusions. This is because of major variations in the methods and assumptions used. However, the majority of these studies indicate that there are net costs from smoking. There is a clear need for refinement of the methods for making cost estimates, particularly for application in developing countries where the tobacco epidemic has yet to peak.

4.1 Introduction and overview

The health effects of tobacco use have been extensively documented (see Chapter 2). The costs and benefits associated with tobacco use are less well documented, and the methods used for cost estimates are complex and controversial. This chapter discusses the types of cost analysis that have been applied to tobacco consumption and reviews the existing cost estimates.

In developing countries, the relative burden of non-communicable disease is growing because of increasing life expectancies brought about by improvements in the standard of living and public health (Murray and Lopez 1996b). Also, most developing countries are at an earlier stage in the smoking epidemic than the high-income

[1] The authors gratefully acknowledge Helmut Geist and Rowena Jacobs for providing information on the environmental effects of tobacco agriculture.

countries, and the burden of tobacco-related disease is expected to treble between 1990 and 2020 (Murray and Lopez 1996a). As a result of both these trends, public health needs in developing countries will be transformed over the next 25 years. The full health consequences of smoking will not be felt until several decades after the increase in smoking prevalence, while childhood mortality and infectious diseases will be decreasing but will still be significant problems. However, because many of the consequences of smoking are not yet realized, tobacco control may not be regarded as a high priority by policy-makers. Careful analyses of the economic and financial implications of increasing tobacco use may prove valuable in planning for public health needs in the near future.

The plan of the chapter is as follows. First, three commonly used types of cost analysis will be described. The purpose, appropriate definitions of cost, and other issues will be discussed for each type of analysis. Then the application of each type of cost analysis to tobacco use will be discussed briefly. Next, existing cost estimates will be reviewed, with an emphasis on the costs of healthcare, because the literature is most extensive for this sector of the economy and because of its importance in public finance. The final section contains conclusions and suggestions for government program development, with an emphasis on important issues for developing countries.

4.2 Types of cost analysis

Confusion can arise in cost estimates because the definition of cost depends on the question that is being considered. Cost estimates using one definition will differ from those using another. Three types of analysis will be discussed and illustrated here: economic cost–benefit analysis (ECBA), GDP-based social cost analysis (GSCA), and expenditure-based cost analysis (EXBA). The approaches used in older studies may not match the prototypes presented, given changing notions of cost over time and data limitations that have forced authors to use approximations and compromises. These definitions represent broad categories that can be used to classify existing cost analyses, and for planning future research. See Leu and Schaub (1984), and Pekurinen (1992) for more detailed discussions of analyses of the costs of tobacco use. Cook (1991) is also an important discussion of the costs of substance abuse, although it is applied to alcohol.

The definition of cost employed and the type of analysis used is generally based on the policy question to be answered. For tobacco policy, key issues include optimal taxation and regulation, and the design and funding of public health campaigns (see Table 4.1). Consistency in defining costs is particularly important in avoiding double counting, aggregating costs over time, and identifying transfers of funds (as opposed to costs). The perspective from which costs are defined is also important. The perspective, for example, could be that of a government bureau, the healthcare sector of the economy, or all of society. Below, the different types of cost analysis are discussed.

4.2.1 Economic cost–benefit analysis (ECBA)

ECBA defines costs as opportunity costs. It is most often used when the policy question concerns the effect of a policy on economic welfare from the whole society's perspective. The underlying assumption is that people are rational agents who always

Table 4.1 Interpretation and use of cost estimates for tobacco policy

Type of estimate	Interpretation of results	Example of policy use
Aggregate costs	Total costs of smoking compared with alternative situation of zero smoking prevalence.	Indication of the size of the smoking problem.
Disaggregated costs	Costs of smoking disaggregated by various cost categories.	Budgetary planning for individual government units.
Avoidable costs	Potential economic benefits from harm reduction strategies.	Determination of the appropriate level of resources or best technique to be devoted to harm reduction strategies.
Cost incidence	The distribution of external costs among various community groupings.	Design of policies to correct undesirable cross-subsidies.
Cost impact	The impact of smoking on government unit's revenues and expenditures, or other group's economic welfare.	Determination of how much the tobacco industry should provide to compensate for smoking-related costs incurred by the public sector or specific groups.

Source: adapted from Table 4.1 in Collins and Lapsley (1998).

maximize their own individual welfare. In the case of tobacco, many economic costs arise from externalities in consumption or production, or from private costs due to mistaken decisions arising from imperfect information (see Chapter 7 for a detailed discussion). ECBA considers both direct and indirect, and tangible and intangible costs of tobacco use, unlike other definitions that only include monetary expenditures. However, in some ways, the ECBA definition of costs is less inclusive than others. For example, assuming utility-maximizing behavior implies that some of the medical care costs borne by the smoker of treating tobacco-related disease should not be counted. Instead, only the unexpected excess medical expenditures are included, since the tobacco user is assumed to account for the expected excess expenditures when deciding whether to consume more tobacco. This has practical significance because there is evidence that smokers do under-estimate the mortality effects of smoking (Schoenbaum 1997).

It is particularly important to avoid double counting in ECBA analyses. To do so, the analyst must identify transfer payments (which are not considered economic costs) and carefully separate primary and secondary markets in evaluating tax policy or the effects of changes in the life expectancy of tobacco users on medical and pension expenditures. Anderson (1977), Zerbe and Dively (1994), and Dinwiddy and Teal (1996) provide thorough guides to ECBA. There is no complete economic cost–benefit estimate of the aggregate cost of smoking, though some estimates of the costs that smokers impose on others (the external cost of smoking) follow the definition as closely as current data permit.

4.2.2 GDP-based social cost analysis (GSCA)

GSCA defines costs as the foregone flows of economic production, as defined by the System of National Accounts (SNA), with gross domestic product (GDP) being the most commonly used measure. The perspective for these analyses is usually that of the whole society, but it may also be that of a specific sector within an economy or government. The focus on foregone production creates differences between GDP-based costs and economic costs. For example, the economic cost of premature death is the welfare loss to the tobacco user from the unexpected increase in the annual excess probability of death from tobacco use. GDP-based costs of premature death would be based on the loss of production from the premature death of the tobacco user, whether expected or not. GDP-based cost analysis does not include intangible costs, such as non-market losses, pain and suffering from illness, other than what is reflected in market transactions.

The Canadian Centre on Substance Abuse (CCSA) has produced guidelines for adapting GDP-based costs analysis to social costs of drug use (Single *et al.* 1996a) based on the pioneering work on the cost of illness by Cooper and Rice (1976). These guidelines modify standard SNA cost definitions in two ways. First, they focus on social costs, or costs that are borne by others in society in addition to some of those borne by tobacco users. Second, they identify a threshold level of drug use that is considered addictive; use above this level is considered beyond the control of the user and, therefore, abusive. Expenditures resulting from abusive drug use are classified as costs. In the case of tobacco, almost all use is considered abusive because of the extreme potential of tobacco for addiction. The social costs of abusive consumption include the costs of morbidity and premature mortality, and the increased medical expenditures incurred by victims of environmental tobacco smoke. The CCSA guidelines also propose expanding traditional SNA-based accounts to include costs within the household and intangible costs that do not result in market transactions. These effects, such as household production lost while caring for an ill smoker, may be particularly significant in developing countries. Collins and Lapsley (1998) provide an informative discussion of this approach to estimating social costs.

4.2.3 Expenditure-based cost analysis (EXBA)

This defines costs as monetary expenditures (and revenues as benefits) that occur because of tobacco use. Intangible costs are excluded, as is the economic value of lost life. The perspective, or the definition, of the economic sector that incurs the expenditures or receives the revenues, is very important in EXBA. Many economic organizations must consider the effect of changes in revenues and expenditures on their budgets, from individual households to national health agencies. Keeping a consistent perspective is very important to avoid double counting. Transfer payments from one sector to another will be included as costs in EXBA, while transfers within a sector are not counted as costs, and neither type of transfer is an economic cost.

4.2.4 Cost-effectiveness analysis (CEA)

Smoking is associated with particular outcomes such as excess death and disability; utilization of healthcare; and costs, of the types described above. However, none of these

types of analysis relates costs to particular outcomes or to changes in outcome; that is, they are not estimates of the cost of doing something so as to produce different results. That is the domain of cost-effectiveness analysis (CEA)—for example, the cost of extending smokers' lives through cessation programs. Gold *et al*. (1996) provide a comprehensive guide to CEA.

4.3 A taxonomy of costs for tobacco policy analysis

This section presents a taxonomy of costs relevant to tobacco policy. Table 4.2 provides a simple classification of aggregate costs from cigarette smoking for each of the approaches discussed in the previous section. The columns show the type of cost analysis and the rows show the various cost categories. The discussion below will compare and contrast the definition of costs used in each approach. In this section, all costs are defined in terms of the net present value arising from each individual smoker, so costs are defined as both current and expected discounted future costs. Issues concerning the treatment of future costs are discussed below.

4.3.1 Consumption

Smokers receive net benefits from that portion of consumption that can be justified by the smoker's knowledge of the health consequences, and other ill effects, of smoking, less out-of-pocket costs. In ECBA, this is usually measured by consumer surplus (see Chapter 6). There is little or no consumption benefit in GSCA since nearly all smoking is classified as abusive consumption (Collins and Lapsley 1991, 1996). In EXBA, the benefits include tax revenues and any reductions in expenditures for social insurance and medical expenditures that result from smoking.

Costs from consumption include those that fall on the smoker, arising mostly from the addictive nature of tobacco consumption and imperfect information about its consequences (see Chapter 6 for a discussion of these costs). Recently, some have described these costs as a type of externality (e.g. Stiglitz 1994b; Viscusi 1995). ECBA characterizes these costs as a welfare loss for smokers who are smoking more than they would with full information and a clear understanding of addiction. EXBA includes an analogous cost from government-funded programs for smoking cessation. Standard GSCA would exclude this type of cost as being a private cost of the smoker, rather than a social cost (Single *et al.* 1996a).

4.3.2 Health effects from smoking

These effects are overwhelmingly negative (see Chapter 2) and can be divided into direct and indirect costs. In some analyses (particularly in EXBA), premature death from adverse health effects may produce savings from reduced medical expenditures arising from the premature death of smokers. These can be divided into direct and indirect costs. For direct costs, three quantities must be measured in each of the three analyses. The first quantity is the incidence or prevalence of each disease caused by smoking. This is usually measured by the Smoking Attributable Fraction (SAF), which measures the average proportion of the occurrence of disease attributable to smoking (see Xie *et al.* 1996, section 3.3, for a good discussion of attributable fractions). Accurate estimation of

Table 4.2 Taxonomy of costs for tobacco policy

Cost category	Economic cost–benefit analysis	GDP-based social cost analysis	Expenditure based analysis
Consumption			
1. Benefit	Consumer surplus of smoker from 'informed' cigarette smoking.		Tax revenues from cigarette sales.
			Lower social insurance expenditures and medical expenditures from premature death due to smoking.
2. Cost	Welfare loss of smokers from cigarette consumption due to unexpected addiction.		Expenditures for smoking cessation programs and treatments.
	Welfare loss from unexpected illness and premature death of smoker due to smoking.	Production loss of smokers from illness and premature death due to smoking.	Expenditures and tax losses from illness and premature death of smokers due to smoking.
	Welfare loss from externalities to non-smokers from illness and premature death of smokers due to smoking.	Production loss and expenses of non-smokers from illness and premature death of smokers due to smoking.	Expenditures and tax losses of non-smokers from illness and premature death of smokers due to smoking.
	Welfare loss from externalities of illness and death due to environmental tobacco smoke.	Production loss and expenses from illness and death due to environmental tobacco smoke.	Expenditures and tax losses from illness and premature death due to environmental tobacco smoke.
	Welfare loss from fires and pollution due to cigarette smoking.	Production and tax revenue loss from fires and pollution due to smoking.	Expenditures and tax losses from fires and pollution due to smoking.
Production			
3. Benefit	Producer surplus.		Producer tax revenues (that are not paid by smokers).
4. Cost	Welfare loss from unexpected illness and death of tobacco workers due to exposure to tobacco.	Production loss from unexpected illness and death of tobacco workers due to exposure to tobacco.	Net expenditures and loss of tax revenue due to illness and premature death of tobacco workers due to exposure to tobacco.
	Welfare loss from environmental pollution due to tobacco production.	Production loss from environmental pollution from tobacco production.	Net expenditures due to environmental pollution from tobacco production.

the SAF is complicated because it depends on the demographic structure, general health, and smoking habits and history of the population, as well as on the characteristics of smokers. The second quantity is the change in utilization of health and other social services as a function of the amount of smoking-related disease. This is particularly important for forecasting smoking-related costs in developing countries where current utilization rates are typically lower than in developed countries, but growing. Measured utilization depends on the health services that are included in the estimate. These services are shown in Table 4.3, and are discussed in more detail in Collins and Lapsley (1998). The third quantity is the expenditures resulting from increased utilization. In countries with good expenditure surveys, these three quantities can be estimated at once. Otherwise, they will have to be estimated separately and total costs modeled as a function of SAF, total utilization, and average cost per unit of utilization. Warner *et al.* (1999) present a detailed discussion of technical issues involved in these estimates.

