Cigarette Smoking and Lifetime Medical Expenditures

THOMAS A. HODGSON

National Center for Health Statistics

CIGARETTE SMOKING IS KNOWN TO CAUSE LUNG cancer, coronary heart disease, cerebrovascular disease, chronic bronchitis, emphysema, and contributes to morbidity and mortality of these and certain other diseases (U.S. Department of Health and Human Services 1989). Smokers at each age require more medical care than persons who have never smoked (Rice et al. 1986) and experience reduced life expectancy (U.S. Department of Health and Human Services 1989). But are lifetime medical care expenditures higher for smokers or neversmokers? Medical care use by the elderly is high and neversmokers, who live longer, might have higher lifetime medical expenditures.

The relationship of smoking to lifetime medical expenditures is an important issue in terms of society's use of scarce resources, the impact on public and private health insurance programs, and which members of society bear the burden of financing medical care. Never smoking might be a cost-effective way to promote health, well-being, and a longer life even if neversmokers incur higher medical expenditures. However, never smoking has the greater benefit of being cost saving if expected lifetime medical expenditures are less for neversmokers. I will examine this issue by estimating and comparing lifetime medical expenditures of smokers and neversmokers.

The Milbank Quarterly, Vol. 70, No. 1, 1992

Studies of Medical Costs

Previous Studies

In this section I will briefly review previous studies that estimated lifetime medical costs of smoking. Leu and Schaub (1983, 1985) estimated that total expected lifetime medical care expenditures beginning at age 35 for Swiss males who do not smoke will be higher than for smokers. Among Swiss males, the contribution of longer life expectancy to medical care expenditures for neversmokers outweighed the higher average annual expenditures for smokers.

In the first version of their study (1983), Leu and Schaub assumed that medical care utilization is related to smoking in the same way that mortality is related to smoking. Thus, it was estimated that the average male smoker has 8 percent more physician visits and 10 percent more hospital days per year than the neversmoker. In a revised version (1985), Leu and Schaub analyzed the demand for medical care in Switzerland using an econometric model and concluded that smokers have somewhat fewer physician visits and slightly more hospital days than neversmokers. The conclusion reached by Leu and Schaub in their first article, that smoking does not increase lifetime medical expenditures, was reaffirmed.

In the United States, excess medical care utilization by smokers is much higher than that reported by Leu and Schaub. In the National Health Interview Survey (NHIS) Rice et al. (1986) found that the average male smoker (17 years of age and over) had 19 percent more physician visits and 63 percent more hospital days per year than neversmokers. This is 2.4 times the excess physician visits and 6.3 times the excess hospital days reported by Leu and Schaub for Swiss males. The higher annual excess medical care of smokers revealed in the U.S. data cumulated over the years a smoker is alive might more than offset the impact of a longer life span on medical care use of neversmokers.

Lippiatt (1990) also reported that smoking lowers lifetime medical costs. This was derived by deducting from expected lifetime medical expenditures required to treat a smoker for certain smoking-related diseases the additional medical costs incurred during the longer life of a nonsmoker. Although methodologically sound, lifetime medical costs of smoking were underestimated because the data employed both underestimate expenditures for the smoker's smoking-related diseases and overestimate medical costs during the longer life of the nonsmoker.

For lifetime costs of smoking-related diseases Lippiatt used the figures of Oster et al. (1984a,b) for the expected lifetime costs of lung cancer, coronary heart disease, and emphysema. Although these three conditions are important smoking-related diseases, in addition, cigarette smoking is a major agent for chronic bronchitis, cerebrovascular disease, peripheral artery occlusive disease, and cancers of the oral cavity, larynx, and esophagus as well as causing bladder cancer. Smoking also increases the risk of pneumonia and influenza, abdominal aortic aneurysm, and gastric and duodenal ulcers; it is a contributing factor in cancers of the pancreas and kidney; and it is associated with cancers of the stomach and uterine cervix (U.S. Department of Health and Human Services 1989, 1990). Lung cancer, coronary heart disease, and emphysema account for less than half of the total short-term hospital days required for all diseases linked to cigarette smoking (Graham 1988). Just the additional diseases for which smoking is a major cause require hospital days equal to 60 percent of the total for the three conditions studied by Oster. By limiting the calculation to costs of lung cancer, coronary heart disease, and emphysema, Lippiatt omitted substantial morbidity, mortality, and health care utilization and severely underestimated lifetime medical costs of smoking.

