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The Economic Costs of the Health Effects of Smoking, 1984

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CIGARETTE SMOKING IS A MAJOR CAUSE OF MORBIDITY and mortality in the United States today. It has been linked to a variety of illnesses, including heart disease, cancer, and respiratory disease. Increasing public awareness of the health risks associated with smoking has led to a decline in the proportion of adults who smoke. Yet, as of 1985, 33 percent of men and 28 percent of women smoked. Although there has been a decline in smoking in recent years, the proportion of adult male smokers who smoke 25 cigarettes or more a day has increased from 24 percent in 1965 to 30 percent in 1985; for women, the proportion increased from 13 percent to 21 percent (National Center for Health Statistics 1985, 73; 1986).

The health hazards of cigarette smoking have been well documented. More than twenty years ago, the *Report of the Advisory Committee to the Surgeon General of the Public Health Service* was published (U.S. Public Health Service 1964). That report and a series of subsequent reports

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of the surgeon general reviewed the major prospective epidemiologic studies in the United States and abroad that established the relation between smoking and various illnesses. Recently, annual authoritative reports have been released by the surgeon general on *The Health Consequences of Smoking* in which cigarette smoking and its relation to cancer (1982), cardiovascular diseases (1983), and chronic obstructive lung disease (1984) were extensively reviewed. The 1985 report presented a comprehensive review of the relation between cigarette smoking and cancer and chronic lung disease in the work place (U.S. Public Health Service, 1982, 1983, 1984, 1985).

In addition to the health risks of smoking, there are important economic consequences. A complete assessment of the economics of smoking requires evaluation of various health, economic, and intangible parameters, including benefits as well as costs of both the production and consumption of tobacco. In many respects the purchase and consumption of tobacco is similar to most other commodities and services purchased in the market place. Expenditures for purchasing tobacco cover the cost of resources used in the production process, profit, and taxes. In return, smokers obtain a certain amount of enjoyment. Thus, to a certain extent, smokers get their money's worth and the cost of resources going into the production of tobacco is offset by the benefits of tobacco consumption to smokers. On the other hand, smokers may not have complete knowledge of the harmful health effects of smoking (Warner 1985); although they know smoking is hazardous they are addicted and unable to quit, and may not consider external effects such as annoyance to nonsmokers or the cost of medical care paid by others. In this situation, costs of smoking other than the purchase price are not fully reflected in the decision process, and benefits to smokers may be less than the combined costs to smokers and nonsmokers.

In this article we focus on costs resulting from the health effects of smoking: expenditures for medical care and the value of productive output lost to morbidity, disability, and premature mortality among smokers. These are important components of an analysis of the economics of smoking. Among smokers who know smoking is hazardous to health, the prospect of quitting may be painful, and continued smoking may have become a means of avoiding the physical and psychological discomforts of withdrawal. The costs of purchasing this tobacco is not offset by the benefits of enjoyment from smoking; these costs can be considered in addition to the health effects of smoking, but they are not quantified in this article.

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This article reviews alternative perspectives and studies of the economic costs of the health effects of smoking, quantifies the magnitude of the costs to the economy by employing a prevalence-based analysis, and compares our findings with those of other researchers. The appendix describes the methodology of attributable risk used in the cost estimates.

Alternative Perspectives of Costs of Smoking

Two distinct methodologies exist for evaluating illness and disease in economic terms, the human capital and willingness-to-pay approaches. The former method, used in this study, is called the human capital approach because an employed person is seen as producing a stream of output over the years that is valued at the individual's earnings (Rice, Hodgson, and Kopstein 1985). The willingness-to-pay method values human life according to the amount people are willing to spend to obtain reductions in the probability of death (Schelling 1968; Acton 1975). The relative merits of these two models is a subject of continuing debate (Robinson 1986). Even within the context of human capital methods employed in this article, there are alternative perspectives from which to view the costs of smoking. Two essential characteristics that distinguish perspectives involve different views on the answer to the question "costs to whom?" and the temporal relation between smoking and costs.

Costs to Whom?

A prevailing view is that the costs of illness to all of society, smokers as well as nonsmokers, and the indirect costs of morbidity and mortality are the value of an individual's total output, without deductions for consumption (Mishan 1971). In accord with this view, cost-of-illness estimates measure the value of resources used (direct costs) and lost (indirect costs) and the total output lost as a result of illness or death is the value forgone. T.C. Schelling (personal communication, February 15, 1984) suggests, on the other hand, that "costs to whom?" requires two different answers: (1) costs to those afflicted by illness and disease, and (2) costs to everyone else, with the monetary impact on others being important because of the welfare gains and losses they entail for the parties to the transactions. Studies may differ in their analyses

of who gains and loses and the amount of benefits and costs to various parties.

The essential distinction between these two views is that the former counts only the value of resources used resulting in forgone alternatives, and resources lost in terms of unemployed labor, while the latter also investigates transfers of resources from one segment of society to another. We are concerned in this article with certain economic costs of the health effects of smoking, including the value of resources used to provide medical care and the value of labor forgone due to morbidity, disability, and premature mortality. The costs estimated are in accord with the first of the two perspectives outlined above. The distribution of a given level of output between consumption and savings and the amount of reallocation of one's output to other members of society is a function of social welfare, fiscal and monetary policy, and other means available to policy makers. The relative shares going to the ill or deceased individuals versus the rest of society are determined by the current economic policies and incentives and are a separate issue.

We should keep in mind, however, that tobacco consumption and accompanying health effects, in concert with the institutional framework of the society, confer monetary benefits on one group through the imposition of monetary costs on another. On average, current and former smokers use more medical care, experience more work-loss days, and have higher mortality rates than persons who have never smoked. Although a smoker may suffer from smoking-induced illness and require medical care, the cost of the treatment may be borne, at least in part, by others. This occurs, for example, when medical care for smoking-related diseases is paid by health insurance funded by premiums collected from both other smokers and nonsmokers, or by public expenditures such as Medicare and Medicaid.

Similar considerations apply to indirect costs. If a smoker loses time from work due to sickness, the real cost is the value of labor not productively employed. The monetary cost of the day lost from work may be borne in whole or in part by the sick worker and dependents, other employees, the employer, or the rest of society. The worker and dependents bear the cost of absences not covered by paid sick leave, other employees may incur costs in the form of lower wages in order to fund sick leave benefits, employers face higher costs for sick leave and additional labor costs or reduced output, and the society as a whole may have to pay higher prices to cover higher costs

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of production and lose tax revenues on income lost by the sick worker. Premature mortality presents a similar situation, although the time horizon is years instead of days. Output lost is a real economic cost. There are also pecuniary transfers, including taxes forgone on income lost by the deceased, Social Security and pension benefits paid to survivors, and Social Security and pension payments forgone by the deceased to the benefit of surviving smokers and nonsmokers.

The deleterious health effects of smoking generate a variety of financial flows in addition to economic costs. These financial flows have distributional effects, transferring control over the use of resources from one group to another, affecting behavior, and changing the relative well-being of individuals. Although outside the scope of this article, which is confined to estimates of resource costs and losses, transfers such as health insurance premiums and payments, Social Security, pension, sickness payments and benefits are important economic values in the social decision-making process. Knowledge of who benefits and who pays and the magnitudes of benefits and costs to various parties can assist in determining the societal response to smoking activities. It might be important to know, for example, the impact of smoking on Social Security, Medicare payments, etc. (Office of Technology Assessment 1985). Some additional aspects of transfer payments are discussed in the section on types of costs.

Finally, it is important not to view the issues in terms of smokers versus nonsmokers. Most deleterious health effects of smoking are self-inflicted on smokers by their consumption of tobacco, although there are possible health effects of passive smoking. On the other hand, economic costs and transfer payments occasioned by smoking-induced disease are shared in varying amounts by ill smokers, nonill smokers, and nonsmokers. For example, although the ill smoker receives medical care covered by health insurance, it is financed by premiums paid by ill smokers, nonill smokers, and nonsmokers.

Temporal Relation between Smoking and Costs

A second essential characteristic that distinguishes perspectives is the temporal relation between smoking and measured costs. Smoking presents a dynamic, time-dependent phenomenon. Some costs of smoking, such as the annoyance caused nonsmokers and property damage from smoking-related fires, are coincident in time with the

purchase and consumption of tobacco. The most important costs of smoking in terms of magnitude of their impact are smoking-related diseases and the attendant morbidity, mortality, medical care costs, indirect losses, and intangible losses from pain, suffering, and other quality-of-life changes. These effects result from cumulative exposure over many years and are far removed and distant in time from the tobacco use that helps cause them.

In this article we present an example of a prevalence-based cost-of-illness analysis in which the current toll of direct and indirect economic costs resulting from prior smoking is estimated. That is, the health care expenditures incurred and value of economic output lost in 1980 as a result of past smoking over many years are calculated. Prevalence-based cost-of-smoking estimates measure the amounts spent during a year and the value of lost economic output for deleterious health effects manifest during the year, but caused by exposure to tobacco over many previous years.

In addition to knowing the current annual burden of past smoking (prevalence costs), it is important to know the future costs likely to result from current levels of smoking (incidence costs) and the reductions in costs to be expected from reductions in smoking. Prevalence costs indicate the maximum annual value of resources that could be gained for other uses as levels of smoking decrease. Even with complete and immediate cessation of all smoking, it would be a number of years before morbidity and mortality rates of former smokers returned to levels comparable to those of persons who never smoked. The total amount saved would be the sum of a series of annual reductions which rise over time to a maximum level. Examples of prevalence- and incidence-based studies of the health effects of smoking are described in a later section.

A related issue is the possible tradeoff between higher than average annual medical care use by and expenditures for smokers and longer life expectancy and additional years of medical care for nonsmokers (Leu and Schaub 1983). To the extent that smokers die prematurely, higher medical care expenditures for smoking-induced disease during the smoker's lifetime are offset to a certain degree by expenditures that would be incurred in future years if the smoker did not smoke and enjoyed longer life (Institute of Medicine 1981). The quantitative nature of total versus net direct costs of smoking, however, remains to be rigorously analyzed, and the conceptual validity of net direct

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Types of Cost

The different types of smoking costs are briefly described below.

Direct Costs

Direct costs of medical care (hospital and nursing home care, services of health practitioners, drugs, etc.) to treat diseases related to smoking result largely from illness self-inflicted on smokers by their consumption of tobacco. The costs of care of nonsmokers exposed to and ill from tobacco smoke are also included. Other direct costs of smoking include costs of cleaning clothes and air of smoke, repairing and replacing articles damaged by cigarette burns, attempts to quit smoking, fires caused by smoking, activities related to smoking and health by private and government groups, and costs to business to hire and train replacements for ill smokers.

Additional direct costs of disease borne by patients and other individuals include costs of transportation to health providers, certain household expenditures, and costs of relocating (such as moving expenses). Transportation costs could be incurred not only for local transportation to hospitals, clinics, physicians, etc., but also for transportation out of state, and out-of-area living costs. Illness can force a family to incur expenses in caring and providing for the sick member of the family. These include extra expenditures for household help for cleaning, laundering, cooking, and babysitting; special diets; special clothing; items for rehabilitation and comfort such as exercycles, vaporizers, humidifiers, and dehumidifiers; alterations of property, such as elevators for invalids and other special housing facilities; and vocational, social, and family counseling services. Other costs originating in disease or illness are expenditures for retraining or reeducation, and care provided by family and friends.

Limitations of data have hindered development of estimates of direct costs other than health expenditures, with existing information being mostly anecdotal. Luce and Schweitzer (1978) included the health care and property costs of fires caused by smoking, but these amounted

to less than 3 percent of the total direct costs. Nonhealth direct costs have been estimated infrequently, usually for a specific disease (cancer, for example), and for relatively small samples. Although not concerned with health effects of smoking, several studies indicate the potential importance of nonhealth direct costs. Lansky et al. (1979) found mean weekly expenditures for 70 families of pediatric cancer patients totaled $56 for transportation, food, clothing, family care, and lodging. Patients receiving out-patient chemotherapy reported similar nonmedical expenses resulting from their diseases of $37 during treatment weeks and $17 during nontreatment weeks (Houts et al. 1984). Although these expenditures seem relatively high, neither study indicates how many weeks they were incurred, their relation to medical care expenditures, or the year of data collection. In their study of costs of caring for children with cancer, Bloom, Knorr, and Evans (1985) found nonmedical direct expenses for a six-month period in 1981 for 569 children with cancer at the Children's Hospital of Philadelphia averaged about $4,000 annually and were almost 20 percent of the medical expenditures incurred during this same period and 15 percent of gross annual family income.

One of the few studies, if not the only one, to attempt to estimate nonhealth-sector costs for the nation for all medical conditions was by Mushkin and Landefeld (1978). They estimated nonhealth direct costs between $23 billion (low estimate) and $29 billion (high estimate) in 1975, adding 19 to 23 percent to direct health care expenditures. These additional expenditures were incurred by consumers for transportation to providers, property losses to fire, and automobile accidents; by government for special education, vocational rehabilitation, counseling, added fire protection, and extra costs to the criminal justice system; and by industry for environmental and safety investments. These were the only nonhealth direct expenditures Mushkin and Landefeld were able to estimate with existing data, and represent only a fraction of the potentially measurable costs. Although these nonmeasured costs are potentially large, their relative importance compared to health care expenditures is uncertain.