In ECBA, only resources expended because of unexpected smoking-related illness

Table 4.3 Health services used in estimating direct healthcare costs of smoking

Cost center	Sources of data	Comments
Hospital services	Medical records, hospital and insurance fund bills, actual costs in public sector hospitals, DRG costs.	Usually highest share of direct costs. In developing countries, families provide significant direct unreimbursed care.
Physician/outpatient services	Fee-for-service bills, out-of-pocket expenses reported on household surveys, etiologic fraction of capitated costs.	Informal payments not accountable, but are common in many countries.
Prescription drugs	Insurance payments, sales data, out-of-pocket expenditures, and formularies.	Does not capture costs of over-the-counter drugs.
Nursing home services	Insurance payments, long-term care facility bills, actual costs in public sector facilities, and reported out-of-pocket expenses.	Many informal facilities with no diagnostic data; costs may include family transfers. Smokers in nursing homes tend to have high co-morbidity.
Home healthcare	Official home healthcare provider bills, insurance payments, and reported out-of-pocket expenses.	Many informal facilities that do not have diagnostic data, and may be part of extended family transfers. Most healthcare in developing countries is in home.
Allied healthcare (rehabilitation, respiratory therapy, nutrition care, etc.)	Insurance payments, facility bills, and reported out-of-pocket payments.	Etiologic fractions are not established in any country.

and premature death are counted as costs (see Chapter 8, for a discussion of how well informed smokers are about the risks of smoking). Economic value-of-life measures are used for evaluating this cost. In some variations of GSCA, all costs are included regardless of the smoker's expectations, and the loss of life is valued as the loss of production to society from premature death. In EXBA, costs are lost revenues from premature death, which are mostly lost tax payments and contributions to public health insurance programs.

Indirect costs include those imposed on the household from smoking-related illness or premature death. These costs cover a wide range, as shown in Table 4.4. A similar list could be constructed for indirect costs imposed on private business, or other people in society, that would include, for example, increased employee health insurance premiums. In ECBA, one example is the extra insurance premiums paid by non-smokers to cover expected smoking-related claims under policies that do not distinguish smokers from non-smokers. As with other costs in ECBA, this concerns effects on society that are unanticipated, or for which adjustment for the expected effects of smoking is not possible. In GSCA, an example of these costs is the extra insurance premiums paid by non-smokers, as well as the loss of production of family members who must care for an ill smoker, even if the probability of smoking-related illness was known by all. In EXBA, an example is the government expenditures caused by illness and premature death from smoking, and those for family members who forego employment to care for an ill smoker. Estimation of indirect economic effects in developing countries must consider the problem of incomplete insurance markets (Dinwiddy and Teal 1996).

The remaining cost categories include more familiar externalities from smoking. These are mostly from death and illness caused by exposure to environmental tobacco smoke, and property damage and injuries caused by smoking-related fires.

4.3.3 Production

On the production side, there are minor benefits. In ECBA, the benefit is producer surplus. In EXBA, the benefits might include producer tax revenues that are not passed on to smokers, although these are likely to be negligible.

The cost categories under production include externalities concerning health and environmental pollution. These costs can be particularly important for some developing countries. For example, tobacco workers may suffer nicotine poisoning known as green tobacco sickness through handling uncured tobacco leaves (Hipke 1993; Ballard *et al.* 1995).

There are three types of environmental cost associated with tobacco production. The first is soil degradation, which occurs because of the high nutrient requirement of tobacco. This high nutrient requirement can lead to pest infestation, and either 'soil mining' or environmental pollution form heavy fertilizer use (Geist 1999a). The second externality is deforestation from the intensive use of wood that is used in curing and processing tobacco leaf (Geist 1998, 1999b, 2000). Third, tobacco production requires large amounts of pesticides that may escape tobacco fields and cause ground and water pollution, and sickness among workers (Erdmann and Pinheiro 1998). Each definition of cost will lead to a different cost estimate. ECBA will define costs as

Table 4.4 Economic effects of fatal illness on the household: type and timing of impact

Type of impact	Timing of Impact			
	Before illness	During illness	Immediate effect of death	Long-term effect of death
Effect on production and earnings	Organization of economic activity Residential location	Reduced productivity of ill adult Re-allocation of labor	Lost output of deceased	Lost output of deceased Reallocation of land and labor
Effect on investment and consumption	Insurance Precautionary savings	Time and household resources use in treatment Spending savings Changes in consumption and investment	Funeral costs Legal fees	Changes in type and quantity of investment and consumption
Effect on household health and composition	Extended family Fertility	Reduced allocation of labor to health maintaining activities	Loss of deceased	Poor health of surviving household members Dissolution or reconstitution of household
Psychic costs		Disutility of ill individual	Disutility to individual Grief of loved ones	

Source: adapted from Table 4.1 in Over, M. *et al.* 1992 from *The Health of Adults in the Developing World*, edited by Richard Feachem *et al.*, Copyright 1992 by International Bank for Reconstruction and Development/The World Bank. Used by permission of Oxford University Press, Inc. (1992).

welfare losses to individuals that occur because of the environmental externalities, or from unexpected effects of working in tobacco production. GSCA will count social costs, principally production losses due to production externalities. EXBA will count governmental, or other organizational, money expenditures.

4.4 Review of cost estimates of tobacco use

This section presents a critical review of estimates of the costs of cigarette smoking and other forms of tobacco use. First, several methodological issues which are used in the detailed descriptions below are discussed. Second, the individual studies and their results are reviewed. Additional reviews of estimates of the cost of smoking can be found in Markandya and Pearce (1989), and Robson and Single (1995).

4.4.1 Methodological issues

Current, future, gross, and net costs

A number of studies attempt to estimate the cost of all past and current smoking; these costs can occur in both the present and the future. Whether future expected costs should be included in the estimate depends on the question that the estimate is intended to answer. The most important element of future costs results from the decreased life expectancy of smokers. In expenditure-based estimates, the shorter life expectancies for smokers will produce cost savings through lower social insurance payments, and increase costs through reduced tax revenues. In some cases the answer to whether future costs should be included is clear: EXBA estimates to be used for budget planning should include expected future costs. However, future costs estimated for expenditure-based analyses should not be confused with economic cost–benefit estimates of economic welfare. The estimation of expected future costs differ under these two definitions. In ECBA, for example, many future costs and benefits from changes in life expectancy due to smoking will be included in the price of tobacco and other prices, to the extent that smokers and other agents in the economy understand the effects of smoking on mortality. Estimating all the costs and savings of changes in life expectancy separately and adding them to the estimate will result in double counting.

The issue of aggregation over time must be addressed whenever future costs are reported as a single summary statistic. Most estimates use the real net present value of future costs, and are therefore adjusted using a real social discount rate. The appropriate real discount rate to use is controversial. It is possible to use a zero discount rate, but if expenditure streams are aggregated over the infinite future, the sum of the costs in each period can be infinite. In developed countries, a real discount rate of between 2.5% and 5% is appropriate when changes in costs are widely dispersed throughout society, when there is a reduction in costs, or when the price of capital is not significantly affected by the proposed program change (Zerbe and Dively 1994). Where a social program uses resources that increase the price or availability of capital significantly, the real discount rate is more appropriately determined by the cost of

borrowing funds for capital investment, and may be as high as 10%. Discount rates used in various studies range from 2.5% to 10%, with, 3% being the most common. The use of very low real discount rates may be interpreted as implying that all healthcare is consumption and none is investment, which may not be a good assumption, particularly in developing countries (see Dinwiddy and Teal (1996) and Stiglitz (1994a) for a discussion of appropriate real discount rates).

A related issue concerns the computation of *gross* versus *net* costs. Gross costs are defined as all of the costs of treating smoking-attributable diseases and all other costs that can be attributed to smoking. They are usually an estimate of costs at any point in time, and are *not* a comparison of the lifetime costs of smokers versus those of non-smokers. Net costs, in contrast, tend to be assessed over lifetimes and are often expressed as a comparison of the lifetime costs of smokers versus those of non-smokers. Net costs take account of the fact that smokers tend to die younger than non-smokers and that they therefore avoid some healthcare costs, and forego some pension benefits, in old age. There are many approaches to calculating net costs. One approach is to estimate the net present value of smoking costs until all those people alive today who have ever smoked are dead, or until a non-smoking population is reached. Another approach is to estimate the difference between costs with the current smoking prevalence and costs in a stationary non-smoking population. A third approach deducts from gross costs the costs of dead smokers who would be alive now if they had not smoked in the past. A fourth deducts the future costs of smokers who died from tobacco-related illness in the current year. Each approach has a different interpretation, which should be considered carefully when the net cost estimate is used for policy analysis. Each approach requires strong assumptions about either the future or the past, including assumptions about smoking prevalence, patterns of healthcare utilization, relative costs, and life expectancies. Almost all studies assume that current conditions can be extrapolated over the average life span.

Life-cycle versus cross-section estimates

Two approaches have commonly been used to estimate costs: the *life-cycle approach* and the *cross-section approach*. Life-cycle studies can be considered incidence-based approaches to calculating costs. This approach estimates costs for smokers and non-smokers over their entire expected lifetimes. The estimated lifetime costs of the existing population of smokers and non-smokers is compared with those for a corresponding hypothetical non-smoking population. The life-cycle approach directly estimates the effect of the shorter life-span of smokers and the resultant change in costs. Summary estimates of current and future costs that aggregate cost flows over time are calculated using net present value analysis (Hodgson 1992). Life-cycle estimates can be used to estimate current costs by simply omitting expected future costs and savings.

Cross-section studies are based on the methodology of Cooper and Rice (Cooper and Rice 1976; Rice *et al.* 1986; Bartlett *et al.* 1994; Max and Rice 1995). The cross-section approach can be considered a prevalence-based approach: it estimates current costs as a function of the effects of all current and past smoking (Rice *et al.* 1986). Cross-section estimates are based on the costs incurred by currently living or recently

deceased smokers without examining the effect of smoking on their life expectancies. They do not, therefore, capture the effects of changes in life expectancy as a function of smoking, and do not include this effect on future costs. However, cross-section estimates can be adjusted to approximate the effects of changes in life expectancy due to smoking status, and can serve as an approximation to net costs estimated with the life-cycle approach.

The quantification of future costs in life-cycle estimates can pose difficult problems. Changes in demographic structure will affect future costs, and forecasts of future demographic changes require strong assumptions because patterns of morbidity and mortality can change rapidly. It is possible, for example, that health will improve for persons in any age group, including the old and very old. This is a particularly important issue for developing countries because the percentage of the population that lives long enough to experience the chronic effects of smoking may increase rapidly (Feachem *et al.* 1995). Also, the cost of services is usually concentrated just before death. In developing countries, these costs may be less dependent on hospital care and more dependent on less-quantifiable transfers from other family members. Finally, aging populations may actually provide resources by providing care to younger ill populations and through other transfers (Normand 1998), particularly in developing countries. However, the very old may require significantly more support from the younger generation in the non-market sector of the economy (James 1994). In at least one study in a US health-maintenance organization (Scitovsky 1994), the oldest group of patients received much less resource-intensive medical care than middle-aged or younger patients, but they did receive more support from families, nursing homes, and home healthcare services. Utilization rates may also change dramatically, especially in developing countries. Similarly, it is difficult to estimate the demographic composition of hypothetical non-smoking populations for use in computing net costs in cross-section studies.

Reporting costs attributable to tobacco use

Careful attention must be paid to how costs are reported in various studies. Aggregate costs have been reported in both cross-section studies (Rice *et al.* 1986) and life-cycle studies (Leu and Schaub 1983). Hodgson (1992) reported the lifetime cost per person for tobacco use in one life-cycle study. Lippiatt (1990) reported the net change in cost per life-year gained from smoking cessation in a life-cycle study. The external cost per pack of cigarettes is often calculated for estimates of the external burden of smoking (see, for example, Manning *et al.* 1989). The cost per unit sold is a useful measure for tax planning; however, it will be difficult to estimate in countries such as Bangladesh and India where manufactured products sold in formal markets constitute a smaller part of consumption (World Health Organization 1997). Measuring costs as a fraction of GDP is a useful measure of aggregate costs, and this measure is used for comparison whenever possible in this review.

Cross-section studies that estimate only current gross costs usually report aggregate costs. Since these estimates take the population and smoking prevalence as fixed, total cost can be readily converted into the other measures. This is not true for net costs because a non-smoking population will have more life-years than one with some

smoking over the expected life spans, and the size of the smoking population will usually differ from that of a non-smoking one. Therefore, the same total costs will imply different costs per person, or per life-year, for a non-smoking population than for a population in which some people smoke. This measurement issue is particularly important for developing countries where rapid demographic change is expected (for further discussion see Thompson and Forbes (1985).

Statistical issues in measuring costs attributable to tobacco use

There are two important statistical issues involved in the measurement of tobacco-related expenditures for cost analysis that need further discussion. These are the relative risks, for smokers versus non-smokers, of using healthcare services, and the possibility of confounding from other health-related characteristics of smokers that would not change if they did not smoke.

Relative risk of using healthcare services from smoking

The smoking-attributable fraction (SAF) is used to calculate the proportion of costs attributable to a given risk factor. Two components are necessary for its estimation: the relative risk of the outcome due to exposure to the risk factor, and the prevalence of the risk factor. The relative risk of healthcare utilization for smokers versus non-smokers has been estimated using two different methods. The first is called the *synthetic method*, since the estimates are built from assumptions about the relative risk and costs of smoking for individual diseases. This method selects those diseases that are known or strongly suspected to be caused by smoking and uses estimates of the relative risk of each disease and smoking prevalence to estimate a disease-specific SAF.