In order to take into account the longer life and medical care expenditures of nonsmokers during these extra years, Lippiatt adjusted the estimates by Oster et al. of lifetime costs of smoking-related diseases. This was done by subtracting estimated average annual per capita medical expenditures of nonsmokers over age 65 for each year of difference in life expectancy between smokers and nonsmokers. Average expenditures for nonsmokers were derived from per capita expenditures for the total population over age 65 (smokers and nonsmokers), the proportion of smokers and nonsmokers in this population, and the difference in average annual medical expenditures between smokers and nonsmokers reported by Leu and Schaub (1983). Because Leu and Schaub severely underestimated the difference in annual medical care use and expenditures between smokers and nonsmokers in the United States, Lippiatt's estimate of a nonsmoker's annual medical expenditures is overstated.

By excluding expenditures for diseases known to be caused by smoking and understating medical care utilization and expenditure differences between smokers and nonsmokers, Lippiatt underestimated lifetime medical costs of smoking. Because Lippiatt finds the tradeoff between medical expenditures and life expectancy to be only $280 per year of ex-

tra life for nonsmokers (in 1986 dollars), we expect more accurate estimates of the costs of smoking-related diseases and the annual medical expenditures of nonsmokers would produce lifetime medical costs higher for smokers than nonsmokers.

Manning et al. (1989) examined lifetime medical care costs of smoking from a somewhat different perspective, but found a positive relationship. Their best estimate is that medical ca e costs of smoking were $.26 per pack of cigarettes smoked in 1986 dollars discounted at 5 percent.

Overview of the Study

In our analysis we use a life-cycle model to verify the findings of Manning et al. (1989) that in the United States smokers have higher lifetime medical expenditures. We also expand upon their analysis to examine the timing of expenditures over the life cycle, population as well as individual expenditures, and sources of payment for medical care. Data employed are for the U.S. population and include medical care use and mortality for all diagnoses and causes of death, thus overcoming the limitations in the Leu and Schaub and Lippiatt studies.

Lifetime medical care expenditures are estimated for males and females in the United States who never smoked and for moderate and heavy smokers, including both current and former smokers. Moderate smokers reported smoking fewer than 25 cigarettes a day and heavy smokers smoked 25 or more per day. Analyzing eversmokers (that is, current and former smokers, hereafter called smokers) takes into account the number of years of smoking and patterns of quitting and recidivism existing in the population at the time of data collection. Thus, estimated expected lifetime medical expenditures of a smoker reflect the average experience in the population of persons who take up smoking and include the impact on expenditures of decisions to quit smoking. In this study, comparison of lifetime expenditures of smokers and neversmokers allows us to assess the impact of becoming a smoker versus not becoming a smoker, but does not address the impact of quitting smoking on medical care expenditures. Subsequent research is planned to analyze quitting and lifetime medical expenditures.

From these estimates of lifetime medical expenditures we determine:

1. the amount of excess medical expenditures required by smokers
2. the relationship of medical expenditures to amount smoked

3. the relative importance to lifetime expenditures of a smoker's higher medical care use and a neversmoker's longer life expectancy
4. the timing of medical expenditures during the life cycle and the phases during which expenditures of smokers exceed those of neversmokers and vice versa
5. the monetary burden smoking imposes on private sources of funding (for example, individuals and employers) and public sources (for example, the federal government's Medicare program)
6. the distribution of current medical care expenditures among the population of smokers and persons who never smoked
7. the ongoing bill for excess medical care required by the population of smokers
8. the aggregate future excess expenditures of the current population of smokers

Other Economic Costs

There are other economic costs associated with smoking in addition to medical care expenditures. These include expenditures and payments related to sick leave, disability, group life insurance, pensions, and retirement benefits (Manning et al. 1989; Warner 1987). The impact of smoking on Social Security benefits is among the most important of these and is substantial. Shoven, Sundberg, and Bunker (1987) estimate that because of shorter life expectancy single male smokers earning the median wage receive almost $18,000 less in benefits than they contribute, whereas nonsmokers receive almost $3,400 more than they pay in (in 1985 dollars). For single women with median earnings the difference between smokers and nonsmokers is smaller, but still considerable. Smoking thus results in a net transfer of Social Security benefits from smokers to nonsmokers. Further consideration of economic implications of smoking other than medical care expenditures lies beyond the scope of this analysis.