Indirect Costs

Indirect costs of smoking are the value of lost productivity, output, or forgone manpower resources when persons lose time from work

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and other productive activities due to morbidity, disability, or premature mortality caused by smoking-induced illnesses. In this article, we estimate these indirect costs of smoking. Illness may also adversely affect productivity in addition to causing time lost from work by lessening the productivity of persons while on the job. Absenteeism also may increase costs of production with the end result that the value of output per unit of input declines. Additional indirect costs include the time a patient and/or family members spend visiting physicians, other health professionals, and hospitalized persons, and time lost from work by family members when someone in the family is ill.

As for nonhealth direct costs, data for estimating indirect costs associated with lessened on-the-job productivity and time lost to various persons besides the patient are sparse. Mushkin and Landefeld (1978) estimated the cost of time spent visiting physicians, dentists, and hospitals, and days lost from work due to another person's illness at about $4 to $6 billion in 1975. This adds 5 percent to the commonly estimated indirect costs resulting from the patient's morbidity and premature mortality. The study by Lansky et al. (1979) of families of pediatric cancer patients found an average loss of pay from accompanying the child to the hospital equal to 14 percent of family income. In the study by Bloom, Knorr, and Evans (1985), families of children with cancer lost wages amounting to 18 percent of family income. Indirect costs such as these, which have not usually been measured in cost-of-illness studies due to lack of data, very likely vary by disease and certain other parameters. These few studies indicate, however, that as for nonhealth direct costs, nonmeasured indirect costs may be a substantial portion of the economic burden of illness.

Intangible Costs

Direct and indirect costs are losses because they represent reduced consumption possibilities; costs result from the consumption of resources that are thus forgone to other uses. In addition to economic, that is, monetary, costs, smoking causes intangible costs. These include intangible costs inflicted on others in the vicinity such as the irritating effects of smoke on the visual and olfactory senses and the respiratory system, and the annoyance these cause, and also noneconomic effects of illness and disease suffered by smokers and their families, friends, coworkers, and care-givers.

Illness and disease are responsible for a wide variety of deteriorations in the quality of life and personal catastrophes that are not reflected in direct and indirect economic costs. Victims may suffer loss of a body part or speech, disfigurement, disability, the pain and grief of impending death. They, and those around them, may be forced into economic dependence and social isolation, unwanted job changes, discrimination in obtaining employment and health and life insurance, loss of opportunities for promotion and education, relocation of living quarters, and other undesired changes in life plans. The environment created by illness often induces anxiety, reduced self-esteem and feeling of well-being, resentment, and emotional problems that often require psychotherapy. Problems of living may develop, leading to family conflict, antisocial behavior, and suicide. The victims and others may experience marked personality changes and reduced sexual function. Premature mortality has direct consequences for the family, affecting, for example, duration of marriage and age at widowhood. Disrupted development and delinquency may occur among children. The quality of life may be reduced beyond the restorative capability of current rehabilitation efforts. The combination of financial strain and psychosocial problems can be especially devastating.

Psychosocial problems have been documented in numerous studies and appear to be widespread. A few examples are studies by Blanchard, Blanchard, and Becker (1976) (depression among widows), Campbell and Campbell (1978) (invasion of privacy, high insurance and interest rates, termination of employment), Cassileth et al. (1984) (mental health status), Derogatis et al. (1983) (psychiatric disorders), Goldberg (1981) (depression), Marinelli and Dell Orto (1977) (self-esteem, sexuality and sexual dysfunction). Intangibles are not easily quantified, and not easily accounted for explicitly in economic models. Consequently, it is not possible to compare the relative importance of economic and intangible costs in a common unit of measurement such as money. It is conceivable, however, that intangible costs are at least commensurate with, and may well exceed, economic costs in terms of their impact on both individual and societal welfare.

Transfer Payments

Smoking generates federal, state and local income and excise taxes (Harvard University Institute for the Study of Smoking Behavior and

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Policy 1985; Warner 1986). Taxes are neither benefits nor costs to the society as a whole. Rather, taxes are a form of transfer payment or reallocation of income from one segment of society to another. Although taxes are a cost to the payer and a benefit to the ultimate payee, the monetary value of the gains and losses offset each other (except for the costs which may be incurred in operating the system for collection and disbursement). Taxes, however, undoubtedly have an impact on the welfare of payers who lose and payees who gain.

Health insurance premiums paid by nonsmokers to cover the cost of medical care for smoking-related diseases incurred by smokers are transfer benefits to smokers, which are offset in monetary value by the transfer costs to nonsmokers. They occur when health insurance premiums do not reflect differential risks of disease to smokers and nonsmokers. The cost of smoking-induced disease is the value of resources devoted to medical care, whether or not paid entirely by smokers who become ill, or subsidized in part or in whole by nonsmokers. These are already counted among costs in terms of medical care expenditures. Health care premiums and out-of-pocket costs for treatment can be summed to obtain (approximately) the value of medical care resources devoted to treating smoking-caused disease, but it is important to avoid double counting. Nevertheless, it may be important to society to know the amount of subsidies involved and the extent to which nonsmokers subsidize medical care of smokers in order to decide consciously whether the society wants these to take place. Real, but as yet unexplored, benefits and costs of these subsidies are the welfare gains to smokers and the welfare losses to nonsmokers.

Social Security, pension, and disability and sickness payments to ill smokers subsidized by nonsmokers (and smokers who do not suffer ill health effects), and payments forgone to smokers who die prematurely to the benefit of nonsmokers are also payments which transfer control over the use of resources from one segment of society to another. They do not represent the monetary value of resource losses caused by smoking and are not benefits or costs to society as a whole. Social Security and disability payments do result in a redistribution of income and welfare gains and losses and are important economic values. These transfer payments can be important economic values in the social decision-making process and assist in determining the societal response to smoking activities.

Studies of Economic Costs of the Health Effects of Smoking

There are a number of studies of the costs of smoking, but no one study has addressed all aspects (Shultz 1985). Alternative perspectives of the costs of smoking differ in the focus of their concern, including:

(1) aggregate costs (e.g., medical care expenditures) due to past smoking, i.e., prevalence-based costs;
(2) lifetime medical care expenditures of smokers versus nonsmokers for all conditions and for specific conditions, including lung cancer, coronary heart disease, chronic obstructive pulmonary disease, i.e., incidence-based costs;
(3) tradeoffs between higher than average annual medical care use and expenditures of smokers and longer life expectancy and additional years of medical care for nonsmokers; and
(4) long-run reductions in smoking and its effect upon the economy, including the future impact of changes in smoking patterns on certain government receipts and expenditures, government deficit or surplus, and employment.

Prevalence-based Social Costs

The majority of cost-of-smoking studies have been prevalence-based analyses of social costs. They have examined costs to the society rather than private costs (accruing to participants in market transactions, such as smokers, for example) or external costs (falling on others such as nonsmokers and business and government organizations). And they have been concerned with the economic costs incurred in a period of time (most often a year) as a result of the prevalence of smoking-induced disease during this same period. Prevalence-based costs measure the value of resources used (direct costs) or lost (indirect costs) during a specified period of time (the base period), regardless of the time of disease onset. The costs of the base-year manifestations or sequelae of smoking-related disease, which may have had its onset in the base year or any time prior to the base year, are included.

Prevalence-based costs assess the current costs of smoking. Current morbidity, mortality, and economic costs result from many past years of tobacco consumption, and current consumption will affect the future

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health of smokers. Therefore, prevalence-based, or current, costs of smoking represent the maximum annual value of resources that could gradually be shifted out of care of smoking-induced illness and into other social priorities if levels of smoking were to decrease. The impact of changes in smoking patterns would take place over a period of years, and the total amount saved would be the sum of a series of annual reductions. Alternatively, if cessation of smoking produced a larger, older population, the health care costs of smoking are resources that could in whole or in part, depending on population dynamics, provide care to an older population with longer lifetimes and lower average annual per capita health care costs.

Simon (1968), Hedrich (1971), Williams and Justus (1974), Freeman et al. (1976), Kristein (1977), Luce and Schweitzer (1978), Forbes and Thompson (1983), Office of Technology Assessment (1985), and Vogt and Schweitzer (1985) have all evaluated social costs of smoking. The results of these studies cannot be compared, however, since the types of costs, diseases, and categories of smokers included, and the methodology employed vary among the studies.

The study reported in this article is prevalence-based and the results will be compared with the studies by Luce and Schweitzer and the Office of Technology Assessment after the presentation of our findings.

Incidence-based Costs

In contrast to prevalence-based costs, which are the costs manifested during a period of time, usually over a year, as a result of smoking-induced disease, incidence-based costs are the lifetime costs expected to occur in a group of smokers as a result of smoking-related disease. An incidence-based study by Oster, Colditz, and Kelly (1984a, 1984b) estimates the direct (medical care expenditures) and indirect (lost wages, salaries, and housekeeping services) economic costs of smoking and benefits of quitting among persons who smoked in 1980 for three smoking-related diseases: lung cancer, coronary heart disease, and emphysema. The economic costs of smoking are the average additional costs per smoker that will be incurred over the smoker's lifetime due to these diseases if he/she continues to smoke throughout life at the same level. Most of the total cost results from indirect losses rather than medical care at younger ages, but direct costs increase dramatically relative to indirect costs at older ages. This general pattern holds true

for women as well as men and for each of the three smoking-related diseases.

Oster, Colditz, and Kelly conclude that a smoker, over his or her lifetime, will require higher medical care expenditures for the three smoking-related diseases than will nonsmokers. Costs increase with the amount smoked, and are higher for men than women due to the higher risks of disease experienced by men (except for chronic obstructive pulmonary disease among heavy smokers 50 years of age and over). Combining Oster, Colditz, and Kelly's projections of cost per smoker and the prevalence of smoking, we estimate $500 billion as the present value of lifetime costs of smoking by current smokers in 1980 for the three diseases. The benefits of quitting are equal to the expected costs of smoking-related diseases, adjusted to take into account that ex-smokers' risks of disease slowly decline over a number of years compared with the risks faced by nonsmokers.

Using a somewhat different model, Lewit (1983) analyzed the reduction in health care costs and savings in indirect costs that would result from a gradual reduction in smoking-related disease in the United States beginning in 1980. During the first 25 years, the sum of health care costs saved was projected to be about $200 billion and the gains in indirect costs were equally substantial although realized more gradually.

Lifetime Medical Care Expenditures of Smokers versus Nonsmokers

Leu and Schaub (1983) examine the impact of smoking on lifetime medical care expenditures of Swiss males. They estimate that although smokers have higher than average annual expenditures for medical care, the longer expected lifetime of nonsmokers means that expected lifetime medical care expenditures for males at age 35 who do not smoke will be 7 percent higher than expenditures for 35-year-old male smokers.

Comparing the methods of Leu and Schaub and Oster, Colditz, and Kelly to estimate lifetime medical care expenditures for smokers, the former includes all medical conditions, while the latter considers only the three smoking-related diseases. Leu and Schaub find lifetime medical care expenditures of 35-year-old male Swiss smokers less than expenditures for nonsmokers. Oster, Colditz, and Kelly report average

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lifetime costs among smokers who quit are substantially reduced. Although it appears that these two studies offer contradictory results, closer examination of the assumptions, data, and methods indicate that they may be logically consistent. On the one hand, nonsmokers, because of their longer lifetimes, might have somewhat higher or negligibly different lifetime health care expenditures over all diseases than smokers who have higher annual per capita expenditures while alive, but die earlier (Leu and Schaub 1983). On the other hand, smokers have higher expected lifetime expenditures for lung cancer, coronary heart disease, and emphysema because they are at higher risk of developing those diseases than nonsmokers (Oster, Colditz, and Kelly 1984a, 1984b).

The conclusion reached by Leu and Schaub, however, that lifetime medical care expenditures of smokers are not higher, and possibly are even lower than those of nonsmokers, may be premature for at least two reasons. First, expenditures are not discounted. The effect of not discounting is to overstate expenditures of nonsmokers since a considerable portion of a nonsmoker's lifetime expenditures are incurred in those extra years of life granted the nonsmoker, after the age at which the smoker would die and cease to incur expenditures. This can be a considerable period of time. For example, in 1977 a male in the United States who died of cancer of the trachea, bronchus, or lung, which is typically related to smoking, on the average died at an age with an expected remaining lifetime of 14 years (Rice and Hodgson 1981).