In high-income countries, separate disease-specific SAFs for many health care services have been estimated from survey and observational data (Rice *et al.* 1986; Miller *et al.* 1998a, 1998b). When the necessary SAF data are not available, researchers have used mortality-based or a combination of morbidity and mortality-based SAFs (Collins and Lapsley 1991). Mortality-based etiologic fractions may under-estimate the true fraction because many diseases caused by tobacco (such as chronic obstructive pulmonary disease) do not cause death until after a prolonged period of morbidity. This morbidity will cause a higher relative rate of utilization than that reflected in a mortality ratio. Alternatively, they may over-estimate it if smoking-related deaths occur after less expensive courses of treatment than non-smoking related deaths. Thus, SAFs may vary considerably across studies.

Assuming accurate disease-specific SAFs, the synthetic method produces conservative estimates of the disease burden of smoking, since it includes only conditions known to be caused by smoking. Consequently, it may significantly under-estimate smoking-related costs. The number of conditions known to be caused by smoking has increased over time (US Department of Health and Human Services (USDHHS) 1989). For example, male infertility and impotence have recently been linked to smoking. Co-morbidities (diseases where smoking is one of several contributing factors) are difficult to include using the synthetic approach, and adjustments to account for them may produce either over-estimates or under-estimates (Xie *et al.* 1996).

The second approach is the *analytic method*. This uses statistical estimates of all resources used by smokers versus non-smokers. In this approach, etiologic fractions are estimated from regression analyses employing data on healthcare utilization and expenditures, risk behavior, socio-demographic status, and health outcomes. The analytic method captures all differences in healthcare costs for smokers and non-smokers, including those from conditions and diseases that are not currently known to be caused by smoking. This approach also provides better adjustments for population characteristics, other risk behaviors, access to medical care, and co-morbidities. A disadvantage of this approach is that it may over-estimate the reduction in healthcare costs if smokers stop smoking. This is because it may be difficult to determine how much of the difference in utilization is due to smoking itself, as opposed to other unmeasured behaviors and characteristics of smokers that will not change, even if these people did not smoke. This issue is discussed further below. A disadvantage of this approach for developing countries is that the necessary data are unlikely to be available. For example, the National Medical Expenditure Survey II (NMES II), used in recent analyses in the United States, was very expensive to develop. However, methodological issues raised in studies in the high-income countries that use the analytic approach will be useful for planning and implementing future surveys in developing countries (Mackay and Crofton 1996).

Confounding from other behaviors and characteristics of smokers

Smokers differ from non-smokers in several ways that are not causally related to smoking and that may remain unchanged even if smokers become non-smokers. Smokers and non-smokers have different levels of education and income, and different rates of insurance coverage, alcohol use, physical activity, and other risk behaviors (Hodgson 1992). If smokers did not smoke but continued to engage in other risk behaviors, then their health expenditures would continue to be higher than those of non-smokers. Ignoring these differences between smokers and non-smokers could lead to an over-estimate of the costs of smoking. In order to handle this problem, investigators have modeled the so-called 'non-smoking smoker' type: that is, a person who does not smoke but has the other characteristics typical of smokers.

There have been two approaches to modeling the non-smoking smoker type. The first approach is relatively *ad hoc*, allocating a fixed proportion of the excess risk of disease to smoking itself, and the remainder to the other characteristics of smokers (Leu and Schaub 1983; Hodgson 1992). This approach has been criticized as being arbitrary (Rice *et al.* 1986; Hodgson 1992). The second approach is to adjust the data statistically for these differences. Statistical adjustment can be used with the synthetic method when estimating SAFs for particular diseases, or with the analytic method when estimating relative healthcare use and expenditures for all diseases. This approach is used when people's use of healthcare is estimated from surveys that record individual characteristics. Manning *et al.* (1989), for example, used this approach to control for drinking and other risky behaviors. That is, they estimated the non-smoking smoker types' levels of healthcare use by considering non-smokers with drinking patterns and other characteristics similar to those of smokers. This approach has the advantage of being less arbitrary than an *ad hoc* adjustment. However, it also assumes that these other factors will remain constant if smokers quit smoking. Such an assump-

tion may be valid where education and income level are concerned, but may be less acceptable for behaviors that are affected by smoking. For example, smokers may take less exercise because of a taste for a sedentary life that is correlated with, but not caused by, smoking, but this may also be a result of the harmful respiratory effects of smoking.

4.4.2 Review of cost estimates

This section reviews cost estimates of smoking. A variety of approaches were used in these studies. Except where noted, the definitions of cost correspond most closely to expenditure-based costs from the perspective of the healthcare sector. The studies on healthcare costs are organized into groups that are reviewed in the following order: gross costs, net costs, and estimates of the external burden of healthcare costs on non-smokers. Estimates of social costs and the total social external burden of smoking are reviewed last; these estimates depend heavily on the economic organization and institutions of individual countries, so this part of the review will be selective and brief.

Estimates of gross cost

Many studies have estimated gross costs; only a few will be summarized here.[1] Whenever possible, estimates for the same region and period have been selected to increase the reliability of independent estimates and the effect of different methodologies. The studies for the United States are summarized in Table 4.5, while Table 4.6 presents the results for other high-income countries, and in Table 4.7 the results for developing countries. The US Centers for Disease Control and Prevention has distributed several versions of a computer program (SAMMEC: Smoking-Attributable Mortality, Morbidity, and Economic Costs) for use in cross-section estimates of smoking costs (Shultz 1985; Shultz *et al.* 1991). Many estimates for single regions or states in the United States using this software have appeared in the public health literature (Robson and Single 1995), and they are too numerous to review here. The SAMMEC methodology is based on the attributable-risk methodology developed for the United States (Cooper and Rice 1976; Hodgson and Meiners 1982; and Rice *et al.* 1986). Therefore it is appropriate only for use in economies with relatively well-developed healthcare systems and relatively mature smoking epidemics.

The United States

Luce and Schweitzer (1978) were among the first to estimate current gross costs for the United States. They used a synthetic cross-section approach with disease specific SAFs for malignant neoplasms, circulatory and respiratory diseases, and injuries from fires. These SAFs were applied to the average cost of each of these illnesses. No adjustment was made for smoking related characteristics. Their estimated direct costs of smoking for 1976 were US$8.2 billion, or 0.46% of GDP. This early study provides the basic methodology used by many synthetic studies based on aggregate data. A strength

[1] One influential cost estimate from the US Office of Technology Assessment (Merdman *et al.* 1993), and a subsequent controversial and poorly documented revision, is not discussed here because of space limitations (for a detailed discussion of these estimates see: Warner *et al*. 1999).

Table 4.5 Estimates of gross healthcare costs, United States

Study	Year of estimate	Services included[a]	Diseases included[b]	Tobacco attributable medical care costs (US$ billion)	% of GDP	Method: analytic vs. synthetic	Method: cross-section vs. life-cycle
Luce and Schweitzer (1978)	1976	F H L M O P[c]	C M R F	8.2	0.46	Synthetic	Cross-section
Rice *et al.* (1986)	1984	F H L M O P	C M R	23.3	0.62	Synthetic	Cross-section
Bartlett *et al.* (1994)	1993	F H L M P	C M R[d]	50.0	0.79	Synthetic	Cross-section
Miller *et al.* (1998b)	1993	F H L M O P	[e]	72.7	1.15	Both	Cross-section
Miller *et al.* (1999)	1993	F H L M O P	[f]	53.4	0.84	Analytic	Cross-section

[a] Services are: F, other professional medical fees; H, hospital; L, long-term care; M, medicine; O, outpatient visits; P, physician fees.
[b] Diseases are: C, cardiovascular and circulatory diseases; M, malignant neoplasms; R, non-malignant respiratory disease; F, health costs from fires.
[c] All costs included in Cooper and Rice (1976).
[d] Emphysema only included in non-malignant respiratory illness (R).
[e] Diseases included in Bartlett (1994), plus all diseases associated with poor health states due to smoking.
[f] All diseases reported in survey.

of their estimate was the use of cost-of-illness estimates from Cooper and Rice (1976), which covered many health services. The study's principal weakness is the use of relatively informal judgmental estimates for SAFs developed by an expert consensus panel.

Similarly, Rice *et al.* (1986) estimated gross costs for 1984 using a synthetic cross-section approach. This study reports aggregate costs to the healthcare system for three broad disease categories: cardiovascular disease, respiratory disease, and malignant neoplasms. The SAFs were estimated using the US National Health Interview Survey (USNHIS). Both current and former smokers were defined as smokers. These SAFs were applied to average national expenditures for various services. This study included a relatively complete list of healthcare services: hospital services, services from a physician or other professionals, nursing-home care, home healthcare, and medications. Due to a lack of data, SAFs for hospital care were applied to several other healthcare services. No adjustment was made for the non-smoking smoker type. They estimated that US$23.3 billion in healthcare costs, or 0.62% of GDP, were attributable to smoking in 1984. The use of SAFs estimated from survey data on utililization, rather than the more subjective estimates used by Luce and Schweitzer (1978) was a significant advance. The principal shortcoming of the study was that no adjustments were attempted for the non-smoker smoking type.

Bartlett *et al.* (1994) estimated gross costs for 1993 using more detailed survey data

on health expenditures and characteristics of smokers versus non-smokers. SAFs were estimated for cardiovascular and cerebrovascular disease, cancer, and emphysema. The SAFs were estimated in three stages: the first stage estimated the effect of smoking on the presence of a smoking-related disease; the second estimated the probability of expenditure in each disease type; and the third estimated conditional smoking-related expenditures. Data on expenditures were taken from the 1987 NMES-II. NMES-II included all medical expenditures reported by the respondents along with extensive demographic, socioeconomic and behavioral information. NMES-II also included a survey of medical service providers reporting healthcare expenditures that respondents might not be able to report, thereby increasing the accuracy of the expenditure estimates. The study also addressed the issue of the non-smoking smoker, as well as other possible sources of bias, by extensive statistical adjustment after categorizing respondents into four categories: current smokers, those who never smoked, and two categories of ex-smokers. Health services considered included: hospital services, ambulatory care, physician services, prescription medications, and home healthcare. They estimated total costs for 1987 and extrapolated them to 1993 using expenditure data from the Health Care Financing Agency (HCFA). Their estimated cost attributable to smoking in 1993 was US$50 billion, or 0.79% of GDP. This study contained the most sophisticated adjustments for other characteristics that might differ among smokers and non-smokers and that might influence expenditures, and used the most complete survey data on individual health expenditures available. However, it limited the analysis to only a few smoking-related disease categories, and omitted other conditions known to be related to smoking (e.g. chronic bronchitis, low birthweight from maternal smoking, and ulcers). Also, SAFs for hospitals had to be used for long-term care costs given the lack of appropriate data on SAFs for long-term care.

Leonard Miller *et al.* (1998a, 1998b) developed and used a more complicated methodology. Their approach combined the synthetic and analytic methods to estimate SAFs. In the synthetic portion of the estimate, expenditures associated with known smoking-related disease categories were estimated in the same way to those of Bartlett *et al.* (1994). These estimates were adjusted based on data on demographic and socioeconomic characteristics, and risk attitudes. In addition, all other health expenditures associated with smoking were estimated, controlling for health status and health insurance status. This was intended to cover health effects associated with smoking that are not included in the major disease categories known to be caused by smoking. The analytic portion of the estimate was obtained in two steps: first, the probability of any expenditure was estimated; second, conditional health expenditures were estimated. Data from the 1987 NMES-II, the Behavioral Risk Factor Surveillance System (BRFSS) and the Current Population Survey (CPS) were used. The problem of the non-smoking smoker type was addressed by statistical adjustment in the synthetic portion of the estimate. Healthcare expenditures were estimated by applying state-specific SAFs to state healthcare expenditures supplied by HCFA. Leonard Miller *et al.* estimated the gross costs of smoking for the United States in 1993 to be US$72.7 billion or 1.15% of GDP.

This estimate was considerably higher than earlier estimates (although the 95% confidence interval for their estimates included some of the earlier estimates). One reason for this may be the use of both the synthetic and analytic approach to estimating SAFs.

The analytic portion of the estimate is supposed to account for health status. However, to the extent that self-reported health status is related to smoking, there may be some double counting of expenditures. In addition, since the study used the same expenditure data as Bartlett *et al.* (1994), the problems associated with estimating long-term care costs remain.

Vincent Miller *et al.* (1999) provides the most recent estimate of gross costs for the United States. These researchers used an analytic approach and estimated costs directly from the 1987 NMES-II. SAFs were calculated from expenditures predicted for the current population and a hypothetical non-smoking population. State-specific SAFs were calculated and applied to 1993 expenditure data to estimate state costs, then summed for the national total. The estimation approach employed is simpler than of Leonard Miller *et al.* (1998b). Two equations are estimated for each of four expenditure categories: ambulatory care, hospital care, prescription medications, and other expenses. One equation predicts the probability of a positive expenditure in each cost category; the second estimates the size of the expenditure, conditional on a positive expenditure. Expenditures attributable to smoking are adjusted for smokers' other characteristics that may influence health expenditures. These include demographic, socio-economic, and life-style characteristics, as well as health insurance status. Their estimate of costs for 1993 was US$53.4 billion, or 0.84% of GDP.