The Model

The model estimating lifetime medical care expenditures is briefly described here, with additional details provided in the appendix. Medical care use, costs, and mortality experience of cross-sections of the population during each age interval are used to generate longitudinal profiles

of costs from age 17 to death. Expected, in the sense of average, lifetime expenditures rather than actual lifetime expenditures of any one individual are estimated. The principal data sources are the National Health Interview Survey for use of hospital and physician services; the National Nursing Home Survey and the National Health and Nutrition Examination Survey Epidemiologic Followup Study for nursing-home care; the American Cancer Society's Cancer Prevention Study II for mortality; and the National Medical Care Utilization and Expenditure Survey and Medicare data files for charges for medical care.

In general, an individual's expected expenditures during age interval t are given by:

$$E_t = E_{at} P_{at} + E_{dt} P_{dt}$$

where

E_{at} = expenditures during age interval t if the individual survives through t

E_{dt} = expenditures during age interval t if the individual dies in t

P_{at} = probability of surviving through age interval t

P_{dt} = probability of dying during age interval t

It is necessary to distinguish whether the individual survives or dies because much higher expenditures are incurred by decedents than survivors.

Lifetime expenditures from age 17 are given by the sum of expected expenditures, E_t, during each of the age intervals:

t = ages 17–34, 35–44, 45–54, 55–64, 65–74, 75–84, 85 and over

Expenditures are discounted to obtain the present value of the stream of dollars occurring over time. It is assumed that all persons surviving to age 85 enjoy the average remaining lifetime calculated by the National Center for Health Statistics, or approximately five years for males and six years for females (National Center for Health Statistics 1990). This simplification is required by lack of data on life expectancy at age 85 for smokers and neversmokers resulting most likely in overestimates of expenditures for smokers and underestimates of expenditures for neversmokers at ages 85 and over. The impact on lifetime expenditures is

negligible, however, because expected expenditures at age 85 and over are a small proportion of the total, especially among smokers.

Lifetime expenditures are estimated for males and females, and according to amount smoked (never smoked, moderate, or heavy smoker). Age- and sex-specific rates of medical care use and mortality according to amount smoked are employed. Medical care expenditures included are for short-term inpatient hospital care, physicians' services (to hospital inpatients and ambulatory patients in doctors' offices, hospital clinics and emergency rooms, patients' homes, and by telephone), and nursing-home care. These medical services account for about three-fourths of total personal health care expenditures (Waldo et al. 1989). The principal services omitted from the analysis because of lack of data on how utilization relates to cigarette smoking are drugs and dental services.

Medical care utilization and expenditures are not evenly distributed throughout the life cycle. Variation of medical care use with age is easily accounted for by employing age-specific data. Equally important, decedents require much more medical care and incur far greater expenditures than survivors among both elderly and nonelderly populations. Decedents have higher expenditures relative to survivors, not only in the year of death, but also for several years prior to death. The disparity in expenditures of decedents versus survivors increases as the time of death approaches and may be more than six times greater in the year death occurs (Lubitz and Prihoda 1984; Riley and Lubitz 1986; Roos, Montgomery, and Roos 1987). This phenomenon is an important aspect of lifetime medical expenditures and is included in the model.

1990 Dollars

Expenditures in this analysis are in estimated 1990 dollars, with dollar magnitudes adjusted to 1990 according to increases in the medical care component of the consumer price index (*Social Security Bulletin* 1991).

Discounting

Medical care use and expenditures are highly concentrated in the later years of life, especially in the several years before death. Because never-smokers live longer, their medical care expenditures are deferred to the future compared with those of smokers. The very long time horizons in this analysis (65 years or more in some instances), and the different dis-

tributions of expenditures over time for smokers and neversmokers, require that lifetime expenditures be discounted in order not to overstate the amount for neversmokers compared with smokers. This analysis employs a relatively low, but reasonable, discount rate of 3 percent. Key results are also presented for a 5 percent discount rate to show the impact of discounting. Total expected lifetime expenditures discounted at 3 percent are about one-third of nondiscounted expenditures.

Causality or Association?

How much of the difference in medical care use and expenditures is due to smoking and how much to other factors that are not equally distributed among smokers and neversmokers? Smokers differ from neversmokers in certain genetic, social, behavioral, and economic characteristics that may contribute to use of medical care. Positive correlations have been reported between smoking and drinking alcohol. The Behavioral Risk Factor Surveys, conducted from 1981 to 1983, found that more heavy smokers (more than one pack a day) had two or more drinks a day than neversmokers (Bradstock et al. 1985). In a study at the Group Health Cooperative of Puget Sound, current smokers were more likely to be problem drinkers (Pearson et al. 1987). Data from the National Health Interview Survey (NHIS) show that in 1985 smokers were more likely than neversmokers to drink heavily, not exercise actively, sleep six hours or less, and skip breakfast (Schoenborn and Benson 1988). However, smokers, especially those who smoked fewer than 25 cigarettes daily, were less likely to be overweight and to snack daily.