Furthermore, these expenditures will be highly concentrated in the more distant years just before the time of death. Lubitz and Prihoda (1984) have shown that, in 1978, Medicare decedents 67 years of age or older represented only 6 percent of beneficiaries but received 27 percent of reimbursements for medical care. These reimbursements were highly concentrated just before death, with one-fourth of reimbursements in the two years preceding death for care received in the last month of life. Assuming a relatively modest discount rate of 3 percent, a dollar of medical care expenditures incurred by a nonsmoker 14 years in the future has a discounted value compared to a dollar of expenditure during the last year of the smoker of only $.66. In other words, a nonsmoker would have to incur $1.52 (52 percent more) in medical care expenditures fourteen years after the expected age of death of the smoker to offset a dollar of medical care in the

smoker's last year of life. Medical care expenditures of nonsmokers are deferred to the future and the appropriate comparison is between the present discounted values of the respective streams of expected annual medical care expenditures.

Second, Leu and Schaub assume relatively low rates of excess medical care use and average annual medical care expenditures for smokers versus nonsmokers. We found actual excess utilization of physicians' services by smokers compared to nonsmokers 2.6 times that calculated by Leu and Schaub and excess use of hospital care 7.7 times higher.

Lack of discounting and the possible underestimation of the amount by which average annual use of medical care by smokers exceeds use by nonsmokers means that Leu and Schaub may have underestimated lifetime medical expenditures of smokers relative to nonsmokers. The amount of understatement is uncertain without further analysis, but could be substantial. Nevertheless, the concept of a tradeoff between higher than average annual medical care use and expenditures of smokers and longer life expectancy and additional years of medical care for nonsmokers is valid and an important aspect of analysis of costs of smoking. The analysis begun by Leu and Schaub should be continued in order to ascertain this relationship with greater certainty.

Impact of Long-run Reductions in Smoking on the Economy

Studies have examined the future impact of changes in smoking patterns on certain economic variables, including government receipts and expenditures, government deficit or surplus, and employment.

Atkinson and Townsend (1977) examined the long-run impact in Great Britain of an increase in cigarette taxes and a reduction in smoking on government tax receipts and certain transfer payments and revenues. They found that a 40 percent reduction in the number of cigarettes smoked, achieved by phasing in from 1977 to 1980 an increase in the cigarette tax, restrictions on advertising, gift coupons and sport sponsorship, and a health education program, would mean a net increase in population of 250,000 persons in 1998, with marginal change in National Health Service usage. By the year 2000, they project a substantial increase in annual tax revenues and a small net annual reduction in government spending, with savings in sickness benefits and widows' pensions more than offsetting extra costs of retirement programs and health education efforts.

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Gori and Richter (1978) use the Wharton long-term econometric model to forecast certain economic effects of elimination of the minimum preventable portion of major causes of death, starting in 1975. Population changes resulting from reductions in mortality are introduced into the Wharton long-term model, and their effects on various economic indicators are forecast every five years from 1980 to 2000, as mortality from preventable diseases is gradually eliminated between 1975 and 2000. Gori and Richter estimate reductions in mortality rates resulting from a policy of disease prevention based on the difference between United States rates and the next-to-the-lowest rates observed in industrialized countries for five major causes of death, including cardiovascular renal diseases, cancer, accidents, diseases of the respiratory system, and diabetes. The next-to-the-lowest rates were used in order to give conservative estimates. Smoking is only one of the factors responsible for observed differences in mortality; others include diet, alcohol and drug abuse, occupational hazards, air and water pollution. The relevant aspect of this analysis for our purposes is the modeling employed, which could be applied to estimate effects of reductions in mortality from smoking.

A key assumption which greatly affects the projections is their restriction of the labor force to persons 16 to 65 years of age. The impact of this by the year 2000 is to increase government transfer payments by about 9 percent over what the Wharton model forecasts in the absence of disease prevention. Furthermore, under this scenario the federal deficit is more than 50 percent larger, and there are relatively minor increases in the gross national product (GNP), civilian labor force, and unemployment.

Although the proportion of elderly in the labor force has been gradually declining in recent years, this assumption of no labor-force participation by persons over 65 years of age can be questioned since 23 percent of this age group had income from earnings in 1980 (Upp 1983). Current thinking leans toward raising the retirement age; starting in 2000 the age at which full Social Security retirement benefits are payable will gradually rise until it reaches 67. Reduced benefits will still be payable at age 62, but the reduction will be larger than it is now. If private pension systems follow the lead of Social Security and raise the age of eligibility for full benefits, incentives will be in place for more workers to work past age 65. The net effect on age at retirement of higher ages for full benefits and the desire of large numbers of workers to retire early is uncertain.

Removing this constraint, Gori and Richter find quite different results for some variables in 2000. With disease prevention, the Wharton model predicts a federal surplus compared to a projected deficit in the absence of disease prevention, with a 65 percent difference in the two estimates. More modest increases in the GNP and government receipts and a much smaller increase in transfer payments are predicted. But with this latter assumption about labor-force participation, much larger increases in unemployment and unemployment benefits result.

Gori and Richter rightly caution that the trends shown and not the numbers are important. In any case, for the purpose of our concern with longer-run reductions in smoking and their impact upon the economy, it is important to note that the direction of change in important economic variables is uncertain. The various models can be quite sensitive to assumptions about key parameters, and a good deal more analysis is required before we can be confident about long-run effects of changes in smoking patterns.

Estimated Economic Costs of the Health Effects of Smoking

Previous studies of the economic costs of smoking, employing the prevalence-based approach, applied global proportions attributable to smoking to illness costs (Hedrick 1971; Luce and Schweitzer 1978). For example, Luce and Schweitzer applied the following smoking percentages to updated cost-of-illness estimates originally published by Cooper and Rice in 1976: neoplasms—20 percent, circulatory system—25 percent, and respiratory system—40 percent. For this article, we have refined the estimates by using the epidemiologic methodology of "attributable risk" to calculate the direct (personal health care expenditures) and indirect (morbidity and mortality) costs associated with cigarette smoking.

Attributable risk is "the maximum proportion of a disease that can be attributed to a characteristic or etiologic factor" (Lilienfeld and Lilienfeld 1980) and assumes that other factors influencing the occurrence of smoking-related diseases are equally distributed among smokers and nonsmokers. But smokers differ from nonsmokers in certain genetic, social, and economic characteristics which may contribute to disease. The prevalence of smoking varies by race (more blacks smoke than

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whites), education (fewer college graduates smoke than persons with only some high school), income (males with lower income smoke more, while the opposite holds for women), and occupation (blue-collar workers smoke more than professional or technical workers) (Vogt 1983; Warner 1983). If factors known to be related to health status and smoking habits are not controlled, the impact of smoking on health and the costs of smoking may be overstated.

An interesting attempt to overcome this problem by Leu and Schaub (1983) analyzed smoking and medical care expenditures using three types of persons: smokers, nonsmokers, and nonsmoking smokers. The latter is a statistical construction having the smoking habits of a nonsmoker but like a smoker in other respects. Leu and Schaub assumed that 65 percent of smokers' excess mortality was due to smoking and 35 percent to other characteristics of smokers. Although it would be important to account for differences in mortality and morbidity between smokers and nonsmokers not due to smoking, the empirical basis for doing so is not readily apparent, and the Leu and Schaub assumption is arbitrary.

The detailed methodology and sources of data for estimating the attributable risks for medical care utilization, morbidity, and mortality and their application to the direct and indirect costs of illness are detailed in the methodology appendix at the end of this article. Summary results are presented below.

Disability and Medical Care Utilization Differentials

Smokers are sicker and require more medical care than those who do not smoke. Table 1 records a comparison of the disability and medical care utilization rates for persons 17 years and over who ever smoked (current and former smokers) and those who never smoked, by age and sex; the data are from the Smoking Supplement of the 1979 National Health Interview Survey (NHIS). Higher rates in all the measures are reported for smokers compared with nonsmokers, ranging from 6 percent for physician visits to 72 percent for persons unable to work or keep house. The differentials between male smokers and nonsmokers are especially high. For example, the number of men reporting that they are unable to work is 88 percent higher for smokers compared with nonsmokers. For male smokers, hospital days are 63 percent higher, restricted-activity days are 55 percent higher, and

TABLE 1
Disability and Medical Care Utilization by Cigarette Smoking Status, Sex and Age: United States, 1979

Smoking status	Both sexes				Males				Females			
	Aged 17 years and over	17–44 years	45–64 years	65 years and over	Aged 17 years and over	17–44 years	45–64 years	65 years and over	Aged 17 years and over	17–44 years	45–64 years	65 years and over
RESTRICTED-ACTIVITY DAYS PER PERSON PER YEAR												
All persons[1]	22.3	15.1	26.3	42.8	20.0	13.7	24.4	39.4	24.4	16.5	28.2	45.2
Ever smoked[2]	24.2	17.9	28.8	41.4	22.9	15.8	27.5	39.8	25.8	20.4	30.7	44.2
Never smoked	20.3	12.1	22.6	43.9	14.8	10.7	14.3	39.5	23.4	13.1	25.9	45.3
BED-DISABILITY DAYS PER PERSON PER YEAR												
All persons[1]	7.5	5.7	8.1	13.8	6.1	4.3	7.1	12.1	8.9	6.9	9.1	15.0
Ever smoked[2]	7.8	6.5	8.8	11.7	6.7	4.8	8.1	11.1	9.3	8.4	9.8	12.7
Never smoked	7.2	4.7	7.1	15.4	4.8	3.5	3.6	14.5	8.6	5.7	8.5	15.7
WORK-LOSS DAYS PER CURRENTLY EMPLOYED PERSON PER YEAR												
All persons[1]	4.9	5.0	4.7	—	4.5	4.5	4.3	—	5.5	5.6	5.4	—
Ever smoked[2]	5.4	5.8	4.6	—	5.0	5.2	4.6	—	6.2	6.9	4.6	—
Never smoked	4.3	4.0	5.1	—	3.6	3.4	3.3	—	5.0	4.5	6.3	—
NUMBER OF PERSONS UNABLE TO WORK OR KEEP HOUSE[3] PER 100 PERSONS[4]												
All persons[1]	5.0	1.1	6.8	17.2	7.9	1.7	11.4	28.6	2.5	0.5	2.6	9.1
Ever smoked[2]	6.2	1.3	9.0	22.1	9.4	2.0	12.7	30.6	2.0	0.5	3.5	7.2
Never smoked	3.6	0.8	3.2	13.3	5.0	1.2	6.8	24.7	2.9	0.5	1.8	9.8
HOSPITAL DAYS PER PERSON PER YEAR												
All persons[1]	1.2	0.8	1.4	2.7	1.1	0.6	1.5	2.5	1.4	0.9	1.3	2.9
Ever smoked[2]	1.4	0.9	1.6	2.9	1.3	0.8	1.7	2.7	1.4	1.1	1.5	3.2
Never smoked	1.1	0.6	1.1	2.6	0.8	0.5	1.0	2.2	1.3	0.8	1.2	2.7
PHYSICIAN VISITS PER PERSON PER YEAR												
All persons[1]	5.0	4.5	5.2	6.8	4.2	3.4	4.7	6.5	5.8	5.6	5.5	6.9
Ever smoked[2]	5.2	4.7	5.3	7.0	4.4	3.6	4.9	6.5	6.2	6.0	5.9	7.9
Never smoked	4.9	4.4	4.9	6.6	3.7	3.1	4.1	6.6	5.6	5.3	5.3	6.6

Ever smoked[2]	7.8	6.5	8.8	11.7	6.7	4.8	8.1	11.1	9.3	8.4	9.8	12.7
Never smoked	7.2	4.7	7.1	15.4	4.8	3.5	3.6	14.5	8.6	5.7	8.5	15.7
WORK-LOSS DAYS PER CURRENTLY EMPLOYED PERSON PER YEAR												
All persons[1]	4.9	5.0	4.7	—	4.5	4.5	4.3	—	5.5	5.6	5.4	—
Ever smoked[2]	5.4	5.8	4.6	—	5.0	5.2	4.6	—	6.2	6.9	4.6	—
Never smoked	4.3	4.0	5.1	—	3.6	3.4	3.3	—	5.0	4.5	6.3	—
NUMBER OF PERSONS UNABLE TO WORK OR KEEP HOUSE[3] PER 100 PERSONS[4]												
All persons[1]	5.0	1.1	6.8	17.2	7.9	1.7	11.4	28.6	2.5	0.5	2.6	9.1
Ever smoked[2]	6.2	1.3	9.0	22.1	9.4	2.0	12.7	30.6	2.0	0.5	3.5	7.2
Never smoked	3.6	0.8	3.2	13.3	5.0	1.2	6.8	24.7	2.9	0.5	1.8	9.8

HOSPITAL DAYS PER PERSON PER YEAR												
All persons[1]	1.2	0.8	1.4	2.7	1.1	0.6	1.5	2.5	1.4	0.9	1.3	2.9
Ever smoked[2]	1.4	0.9	1.6	2.9	1.3	0.8	1.7	2.7	1.4	1.1	1.5	3.2
Never smoked	1.1	0.6	1.1	2.6	0.8	0.5	1.0	2.2	1.3	0.8	1.2	2.7
PHYSICIAN VISITS PER PERSON PER YEAR												
All persons[1]	5.0	4.5	5.2	6.8	4.2	3.4	4.7	6.5	5.8	5.6	5.5	6.9
Ever smoked[2]	5.2	4.7	5.3	7.0	4.4	3.6	4.9	6.5	6.2	6.0	5.9	7.9
Never smoked	4.9	4.4	4.9	6.6	3.7	3.1	4.1	6.6	5.6	5.3	5.3	6.6

Source: Smoking Supplement of the 1979 National Health Interview Survey.
Note: These estimates will be slightly different than other published National Health Interview Survey estimates because these are computed from the one-third sample of persons who were given the smoking supplement. In addition, the variables "unable to work/keep house" and "hospital days" reflect slight definitional modifications from other published estimates.
[1] Excludes persons of unknown smoking status.
[2] Includes current and former smokers.
[3] Includes only females keeping house.
[4] Number of persons unable to work or keep house is not adjusted by labor-force participation, employment, or housekeeping rates.

bed-disability and work-loss days are about 40 percent higher. The differentials in these disability and medical care utilization measures for female smokers compared with nonsmoking women are lower, ranging from 8 to 24 percent. For women reporting that they are unable to work or keep house, the rates are higher for the nonsmokers, except for those 45 to 64 years of age.