The estimate by Vincent Miller *et al.* (1999). was much lower than that of Leonard Miller *et al.* (1998b), even though the two studies used similar data and methods. Part of the difference results from the simpler statistical specification of the more recent study that they describe as a set of reduced-form equations in which all explanatory variables are exogenous. However, the authors neither justify the chosen reduced-form specifications, nor do they perform any exogeneity tests. Examination of the regression specification reveals some variables that may well not be exogenous. For example, both self-reported taste for risk, as well as specific risk behaviors, such as seat-belt use were included in the specification, which cannot occur in a true reduced form. Also, self-reported physical activity is used as an explanatory variable; however, the level of physical activity is probably affected by smoking as well as being an indicator of smokers' tastes. Failing to account for endogeneity can easily result in biased estimates.

High-income countries other than the United States

Australia Collins and Lapsley (1991, 1996) provide cross-section estimates using the synthetic approach, closely following a GDP-based definition of social costs. Both gross and net costs are estimated; the gross cost estimates are discussed here, and net costs are discussed below. SAFs for current and ex-smokers are estimated from meta-analyses of the relative risks for smoking-related conditions (although some of the SAFs used in the 1991 study were based on relative risks of mortality). No adjustment is made for the non-smoking smoker type. Medical care included hospital care, the services of physicians and other professionals, medications, nursing homes, home and community health services, and allied healthcare services. The costs of healthcare were estimated from the average costs of professional encounters or institutional bed-days. Their original (1991) gross cost estimate for 1988 was Aust$759.5 million, or 0.24% of

Table 4.6 Estimates of gross health care costs, other high-income countries

Authors	Year of estimate	Services included[a]	Diseases included[b]	Tobacco attributable medical care costs	% of GDP	Method: analytic vs. synthetic	Method: cross section vs. life cycle
Australia				Aust$ million			
Collins and Lapsley (1991)	1988	F H L M O P	C G M O R	759.5	0.24	Synthetic	Cross-section
Collins and Lapsley (1996)	1988	F H L M O P	C G M O R	910.9	0.29	Synthetic	Cross-section
Collins and Lapsley (1996)	1992	F H L M O P	C G M O R	1597.5	0.41	Synthetic	Cross-section
Canada				Can$ million			
Collishaw and Myers (1984)	1979	H P	[c]	1118.0	0.40	Analytic	Cross-section
Choi and Nethercott (1988) (Ontario)	1979	H P	[c]	261.0	0.25	Analytic	Cross-section
Raynauld and Vidal (1992)	1986	H[d]	Is MR[e]	615.0	0.12	Synthetic	Cross-section
Choi and Pak (1996) (Ontario)	1988	H P	[c]	765.0	0.30	Analytic	Cross-section
Xie *et al.* (1996) (Ontario)	1992	F H L M O P	C G M O R	1073.0	0.38	Synthetic	Cross-section
Kaiserman (1997)	1991	H L M O P	[c]	3798.0	0.56	Analytic	Life-cycle
Finland				FIM million			
Pekurinen (1992)	1987	H M O P	C M R	524–594	0.14–0.15	Both	Cross-section
Pekurinen (1999)	1995	H M O P	C M R	924.0	0.17	Both	Cross-section
New Zealand				NZ$ million			
Gray *et al.* (1988)	1984	H	C M R O[f]	61	0.16	Synthetic	Cross-section
Phillips *et al.* (1992)	1989	H M O P	C M R O[f]	185.4	0.29	Synthetic	Cross-section
United Kingdom				£ million			
Maynard *et al.* (1987)	1985–86	[g]	C G M R	290–497	0.08–0.13	Synthetic	Cross-section

[a] Services are: F, other professional medical fees; H, hospital; L, long-term care; M, medicine; O, outpatient visits; P, physician fees.
[b] Diseases are: C, cardiovascular and circulatory disease; G, gastrointestinal diseases; Is, ischemic heart disease; M, malignant neoplasms; R, non-malignant respiratorydisease; O, other. (C includes Is.)
[c] Estimates of attributable risk for hospitalization for all causes due to tobacco use from survey data. Includes medical costs from fires.
[d] Includes other unspecified health service expenditures. See text for discussion.
[e] Non-malignant respiratory disease (R) includes COPD only.
[f] Other diseases (O) includes fire injuries and perinatal complications.
[g] Estimated inpatient, outpatient, and general practice expenditures to National Health Service.

GDP. Their revised (1996) estimate for 1988 increased to Aust$910.9 million, or 0.29% of GDP. The estimate in the 1996 report for 1992 was Aust$1.6 billion, or 0.41% of that year's GDP. They attributed the increase in costs to an increase in the number of diseases that are known to be caused by smoking, increases in SAFs, and the use of disease-specific averages for hospital costs. A strength of these synthetic estimates is the use of a comprehensive list of smoking related diseases.

Canada Collishaw and Myers (1984) estimated gross costs for 1979 using the analytic method. The costs of hospitalization and physicians' services were estimated with SAFs for utilization calculated from the Canada Health Survey. These SAFs were applied to total days of hospital care and physician visits and the average cost per hospital separation or visit. No adjustments were made for the non-smoking smoker type. They concluded that smoking increased healthcare costs in Canada by Can$1.12 billion in 1979, or 0.4% of GDP.

Choi and Nethercott (1988) and Choi and Pak (1996) adapted the approach of Collishaw and Myers to Ontario Province, Canada for 1979 and 1988, respectively, using local estimates of the costs of using hospitals' and physicians' services. Estimated costs for 1979 and 1988 were 0.25% and 0.30% of Ontario's GDP, much lower than the national estimates of Collishaw and Myers.

Raynauld and Vidal (1992) conducted a synthetic study that included ischemic heart disease, cancer and chronic obstructive pulmonary disease. SAFs were calculated using data from the United States. Hospitalization costs are included. Other healthcare services are included but these are not clearly specified and apparently do not include long-term care for the elderly. These other costs are estimated by extrapolating costs for Saskatchewan to all of Canada and applying the SAFs to that estimate. No adjustments are made for the non-smoking smoker type. The estimate of gross costs for 1986 is Can$ 615 million, or 0.12% of Canadian GDP. This low estimate may be due to the restricted number of diseases included. However, it is difficult to evaluate the estimate because of the incomplete specification of the medical services included.

Xie *et al.* (1996, also reported in Xie *et al.* 1999) provide a more recent estimate for Ontario, based on the CCSA guidelines and using the synthetic approach. They used relative risks for smoking-related disease taken from the literature, and used separate SAFs for morbidity and mortality. Separate age-specific and gender-specific SAFs were calculated for current and former smokers and those who had never smoked, using relative risks from the literature, and prevalence rates for Ontario. An unusual feature of the estimates is an attempt to include the costs of co-morbidity due to tobacco. All major health services were included in the estimate. Total utilization levels were from Ontario health reports, or estimated from Canadian data. The cost data were average costs per episode of care, or average per capita costs. The SAFs were applied to total levels of utilization, and costs were estimated from average cost data. No adjustments were made for the non-smoking smoker type. Xie *et al.* estimated that the gross costs for 1992 were Can$1.1 billion or 0.38% of Ontario GDP. Two strengths of this study are the careful use of relative risks for morbidity in estimating the SAFs, and the comprehensive list of diseases used.

The same team of authors also produced an estimate for all of Canada (Single *et al.*

1996b) that also very closely follows the CCSA guidelines for cost estimates. The results are quite close to the estimates of Xie *et al.* (1996): the gross medical costs for Canada were Can$2 676 million in 1992, or 0.39% of that year's GDP.

Kaiserman (1997) estimated both gross and net costs for 1986 using the approach of Rice *et al.* (1986). The gross cost estimates are reported here. Costs were estimated using the analytic method by comparing smokers' and non-smokers' use of health services. Relative risks for hospital admissions, outpatient visits, and prescription drugs were calculated from Canadian national survey data. SAFs were calculated from these relative risks and Canadian smoking prevalence. Average hospital costs were estimated from published reports from Canadian survey data. The Canadian Medical Association estimated average outpatient costs, and the average prescription cost was estimated from Ontario data. No adjustment was made for the non-smoking smoker type. Kaiserman estimated that direct medical costs in 1991 were Can$3.8 billion, or 0.56% of GDP, much higher than the other Canadian estimates. The differences result, in part, from Kaiserman's exclusion of observations that implied lower costs for smokers, which likely biased the estimates upward.

Finland Pekurinen (1992) conducted a cross-section study for Finland that reported both gross and net costs. The gross costs are discussed here. Hospital care, prescription medicine, outpatient visits, and physician services are included in the analysis. The study used both analytic and synthetic approaches. Hospitalization costs were estimated using the synthetic method; the diseases included were smoking-related cancers, cardiovascular disease, and respiratory disease (bronchitis and chronic obstructive pulmonary disease). Low and high estimates of SAFs were chosen from previous studies, and generally limited to those diseases with long-established evidence of a causal association with smoking. Average daily hospital costs and total utilization were estimated from Finnish survey data. The costs of visits to physicians and outpatient care were estimated using the analytic method from Finnish survey data that included information on smoking status, combined with average costs per visit estimated from separate data sources. Prescription medicine costs were estimated using Finnish survey data using the same methods as for physician costs. There was no adjustment for the non-smoking smoker type. Pekurinen's estimated gross costs for 1987 ranged from FIM524 to FIM594 million, or between 0.14% and 0.15% of GDP, respectively.

Pekurinen (1999) recently updated these estimates, using more recent relative risk estimates for smoking-related disease and new national data. The estimated costs for 1995 were FIM924 million, or 0.17% of GDP. The estimated total cost thus remained approximately the same as a percentage of GDP. However, the apparent similarity of the earlier and later estimates hid several significant changes that had taken place in Finland over the period: decreased smoking prevalence, increased hospital utilization and increased average costs.

New Zealand Gray *et al.* (1988) used a synthetic approach to estimating gross costs from cardiovascular and cerebrovascular disease, smoking related cancers, chronic obstructive pulmonary disease, low birthweight, and fire injuries. The only healthcare service included was hospitalization for acute care. Age- and gender-specific SAFs for hospitalization were calculated from relative risks for mortality attributable to

smoking, using prevalence data from the New Zealand census. Costs were estimated by applying the SAFs to total utilization and average cost per hospital day from national survey data. No adjustment was made for the non-smoking smoker type. Direct hospital costs were estimated to be NZ$61 million for 1984, or 0.16% of GDP. This early study provides conservative estimates because it is limited to hospital costs and includes only the major smoking-related diseases.

Phillips *et al.* (1992) used a synthetic approach to update and refine the estimates of Gray *et al.* (1988). They included the same diseases but also took account of outpatient visits, professional services and prescription drugs, as well as hospitalization for acute care. Their SAFs for hospitalization were taken from previous studies for Australia and New Zealand. Their SAF for prescription drugs were estimated from a random sample within a private practice, while that for outpatient care was based on data from a regional survey. Average costs of hospitalization were disease-specific estimates taken from hospital cost-reporting systems. The costs of an average outpatient visit and prescription drugs were calculated from published fee schedules. No adjustment was made for the non-smoking smoker type. Their estimated direct medical costs of smoking for 1989 were NZ$185.4 million, or 0.29% of GDP.

United Kingdom Maynard *et al.* (1987) estimated the 1985–86 budgetary cost of smoking for the National Health Service (NHS) in the United Kingdom. This study used the synthetic method applied to cardiovascular, malignant and benign respiratory disease, other cancers, and gastrointestinal disease. The SAFs were taken from studies by the Royal College of Physicians, and cost data for hospitalization, outpatient services, and visits to general practitioners were obtained from the NHS. No adjustment was made for the non-smoking smoker type. The researchers estimated that smoking cost between £290 million and £497 million in 1985–86, or between 0.08% and 0.13% of GDP. Their estimate is surprisingly low, given that the prevalence of smoking in the United Kingdom is comparable to that in other developed countries, even after considering the relatively low rate of national health expenditure in the United Kingdom as a percentage of GDP. Few details are provided, however, making it difficult to assess the quality of the estimates.

Middle-income and low-income countries

South Africa Yach (1982) estimated gross costs using the synthetic approach, and included costs from ischemic heart disease, cancer, and bronchitis. SAFs specific to South Africa's different racial and ethnic groups were calculated from relative risk statistics in the literature. Estimates of smoking prevalence in South Africa were also made separately for each racial and ethnic group. Of healthcare services, only hospital costs were included, and these were estimated from the average length of stay and average cost per day in South African hospitals. There was no adjustment for the non-smoking smoker type. The total estimated smoking-attributable costs were 17.6 million Rand, or 0.03% of GDP. This is a very early study based on limited data; hence, it is likely to have under-estimated smoking-related costs.