If factors related to health status and smoking habits are not controlled, the impact of smoking on health and medical expenditures may be overstated. There is evidence from several sources, however, that most of the observed difference between smokers and neversmokers in mortality, medical care use, and expenditures is the result of smoking and is not just correlated with it. Neversmokers, especially males, have higher income and more education than smokers, but the difference in medical care use cannot be attributed to health habits, practices, or lifestyles related to income and education because smokers use more medical care at all levels of income and education according to data from NHIS as computed by the Office of Analysis and Epidemiology. Mattson, Pollack, and Cullen (1987) estimated death rates for males in the United States in 1982 for smoking-related diseases and for all causes of

death according to age and smoking status. Applying these estimates to the number of males in the civilian noninstitutionalized population in 1985 by smoking status, it can be calculated that 74 percent of excess deaths among male smokers aged 35 to 84 was due to smoking-related diseases.

An interesting statistical construct, the nonsmoking smoker-type, has been employed to assess medical care expenditures due to smoking rather than just associated with smoking (Leu and Schaub 1983; Manning et al. 1989). The nonsmoking smoker-type does not smoke but is like a smoker in other respects that distinguish smokers from never-smokers and contribute to morbidity, mortality, and medical care use. These include education, family income, race, health insurance coverage, and lifestyle attributes such as drinking habits, exercise, and seat belt use. Thus, the nonsmoking smoker-type experiences medical care use and mortality that lie between those of the smoker and never-smoker.

Higher medical care use and higher mortality have opposite impacts on lifetime expenditures. Thus, the higher medical care use of the nonsmoking smoker-type will increase lifetime expenditures relative to neversmokers and decrease the excess lifetime expenditures associated with smoking. This will be partially offset, however, by the impact of the higher mortality rates of the nonsmoking smoker-type, which reduce life expectancy and thus lifetime expenditures relative to neversmokers and increase excess lifetime expenditures of smoking. Controlling for other differences between smokers and neversmokers besides smoking that affect medical costs has a rather small impact on excess lifetime medical expenditures according to research reported by Manning et al. (1989). Manning and his colleagues estimated lifetime medical costs per pack of cigarettes and found that excess lifetime costs of smokers compared with nonsmoking smoker-types were 87 percent of excess lifetime costs of smokers compared with neversmokers.

Although the preferred comparison for ascertaining medical care expenditures due to smoking is between the smoker and nonsmoking smoker-type, we are only able to compare eversmokers and neversmokers in our study. Nevertheless, because Manning et al. also used data from the NHIS, it is reasonable to conclude from their results that the findings we report would be only slightly different quantitatively and no different qualitatively if formulated in terms of smokers versus nonsmoking smoker-types.

Lifetime Expenditures

Mortality

Smokers have higher death rates than neversmokers at all ages over 35 years (figure 1). The analysis begins at age 17 because data on medical care use and expenditures by smoking status are available beginning at this age. However, we lack data on mortality by smoking status for persons aged 17 to 34 and it is assumed that no deaths occur until age 35. This assumption should have a negligible impact on our results because less than 4 percent of persons die before age 35 (National Center for Health Statistics 1990) and smoking should not be a major determinant of mortality between the ages of 17 and 35. Excluding deaths prior to age 35 has a slight impact on lifetime expenditures of both smokers and neversmokers and even less of an impact on the difference in their expenditures. Death rates rise steadily with age, are higher for males than females, and higher for smokers than neversmokers in each sex.