Similar patterns are seen by age. The disability and medical care utilization rates for smokers under age 65, especially males, are significantly higher than for nonsmokers. For those aged 65 and over, the differentials are not as large and for several measures (bed-disability days for men and women, restricted-activity days for women and women unable to keep house), the rates are slightly higher for nonsmokers. It is possible that some older persons suffer from a variety of chronic illnesses regardless of their smoking history, resulting in slightly higher disability rates. Also, these rates increase with age for smokers, and nonsmokers aged 65 and over tend to be older than smokers in the same age group.

Morbidity and Medical Care Attributable Risks

The availability of morbidity and medical care utilization rates by types of condition and smoking status enabled us to estimate for the first time the proportion of the illness measure or type of medical care used that can be attributed to smoking. We focused on the three major diagnostic categories most clearly associated with smoking—neoplasms, diseases of the circulatory system, and diseases of the respiratory system. Thus, 30 percent of the men and 17 percent of the women 17 years of age and over who suffer from these three major conditions and who report they are unable to work or keep house may be attributed to smoking (appendix table 1). Almost 3 out of 10 hospital days of care for them are estimated to be associated with smoking and the proportion is higher for men and for those under age 65. Almost 1 out of 5 visits by men and 1 out of 15 visits by women to physicians outside of hospitals may be attributed to smoking, while 1 out of 7 days lost from work is associated with smoking.

Direct Costs

Direct costs of smoking are the amounts spent for hospital care, physician and other professional services, drugs, and nursing home

Direct Costs: Total Person
Diseases of the Circul
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Age
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Under 65 years
65 years and over
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TABLE 2
Direct Costs: Total Personal Health Care Expenditures for Neoplasms and Diseases of the Circulatory and Respiratory Systems, and Amount Attributed to Smoking by Sex and Age: United States, 1980

Age	Both sexes	Males	Females
TOTAL EXPENDITURES[1] (millions)			
All ages	$62,198	$27,675	$34,523
Under 65 years	32,631	15,830	16,801
65 years and over	29,568	11,845	17,722
AMOUNT ATTRIBUTED TO SMOKING (millions)			
All ages	$14,384	$8,220	$6,164
Under 65 years	8,734	5,366	3,368
65 years and over	5,650	2,854	2,796
PERCENTAGE OF TOTAL ATTRIBUTED TO SMOKING			
All ages	23.1%	29.7%	17.9%
Under 65 years	26.8	33.9	20.0
65 years and over	19.1	24.1	15.8

Note: Numbers and percentages may not add to totals due to rounding.
[1] From Hodgson and Kopstein (1984).

care in behalf of current and former smokers. The data on attributable risks for medical care services enabled us to estimate the direct costs of smoking much more accurately than previous cost estimates. These factors were applied to personal health care expenditures for these three major diseases. Direct costs of smoking total $14.4 billion in 1980, accounting for almost one-fourth of the total expenditures for personal health care for neoplasms and diseases of the circulatory and respiratory systems (table 2). About $8.2 billion, or 57 percent, are the costs of smoking for men; $8.7 billion, or 61 percent, are for persons under age 65 (figure 1).

Table 3 records the direct costs of smoking by type of care. Hospital care accounts for the largest share—69 percent of the total. Professional services and nursing home care each account for 13 percent of the total, and 5 percent are for drugs.

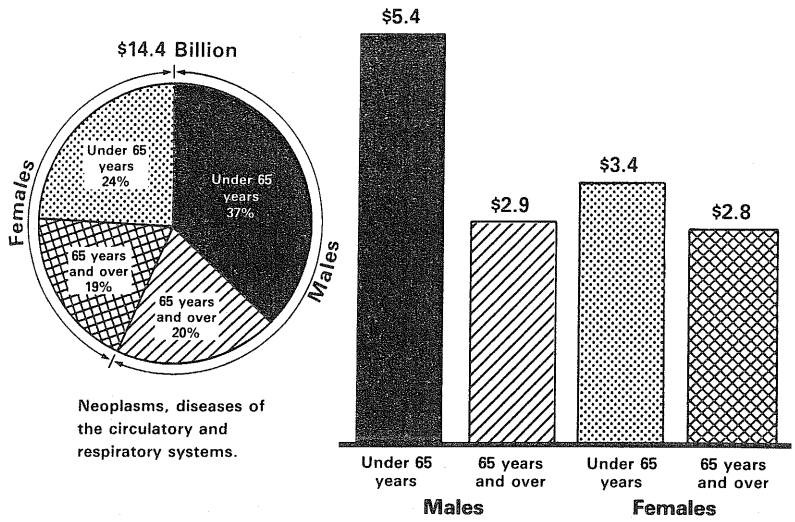


FIG. 1. Direct costs of smoking by age and sex, 1980 (in billions of dollars).

Morbidity Costs

Morbidity costs are the value of losses in output for people who are ill and disabled and unable to work. We use average earnings by age and sex and impute a value for housekeeping services for women who are unable to keep house because of illness and disability. The attributable risks shown in appendix table 1 were applied to person-years lost and to total morbidity costs for the three major diseases as described in the methodology appendix. A total of 528,000 person-years are estimated to be lost to productivity by current and former smokers, at a total cost of $7.4 billion (table 4 and figure 2). Fifty-six percent of the person-years lost and 72 percent of the morbidity smoking costs are attributed to men. The distribution by age shows that 85 percent of the person-years lost and 96 percent of the morbidity costs of smoking are for persons under age 65, reflecting the higher attributable risks for those under age 65, and their higher earnings.

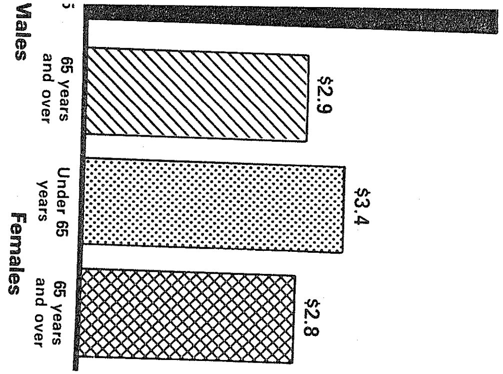
Mortality Costs

As indicated earlier, previous studies of the economic costs of smoking applied global proportions attributed to smoking to illness costs. For

TABLE 3

Direct Costs: Personal Health Care Expenditures for Neoplasms and Diseases of the Circulatory and Respiratory Systems Attributed to Smoking by Type of Health Care, Sex, and Age: United States, 1980

	Both sexes	Males	Females



nd sex, 1980 (in billions of dollars).

s in output for people who are We use average earnings by age ceeping services for women who ss and disability. The attributable applied to person-years lost and major diseases as described in 28,000 person-years are estimated and former smokers, at a total ure 2). Fifty-six percent of the e morbidity smoking costs are y age shows that 85 percent of the morbidity costs of smoking g the higher attributable risks her earnings.

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TABLE 3
Direct Costs: Personal Health Care Expenditures for Neoplasms and Diseases of the Circulatory and Respiratory Systems Attributed to Smoking by Type of Health Care, Sex, and Age: United States, 1980

Type of care	Both sexes			Males			Females		
	All ages	Under 65 years	65 years and over	All ages	Under 65 years	65 years and over	All ages	Under 65 years	65 years and over
AMOUNT IN MILLIONS									
All personal health care	$14,384	$8,734	$5,650	$8,220	$5,366	$2,854	$6,164	$3,368	$2,796
Hospital care	9,988	7,206	2,782	5,848	4,462	1,386	4,140	2,744	1,396
Professional services	1,874	857	1,017	1,272	502	770	602	355	247
Nursing home care	1,847	287	1,560	658	187	471	1,189	100	1,089
Drugs	676	384	292	443	216	227	233	168	65
PERCENTAGE DISTRIBUTION									
All personal health care	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Hospital care	69.4	82.5	49.2	71.1	83.2	48.6	67.2	81.5	49.9
Professional services	13.0	9.8	18.0	15.5	9.4	27.0	9.8	10.5	8.8
Nursing home care	12.8	3.3	27.6	8.0	3.5	16.5	19.3	3.0	38.9
Drugs	4.7	4.4	5.2	5.4	4.0	8.0	3.8	5.0	2.3

Note: Numbers and percentages may not add to totals due to rounding.

TABLE 4

Morbidity Losses: Person-years Lost to Productivity and Morbidity Costs for Neoplasms and Diseases of the Circulatory and Respiratory Systems and Amount Attributed to Smoking by Sex and Age: United States, 1980

Age	Person-years lost (in thousands)			Morbidity costs (in millions)		
	Both sexes	Males	Females	Both sexes	Males	Females
TOTAL[1]						
All ages	2,621	1,170	1,451	$27,372	$19,726	$7,646
Under 65 years	1,628	873	755	25,603	18,580	7,023
65 years and over	993	297	696	1,769	1,146	623
AMOUNT ATTRIBUTED TO SMOKING						
All ages	528	293	234	7,381	5,301	2,080
Under 65 years	448	230	218	7,116	5,086	2,030
65 years and over	80	63	16	264	215	50
PERCENTAGE OF TOTAL ATTRIBUTED TO SMOKING						
All ages	20.1%	25.0%	16.1%	27.0%	26.9%	27.2%
Under 65 years	27.5	26.3	28.9	27.8	27.4	28.9
65 years and over	8.1	21.2	2.3	14.9	18.8	8.0

Note: Numbers and percentages may not add to totals due to rounding.
[1] From Rice, Hodgson, and Kopstein (1985).

AMOUNT ATTRIBUTED TO SMOKING						
All ages	528	293	234	7,381	5,301	2,080
Under 65 years	448	230	218	7,116	5,086	2,030
65 years and over	80	63	16	264	215	50
PERCENTAGE OF TOTAL ATTRIBUTED TO SMOKING						
All ages	20.1%	25.0%	16.1%	27.0%	26.9%	27.2%
Under 65 years	27.5	26.3	28.9	27.8	27.4	28.9
65 years and over	8.1	21.2	2.3	14.9	18.8	8.0

Note: Numbers and percentages may not add to totals due to rounding.
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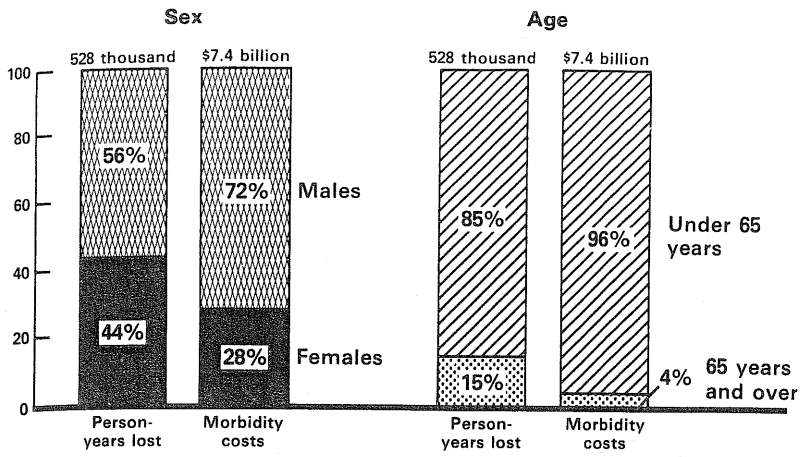

FIG. 2. Morbidity costs of smoking for neoplasms and diseases of the circulatory and respiratory systems, by sex and age, 1980.

this article we refined the mortality costs by estimating the attributable risks for 19 specific causes of death for males and females based on weighted mortality ratios from 4 prospective studies on smoking as described in the appendix. The attributable risks of cancer mortality from smoking among men ranges from 81 percent for cancer of the trachea, bronchus, and lung to 18 percent for stomach cancer; for women the range is from 56 percent for cancer of the esophagus to 13 percent for kidney cancer (appendix table 4). Not surprisingly, the attributable risks for emphysema and chronic bronchitis are very high—87 percent for males and 72 percent for females. The attributable risks for aortic aneurysm are also high—66 percent for males and 49 percent for females.