McIntyre and Taylor (1989) provide a synthetic estimate for South Africa that includes the costs of circulatory and benign respiratory diseases, chronic obstructive

Table 4.7 Estimates of gross healthcare costs for developing countries

Study	Year of estimate	Services included[a]	Diseases included[b]	Tobacco attributable medical care costs	% of GDP	Method: analytic vs. synthetic	Method: cross section vs. life cycle
South Africa				Rand million			
Yach (1982)	1980–81	H	Is M R[c]	17.6	0.03	Synthetic	Cross-section
McIntyre and Taylor (1989)	1985	H O P	C M R[d]	128.5	0.10	Synthetic	Cross-section
Puerto Rico				US$ million			
Dietz *et al.* (1991)	1983	F H L M O P	C G M R O[e]	55.9	0.43	Synthetic	Cross-section
India				Rupees million			
Rath and Chaudry (1995)	1990–91	H P	M[f]	833.0	0.02	Synthetic	Cross-section
Peoples Republic of China				Yuan billion			
Jin *et al.* (1995)	1989	H O	C G M R	6.94	0.43	Synthetic	Cross-section
Venezuela				Bolivares billion			
Pan American Sanitary Bureau (1998)	1997	H[g]	C M R O	129.0	0.30	Synthetic	Cross-section

[a] Services are: F, other professional medical fees; H, hospital; L, long-term care; M, medicine; O, outpatient visits; P, physician fees.
[b] Diseases are: C, cardiovascular and circulatory diseases; G, gastrointestinal diseases; Is, ischemic heart disease; M, malignant neoplasms; R, non-malignant respiratory disease; O, other. (C includes Is.)
[c] Non-malignant respiratory disease (R) includes bronchitis only.
[d] Non-malignant respiratory disease (R) includes COPD only.
[e] Other disease (O) includes tuberculosis and pediatric conditions.
[f] Costs for first 3 years of treatment only for cancers of oral cavity, pharynx, larynx, and lungs.
[g] Includes basic hospital room and board services only; omits tests, examinations, intensive care and other services.

pulmonary disease, and cancer. The SAFs for hospitalizations and outpatient visits were assumed to be equal to the SAF for mortality. The cost of a hospital day and an outpatient visit were estimated from costs in the Cape Province. The researchers' estimated gross costs for 1985 were 128.5 million Rand, or 0.10% of GDP. Although this figure is higher than that of Yach (1982) it is also based on very limited data and is likely to have under-estimated gross costs.

Puerto Rico Dietz *et al.* (1991) estimated costs for 1983 using the synthetic approach. The diseases considered were cancer, diseases of the circulatory, respiratory and digestive organs, tuberculosis, and pediatric and infant conditions. SAFs were calculated from US mortality data and Puerto Rican rates of smoking. Healthcare utilization rates were taken from US data. Average cost data were from the HCFA and the Puerto Rican Department of Health. There was no adjustment for the non-smoking smoker type. The health services considered were the same as in Rice *et al.* (1986). The estimated cost for 1983 was US$ 55.9 million, or 0.43% of GDP. This study is one of the most complete for a developing country, but the use of US data for relative risk and healthcare utilization is an important limitation.

India Rath and Chaudry (1995) estimated the cost of treatment for the first three years of care for cancers that have a high SAF. These include cancers of the oral cavity, larynx, pharynx, and lungs. The data are from a sequential sample of 342 patients in a New Delhi cancer center who were followed until death or 3 years from their initial hospital visit. All expenditures for diagnosis, hospital treatment, and physician consultation were recorded. Estimates for India were derived from the costs per patient in the sample, from the total number of the sample members' hospital admissions for the cancers, and the SAF of the cancers. The total estimated cost of cancer care due to tobacco use for these cancers in India was 833 million Rupees, or 0.02% of GDP.

People's Republic of China Jin *et al.* (1995) estimated the gross costs of smoking using the synthetic method. They included smoking-related cancers, coronary heart disease, stroke, hypertension, respiratory diseases, and ulcers. SAFs were calculated from age-specific and gender-specific smoking rates and relative risks for death and morbidity from previous research in China. Estimates of the level of healthcare use were made for each disease, using a 1985–86 survey on health services that included both urban and rural areas. Costs for outpatient visits and hospitalization were taken from national data on fees, categorized by disease and type of institution. No adjustment was made for the non-smoking smoker type. Estimated costs were 6.94 billion Yuan in 1989, or 0.43% of GDP. Rural areas accounted for 62% and urban areas 38% of the total. Men accounted for most of the costs because of the higher prevalence and longer history of smoking in men (see Chapter 2).

The breakdown of direct costs by each disease is interesting. Respiratory illness (other than cancer) accounted for 58.8% of the total direct cost. Circulatory disease accounted for 14.5% and all cancers accounted for only 6.1%. The relatively high proportion of costs due to non-malignant respiratory illness may be related to the joint effects of smoking and air pollution (both indoor and outdoor) in China. This study is one of the most complete for developing countries. Its greatest strength is the use of

data from national surveys and health censuses to estimate SAFs, utilization rates and costs.

Venezuela The Pan American Sanitary Bureau (1998), part of the Pan-American Health Organization, provided a recent estimate of costs for 1967–97 and part of 1998 using the synthetic method. The conditions included are smoking-related cancers, cardiovascular disease, other benign respiratory disease, and childhood diseases resulting from active and passive smoking. The services included are: hospital inpatient care, medications, and selected outpatient treatments (such as radiation therapy and cardiac rehabilitation). The non-smoking smoker type is not discussed. The estimated costs for basic services in 1997 are 129 billion Bolivares, or 0.30% of GDP. Other hospital-based expenditures for tests, prescriptions, intensive care, and other services are not broken down by year. The total costs for all hospital services for 1967–97 implies a ratio of 1.55 of these other cost categories for every Bolivare spent in basic service costs. Applying this ratio produces a total hospital cost of 200 billion Bolivares, or 0.47% of GDP in 1997.

Estimates of net costs

We turn now to a review of the existing estimates of net costs, which, as we have seen, take account of the impact of smokers' tendency to die earlier than non-smokers. These are summarized in Table 4.8. Several are quite controversial, because they include cost savings resulting from premature tobacco-related death. Several techniques have been used to calculate net costs, making comparison between studies difficult. This review reports the cost estimates contained in the studies, along with, where possible, estimates that could be calculated without using additional assumptions not stated in the study. For cross-section studies, the net estimates reported in the study will be given. The results of life-cycle studies that report the costs of stationary populations depend heavily on current smoking prevalence. Therefore, the ratio of the lifetime costs of a smoker versus a non-smoker will be reported whenever available. Otherwise the net present value of the costs of the current cohort of smokers will be reported. Adjusted cross- section studies will be discussed first, followed by a review of the life-cycle studies.

Cross-section estimates

Australia Collins and Lapsley (1991, 1996) estimated net costs for 1988 by estimating the healthcare costs of people who would have been alive in 1988 had they not smoked. They note that these calculations are speculative because there are no relative risk estimates for tobacco-related mortality for older individuals. In their 1991 study, they used SAFs from Holman and Armstrong (1990). The resulting net costs for 1988 were Aust$610 million or 0.19 of GDP, about four-fifths of gross costs. The method employed in their 1996 study was the same, except that it used revised SAF estimates from English *et al.* (1995). The resulting estimate of net cost for 1988 is Aust$484 million, just over half of their gross costs estimate. The estimate for 1992 is Aust$833 million, or 0.21% of GDP for that year. The increase in estimated smoking-related mortality rates accounts for the difference in their estimates.

Table 4.8 Estimates of net healthcare costs for high-income countries

Study	Year of estimate	Services included[a]	Diseases included[b]	Discount rate (%)	Annual tobacco-attributable medical care costs[c]	% of GDP	Smoker/ non-smoker costs	Method: analytic vs. synthetic
Adjusted cross-section								
Australia					Aust$ million			
Collins and Lapsley (1991)	1988	F H L M O P	C G M O R	—	609.6	0.19	—	Synthetic
Collins and Lapsley (1996)	1988	F H L M O P	C G M O R	—	484.1	0.15	—	Synthetic
Collins and Lapsley (1996)	1992	F H L M O P	C G M O R	—	832.5	0.21	—	Synthetic
Canada					Can$ billon			
Forbes and Thompson (1983)	1980	H L P	[d]	—	1.16	0.37	Men: 1.25 Women: 1.15	Both
Kaiserman (1997)	1991	H L M P	[e]	4	2.3	0.34	—	Analytic
Finland					FIM million			
Pekurinen (1992)	1987	H M O P	C M R	4	(16) to 93	<0.024		Both
Life-cycle								
Switzerland					Swiss Franc million			
Leu and Schaub (1983)	1976	H P	Is M R	0	0	0	0.93–1.00[g]	Synthetic
Leu and Schaub (1985)	1976	H P	[e]	0–10	—	—	0.83–0.97[g]	Analytic
United States					US$ billion			
Lippiatt (1990)	1986	F H L M O P	Is M R	3–5	(49.5)–(22.3)[h]	—	—	Synthetic
Manning *et al.* (1991)	1986	F H L M O P[f]	[e]	5	9.2	0.22		Analytic
Hodgson (1992)	1985	F H L O P	[e]	3–5 3 for ratio	501–473[h]	—	Men: 1.32 Women: 1.24	Analytic
Netherlands					Guilders billion			
Barendregt *et al.* (1997)	1988	F H L M O P	C M R[j]	0	—	—	Men: 0.87 Women: 0.85	Synthetic

[a] Services are: F, other professional medical fees; H, hospital; L, long-term care; M, medicine; O, outpatient visits; P, physician fees.
[b] Diseases are: C, cardiovascular and circulatory diseases; G, gastrointestinal diseases; Is, ischemic heart disease; M, malignant neoplasms; R, non-malignant respiratory disease; O, other. (C includes Is.)
[c] See text for explanation of these columns (parentheses indicates negative cost, or net savings from smoking).
[d] Excess expenditures for all diseases for adults inferred from excess mortality rates of smokers. Smoking-related illnesses used for children.
[e] Includes all excess expenditures of smokers estimated from survey data or health census data.
[f] Only lung cancer included in malignant neoplasm (M), only COPD included in respiratory illness (R).
[g] Range includes ratio of smokers to non-smoker and smoker to non-smoking smoking type.
[h] Present value of costs incurred by current cohort of smokers.
[j] R includes COPD Only.

Canada Forbes and Thompson (1983) also estimated net costs using a cross-section approach. Cost is expressed as the difference in per capita healthcare costs in the current population and per capita costs in a hypothetical stationary population with no smoking. This approach has been criticized as difficult to interpret (Leu and Schaub 1985; Pekurinen 1992). Both the synthetic and analytic approaches have been used to estimate levels of use of healthcare services that result from smoking. The synthetic approach is used, and the researchers include some effects of parents' smoking on children, including some children's diseases, medical care for newborns, and complications of pregnancy. Relative risks for various smoking-related conditions of newborns and children are taken from the literature and used to calculate SAFs. These SAFs are applied to disease-specific average hospital costs per diagnosis. For adults, the SAF for hospitalization was calculated from the relative risk for hospitalization due to smoking, and the latter was assumed to be equal to the relative risks of smoking-related death in the United States. The long-term care costs of the elderly were estimated by calculating the relative proportion of elderly institutionalized smokers to the elderly proportion of the population in general, and then attributing the costs pro rata accordingly. The services included are hospitalization and long-term care for adults, and physicians' visits for children. Forbes and Thompson estimated that smoking increased the 1980 per capita medical care costs of Canadian men by 16%, and of women by 10%. This implies a net cost of Can$1.16 billion, or 0.37% of GDP. The fact that less than 30% of Canadians smoke, together with the reported average costs for the current and the hypothetical population, implies that the ratio of lifetime costs for smokers versus non-smokers is rather high: 1.25 for men and 1.15 for women.

Kaiserman (1997) estimated net costs from gross cross-section estimates by calculating the net present value of future savings from people who had died from smoking during the year, using a 4% discount rate. The SAFs for mortality were taken from a US study. The net cost for Canada is 2.3 Can$ billion, or 0.34% of GDP. Kaiserman's net cost estimate is 60% of that for gross costs. A major drawback is that this approach does not seem to account for the shorter life expectancies of smokers who survived the year.

Finland Pekurinen (1992) estimated the net present value of savings from smoking-related deaths in 1987. As in the case of Kaiserman, this does not represent a complete analysis of net costs, and in fact Pekurinen only reports gross costs in his final results. The number of deaths from smoking was calculated using SAFs derived from the literature for selected diseases and applied to Finnish cause-of-death statistics. Net present value was calculated using a 4% discount rate. The estimated discounted future healthcare cost savings from smoking-related deaths in 1987 is between FIM430 million and FIM 610 million. Subtracting this from the gross costs results in somewhere between a net savings of FIM16 million and a net cost of FIM93 million (less than 0.024% of GDP).

Life-cycle approach

Switzerland Leu and Schaub (1983) provide an early and well-known life-cycle cost estimate using the synthetic method. Their study used two approaches to estimating

net costs. The first was a comparison between the total healthcare costs that would have been incurred for the male Swiss population in 1976, if no one who had been born after 1876 had ever smoked, with actual male healthcare costs for the same year. The second analyzed the lifetime costs of a smoker versus those of a person who had never smoked. Both of these approaches used the life-cycle approach to net costs. The SAFs were calculated from the relative risks of smoking-related mortality for various specific diseases, and were applied to the utilization rates of hospital services and physicians' services for Swiss males. The issue of the non-smoking smoker is addressed by assuming that 65% of smokers' additional use of healthcare is due to smoking. Only hospital costs and physicians' fees were included in the estimate. Net cost was estimated using two methods: the expected value of the life-cycle costs of a smoker versus a non-smoking smoker type; and simulation of a hypothetical non-smoking population. Excess mortality due to smoking was estimated using US mortality ratios stratified by age and amount smoked per day. The researchers concluded that lifetime healthcare costs are between 6% and 7% higher for non-smokers than for smokers, and that past smoking did not increase costs in 1976.