Probabilities of survival are derived from the death rates. Table 1 shows the probability of an individual 17 years old surviving to the age

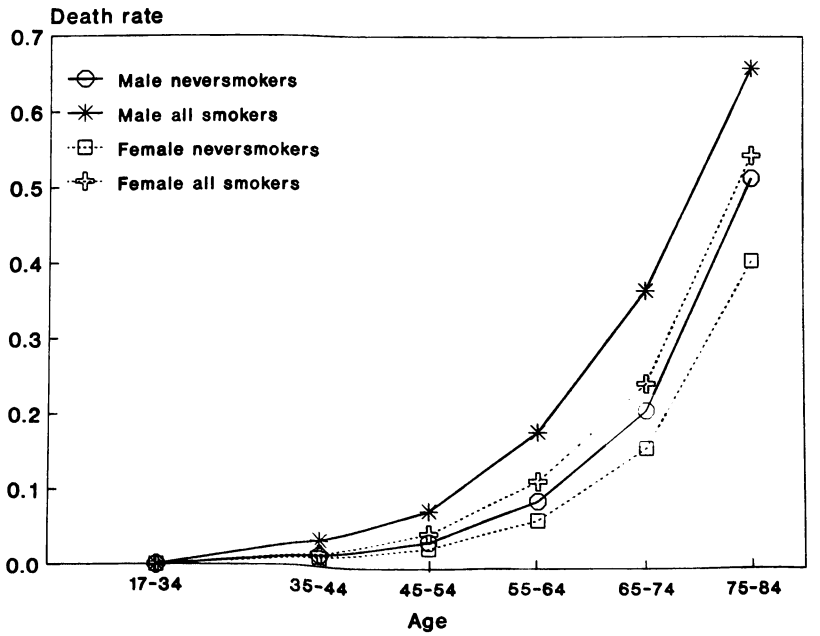

FIG. 1. Death rates during age intervals according to sex and smoking status.

TABLE 1
Probability of Survival by Age, Sex, and Smoking Status[a]

Age (years)	Male		Female		Ratio of neversmokers to smokers	
	Neversmokers	All smokers	Neversmokers	All smokers	Male	Female
35	1.000	1.000	1.000	1.000	1.00	1.00
45	0.986	0.966	0.988	0.984	1.02	1.00
55	0.951	0.893	0.962	0.939	1.06	1.02
65	0.867	0.733	0.901	0.831	1.18	1.08
75	0.689	0.466	0.760	0.630	1.48	1.20
85	0.336	0.159	0.453	0.289	2.11	1.57

Source: Derived from data in the American Cancer Society's Cancer Prevention Study II.
[a] Probabilities are those of a 17-year-old surviving to the age shown.

shown by sex and smoking status. Probabilities of survival are higher for females, but the same patterns are observed among smokers and neversmokers of both sexes. The benefit of lower death rates among neversmokers at all ages accumulates with age and creates a steadily widening gap in survival rates. For example, whereas 87 percent of male neversmokers and 73 percent of smokers survive to age 65, 34 percent of neversmokers survive to age 85 compared with only 16 percent of smokers. In terms of relative survival, out of male neversmokers and smokers alive at age 35, 18 percent more of the neversmokers survive to age 65, 48 percent more of the neversmokers survive to age 75, and more than twice as many of the neversmokers live to age 85. Among females, the probability of surviving is 8 percent higher for neversmokers at age 65, 20 percent higher at age 75, and 57 percent higher at age 85. Smoking exacts a much greater toll among males in terms of premature mortality.

The disparity in mortality between male and female smokers reflects differences in cigarette smoke exposure (U.S. Department of Health and Human Services 1980). The mean age of onset of regular smoking among successive cohorts of men has been less than 20 years since before 1900. It has declined slowly over time to between 15 and 16 years for cohorts born between 1951 and 1960. Among women born at the beginning of the century, however, the mean age at onset was 35 years. Although this declined steadily, it was not until the 1951–1960 birth

cohort, now 30 to 40 years of age, that it became nearly identical to that of men.

Exposure also depends on the likelihood of quitting smoking. Among cigarette smokers, quit ratios (the proportion of eversmokers who are former smokers) have been increasing for both sexes at similar rates since 1965 (U.S. Department of Health and Human Services 1990). Although higher for males than females, the gender difference is only a couple of percentage points when quit ratios are adjusted to account for use of other tobacco products besides cigarettes.

In addition to age at initiation and likelihood of quitting, smoke exposure depends on various dimensions of the style of smoking, including type of cigarette, depth of inhalation, and fraction of cigarette smoked. With each new generation, the surgeon general has concluded, men and women have become more similar in their smoking habits, and female exposure closer to that of men. In future years we can expect male and female mortality from smoking also to become more similar.