As indicated earlier, for mortality the cost or value to society of all deaths attributed to smoking is the product of the number of deaths attributed to smoking and the expected values of an individual's future earnings, with sex and age taken into account. This method of derivation takes into consideration life expectancy for different age and sex groups, changing patterns of earnings at successive ages, varying labor-force participation rates, imputed values of housekeeping

services, and the appropriate discount rate to convert a stream of costs or benefits into its present worth (Rice, Hodgson, and Kopstein 1985). We used two discount rates: 4 and 6 percent. We also estimated the person-years lost, based on the number of years remaining at the time of death, from the 1980 life tables published by the National Center for Health Statistics (1984).

Table 5 records the number of deaths and person-years lost to productivity for all causes of death attributed to smoking by age and cause of death. Mortality costs at 4 and 6 percent by age, and cause of death are shown in table 6. (Similar data by sex are available from the authors.) The following are highlights of our findings:

- A total of 270,269 deaths in 1980 were due to smoking, resulting in 3.9 million person-years lost;
- Premature deaths from smoking cost the nation $16.8 billion in 1980;
- About 69 percent of the premature deaths and person-years lost are attributable to smoking among men. Men account for 80 percent of the costs, reflecting the higher risks for men and their higher earnings compared with women;
- About 31 percent of the deaths attributed to smoking occur for those aged 45 to 64; this age group accounted for almost half of the person-years lost and 70 percent of the mortality costs (figure 3);
- More than half the premature deaths from smoking are caused by diseases of the circulatory system. Almost two-fifths are deaths due to malignant neoplasms. Smoking-related neoplasms, however, represent a higher proportion of person-years lost (42 percent) and of costs (46 percent), because smokers who die from cancer are usually in the younger age groups;
- Of the 1.5 million deaths for persons 20 years and over in 1980 due to neoplasms and diseases of the circulatory and respiratory systems combined, 17 percent are attributed to smoking; 19 percent of the 20.9 million person-years lost and 22 percent of total mortality costs are attributed to smoking (table 7).

Other estimates of the number of deaths attributed to smoking are higher than ours (Ravenholt 1985). Our estimates are conservative

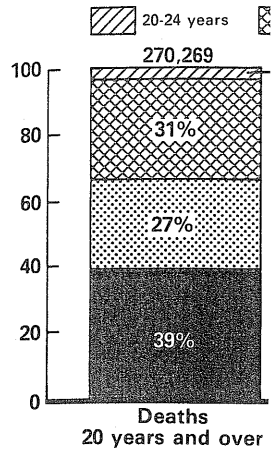

FIG. 3. Mortality losse
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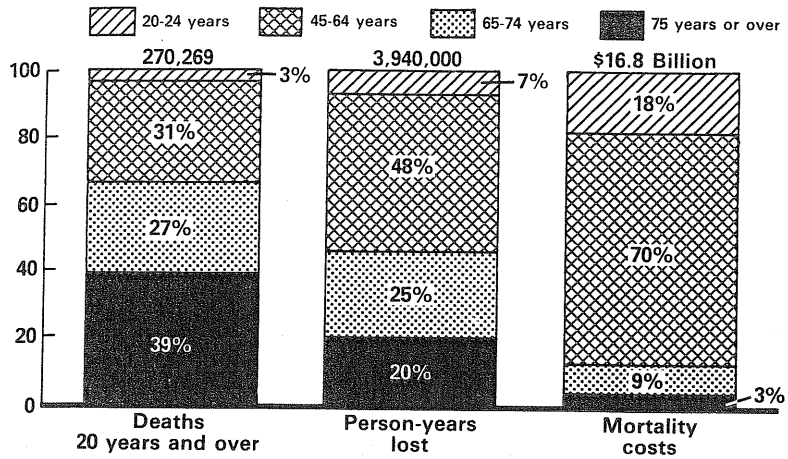

FIG. 3. Mortality losses attributed to smoking: Distribution of deaths, person-years lost, and costs, by age, 1980.

for several reasons: We have not taken into account the adverse effects of passive smoking, risks of abortions, stillbirths and neonatal deaths, or deaths under age 20 that might be associated with smoking. There is a growing body of literature that has concluded that involuntary exposure to tobacco smoke represents a significant public health problem resulting in premature deaths (Repace and Lowrey 1985; Garland et al. 1985; National Research Council 1986). The prospective studies upon which the attributable risks were estimated were performed several years ago and did not attempt to measure the adverse effects of smoking on these additional health problems, or certain current occupational and environmental hazards that greatly increase the risk of death for smokers. The studies were based on old smoking habits. For women, whose smoking habits have approached those of men only in the past decades, the earlier epidemiologic data may well be outdated. Women currently suffering from lung cancer, whose smoking histories date back two or three decades, may have smoked more intensively than women who were in the earlier prospective studies upon whom the attributable risk estimates were based.

TABLE 5

Mortality Losses: Deaths and Person-years Lost to Productivity for All Causes of Death Attributed to Smoking by Age and Cause of Death: United States, 1980

Cause of death	Number of deaths					Person-years lost (in thousands)				
	Aged 20 years and over	20–44 years	45–64 years	65–74 years	75 years and over	Aged 20 years and over	20–44 years	45–64 years	65–74 years	75 years and over
TOTAL	270,269	7,130	84,700	73,426	105,013	3,940	276	1,872	998	795
MALIGNANT NEOPLASMS	103,170	2,804	40,295	35,236	24,835	1,674	108	894	475	196
Trachea, bronchus, lung	74,705	1,787	30,195	26,462	16,261	1,215	66	665	354	129
Larynx	2,603	46	1,115	903	539	42	2	24	12	4
Lip, oral cavity, pharynx	5,382	236	2,391	1,572	1,183	93	9	54	22	9
Esophagus	4,837	110	2,079	1,510	1,138	80	4	46	21	9
Bladder	3,612	23	613	1,146	1,830	43	1	13	15	14
Kidney	1,731	69	655	551	456	28	3	15	7	4
Pancreas	5,228	105	1,652	1,753	1,718	78	4	37	24	14
Stomach	3,142	98	805	921	1,318	47	4	19	13	11
Cervix	1,930	330	790	418	392	47	15	22	7	4
DISEASES OF THE CIRCULATORY SYSTEM	141,546	3,796	39,718	30,687	67,345	1,948	146	875	420	506
Ischemic heart disease	86,036	2,585	31,684	18,324	33,443	1,283	96	692	246	248
Cerebrovascular disease	22,637	444	2,551	4,411	15,231	262	19	61	64	118
Hypertension	5,425	151	1,119	1,326	2,829	73	6	26	19	22
Aortic aneurysm	8,612	1,140	1,522	2,957	3,993	107	6	32	39	31
Atherosclerosis	8,993	16	376	1,077	7,524	78	1	8	15	54
Cardiac arrest	9,843	460	2,466	2,592	4,325	144	19	56	36	33
DISEASES OF THE RESPIRATORY SYSTEM	22,917	412	4,063	6,799	11,643	282	17	88	91	85
Emphysema, chronic bronchitis	14,098	112	2,989	5,230	5,767	184	4	64	71	44
Influenza, pneumonia	8,819	300	1,071	1,569	5,876	98	13	24	21	40
OTHER CAUSES OF DEATH	2,636	118	624	704	1,190	37	5	14	10	9
Respiratory tuberculosis	536	35	182	150	169	8	1	4	2	1
Ulcer	2,100	83	442	554	1,021	29	3	10	8	8

Note: Numbers may not add to totals due to rounding.

Kidney	3,612	23	613	1,146	1,138	80	4	46	21	9
Pancreas	1,731	69	655	551	1,830	43	1	13	15	9
Stomach	5,228	105	1,652	1,753	456	28	3	15	7	14
Cervix	3,142	98	805	921	1,718	78	4	37	24	4
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Cerebrovascular disease	86,036	2,585	31,684	18,324	67,345	1,948	146	875	420	4
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Atherosclerosis	8,612	1,140	1,522	2,957	2,829	73	6	26	19	118
Cardiac arrest	8,993	16	376	1,077	3,993	107	6	32	39	22
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OTHER CAUSES OF DEATH	2,636	118	624	704	1,190	37	5	14	10	9
Respiratory tuberculosis	536	35	182	150	169	8	1	4	2	1
Ulcer	2,100	83	442	554	1,021	29	3	10	8	8

Note: Numbers may not add to totals due to rounding.

TABLE 6

Mortality Costs: Discounted Productivity Losses for All Causes of Death Attributed to Smoking by Discount Rate, Age and Cause of Death: United States, 1980 (in millions)

Cause of death	Discounted at 4 percent					Discounted at 6 percent				
	Aged 20 years and over	20–44 years	45–64 years	65–74 years	75 years and over	Aged 20 years and over	20–44 years	45–64 years	65–74 years	75 years and over
TOTAL	$16,814	$3,017	$11,811	$1,565	$420	$14,836	$2,439	$10,565	$1,435	$398
MALIGNANT NEOPLASMS	7,687	1,131	5,684	753	118	6,803	919	5,082	691	110
Trachea, bronchus, and lung	5,631	733	4,261	559	78	4,999	599	3,813	513	73
Larynx	202	20	161	19	2	180	16	144	18	2
Lip, oral cavity, pharynx	502	103	359	35	5	441	83	321	32	5
Esophagus	382	47	297	33	5	339	38	265	31	5
Bladder	113	9	74	23	7	102	7	67	21	7
Kidney	140	30	96	12	2	123	24	85	11	2
Pancreas	316	44	226	38	8	281	35	202	35	8
Stomach	172	39	106	21	6	150	31	94	20	6
Cervix	227	108	105	12	3	189	85	90	11	2
DISEASES OF THE CIRCULATORY SYSTEM	8,086	1,648	5,527	656	255	7,118	1,330	4,946	601	241
Ischemic heart disease	6,117	1,133	4,475	382	127	5,400	922	4,007	351	120
Cerebrovascular disease	667	177	328	102	60	580	140	290	93	56
Hypertension	258	63	153	31	12	225	50	136	28	11
Aortic aneurysm	325	65	183	60	17	288	52	165	55	16
Atherosclerosis	96	6	44	23	23	87	5	40	21	21
Cardiac arrest	623	203	345	58	17	536	160	308	53	16
DISEASES OF THE RESPIRATORY SYSTEM	878	185	508	142	43	775	149	455	130	41
Emphysema, chronic bronchitis	534	47	352	110	26	479	38	316	101	24
Influenza, pneumonia	344	138	156	32	18	296	111	139	29	17
OTHER CAUSES OF DEATH	163	52	91	15	5	141	42	81	14	4
Respiratory tuberculosis	50	16	30	3	1	44	13	27	3	1
Ulcer	113	36	61	12	4	98	29	54	11	4

Note: Numbers may not add to totals due to rounding.

Bladder	382	47	297	33	5	339	38	321	32	3	
Kidney	113	9	74	23	7	102	7	265	31	5	
Pancreas	140	30	96	12	2	123	24	67	21	7	
Stomach	316	44	226	38	8	281	35	85	11	2	
Cervix	172	39	106	21	6	150	31	202	35	8	
DISEASES OF THE CIRCULATORY SYSTEM	227	108	105	12	3	189	85	94	20	6	
Ischemic heart disease	8,086	1,648	5,527	656	255	7,118	1,330	90	11	2	
Cerebrovascular disease	6,117	1,133	4,475	382	127	5,400	922	4,946	601	241	
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Aortic aneurysm	258	63	153	31	12	225	50	290	93	56	
Atherosclerosis	325	65	183	60	17	288	52	136	28	11	
Cardiac arrest	96	6	44	23	23	87	5	165	55	16	
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OTHER CAUSES OF DEATH	163	52	91	15	5	141	42	81	14	4	
Respiratory tuberculosis	50	16	30	3	1	44	13	27	3	1	
Ulcer	113	36	61	12	4	98	29	54	11	4	

Note: Numbers may not add to totals due to rounding.