Leu and Schaub's results were controversial. The researchers have been criticized for using mortality data to estimate the SAFs, for their use of fixed, multiplicative, factors to adjust SAFs, and for the inclusion of only two major healthcare services. An additional criticism of their methods is as follows. Leu and Schaub relied on only a few smoking-related diseases to calculate the excess costs of living smokers, but used all-cause differences in mortality rates for smokers versus non-smokers. The result is that they under-estimate the lifetime costs of smoking. There are two reasons for this. First, some costs of smoking-related disease among living smokers will be missed, but will implicitly be counted as cost savings when smokers die early. Second, conditions that are considered associated with, but not caused by, smoking will be omitted from the costs of living smokers, but will be counted as costs savings after smokers die. The implication of this is that the mortality data used for life-cycle estimates must undergo the same statistical adjustments as the data for healthcare utilization and costs. Finally, the estimated health care expenditure patterns in Switzerland were very different than those in the United States, so critics have questioned the extent to which the results can be generalized to elsewhere (Hodgson 1992).

Leu and Schaub (1985) addressed most of these issues in further research. Details were not provided, but the revised estimates are based on a multi-equation econometric model for healthcare expenditures developed by Leu and Doppmann (1984) using data from the first comprehensive Swiss healthcare survey. Visits to physicians and hospitalization remained the only services included in this study, which uses the analytic approach. The lifetime costs of 35-year-old males are calculated by smoking status using discount rates from 0 to 10%. The ratio of lifetime costs of 35-year-old male smokers to non-smoking smoker types was 0.91 to 0.97 (for discount rates of 0 to 10%, respectively). The cost ratios of smokers to non-smokers ranged from 0.83 to 0.94. The non-smoking smokers had higher lifetime costs than non-smokers. These estimates answered most of the previous criticisms. However, only two major health services were still included, and it is unclear whether comparable statistical adjustments were done for estimated health utilization and mortality rates by smoking status.

United States Lippiatt (1990) conducted a life-cycle study that estimated the change in the net present value of healthcare costs for the US population aged between 25 and 79 years as a function of changes in cigarette consumption. Effects of both changes in smoking prevalence and in the average amount smoked were modeled. The synthetic approach was used to calculate excess use of healthcare services for three disease categories: lung cancer, coronary heart disease, and chronic obstructive pulmonary disease. There was no adjustment for the non-smoking smoker type. Healthcare costs included were: hospital costs, physicians' fees, and insurance fees. Changes in life-span from smoking were estimated with the life-table approach, using data from Oster *et al.* (1984a, 1984b). Average medical costs were estimated from several sources, including Leu and Schaub (1983). Lippiatt's estimates indicated that the net present value of increased healthcare costs of longer-lived ex-smokers was greater than the cost savings from reduced smoking and smoking cessation. A decrease in cigarette sales of 1% would increase the net present value of healthcare costs by between approximately US$191 million and $ 405 million (with discount rates of 5% and 3%, respectively). These estimates implied a healthcare cost of smoking cessation of between $280 and $132 per life-year gained. These estimates implied a net present value of medical care savings of between $22.3 and $49.5 billion from smoking in 1986. A strength of Lippiatt's approach is the detailed modeling of the effects of smoking based on Oster *et al.* (1984a, 1984b), particularly the estimation of the change in life expectancy of ex-smokers. The important weaknesses of the study are the very limited number of diseases included, and the use of Leu and Schaub's (1983) estimates of average medical costs.

Manning *et al.* (1989, 1991) reported a life-cycle study that estimated the net present value of the external healthcare burden in terms of cost per pack of cigarettes sold, as well as aggregate net healthcare costs. Their studies used the analytic approach to estimate excess utilization by smokers using data from the RAND Health Insurance Experiment (HIE) and the US NHIS. Statistical adjustment was used to model the cost savings for the non-smoking smoker type using socio-demographic, life-style and clinical information. A unique feature of this approach is the researchers' adjustment for two other major risk behaviors for ill health in the United States: heavy alcohol consumption and physical inactivity. The life-table method was used to model changes in population age structure from changes in smoking prevalence. Excess mortality risk was estimated from a 1984 health risk appraisal program developed by the Centers for Disease Control and Prevention. This allowed the same types of adjustments to be made for mortality rates as for healthcare use, another unique feature of this study. Data on the utilization and cost of healthcare came from the RAND HIE, and included all costs except those for maternity care, infant care, and dental care. Utilization rates for the elderly (who were omitted from the HIE) were obtained from the NHIS. Manning *et al.*'s estimates were used for an analysis of the tax rate needed to cover the net annual social costs of cigarette smoking. Therefore the costs are expressed in cents per pack. They estimated that aggregate net healthcare costs, including the costs of infant morbidity from maternal smoking, were 32 cents per pack in 1986, at a discount rate of 5%, implying total costs of US$9.2 billion, or 0.22% of GDP. The main strength of these estimates was the consistent analysis of smoking-related mortality and morbidity. The inclusion of measures of alcohol intake and physical

activity may or may not be a strength in the base-case estimate. As noted in the discussion on Vincent Miller *et al.* (1999), there are unresolved issues in adjustment for these potentially endogenous variables. Manning *et al.* (1989, 1991) were aware of this problem and performed a sensitivity analysis for smoking-related characteristics in their estimates of external burden, which is discussed below.

Hodgson (1992) estimated the expected lifetime medical expenditures of smokers (defined as current and former smokers) versus those who had never smoked, and the total net present value of costs for the current cohort of smokers. Relative risks of healthcare utilization were estimated using the analytic approach. A unique aspect of Hodgson's approach was the separate estimation of costs for survivors and decedents. Hodgson described this as important because only survivors are represented in most healthcare utilization surveys, a factor that may introduce a bias in the estimates. Hospitalization and use of physicians' and outpatient services for survivors were based on data from the NHIS. Hospital utilization for decedents was estimated using the US National Medical Care Utilization and Expenditure Survey (NMCUES). Age-specific and sex-specific average hospital costs were estimated using NMCUES. Long-term care utilization by the elderly was estimated using the National Nursing Home Survey, and several other health and demographic surveys. There is no adjustment for the non-smoking smoker in the main analysis. The effects of smoking on mortality are modeled using the life-table approach, using data from the American Cancer Society's Cancer Prevention Study II. The results of this study are that the excess health care costs of smokers outweigh the increased cost of medical care over the longer lives of non-smokers.

Hodgson estimated that the smoking population over 25 years of age increased the net present value of lifetime health expenditures by US$473 to 501 million (with discount rates of 3% and 5%, respectively). Hodgson used Manning *et al.*'s (1989) estimate that adjustment for the non-smoking smoker would reduce excess costs by about 13%, producing a lower bound estimate of between $412 million and $436 million. At a 3% discount rate, he estimated that the ratio of lifetime costs of smokers to non-smokers was 1.32 for men and 1.24 for women. Hodgson did not provide an estimate of gross costs, but an approximation of annual gross costs can be derived from some of the estimates in the paper. For the period of the study, gross costs were approximately $40 billion per year from 1985 to 1989 (see Warner *et al.* 1999), or between 0.7% and 1.0% of GDP (0.6–0.9% with the adjustment for the non-smoking smoker). This tends towards the higher end of the range of gross cost estimates for the United States, especially since the estimates omit some of the total US healthcare expenditure because of the omission of other services (such as dentistry) and medicines. The main drawback of the study is the use of a fixed adjustment factor for the non-smoking smoker type.

Netherlands Barendregt *et al.* (1997) estimated costs over time from 1988 onwards for the Dutch population compared to a hypothetical population of non-smokers, using the synthetic approach. The diseases included were heart disease, stroke, smoking-related cancer, and COPD. The life-table method was used to model the Dutch population in the absence of smoking. Details of the population modeling were not reported, but adjustments for the non-smoking smoker type appear to have been made

in both. This study did not estimate a net present value of future costs, but rather reports the length of time it takes for the cost savings from smoking cessation to be just balanced by the increased costs from the longer life expectancies of non-smokers, using discount rates of 0–10%. With no discounting, savings are balanced by costs for males in 26 years, and after 50 years the healthcare costs are about 7% higher. The results for women are similar, with costs ultimately 4% higher. Using discount rates of 3% and 5% produces similar results. These results imply that smoking reduces net healthcare costs with a discount rate of up to 5%. At 10%, the break-even point becomes very large, and smoking begins to increase net costs. The ratio of undiscounted costs of smokers to non-smokers is 0.87 for men and 0.85 for women. The small number of tobacco-related diseases included in this study, however, may result in a substantial under-estimate of costs.

Estimates of external burden

Estimates of the external burden of cigarette smoking (shown in Table 4.9) do not address the total cost of smoking, but rather the costs borne by the non-smoking population. These estimates attempt to follow the economic cost–benefit approach as much as possible. Under the usual economic definition, costs incurred to anyone within the same household are not considered external costs, possibly leading to an under-estimate of the external burden under other definitions of cost. In this review, costs incurred within the household are also reported whenever available. The results reported below do not include the effect of tobacco tax revenues.

Canada

Stoddart *et al.* (1986) presents a cross-section estimate of gross costs for Ontario, Canada in 1978. Their study used the synthetic approach to estimate excess healthcare utilization. The diseases considered were lung cancer, coronary heart disease, bronchitis, and emphysema. A sensitivity analysis also considered non-respiratory smoking-related cancers (cancers of the oral cavity, esophagus, larynx, pharynx, bladder, and pancreas); stroke; aortic aneurysm; pneumonia and influenza; pulmonary tuberculosis; digestive ulcers; and pulmonary disease. There was no adjustment for the non-smoking smoker type. The conclusion of the study is that smoking imposes an external burden of between Can$39.1 and $81.1 million. A sensitivity analysis that increased the costs of hospital care per day, included more healthcare services, and increased the SAFs of disease to the highest plausible values resulted in an estimate of Can$145.0 million. These estimates imply external gross costs of between 0.04% and 0.16% of GDP. The main weakness of the base case of this study is its very conservative selection of diseases.

Raynauld and Vidal (1992) calculate an estimate of external burden for Canada in 1986 from their gross cost estimate discussed above. The external burden is calculated by estimating the current and future medical care costs, and savings due to premature death from smoking between 1986 and 2071, using 3% for the discount rate. The estimated external burden is Can$153 million or 0.03% of Canadian GDP. Their method may be inconsistent because they appear to assume that current smoking does

Table 4.9 Estimates of external healthcare cost burden for high-income countries

Study	Year of estimate	Services included[a]	Diseases included[b]	Discount rate (%)	Tobacco-attributable costs	% of GDP	Method: analytic vs. synthetic
Gross costs cross-section							
Canada (Ontario)					Can$ million		
Stoddart *et al.* (1986)	1978	H O P	C G M R	—	39.1–145.0	0.04–0.16	Synthetic
Raynauld and Vidal (1992)	1986	H[c]	Is M R[d]	3	153	0.03	Synthetic
Finland					FIM million		
Perkurinen (1992)	1987	HOM	C M R	—	255–294	0.07–0.08	Synthetic
Net costs life-cycle							
United States					US$ billion		
Manning *et al.* (1991)	1986	F H L M O P	[e]	0	3.5 (in home costs excluded)	0.08	Analytic
				5	3.5–8.1	0.08–0.19	
				10	4.6	0.11	
				5	4.0 (low birthweight included)	0.09	
Viscusi (1995)	1993	F H L M O P	[e]	0–5	1.9–9.2 (from Manning)	0.03–0.15	Analytic
				0–5	2.8–10.4 (tar adjusted)	0.04–0.16	
				0–5	1.9–8.5 (lag tar adjusted)	0.03–0.13	

[a] Services are: F, other professional medical fees; H, hospital; L, long-term care; M, medicine; O, outpatient visits; P, physician fees.
[b] Diseases are: C, cardiovascular and circulatory diseases; G, gastrointestinal diseases; Is, ischemic heart disease; M, malignant neoplasms; R, non-malignant respiratory disease; O, other. (C includes Is.)
[c] Includes other unspecified health service expenditures. See text for discussion.
[d] Non-malignant respiratory (R) disease includes COPD only.
[e] Includes all expenditures for all conditions attributable to smokers.

not cause any increase in the use of long-term care among the living, yet they include reduced use of long-term care due to premature death in the savings.

Finland

Pekurinen (1992) reported the gross external burden of smoking from the cross-section estimates for 1987 reported above. The estimated external costs (after adjustments for cross-subsidization in healthcare) are between FIM255 million and FIM294 million, or 0.07–0.08% of GDP.

United States

Manning *et al.* (1989, 1991) reported net external costs from the life-cycle estimates discussed above. The external costs are calculated in the same way as aggregate net costs. These researchers' base-case cost, discounted at 5%, was US$6.6 billion, or 0.15% of GDP. A sensitivity analysis that varied discount rates and included the different assumptions for non-smoking characteristics of smokers, among other things, produced a range of between US$3.5 and $8.1 billion, or 0.08–0.19% of GDP.

Viscusi (1995) performed a life-cycle study of the excess smoking-attributable social burden per pack of cigarettes. His base case consisted of updated estimates based on Manning *et al.* (1989, 1991). The new analysis consists of two adjustments. One is for changes in the tar levels of cigarettes over time, on the theory that tar levels have dropped dramatically and that cigarettes should therefore have less severe health effects than indicated by SAFs that were estimated for a population that smoked higher-tar cigarettes. The second adjustment was the use of lags in health effects to account for the fact that the effects of cumulative exposure to smoke represented in estimated SAFs often take place decades after consumption. Viscusi estimated the cost, in cents per pack, in order to calculate the tax needed to cover annual net costs from smoking. His base-case estimate of external costs ranged between US$1.9 and $9.2 billion, or 0.03–0.15% of GDP. With the tar adjustment, costs are from $2.8 to $10.4 billion. With the tar adjustment and lagged health effects, the costs range from $1.9 to $8.5 billion, or 0.03–0.13% of GDP. Viscusi's estimates are largely the same as those of Manning *et al.* except that the lower-bound external cost is smaller.