Mortality rates and probabilities of survival demonstrate that neversmokers live longer than smokers, and many more neversmokers reach those years of life characterized by high medical care expenditures. Differences in death rates of smokers and neversmokers impact on medical care costs in two ways. On the one hand, there is a high cost associated with dying that is incurred earlier in the life span for smokers and has a present value diminished less by discounting, whereas those who live longer incur additional expenditures in later years that rise with age for both survivors and decedents (figure 2).

The disparity in medical care spending for older and younger persons, coupled with the longer life expectancy of neversmokers, raises the issue of whether neversmokers have higher lifetime medical expenditures than smokers, with smoking holding down medical costs. In order to determine whether smokers or neversmokers have higher lifetime expenditures, it is necessary to take into account differences not only in life expectancy, but also in medical care used and expenditures incurred during the years lived.

Age-specific Expenditures

In figure 2 we have age-specific medical expenditures for male smokers and neversmokers according to whether one survives to the end of the

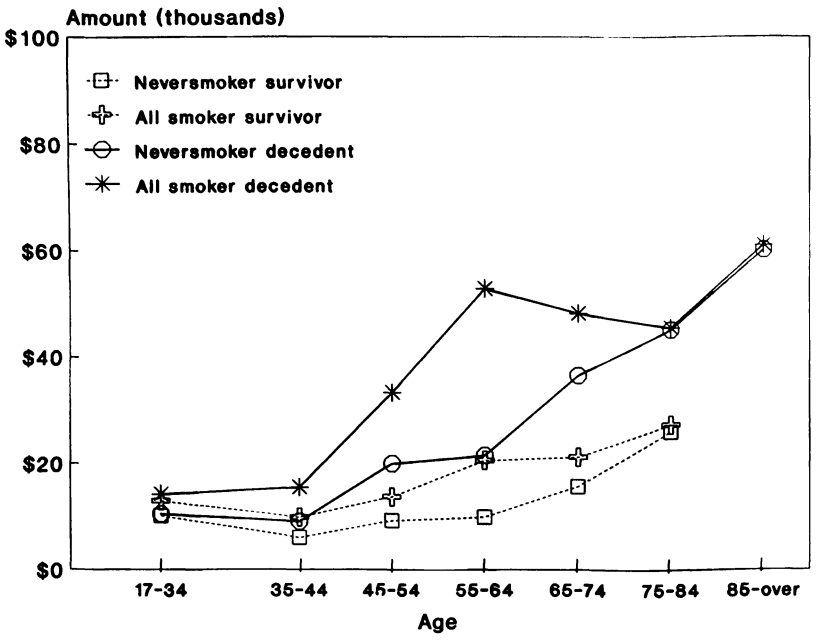

FIG. 2. Male medical expenditures during age intervals according to smoking and survival status.

age interval or dies during it. For example, male smokers who survive to the end of the age span 45–54 incur an average of $13,579 in medical care expenditures during these ten years, and male smokers who die between the ages of 45 and 54 incur an average expenditure of $33,201 per smoker. Neversmokers 45 to 54 years old who survive to age 55 require $9,175 per person, and neversmoker decedents aged 45 to 54 average $19,818 in expenditures. The following conclusions are evident:

1. Expenditures generally increase with age and are much higher at older ages.
2. Expenditures incurred at any age depend on whether the individual survives or dies, with expenditures for decedents higher than for survivors, especially at older ages.
3. Expenditures for smokers exceed those for neversmokers at every age among both survivors and decedents.
4. To be a smoker is expensive, and to be a smoker and die is most expensive.

Although expenditures for females tend to exceed those for males, the relationships observed for males, in terms of survivors versus decedents, smokers versus neversmokers, generally hold for females also (figure 3).

Expected Expenditures

Applying probabilities of surviving and dying to survivor and decedent expenditures yields age-specific expected medical expenditures (figure 4). These are the discounted expenditures we expect the average individual aged 17 to incur during each age interval for the remainder of his or her life, according to whether the person is a smoker or neversmoker. A 17-year-old deemed to be a smoker is one who is or will become a smoker, probably within five years. Females generally have higher medical expenditures than males, but the relationship of expenditures to smoking is the same for both. Through age 74, smokers have higher expenditures at each age, but after age 75 neversmokers have higher expenditures. Here we see the impact of lower mortality rates and longer life expec-