TABLE 7

Mortality Losses: Deaths, Person-years Lost to Productivity, and Mortality Costs for Neoplasms and Diseases of the Circulatory and Respiratory Systems, and Amount Attributed to Smoking by Sex and Age: United States, 1980

Age	Deaths*			Person-years (in thousands)			Mortality costs (in millions)					
							Discounted at 4 percent			Discounted at 6 percent		
	Both sexes	Males	Females	Both sexes	Males	Females	Both sexes	Males	Females	Both sexes	Males	Females
TOTAL												
Aged 20 years and over	1,535,184	806,485	728,699	20,918	10,700	10,218	$75,069	$48,738	$26,331	$65,470	$42,724	$22,746
20–64 years	376,464	235,062	141,402	9,449	5,387	4,062	63,017	43,064	19,953	54,367	37,466	16,901
65 years and over	1,158,720	571,423	587,297	11,469	5,313	6,156	12,052	5,674	6,378	11,103	5,258	5,845
AMOUNT ATTRIBUTED TO SMOKING												
Aged 20 years and over	267,633	185,832	81,801	3,904	2,697	1,206	16,651	13,369	3,282	14,696	11,844	2,851
20–64 years	91,088	71,364	19,724	2,130	1,581	550	14,683	12,097	2,587	12,881	10,666	2,215
65 years and over	176,545	114,468	62,077	1,773	1,117	656	1,967	1,272	694	1,814	1,179	635
PERCENTAGE OF TOTAL ATTRIBUTED TO SMOKING												
Aged 20 years and over	17.4%	23.0%	11.2%	18.7%	25.2%	11.8%	22.2%	27.4%	12.5%	22.4%	27.7%	12.5%
20–64 years	24.2	30.4	13.9	22.5	29.3	13.5	23.3	28.1	13.0	23.7	28.5	13.1
65 years and over	15.2	20.0	10.6	15.5	21.0	10.7	16.3	22.4	10.9	16.3	22.4	10.9

Note: Numbers and percentages may not add to totals due to rounding.

and over	1,535,184	806,485	728,699	20,918	10,700	10,218	$75,069	$48,738	$26,331	$65,470	$42,724	$22,746
20–64 years	376,464	235,062	141,402	9,449	5,387	4,062	63,017	43,064	19,953	54,367	37,466	16,901
65 years and over	1,158,720	571,423	587,297	11,469	5,313	6,156	12,052	5,674	6,378	11,103	5,258	5,845
AMOUNT ATTRIBUTED TO SMOKING												
Aged												
20 years and over	267,633	185,832	81,801	3,904	2,697	1,206	16,651	13,369	3,282	14,696	11,844	2,851
20–64 years	91,088	71,364	19,724	2,130	1,581	550	14,683	12,097	2,587	12,881	10,666	2,215
65 years and over	176,545	114,468	62,077	1,773	1,117	656	1,967	1,272	694	1,814	1,179	635
PERCENTAGE OF TOTAL ATTRIBUTED TO SMOKING												
Aged												
20 years and over	17.4%	23.0%	11.2%	18.7%	25.2%	11.8%	22.2%	27.4%	12.5%	22.4%	27.7%	12.5%
20–64 years	24.2	30.4	13.9	22.5	29.3	13.5	23.3	28.1	13.0	23.7	28.5	13.1
65 years and over	15.2	20.0	10.6	15.5	21.0	10.7	16.3	22.4	10.9	16.3	22.4	10.9

Note: Numbers and percentages may not add to totals due to rounding.
* Excludes deaths for which age is not available.

Total Economic Costs of the Health Effects of Smoking

The total economic costs of smoking amount to $38.6 billion in 1980. Direct costs account for 37 percent, morbidity costs for 19 percent and mortality costs 44 percent (table 8). Not surprisingly, the economic costs of smoking for men are considerably higher than for women—$27 billion and $11.6 billion, respectively. For men mortality costs are highest—50 percent of the total; for women, direct costs are highest—53 percent of the total economic costs.

Smoking clearly has severe consequences for the nation, amounting to 8.5 percent of the total economic costs of all illnesses in 1980. Direct costs of smoking account for 6.8 percent of the total direct costs, and indirect costs represent almost 10 percent of the total indirect costs for all illnesses. It is evident that people who smoke die earlier, and their productivity losses are very high.

We updated our figures to 1984 and the costs are even more staggering—$53.7 billion in 1984 (figure 4). To obtain 1984 values, direct costs were adjusted by the percentage change in total personal health care expenditures as reported by the Health Care Financing Administration. Indirect costs were adjusted by the percentage change in average weekly earnings as reported by the Bureau of Labor Statistics. Direct costs represent a larger share of the total—43 percent compared with 37 percent in 1980 because medical care costs have been rising faster than earnings that are the basis for estimating indirect costs. Again, mortality costs are relatively higher for males and direct costs are highest for females.

Comparison with Other Cost-of-smoking Studies

The studies by Luce and Schweitzer (1978) and the Office of Technology Assessment (1985) (OTA) also estimate medical care expenditures and the value of lost productivity from morbidity and premature mortality from smoking-induced disease. Their methodology is similar to that of the study reported in this article. Each of the three studies estimated costs of smoking by applying attributable risks to direct and indirect costs of neoplasms and circulatory and respiratory diseases. The costs of neoplasms and circulatory and respiratory diseases from which the costs of smoking are derived are consistent. Luce and Schweitzer inflated Cooper and Rice's (1976) estimates of costs in 1972 to 1976;

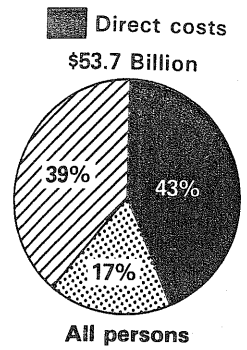

FIG. 4. Economic costs

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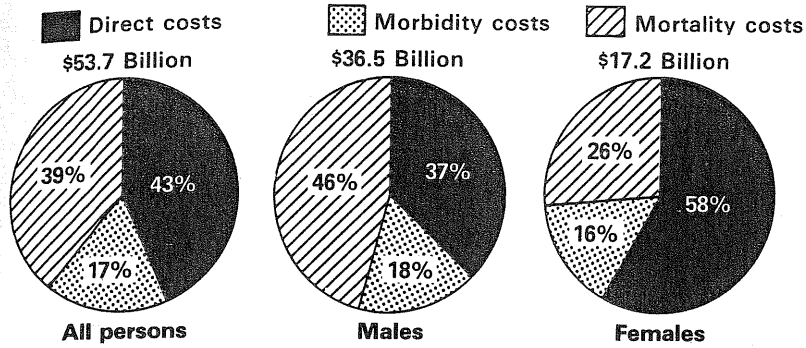

FIG. 4. Economic costs of smoking, by type of cost and sex, 1984.

OTA inflated Hodgson and Kopstein (1984) and Rice, Hodgson, and Kopstein's (1985) estimates of 1980 costs to 1985; and this article utilized Hodgson and Kopstein (1984) and Rice, Hodgson, and Kopstein (1985) cost estimates. The principal sources of variation among the studies are the estimates of attributable risks.

Luce and Schweitzer used attributable risks for three major diagnostic groups of diseases—neoplasms and circulatory and respiratory diseases—from Boden's (1976) study of the economic impact of environmental disease on health care delivery. For each major diagnostic group, the attributable risk was applied to total direct and indirect costs for that disease to estimate the amount due to smoking. Boden does not indicate how these attributable risks were derived. OTA improved upon this method by attributing costs of smoking according to the estimated proportion of smoking-related deaths for each disease by age and sex. By this method OTA accounted for the influence of declining attributable risks, declining per capita indirect costs, and increasing per capita health expenditures with increasing age. For our estimates, we introduce an additional refinement by estimating health care costs and indirect morbidity losses related to smoking from differences in medical care use and time lost from productive activity between smokers and nonsmokers observed in the National Health Interview Survey, rather than by differences in mortality which is characteristic of earlier studies.

TABLE 8
Economic Costs of Smoking for All Diseases Attributed to Smoking by Type of Cost, Age, and Sex: United States, 1980 and 1984

Age and sex	1980 Total	1980 Direct costs	1980 Indirect costs: Morbidity	1980 Indirect costs: Mortality*	1984 Total	1984 Direct costs	1984 Indirect costs: Morbidity	1984 Indirect costs: Mortality
AMOUNT (in millions)								
BOTH SEXES	$38,579	$14,384	$7,381	$16,814	$53,711	$23,338	$9,286	$21,087
Under 65 years	30,678	8,734	7,116	14,828	40,241	12,872	8,935	18,434
65 years and over	7,899	5,650	264	1,985	13,471	10,466	351	2,654
MALES TOTAL	27,022	8,220	5,301	13,501	36,494	13,376	6,501	16,617
Under 65 years	22,669	5,366	5,086	12,217	29,060	7,899	6,220	14,941
65 years and over	4,353	2,854	215	1,284	7,434	5,477	281	1,676
FEMALES TOTAL	11,557	6,164	2,080	3,313	17,217	9,962	2,785	4,470
Under 65 years	8,009	3,368	2,030	2,611	11,180	4,973	2,715	3,492
65 years and over	3,547	2,796	50	701	6,037	4,989	70	978
PERCENTAGE DISTRIBUTION BY TYPE OF COST								
BOTH SEXES	100.0%	37.3%	19.1%	43.6%	100.0%	43.5%	17.3%	39.3%
Under 65 years	100.0	28.5	23.2	48.3	100.0	32.0	22.2	45.8
65 years and over	100.0	71.5	3.3	25.1	100.0	77.7	2.6	19.7
MALES TOTAL	100.0	30.4	19.6	50.0	100.0	36.7	17.8	45.5
Under 65 years	100.0	23.7	22.4	53.9	100.0	27.2	21.4	51.4
65 years and over	100.0	65.6	4.9	29.5	100.0	73.7	3.8	22.5

Age and sex	Total	Direct costs	Morbidity	Mortality	Total	Direct costs	Morbidity	Mortality
AMOUNT (in millions)								
BOTH SEXES	$38,579	$14,384	$7,381	$16,814	$53,711	$23,338	$9,286	$21,087
Under 65 years	30,678	8,734	7,116	14,828	40,241	12,872	8,935	18,434
65 years and over	7,899	5,650	264	1,985	13,471	10,466	351	2,654
MALES TOTAL	*27,022*	*8,220*	*5,301*	*13,501*	*36,494*	*13,376*	*6,501*	*16,617*
Under 65 years	22,669	5,366	5,086	12,217	29,060	7,899	6,220	14,941
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PERCENTAGE DISTRIBUTION BY TYPE OF COST								
BOTH SEXES	100.0%	37.3%	19.1%	43.6%	100.0%	43.5%	17.3%	39.3%
Under 65 years	100.0	28.5	23.2	48.3	100.0	32.0	22.2	45.8
65 years and over	100.0	71.5	3.3	25.1	100.0	77.7	2.6	19.7
MALES TOTAL	100.0	30.4	19.6	50.0	100.0	36.7	17.8	45.5
Under 65 years	100.0	23.7	22.4	53.9	100.0	27.2	21.4	51.4
65 years and over	100.0	65.6	4.9	29.5	100.0	73.7	3.8	22.5
FEMALES TOTAL	100.0	53.3	18.0	28.7	100.0	57.9	16.2	26.0
Under 65 years	100.0	42.1	25.3	32.6	100.0	44.5	24.3	31.2
65 years and over	100.0	78.8	1.4	19.8	100.0	82.6	1.2	16.2

Note: Numbers and percentages might not add to totals due to rounding.
* Discounted at 4 percent.

Converting the costs estimated by these three studies to 1984 values (table 9) facilitates comparison of the different results. Our results are quite close to those of Luce and Schweitzer. The principal differences are with the OTA results. OTA estimates indirect costs to be 40 percent higher because of a higher estimate of mortality and a younger age distribution of the deaths due to smoking. In the OTA study 314,000 deaths were attributed to smoking versus 270,000 in our study. Deaths under 65 years of age, when indirect costs of mortality are higher, represented 41 percent of deaths from smoking in the OTA study compared with 34 percent in our study.

The apparent similarities of these estimates mask substantial differences in estimated costs of the three component diseases—neoplasms and circulatory and respiratory diseases. There is, in general, a lack of consistency among the studies in terms of the magnitudes of the estimated proportions for a given medical condition. Although OTA and we calculate similar proportions for circulatory diseases (13 and 14 percent) and Luce and Schweitzer and OTA are very close on respiratory disease (40 and 41 percent), for the most part results of the three studies are quite different. The three studies differ in their application of the attributable risks to the direct and indirect costs of neoplasms and circulatory and respiratory diseases, which increases the differences in results for specific diseases.

Although total costs in the three studies are fairly close, with the low estimate by Luce and Schweitzer being 85 percent of the high estimate by OTA, this is achieved through rather wide disparities in estimated costs of the various medical conditions which partly cancel out in the aggregate. The substantial amount by which OTA's estimated cost of neoplasms exceeds Luce and Schweitzer's estimate, coupled with larger costs of circulatory and respiratory diseases estimated by Luce and Schweitzer, results in nearly equal estimates of total costs.