Viscusi's adjustments to the standard analysis, however, are controversial. The problem with his adjustment for lower tar levels is that nicotine and tar levels dropped together, and there is substantial new evidence that smokers compensate for lower nicotine levels by smoking cigarettes more intensely. Therefore any tar adjustment may be inappropriate (Parish *et al.* 1995). The use of lags is also disputable in the case of some smoking-related diseases such as heart attack and stroke, which are likely to be the result of current as well as past smoking.

Review of existing studies on the social costs of smoking

Several of the studies discussed here also report estimates of the total social costs of smoking: that is, all the indirect costs of morbidity and premature mortality, as well as direct medical costs. The review will be selective and brief because the definition of social cost can vary greatly. The reader should consult the original studies for more detailed discussions. There are several analyses of the costs of tobacco use on old-age pensions

and medical plans, which will not be reviewed here since the results depend on the details of the specific programs (Wright 1986; Shoven *et al.* 1987; Herdman *et al.* 1993).

Cross-section estimates of gross social costs in Canada and the United States follow a conceptual framework that is broadly similar to that of the 'cost of illness' concept as described by Hodgson and Meiners (1982). This preceded the GDP-based social definition of cost. Luce and Schweitzer (1978), for example, estimated the total social cost of annual consumption for the United States to be 1.6% of GDP, while Rice *et al.* (1986) estimated it to be 1.4%. The Canadian social cost estimates range from 1.3% of Ontario GDP (Choi and Pak 1996; Xie *et al.* 1996) to 2.2% for all Canada (Kaiserman 1997). The lowest estimates are from Pekurinen (1992, 1999) for Finland, where costs were 1.2–1.3% of GDP in 1987, but fell to 0.8% in 1995. Pekurinen attributed this decline to a large drop in smoking prevalence during the intervening years. This seems to place a very large emphasis on current (as opposed to past) smoking in the cost estimate, but it is a direct result of using SAFs calculated using current smoking prevalence to estimate costs. The only comprehensive estimate based on local data for a developing country is Jin *et al.*'s (1995) estimate of 1.7% of GDP for China. The estimates of net social cost by Collins and Lapsley (1991, 1996) for Australia, range between 2.1% and 3.4% of GDP. These estimates follow the CCSA definitions closely and are not directly comparable with the estimates for Canada and the United States. They are more comprehensive than other estimates in that they attempt to estimate the social cost of unwanted nicotine addiction.

Estimates of external burden are lower. Pekurinen's (1992, 1999) estimates of gross external costs for Finland ranged from 0.3% to 0.5% of GDP. The net cost estimates of Manning *et al.* (1989, 1991) ranged from a saving of 0.6% to a cost of 0.2% of GDP, with a base-case estimate of a cost of 0.1%. Savings occur in the base case when the discount rate is less than 3.5%. If internal costs that occur within the family, such as the effects of parental smoking on children's health, were included, the break-even discount rate would be higher. If the costs of morbidity and mortality to others within the family are included, but the mortality costs to the smoker are excluded, the base-case estimate rises from 0.1% of GDP to 0.3%. Viscusi (1995) includes a sensitivity analysis on the effect of including costs of mortality from environmental tobacco smoke (ETS) on non-family members, which results in a wide range of estimates: from a saving of 0.11% of GDP to a cost of 0.36% of GDP. Viscusi considers the upper-bound estimates of the costs due to environmental tobacco smoke to be extremely unlikely, and concludes that the median estimate of approximately no net external costs is a realistic upper bound.

Some estimates indicate that any external social costs of smoking are recovered from tax revenue from tobacco users. This question, however, is beyond the scope of this chapter. The estimates of net extenal burden on non-smokers that include the effects of taxes paid by smokers are not discussed here. See the individual studies for these estimates. It is very difficult to compare studies across different countries since the results depend heavily on the characteristics of the individual tax systems and social insurance programs, and studies do not analyse tax incidence consistently. Also, the results for high-income countries assume a tobacco tax system which can be administered with high compliance; this may not be characteristic of developing countries where formal tobacco markets are still relatively small.

4.5 Conclusion

Estimates of the gross healthcare costs of smoking for high-income countries range from around 0.10–1.1% of GDP, with relatively higher estimates in countries where healthcare costs account for a greater share of GDP. The relatively small number of studies from developing countries suggests that the gross cost of smoking can be as high in these countries as in developed countries. However, these studies are of uneven quality and are often based on very limited data, making it impossible to draw overall conclusions at this time.

As far as studies of the net costs of smoking are concerned, it is difficult to reach conclusions for any group of countries. This is because of differences in the methodologies used. The majority of the cross-section studies indicate that the net costs of smoking are positive, with only the low estimates for Finland implying healthcare cost savings from smoking. The life-cycle cost studies show little agreement and are very sensitive to the details of the study. We consider that the most methodologically sound of these studies are Hodgson (1992) and Manning *et al.* (1991). The main strength of Hodgson's study is the separate estimation of survivors' and decedents' costs. The main strength of the study by Manning *et al.* is the careful modeling of, and sensitivity analysis for, the non-smoking smoker type, both for disease incidence and mortality. Both Hodgson and Manning (for the base cose) conclude that there are net costs from smoking. The results of the studies of the external costs of smoking indicate that there are external burdens for gross and net healthcare costs due to tobacco use.

The estimates of both gross and net total social costs are fairly high because of the large costs of deaths caused by smoking, and they indicate that productive assets (i.e. smokers' lives) equal to 1% or more of GDP are lost each year due to smoking. In contrast, the estimates of the external burden of social costs have a very wide range, and there is no clear consensus. As with net cost estimates, these estimates are sensitive to the assumptions used. Overall, however, the cost estimates agree that smoking increases the current medical and social costs of living individuals. There is less consistency concerning how much these costs are reduced by savings from the shorter lifespans of smokers.

There are several methodological considerations that are important for developing countries. The first is that the definition of costs used in the study will have an important influence on the result. The first task in any estimation of the costs associated with tobacco use is to carefully state the policy question that the estimate is intended to answer, so that the most appropriate definition of costs and perspective can be chosen.

Second is the issue of gross versus net costs. The estimates of gross costs are much more consistent than the estimates of net and external costs, and should therefore be reported separately with a carefully documented sensitivity analysis of all estimates. This permits policy-makers to evaluate the tradeoffs between the almost certain short-run costs of smoking and the more uncertain longer-run effects that occur with longer life expectancies in a population with less smoking.

Third is the calculation of net costs. There are several methods for estimating net costs, which range from estimates of the future net present value of costs from current smokers, to the comparison of healthcare costs in populations with and without smoking. These different approaches have different interpretations, though some may

turn out to be equivalent in special cases. Interpretations of the concept of net cost used in some estimates for high-income countries are shown in Table 4.10. The choice of the type of net cost analysis should be carefully justified and its connection to the policy question being answered should be explained. If the life-cycle approach is chosen then the very large uncertainties involved in forecasting healthcare utilization

Table 4.10 Net health cost interpretations from research studies in developed countries

Author	Country	Conclusion
Leu and Schaub (1983)	Switzerland	Male smokers' lifetime healthcare expenditures are slightly lower than if they had never smoked. In 1976, aggregate male medical care expenditure was the same as it would have been if nobody born after 1876 had ever smoked
Leu and Schaub (1985)	Switzerland	The ratio of lifetime medical care costs of male Swiss smokers to comparable non-smokers is between 0.91 and 0.97, for discount rates of 0 to 10%.
Manning *et al.* (1991)	United States	Each pack of cigarettes consumed increases the net present value of current and future health costs by about 30 cents, discounted at 5%.
Pekurinen (1992)	Finland	The total cost of health expenditures in 1987 attributed to smoking was in the range FIM524–594 million. The net present value of health care expenditure avoided due to deaths attributed to smoking in that year was in the range FIM431–610 million.
Hodgson (1992)	United States	The current population of smokers will increase the cost of health care by about 500 US$ billion (discounted at 3%) spread out over their remaining lifetimes.
Collins and Lapsley (1996)	Australia	In 1992 the healthcare benefits resulting from past and current premature deaths of smokers accounted for about 48% of the gross healthcare costs attributable to smoking (Aust$1600 million).
Barendregt *et al.* (1997)	Netherlands	The ratio of undiscounted medical costs of smokers to non-smokers is 0.87 for men and 0.85 for women. The discounted lifetime medical cost of smokers is less than non-smokers until the discount rate is about 10%.

and costs should be kept in mind when designing the sensitivity analysis. This is a particularly important consideration for developing countries.

The fourth issue concerns the use of the synthetic and analytic approaches. The analytic approach depends on availability of national survey data, and is difficult even in countries with extensive survey databases, such as the United States and Canada. For countries with limited survey data, the synthetic approach may be most practical. However, the diseases selected should be the result of careful epidemiological analysis in order to identify all conditions that are causally related to tobacco use. The estimates should be identified as lower bounds, since this review suggests that including only the most obvious tobacco-related diseases produces a downward bias in the estimated costs. The services included also have an important effect on costs, and this issue should also be considered in evaluating whether the estimate is a lower bound. The treatment of healthcare services is especially important for developing countries where many healthcare services are likely to move from the household to the formal market sector within the lifetimes of current smokers.

Adjusting for the non-smoking characteristics of smokers (that is, accounting for the non-smoking smoker type) is a difficult and still-unresolved issue that requires careful analysis of smoking patterns and their interaction with other behaviors and life-style. Kato *et al.* (1989) and Thornton *et al.* (1994) report that ex-smokers do change important non-smoking behaviors, such as diet, as time since smoking cessation increases. Therefore, some non-smoking characteristics of current smokers are not completely exogenous. This issue needs further research because it has had a significant impact on existing cost estimates.

While this review recommends that the synthetic approach be taken in countries with limited resources for national health surveys, the goal should be to use all available information regarding healthcare utilization and smoking status. The strengths and weaknesses of existing cost estimates should be critically examined in order to improve future efforts. In countries where surveys are being developed, there is an opportunity for researchers to contribute to their design in order to collect the information needed for better estimates at a reasonable cost. New developments in the epidemiology of tobacco-related disease will suggest modifications. For example, the duration of smoking and the age at which smoking was started may be important determinants of the development of lung cancer (Peto 1986; Wiencke *et al.* 1999). Therefore, information on individuals' history of smoking and changes in their risk behaviors as a function of smoking status may be as important as estimates of current prevalence, and modification of future surveys to collect this information should be seriously considered.

References

Anderson, L. (1977). *Benefit-Cost Analysis: a Practical Guide*. Lexington, MA, Lexington Books.

Ballard, T., Ehlers, J., Freund, E. *et al.* (1995). Green tobacco sickness: occupational nicotine poisoning in tobacco workers. *Archives of Environmental Health*, **50**(5), 384–9.

Barendregt, J. J., Bonneux, L., and Van der Maas, P. J. (1997). The health care costs of smoking. *New England Journal of Medicine*, **337**(15), 1052–7.

Bartlett, J. C., Miller, L. S., Rice, D. P. (1994). Medical care expenditures attributable to cigarette smoking–United States, 1993. *Morbidity and Mortality Weekly Report*, **43**(26), 469–72.

Choi, B. C. K. and Nethercott, J. R. (1988). The economic impact of smoking in Canada. *International Journal of Health Planning and Management*, **3**, 197–205.

Choi, B. and Pak, A. W. (1996). Health and social costs of tobacco use in Ontario, Canada, 1979 and 1988. *Journal of Epidemiology and Community Health*, **50**(1), 81–5.

Collins, D. and Lapsley, H. (1998). Estimating and disaggregating the social costs of tobacco. In *The Economics of Tobacco Control: Towards an Optimal Policy Mix* (ed. I. Abedian, R. van der Merwe, N. Wilkins, and P. Jha.), pp. 155–78. Cape Town, Applied Fiscal Research Centre: University of Cape Town.

Collins, D. J. and Lapsley, H. M. (1991). *Estimating the Economic Costs of Drug Abuse in Australia.* Monograph Series no. 15. Sydney, Australia, Commonwealth Department of Human Services and Health.

Collins, D. J. and Lapsley, H. M. (1996). *The Social Costs of Drug Abuse in Australia in 1988 and 1992.* Monograph Series no. 30. Sydney, Australia, Commonwealth Department of Human Services and Health.

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

Cook, P. J. (1991). The Social Costs of Drinking. In *Tne Negative Social Consequences of Alcohol Use*. Oslo, Norway, Norwegian Ministry of Health and Social Affairs.

Cooper, B. S. and Rice, D. P. (1976). The economic cost of illness revisited. *Social Security Bulletin*, **39**(2), 21–36.

Dietz, V. J., Novotny, T. E., Rigau-Perez, J. G. *et al.* (1991). Smoking-attributable mortality, years of potential life lost, and direct health care costs for Puerto Rico, 1983. *Bulletin of PAHO*, **25**(1), 77–86.

Dinwiddy, C. and Teal, F. (1996). *Principles of Cost Benefit Analysis for Developing Countries*. Cambridge, Cambridge University Press.