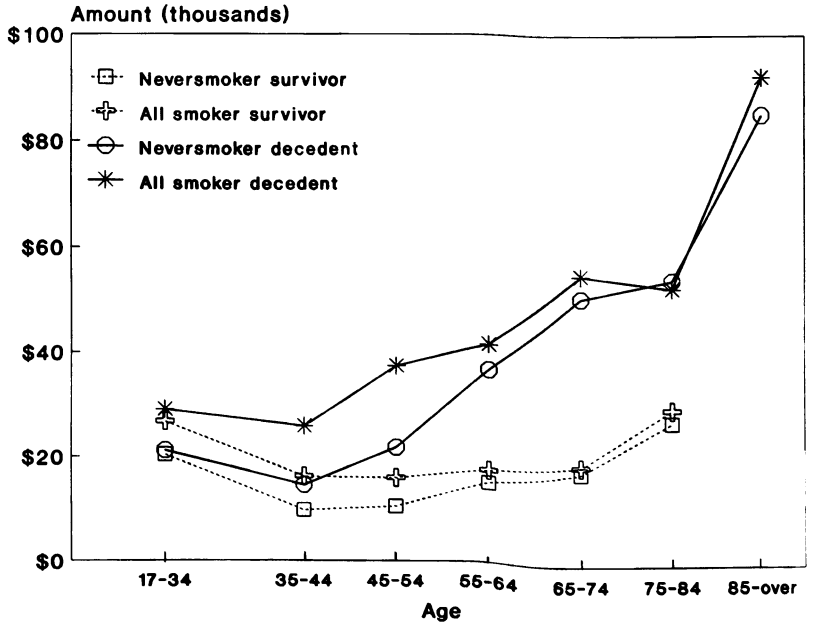

FIG. 3. Female medical expenditures during age intervals according to smoking and survival status.

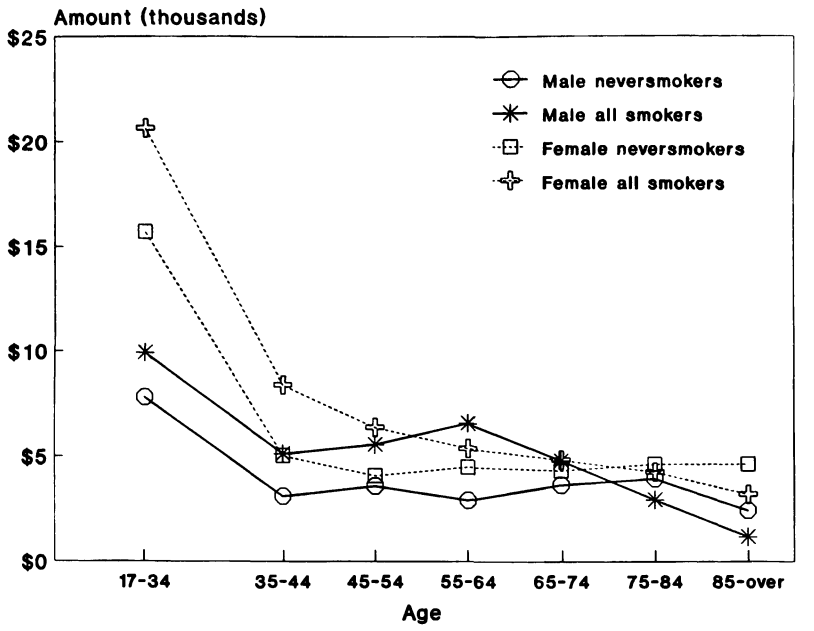

FIG. 4. Expected medical expenditures of a 17-year-old during age intervals according to sex and smoking status, discounted at 3 percent.

tancy of neversmokers. Smokers who do survive to older ages have higher medical care costs (figures 2 and 3). However, because of lower probabilities of survival, so many fewer smokers compared with neversmokers live to age 75 or beyond that the average, or expected, expenditure that will be incurred is less per smoker than per neversmoker. Expected expenditure is the proper conceptual measure for estimating average lifetime expenditures and is the basis for the analysis in the remainder of this article.

The influence of discounting on monetary values far in the future is apparent. Although discounting decreases the present value of all expenditures, the impact is greatest on more highly discounted expenditures in later years. Because future expenditures become less important relative to more current expenditures, the impact of high expenditures by neversmokers relative to smokers in the later years of life on the gap between smokers and neversmokers before age 75 is diminished.