We prefer our estimates of health care expenditures and morbidity costs associated with smoking because they are based upon observed differences between smokers and nonsmokers in health care utilization and disability, including, for example, work-loss days and persons unable to work. Unfortunately, sample sizes prohibit estimation of costs by medical condition; it may be possible to overcome this by combining several years of data from the National Health Interview Survey. With respect to mortality costs, we estimated separate attributable risks for males and females for each specific cause of death

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TABLE 9
Economic Costs of and Percentage of Deaths from Neoplasms and Diseases of the Circulatory and Respiratory Systems Attributed to Smoking, Three Studies

	Luce and Schweitzer (1978)	Rice et al. 1986 (current study)	OTA (1985)
AMOUNT ATTRIBUTED TO SMOKING (in billions of 1984 dollars)			
TOTAL	$52.8	$53.7	$62.2
Type of cost			
Direct costs	21.0	23.3	19.8
Indirect costs	31.8	30.4	42.4
Disease			
Neoplasms	8.8	N.A.*	24.7
Circulatory diseases	26.1	N.A.*	24.3
Respiratory diseases	17.9	N.A.*	13.1
PERCENTAGE ATTRIBUTED TO SMOKING			
TOTAL	22.6%	23.0%	26.6%
Type of cost			
Direct costs	21.2	23.5	19.7
Indirect costs	23.9	22.8	31.8
Disease			
Neoplasms	13.1	N.A.*	36.7
Circulatory diseases	22.3	N.A.*	20.8
Respiratory diseases	37.4	N.A.*	27.2
PERCENTAGE OF DEATHS			
TOTAL	25	17	21
Disease			
Neoplasms	20	25	32
Circulatory diseases	25	14	13
Respiratory diseases	40	18	41**

Note: To obtain 1984 values, direct costs estimated by each study are adjusted by the percentage change in total personal health care expenditures reported by the Health Care Financing Administration. Indirect costs are adjusted by the percentage change in average weekly earnings reported by the Bureau of Labor Statistics.
* Data from the Smoking Supplement of the 1979 National Health Interview Survey were used to estimate attributable risks for medical care and morbidity losses due to smoking. Limitations in sample size prohibit disaggregation of health care expenditures and morbidity costs by medical condition.
** OTA reports 48 percent of deaths from respiratory diseases were due to smoking, but their total for the denominator of the proportion excludes deaths from acute respiratory infections besides acute bronchitis and bronchiolitis, other diseases of upper respiratory tract, pneumonconioses, and other lung diseases due to external agents, and certain other diseases of the respiratory system.

associated with smoking rather than using one factor for each major diagnostic group of diseases. Thus, the total number of deaths attributed to smoking in our study is lower than the estimates of other researchers.

Conclusions

According to our estimates, smoking has severe economic consequences for the nation, amounting to a staggering $53.7 billion in 1984. We believe that our contribution to the literature on the economic costs of the health effects of smoking using the prevalence-based approach is four-fold:

(1) The many conceptual issues involved in estimating the health effects of smoking were discussed and we categorized the alternative perspectives and methods of estimation, and compared the different cost estimates;
(2) For the first time, attributable risks based on health status and medical care differentials by age, sex, and diagnosis observed in the NHIS were developed to estimate the direct and morbidity costs;
(3) Attributable risks were developed by specific cause of death and by sex based on weighted mortality ratios for current and former smokers and nonsmokers from four major prospective studies;
(4) Mortality costs were based on current (1980) lifetime earnings values applied to deaths by age and sex.

Projections of future costs of smoking assume maintenance of current smoking behavior, including the prevalence and incidence of smoking, the amount smoked, and the type of cigarettes. Sensitivity analyses on these parameters could indicate potential changes in costs that might occur with changes in smoking habits. Beyond smoking itself, there are a number of factors influencing the health effects of smoking and attendant economic costs which are very difficult to predict and which have the potential to either increase or decrease costs. Progress in eliminating competing disease and increasing life expectancy would increase the relative risk of smoking-related morbidity and mortality. Changes in personal health practices, such as diet and exercise and exposure to chemicals in air, water, and food, may alter risks associated

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with smoking to the extent that there are synergistic relations among risks for diseases such as cancer, coronary heart disease, and pulmonary disease.

Medical treatment has changed significantly over the years and changes will continue into the future. The cost of treating an illness may increase or decrease as the method of treatment changes. In a series of studies, Anne Scitovsky (Scitovsky 1968; Scitovsky and McCall 1977; Scitovsky 1985) examined changes in the costs of treatment of selected illnesses. In the years between 1951 and 1964 reduction in average length of stay was the main cost-saving change observed. Savings due to shorter lengths of stay were outweighed, however, by increases in the number of diagnostic tests and therapeutic procedures per case, greater use of specialists, and substitution of in-patient for out-patient care. During the period 1964 to 1971, average length of stay continued to decline and the number of diagnostic tests increased, raising the costs for some conditions and lowering costs of others. Between 1971 and 1981, the rate of increase in the use of ancillary services seems to have slowed, but costs were raised substantially by the introduction of several expensive "big-ticket" technologies. Although methods of treatment are certain to change, how these changes, coupled with changes in financing mechanisms that also affect medical care utilization and costs, will affect expenditures is uncertain. Advances in medical therapy may improve survival rates or lessen the severity of the condition and affect medical care expenditures and indirect costs.

The future economic costs of the health effects of smoking depend on many diverse factors including smoking behavior, the incidence or prevalence of smoking-induced diseases, methods and costs of treatment, and valuation of losses in productivity. Nevertheless, the magnitude of the current costs of the health effects of smoking to the economy justifies concern over the misallocation of the nation's resources to harmful uses.

Methodology Appendix

Direct Costs

Direct costs, or personal health care expenditures, in the United States in 1980 have been estimated for major diseases, including neoplasms

and diseases of the circulatory and respiratory systems, for males and females and the two age groups under 65 years of age and 65 years of age and over (Hodgson and Kopstein 1984; Rice, Hodgson, and Kopstein 1985). Applying attributable risks as explained below to personal health care expenditures gives the estimated direct costs of neoplasms and circulatory and respiratory diseases due to cigarette smoking.

The Smoking Supplement to the 1979 National Health Interview Survey (NHIS) provides estimates of utilization of hospital care and physician services for smokers (current and former) and persons who never smoked, by sex, age, and medical condition. Owing to limitations in sample size, our analysis combines the three major diagnostic categories most clearly associated with smoking—neoplasms, diseases of the circulatory system, and diseases of the respiratory system.

Five steps were required to estimate direct costs of smoking:

(1) Per capita rates of utilization of days of hospital care and physician visits for neoplasms and circulatory and respiratory diseases combined were calculated for smokers and nonsmokers by sex and age (appendix table 1). Differences in these rates between smokers and nonsmokers were tested for statistical significance by the standard normal test.

(2) The attributable risk associated with smoking, that is, the maximum proportion of hospital days and physician visits that could be attributed to smoking, were calculated for males and females 17 to 44 years of age, 45 to 64 years, and 65 years and over. The basic formula used is that in Lilienfeld and Lilienfeld (1980):

$$\text{attributable risk} = \frac{p(r-1)}{p(r-1)+1}$$

$$r = \text{relative risk} = \frac{\text{rate in exposed}}{\text{rate in nonexposed}}$$

p = proportion of the population that ever smoked (current plus former smokers)

(3) The number of hospital days and physician visits for neoplasms and circulatory and respiratory diseases combined that were due to smoking were calculated for males and females in the three age groups by applying the attributable risks in (2) to the total

APPENDIX TABLE 1

Disability and Medical Care Utilization by Cigarette Smoking Status and Attributable Risk for Neoplasms and Diseases of Circulatory and Respiratory Systems, by Sex and Age: United States, 1979

Smoking status and attributable risk	Both sexes			Males			Females		
	Aged 17 years and over	17–64 years	65 years and over	Aged 17 years and over	17–64 years	65 years and over	Aged 17 years and over	17–64 years	65 years and over

MEAN LOSS DAYS PER 100 CURRENTLY EMPLOYED PERSONS AND BED-DISABILITY DAYS PER 100 FEMALES KEEPING HOUSE

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Smoking status and attributable risk	Both sexes			Males			Females		
	Aged 17 years and over	17–64 years	65 years and over	Aged 17 years and over	17–64 years	65 years and over	Aged 17 years and over	17–64 years	65 years and over
WORK-LOSS DAYS PER 100 CURRENTLY EMPLOYED PERSONS AND BED-DISABILITY DAYS PER 100 FEMALES KEEPING HOUSE									
Smokers	301.09	286.44	517.97	163.98	161.90	*	447.64	429.17	619.00
Never smoked	243.44	208.46	432.05	161.90	135.67	*	283.39	252.01	398.88
Attributable risk (percentage)	19.6%	21.5%	11.3%	9.9%**	11.0%**	*	23.0%	25.6%	13.1%
NUMBER OF PERSONS UNABLE TO WORK OR KEEP HOUSE PER 1,000 PERSONS									
Smokers	27.78	16.77	108.22	42.54	24.97	154.73	8.59	6.36	28.53
Never smoked	13.86	4.97	53.95	20.05	8.27	107.83	10.35	2.85	37.33
Attributable risk (percentage)	27.1%	39.0%	16.9%	30.2%	38.4%	22.8%	16.8%	43.4%	***
HOSPITAL DAYS PER 100 PERSONS									
Smokers	50.60	37.90	143.40	48.96	36.73	127.08	52.72	39.38	171.91
Never smoked	30.78	16.86	93.47	19.98	10.57	90.14	36.90	20.89	94.49
Attributable risk (percentage)	30.3%	37.7%	19.7%	37.4%	47.1%	21.7%	24.7%	29.7%	18.2%
PHYSICIANS VISITS PER 100 PERSONS									
Smokers	141.60	118.22	312.55	131.59	99.98	333.36	154.60	140.99	276.21
Never smoked	127.21	107.61	215.52	93.63	79.34	200.10	146.26	125.68	200.28
Attributable risk (percentage)	11.5%	9.0%	17.9%	17.9%	11.8%	31.1%	7.0%	7.1%	6.5%

* Figures do not meet standards of reliability or precision.
** P value greater than .2 for the difference in rates between smokers and never smoked.
*** Represents a negative and significant value.

days and visits (smokers plus nonsmokers) in each of the sex and age groups.

(4) The attributable risks in appendix table 1 for those 17 to 64 years of age were derived separately for each sex by adding together the number of hospital days or physician visits due to smoking at ages 17 to 44 years and 45 to 64 years from (3) and dividing by the total days or visits for neoplasms and respiratory and circulatory disease among smokers and nonsmokers 17 to 64 years of age. The following weighted average illustrates the method employed:

$$AR_{i+j} = \frac{AR_i N_i + AR_j N_j}{N_i + N_j}$$

i = 17 to 44 years of age
j = 45 to 64 years of age
AR = attributable risk (calculated in step (2) for i and j)
N = number of hospital days or physician visits incurred by smokers and nonsmokers for neoplasms and circulatory and respiratory diseases.

Attributable risks for all ages 17 years and over were calculated in a similar manner. Attributable risks for both sexes at a given age were obtained by summing the number of days or visits attributed to smoking for each sex and dividing by the total.

(5) The direct costs attributed to smoking shown in tables 2 and 3 were derived by applying the attributed risks in appendix table 1 to total personal health care expenditures by type of care, age, and sex for neoplasms and circulatory and respiratory diseases. Costs of hospital care, nursing home care, and professional services (not including those of physicians) were calculated from the attributable risks for hospital care. The rationale for applying risk of hospital care to other professional services is that these services consist of home health services and private duty nursing care. Forty percent of home health services in 1980 was paid for by the hospital insurance component of Medicare and was for further treatment of a condition treated in a hospital or skilled nursing facility just prior to receiving home health services. Most private-duty nursing services were provided in the hospital. Costs of physician visits and drugs were calculated from the attributable risks for physician visits.

Morbidity Costs

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Morbidity Costs

Morbidity costs consist of the productivity losses to society, as measured by wages, salaries, and supplements, resulting from days lost from work among the currently employed, persons unable to work because of illness and disability, persons institutionalized for health reasons, and the imputed value of housekeeping services of women who are unable to keep house because of illness and disability.

Using a methodology parallel to that for direct costs, attributable risks for indirect morbidity losses due to smoking were derived from the NHIS for work-loss days among currently employed persons, bed-disability days among females whose usual activity is keeping house, and persons unable to work or keep house (appendix table 1). These attributable risks were applied to the components of total morbidity losses for neoplasms and circulatory and respiratory diseases estimated by Rice, Hodgson, and Kopstein (1985) to obtain person-years lost and morbidity costs of smoking.

Mortality Costs

Mortality costs are the present discounted values of wages, salaries and supplements, and the imputed values of housekeeping services lost following the premature death of persons who would otherwise be productively employed or keeping house. As for direct costs and morbidity costs, the methodology consists of estimating attributable risks for deaths due to smoking and applying these to total mortality costs of specific diseases estimated by Rice, Hodgson, and Kopstein (1985). Mortality costs, however, are estimated for 19 specific causes of death attributed to smoking and are not limited to the sum of the losses from neoplasms and respiratory and circulatory diseases.