English, D., Holman, C. D. J., Milne, E. *et al.* (1995). *The quantification of drug caused morbidity and mortality in Australia*, 1995 edition. Canberra, Australia, Commonwealth Department of Human Services and Health.

Erdmann, C. and Pinheiro, S. (1998). *Special Communication: Pesticides used on tobacco crops in southern Brazil*. Berkeley, California, Division of Public Health Biology and Epidemiology, School of Public Public Health, University of California.

Feachem, R., Kjellstrom, T., Murray, C. *et al*. (ed.) (1995). *The Health of Adults in Developing Countries*. Oxford, The World Bank and Oxford University Press.

Forbes, W. F. and Thompson, M. E. (1983). Estimating the health care costs of smokers. *Canadian Journal of Public Health*, **74**(3), 183–90.

Geist, H. (1998). How tobacco farming contributes to tropical deforestation. In *The Economics of Tobacco Control: Towards an Optimal Policy Mix* (ed. I. Abedian, R. van der Merwe, N. Wilkins, and P. Jha), pp. 232–44. Cape Town, Applied Fiscal Research Centre: University of Cape Town.

Geist, H. (1999a). Soil mining and societal responses: The case of tobacco in Eastern Miombo Highlands. In *Coping with changing environments: Social dimensions of endangered ecosystems in the developing world* (ed. B. Lohnert and H. Geist), pp. 119–148. Ashgate, Aldershot.

Geist, H. (1999b). Global assessment of deforestation related to tobacco farming. *Tobacco Control,* **8**(1), 18–28.

Geist, H. (2000). Transforming the fringe: Tobacco-related wood usage and its environmental implications. In *Marginality, landscape, and environment* (ed. R. Majoral, F. Delgado-Cravidão, H. Jussila). Ashgate, Aldershot (in press).

Gold, M., Siegal, J. E., Russell, L. B. *et al*. (ed.) (1996). *Cost-Effectiveness in Health and Medicine*. New York, Oxford University Press.

Gray, A. J., Reinken, J. A., and Laugesen, M. (1988). The cost of cigarette smoking in New Zealand. *New Zealand Medical Journal*, **101**(846), 270–3.

Herdman, R., Hewitt, M., and Laschober, M. (1993). *Smoking-related Deaths and Financial Costs: Office of Technology Assessment Estimates for 1990*. Washington, DC, Office of Technology Assessment.

Hipke, M. (1993). Green tobacco sickness. *Southern Medical Journal*, **86**(9), 989–92.

Hodgson, T. A. (1992). Cigarette smoking and lifetime medical expenditures. *Milbank Quarterly*, **70**(1), 81–125.

Hodgson, T. and Meiners, M. (1982). Cost-of-illness methodology: a guide to current practices and procedures. *Milbank Memorial Fund Quarterly*, **60**(3), 429–62.

Holman, C. and Armstrong, B. K. (1990). *The Quantification of Drug-Caused Morbidity and Mortality in Australia, 1989*. Canberra, Australia, Commonwealth Department of Human Services and Health.

James, E. (1994). *Averting the Old Age Crisis*. World Bank, Washington, D.C., World Bank: Investing in Health, World Development Report 1993, Washington DC).

Jin, S., Lu, B. Y., Yan, D. Y. *et al.* (1995). An Evaluation on Smoking-induced Health Costs in China (1988–1989). *Biomedical And Environmental Sciences*, **8**, 342–9.

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

Kato, I., Tominga, S., and Suzuki, T. (1989). Characteristics of past smokers. *International Journal of Epidemiology*, **18**(2), 345–54.

Leu, R. E. and Doppmann, R. J. (1984). The demand for health care in Switzerland—a latent variable approach. In *System Science in Health Care* (ed. W. von Eimeren, R. Engelbrecht, and C. D. Flagle), pp. 932–5, Heidelberg, Springer.

Leu, R. E. and Schaub, T. (1983). Does smoking increase medical care expenditure? *Social Science and Medicine*, **17**(23), 1907–14.

Leu, R. E. and Schaub, T. (1984). Ecopnomic aspects of smoking. *Effective Health Care*, **2**(3), 111–23.

Leu, R. E. and Schaub, T. (1985). More on the impact of smoking on medical expenditure. *Social Science and Medicine*, **21**(7), 825–7.

Lippiatt, B. C. (1990). Measuring medical cost and life expectancy impacts of changes in cigarette sales. *Preventive Medicine*, **19**, 515–32.

Luce, B. R. and Schweitzer, S. O. (1978). Smoking and alcohol abuse: a comparison of their economic consequences. *New England Journal of Medicine*, **298**(10), 569–71.

Mackay, J. and Crofton, J. (1996). Tobacco and health: tobacco and the developing world. *British Medical Bulletin*, **52**(1), 206–21.

Manning, W., Keeler, E. B., Newhouse, J. P. *et al.* (1989). The taxes of sin: do smokers pay their way? *JAMA*, **261**(11), 1604–9.

Manning, W., Keeler, E. B., Newhouse, J. P. *et al.* (1991). *The Costs of Poor Health Habits*. Cambridge, MA, Harvard University Press.

Markandya, A. and Pearce, D. (1989). The social costs of tobacco smoking. *British Journal of Addiction*, **84**, 1139–50.

Max, W. and Rice, D. P. (1995). The cost of smoking in California. *Tobacco Control*, **4**(supplement 1), S39–S46.

Maynard, A., Hardman, G., and Whelan, A. (1987). Measuring the social costs of addictive substances. *British Journal of Addiction*, **82**, 701–6.

McIntyre, D. E. and Taylor, S. P. (1989). Economic aspects of smoking in South Africa. *South African Medical Journal*, **75**(9), 432–5.

Miller, L., Zhang, X., Novotny, T. *et al.* (1998a). State estimates of Medicaid expenditure attributable to cigarette smoking, Fiscal year 1993. *Public Health Reports*, **113**(2), 140–51.

Miller, L., Zhang, X., Rice, D. P. *et al.* (1998b). State estimates of total medical expenditures attributable to cigarette smoking, 1993. *Public Health Reports*, **113**(5), 447–58.

Miller, V. P., Ernst, C., and Collin, F. (1999). Smoking-attributable medical care costs in the USA. *Social Science and Medicine*, **48**(3), 375–91.

Murray, C. J. L. and Lopez, A. D. (ed.) (1996a). *The Global Burden of Disease: a Comprehensive*

Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020. Global Burden of Disease; 1. Cambridge MA, Harvard University Press.

Murray, C. J. L. and Lopez, A. D. (ed.) (1996b). *Global Health Statistics: a Compendium of Incidence, Prevalence and Mortality for Over 200 Conditions*. Global Burden of Disease; 2. Cambridge MA, Harvard University Press.

Normand, C. (1998). Ten popular health economic fallacies. *Journal of Public Health Medicine*, **20**(2), 129–32.

Oster, G., Colditz, G. A., and Kelly, N. L. (1984a). *The Economic Costs of Smoking and Benefits of Quitting*. Lexington, MA, D. C. Health.

Oster, G., Colditz, G. A., and Kelly, N. L. (1984b). The economic costs of smoking and the benefits of quitting for individual smokers. *Preventive Medicine*, **13**, 377–89.

Over, M., Ellis, R., Huber, J. H. *et al*. (1992). The Consequences of Adult Ill-Health. In *The Health of Adults in the Developing World*. (ed. R. Feachem, T. Kjellstrom, C. Murray, M. Over and M. Phillips), pp. 161–207, New York, Oxford University Press.

Pan American Sanitary Bureau (1998). *Cost–benefit Analysis of Smoking. Caracas, Venezuela.* Pan American Health Organization.

Parish, S., Collins, R., Peto, R., *et al.* (1995). Cigarette smoking, tar yields, and non-fatal myocardial infarction:14,000 cases and 32,000 controls in the United Kingdom. The International Studies of Infarct Survival (ISIS) Collaborators. *BMJ*, **311**(7003), 471–7.

Pekurinen (1992). *Economic Aspects of Smoking. Is There a Case for Government Intervention in Finland?* Helsinki, VAPK Publishing.

Pekurinen, M. (1999). *The Economic Consequences of Smoking in Finland 1987–1995*. Helsinki, Health Services Research, Ltd.

Peto, R. (1986) Influence of dose and duration of smoking on lung cancer rates. In *Tobacco: a major international health hazard* (ed. R. Peto and D. Zaridze), pp. 23–33. Lyon, International Agency for Research on Cancer, 1986. IARC Scientific Publications, no. 74.

Phillips, D., Kawachi, I., and Tilyard, M. (1992). The costs of smoking revisited. *New Zealand Medical Journal*, **105**, 240–2.

Rath, G. K. and Chaudry, K. (1995). Cost of management of tobacco-related cancers in India. In *Tobacco and Health* (ed. K. Slama), pp. 559–564. New York, Plenum.

Raynauld, A. and Vidal, J.-P. (1992). Smokers burden on society: myth and reality in Canada. *Canadian Public Policy*, **18**(3), 300–17.

Rice, D. P., Hodgson, T. A., Sinsheimer, P. *et al.* (1986). The economic costs of the health effects of smoking, 1984. *Milbank Quarterly*, **64**(4), 489–547.

Robson, L. and Single, E. (1995). *Literature Review of Studies on the Economic Costs of Substance Abuse*. Toronto, Canadian Centre on Substance Abuse.

Schoenbaum, M. (1997). Do smokers understand the mortality effects of smoking? Evidence from the health and retirement survey. *American Journal of Public Health*, **87**(5), 755–9.

Scitovsky, A. A. (1994). The high cost of dying revisited. *Milbank Quarterly*, **72**(4), 561–91.

Shoven, J. B., Sundberg, J. O. *et al.* (1987). *The Social Security Cost of Smoking*. NBER Working Paper Series, no. 2234. Cambridge, MA, National Bureau of Economic Research.

Shultz, J. M. (1985). *SAMMEC: Smoking-Attributable Mortality, Morbidity, and Economic Costs*. (Computer software and documentation.) Minneapolis, MN, Minnesota Center for Nonsmoking and Health, Minnesota Department of Health.

Shultz, J. M., Novotny, T. E., and Rice, D. P. (1991). Quantifying the disease impact of cigarette smoking with SMMEC II software. *Public Health Reports*, **106**(3), 326–33.

Single, E., Collins, D., Easton, B. *et al.* (1996a). *International Guidelines for Estimating the Costs of Substance Abuse*. At <http://www.ccsa.ca/intguide.htm>. Ottowa, Canada, Canadian Centre on Substance Abuse: accessed January, 1999.

Single, E., Robson, L., Xie, X. *et al.* (1996b). *The Costs of Substance Abuse in Canada. A Cost Estimation Study*. Ottowa, Canada, Canadian Centre on Substance Abuse.

Stiglitz, J. E. (1994a). Discount rates: the rate of discount and the theory of the second best. In *Cost–benefit Analysis* (ed. R. Layard and S. Glaister), pp. 116–59, Cambridge, Cambridge University Press.

Stiglitz, J. E. (1994b). *Whither Socialism?* Cambridge, MA, MIT Press.

Stoddart, G. L., Labelle, R. J., Barer, M. L. *et al.* (1986). Tobacco taxes and health care costs: do Canadian smokers pay their way? *Journal of Health Care Economics*, **5**, 63–80.

Thompson, M. E. and Forbes, W. F. (1985). Reasons for the disagreements on the impact of smoking on medical care expenditures: a proposal for a uniform approach. *Social Science and Medicine*, **21**(7), 771–3.

Thornton, A., Lee, P., and Fry, J. *et al.* (1994). Differences between smokers, ex-smokers, passive smokers and non-smokers. *Journal of Clinical Epidemiology*, **47**(10), 1143–62.

US Department of Health and Human Services (1989). *Reducing the Health Consequences of Smoking: 25 Years of Progress.* A report of the Surgeon General, DHHS publication no (CDC) 90–8416, US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Center for Chronic Disease Prevention and Control, Office of Smoking and Health.

Viscusi, W. K. (1995). Cigarette taxation and the social consequences of smoking. *Tax Policy and the Economy* (ed. J. M. Poterba), Cambridge, MA, MIT Press. **9**: 51–101.

Warner, K. E., Hodgson, T. A., and Carroll, C. E. (1999). The medical costs of smoking in the United States: estimates, their validity, and their implications. *Tobacco Control*, **8**(3), 290–300.

Wiencke, J. K., Thurston, S. W., Kelsey, K. T. *et al.* (1999). Early age at smoking initiation and tobacco carcinogen DNA damage in the lung. *Journal of the National Cancer Institute*. **91**(7), 614–9.

World Health Organization (1997). *Tobacco or Health: A Global Status Report*. Geneva, World Health Organization.

Wright, V. B. (1986). Will quitting smoking help Medicare solve its financial problems? *Inquiry*, **23**, 76–82.

Xie, X., Rehm, J., Single, E. *et al.* (1996). *The Economic Costs of Alcohol, Tobacco, and Illicit Drug Abuse in Ontario: 1992*. Toronto, Canada, Addiction Research Foundation.

Xie, X., Robson, J., Single, E. *et al.* (1999). The economic consequences of smoking in Ontario. *Pharmacological Research*, **39**(3), 185–91.

Yach, D. (1982). Economic aspects of smoking in South Africa. *South African Medical Journal*, **62**, 167–70.

Zerbe, R. O. and D. D. Dively (1994). *Benefit-Cost Analysis*. New York, Harper Collins.