Deaths in 1980 from these causes by sex and age were provided by the Division of Vital Statistics of the National Center for Health Statistics from unpublished tabulations. Total person-years lost were estimated by applying the remaining years of life at each 5-year age group from the 1980 life tables (National Center for Health Statistics 1984) to the number of deaths. Total mortality costs for the 19 causes of death discounted at 4 and 6 percent were calculated by multiplying the present value of future earnings lost from Rice, Hodgson, and Kopstein (1985) by the total number of deaths by age and sex. Attributable risks of smoking taking into account two levels of exposure—

APPENDIX TABLE 2

Mortality Ratios from Prospective Studies Used to Calculate Attributable Risk of Smoking, by Sex, Smoking Status and Cause of Death

Cause of death	ACS—25 state				U.S. veterans		British physicians				Swedish			
	Males		Females		Males		Males		Females		Males		Females	
	Current smokers	Former smokers	Current smokers	Former smokers	Current smokers	Former smokers	Current smokers	Former smokers	Current smokers	Former smokers	Current smokers	Former smokers	Current smokers	Former smokers
MALIGNANT NEOPLASMS														
Trachea, bronchus, lung	8.53	4.35	3.58	1.23	12.14	5.00	14.00	4.30	6.71	3.29	7.0	4.5	6.1	1.5
Larynx	6.52	8.41	3.25	1.74	9.95	10.53	13.00	4.00	2.09	1.50	—	—	—	—
Lip, oral cavity, pharynx	6.52	2.25	3.25	1.74	8.25	2.05	13.00	4.00	2.09	1.50	—	—	—	—
Esophagus	3.96	1.66	4.89	1.87	6.17	1.57	4.67	1.67	—	—	—	—	—	—
Bladder	2.55	1.59	2.00	1.94	2.15	1.55	2.11	1.22	—	—	1.8	1.6	2.3	—
Kidney	1.57	1.55	—	1.02	1.45	1.74	2.67	3.00	—	—	—	—	—	—
Pancreas	2.14	1.37	1.42	1.15	1.84	1.17	1.57	—	1.30	1.22	3.1	2.5	4.8	5.5
Stomach	—	1.26	—	—	1.60	—	—	—	—	—	—	2.3	—	—
Cervical	—	—	—	—	—	—	—	—	—	—	—	—	3.0	1.4
DISEASES OF THE CARDIOVASCULAR SYSTEM														
Ischemic heart disease														
Under 65 years	2.03	1.39	1.77	1.16	1.76	1.29	—	—	—	—	1.7	1.3	1.5	1.5
65 years and over	1.36	1.17	1.28	1.27	1.61	1.30	—	—	—	—	—	—	—	—
Cerebrovascular disease	1.32	—	1.65	1.28	1.52	1.15	—	—	—	—	1.0	1.1	—	1.6
Hypertension	1.41	—	—	—	1.41	1.44	1.35	1.11	1.62	—	1.3	1.4	1.1	1.4
Aortic aneurysm	3.08	—	3.77	—	5.24	3.04	6.60	3.20	1.11	3.00	1.6	—	1.8	—
Atherosclerosis	—	—	—	—	1.86	1.15	1.38	—	1.44	1.29	2.0	2.0	1.0	2.8
DISEASES OF THE RESPIRATORY SYSTEM														
Emphysema, chronic bronchitis	7.52	—	5.40	—	10.08	10.23	24.67	14.67	18.87	5.00	—	—	—	—
Influenza, pneumonia	1.83		1.28		1.87									

Kidney	1.57	1.55	—	1.02	2.15	1.55	2.11	1.22	—	—	—	—	—	—
Pancreas	2.14	1.37	1.42	1.15	1.45	1.74	2.67	3.00	—	—	1.8	1.6	2.3	—
Stomach	—	1.26	—	—	1.84	1.17	1.57	—	—	—	—	—	—	—
Cervical	—	—	—	—	1.60	—	—	—	1.30	1.22	3.1	2.5	4.8	5.5
DISEASES OF THE CARDIOVASCULAR SYSTEM					—	—	—	—	—	—	—	2.3	—	—
Ischemic heart disease									—	—	—	—	3.0	1.4
Under 65 years	2.03	1.39	1.77	1.16	1.76	1.29	—	—	—	—	1.7	1.3	1.5	1.5
65 years and over	1.36	1.17	1.28	1.27	1.61	1.30	—	—	—	—	—	—	—	—
Cerebrovascular disease	1.32	—	1.65	1.28	1.52	1.15	—	—	—	—	1.0	1.1	—	1.6
Hypertension	1.41	—	—	—	1.41	1.44	1.35	1.11	1.62	—	1.3	1.4	1.1	1.4
Aortic aneurysm	3.08	—	3.77	—	5.24	3.04	6.60	3.20	1.11	3.00	1.6	—	1.8	—
Atherosclerosis	—	—	—	—	1.86	1.15	1.38	—	1.44	1.29	2.0	2.0	1.0	2.8
DISEASES OF THE RESPIRATORY SYSTEM														
Emphysema, chronic bronchitis	7.52	—	5.40	—	10.08	10.23	24.67	14.67	18.87	5.00	—	—	—	—
Influenza, pneumonia	1.83	—	1.28	—	1.87	—	—	—	—	—	—	—	—	—
OTHER CAUSES OF DEATH														
Respiratory tuberculosis	—	—	—	—	2.12	1.26	5.00	3.67	—	—	—	—	—	—
Ulcer	2.50	—	—	—	3.50	2.50	2.50	1.50	—	—	3.8	3.3	2.7	—

Sources: American Cancer Society and U.S. veterans data from Hammond (1966); British physicians data from Doll and Peto (1976) and Doll et al. (1980); Swedish data from Cederlof, Friberg, and Lundman (1977).
— Data not available

APPENDIX TABLE 3
Basic Data for Estimating Male Current Mortality Ratio for Lung Cancer from Four Prospective Studies

Term	Symbol	Prospective studies			
		ACS—25 state	U.S. veterans	British physicians	Swedish
Deaths exposed	(a_i)	2,203.4	940.7	210.6	31.4
Deaths unexposed	(b_i)	83	78	7.1	7
Person-years exposed	(N_{li})	1,459,218	440,935	151,200	40,780
Person-years unexposed	(N_{oi})	468,828	443,856	71,394	63,520
Person-years total	(T_i)	1,928,046	884,791	222,594	104,300
Mortality ratio	(MR_i)	8.53	12.14	14.0	7.0

Sources: American Cancer Society and U.S. veterans data from Hammond (1966); British physicians data from Doll and Peto (1976) (males) and Doll et al. (1980) (females); Swedish data from Cederlof et al. (1977).

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b_i = age-adjusted
study i

Person-years total		1,928,046	884,791	222,594	104,300
Mortality ratio (T_i)		8.53	12.14	14.0	7.0
(MR_i)					

Sources: American Cancer Society and U.S. veterans data from Hammond (1966); British physicians data from Doll and Peto (1976) (males) and Doll et al. (1980) (females); Swedish data from Cederlof et al. (1977).

current and former smokers—were applied to the total costs to obtain mortality costs of smoking.

The attributable risk formula for two levels of exposure can be expressed as (Walter 1976):

$$AR = \frac{p_0 + p_1 (MR_1) + p_2 (MR_2) - 1}{p_0 + p_1 (MR_1) + p_2 (MR_2)}$$

p_0 = proportion of those who never smoked in the population
p_1 = proportion of current smokers in the population
MR_1 = mortality ratio for current smokers compared with those who never smoked
P_2 = proportion of former smokers in the population
MR_2 = mortality ratio for former smokers compared with those who never smoked

For males and females, overall mortality ratios for both current and former smokers were determined for 19 diseases considered to be causally related to cigarette smoking by combining age-adjusted mortality ratios from four prospective studies on smoking: American Cancer Society 25-State Study, United States Veterans Study, British Physicians Study, and the Swedish Study (appendix table 2). Although there are other major prospective studies on smoking, these four are the only studies for which person-years of exposure data are available to estimate age-adjusted mortality ratios. Person-years are the number of persons in the study group multiplied by the number of years each person was followed until death or the study ended.

Overall mortality ratios for each disease were obtained by treating each study as a separate stratum and weighting the mortality ratios by the number of deaths from each cause and the person-years exposed and unexposed in the four studies (Rothman and Boice 1979):

$$\text{Mortality Ratio} = \frac{\sum_{i=1}^{4} a_i N_{oi}/T_i}{\sum_{i=1}^{4} b_i N_{1i}/T_i}$$

a_i = age-adjusted number of deaths in the exposed group in study i
N_{oi} = person-years in the unexposed group in study i
b_i = age-adjusted number of deaths in the unexposed group in study i

APPENDIX TABLE 4
Weighted Average Mortality Ratios and Attributable Risk of Smoking, by Sex, Smoking Status, and Cause of Death

ICD Number	Cause of death	Mortality ratio: Males, Current smokers	Mortality ratio: Males, Former smokers	Mortality ratio: Females, Current smokers	Mortality ratio: Females, Former smokers	Attributable risk (percentage): Males, All smokers	Attributable risk (percentage): Females, All smokers
MALIGNANT NEOPLASMS							
162	Trachea, bronchus, lung	10.02	4.47	3.67	1.29	81.8%	45.7%
161	Larynx	7.33	8.84	3.25	1.74	82.7	44.0
140–149	Lip, oral cavity, pharynx	6.62	2.28	3.25	1.74	71.6	44.0
150	Esophagus	4.80	1.65	4.90	1.87	62.1	56.4
188	Bladder	2.30	1.60	1.89	1.94	40.3	29.2
189	Kidney	1.47	1.63	1.50	1.02	27.0	13.2
157	Pancreas	2.00	1.37	1.48	1.26	33.0	15.5
151	Stomach	1.49	1.17	2.30	—	17.7	27.9
180	Cervix	NA	NA	3.00	1.40	NA	39.6
DISEASES OF THE CARDIOVASCULAR SYSTEM							
410–414	Ischemic heart disease						
	Under 65 years	1.88	1.38	1.67	1.17	31.7	19.3
	65 years and over	1.49	1.20	1.28	1.27	15.4	7.9
430–438	Cerebrovascular disease	1.32	1.00	1.45	1.28	10.8	15.1
401–404	Hypertension	1.39	1.21	1.43	1.40	17.5	16.0
441	Aortic aneurysm	4.46	2.95	3.19	3.01	65.6	49.2
440	Atherosclerosis	1.83	1.14	1.94	2.40	26.3	33.3
427.5	Cardiac arrest*	3.00	—	3.00	—	43.1	37.3
DISEASES OF THE RESPIRATORY SYSTEM							
491–492	Emphysema, chronic bronchitis	10.13	10.97	7.40	4.89	86.7	71.6
480–487	Influenza, pneumonia	1.79	—	1.29	1.17	23.0	10.2
OTHER CAUSES OF DEATH							
010–112	Respiratory tuberculosis	2.56	1.95	—	—	46.8	—
531–534	Ulcer	2.88	2.12	3.21	2.45	51.3	47.0

* Mortality ratios from U.S. Public Health Service 1983, 104; data for all other causes of death are calculated from Table 7.
— Data not available

151	Stomach	1.49	1.17	2.30	—	17.7	27.9
180	Cervix	NA	NA	3.00	1.40	NA	39.6
DISEASES OF THE CARDIOVASCULAR SYSTEM							
410–414	Ischemic heart disease						
	Under 65 years	1.88	1.38	1.67	1.17	31.7	19.3
	65 years and over	1.49	1.20	1.28	1.27	15.4	7.9
430–438	Cerebrovascular disease	1.32	1.00	1.45	1.28	10.8	15.1
401–404	Hypertension	1.39	1.21	1.43	1.40	17.5	16.0
441	Aortic aneurysm	4.46	2.95	3.19	3.01	65.6	49.2
440	Atherosclerosis	1.83	1.14	1.94	2.40	26.3	33.3
427.5	Cardiac arrest*	3.00	—	3.00	—	43.1	37.3
DISEASES OF THE RESPIRATORY SYSTEM							
491–492	Emphysema, chronic bronchitis	10.13	10.97	7.40	4.89	86.7	71.6
480–487	Influenza, pneumonia	1.79	—	1.29	1.17	23.0	10.2
OTHER CAUSES OF DEATH							
010–112	Respiratory tuberculosis	2.56	1.95	—	—	46.8	—
531–534	Ulcer	2.88	2.12	3.21	2.45	51.3	47.0

* Mortality ratios from U.S. Public Health Service 1983, 104; data for all other causes of death are calculated from Table 7.
— Data not available
NA Not applicable

N_{1i} = person-years in the exposed group in study i
T_i = total person-years in study i ($T_i = N_{oi} + N_{1i}$)

To illustrate this methodology, the overall mortality ratio of 10.02 (MR_1) for lung cancer for male current smokers was computed by applying the above formula to the data shown in appendix table 3. A similar procedure was followed to estimate the weighted mortality ratio of 4.47 (MR_2) in male former smokers. Combining these overall mortality ratios for current and former smokers with the proportions of male smokers in 1980 results in an attributable risk due to smoking of 81.8 percent for lung cancer mortality in men (appendix table 4).

Ischemic heart disease (IHD) is the only disease for which age-specific mortality ratios were used to calculate separate attributable risks for smoking under age 65 and 65 years and over. Because mortality ratios for smoking for IHD decline with age (U.S. Public Health Service 1983) and deaths due to IHD rise rapidly with age, applying an overall attributable risk to all IHD deaths could have substantially overestimated the mortality losses for the elderly while underestimating the losses for those under age 65.

To estimate mortality costs due to cigarette smoking by cause of death, the attributable risks in appendix table 4 were applied to the total number of deaths from the 19 specific causes of death attributable to smoking, to person-years lost, and to mortality costs discounted at 4 percent and 6 percent for males and females aged 20 and over in 5-year age groups.

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