The net effect on smoker versus neversmoker lifetime expenditures of higher expenditures for smokers up to age 75 and lower expenditures

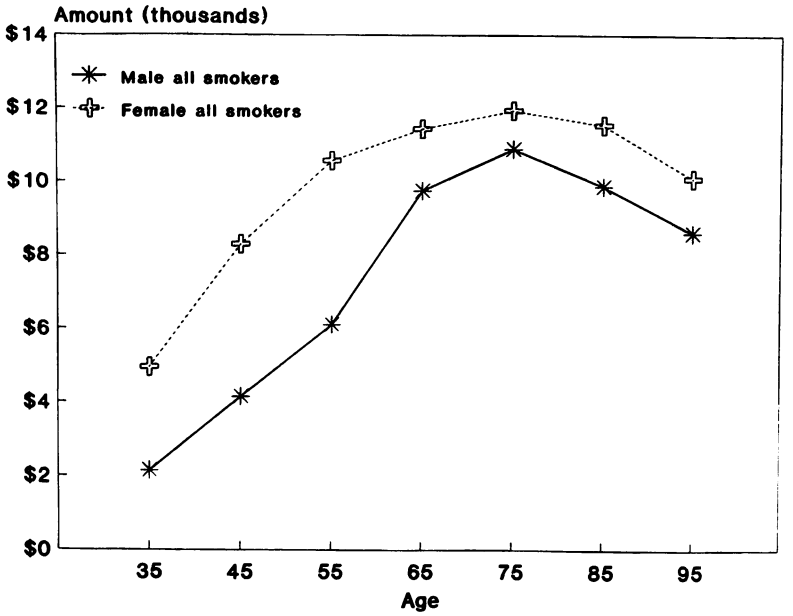

FIG. 5. Cumulative expected excess medical expenditures for a smoker from age 17 to selected ages according to sex, discounted at 3 percent.

after age 75 is shown in figure 5. Figure 5 plots the cumulative excess (smoker minus neversmoker) expenditures that smokers incur from age 17 to the age shown. The cumulative difference reaches a peak at age 75 and declines thereafter. The total of medical expenditures incurred by male and female smokers remains higher than for neversmokers throughout their lives; the gap narrows after age 75 but remains positive. The net lifetime excess expenditures for smokers compared with neversmokers is shown at age 95. Over their lifetimes male smokers average $8,638 more than neversmokers and female smokers average $10,119 more.

Total Lifetime Expenditure

Total expected lifetime medical expenditures from age 17 are higher for smokers than neversmokers and increase with the amount smoked (table 2). Lifetime expenditures for male moderate smokers (fewer than 25 cigarettes a day) for hospital care, physicians' services, and nursing-home care average $32,891 in 1990 dollars, which is $5,615 and 21 percent higher than the $27,276 for neversmokers. Heavy smokers (25 or more

TABLE 2
Lifetime Medical Expenditures by Sex and Smoking Status, Discounted at 3 Percent[a]

Sex	Neversmokers	All smokers	Moderate smokers	Heavy smokers
Males				
Lifetime expenditures	$27,276	$35,914	$32,891	$40,187
Excess expenditures	$0	$8,638	$5,615	$12,911
Ratio to neversmokers	1.00	1.32	1.21	1.47
Females				
Lifetime expenditures	$42,783	$52,902	$48,918	$60,347
Excess expenditures	$0	$10,119	$6,135	$17,564
Ratio to neversmokers	1.00	1.24	1.14	1.41

[a] Values are in 1990 dollars.

cigarettes a day) utilize medical care costing $40,187, $12,911 and 47 percent higher than neversmokers. The average for all male smokers is $35,914, exceeding expenditures for neversmokers by $8,638 and 32 percent. To the extent that self-reported cigarette consumption is underreported (Hatziandreu et al. 1989; Warner 1978), some moderate smokers may consume more than 25 cigarettes a day and the least amount consumed by heavy smokers may be more than 25 cigarettes a day.

Females use more medical care at most ages and live longer than males, and therefore have higher lifetime expenditures. The amount of smoker excess expenditures is higher for females than males, but the ratio of smoker to neversmoker expenditures is smaller for females. Excess lifetime expenditures are $6,135 for moderate smokers, $17,564 for heavy smokers, and average $10,119 for all female smokers. Lifetime expenditures are 14 percent higher for female moderate smokers than neversmokers and 41 percent higher for heavy smokers, with average expenditures 24 percent higher for all female smokers.

To show the sensitivity of our results to the discount rate, we have also estimated lifetime expenditures discounted at 5 percent. At higher discount rates dollar amounts are less, but the disparity between smokers and neversmokers increases. At 5 percent, average smoker lifetime expenditures are 37 percent higher for males and 31 percent higher for females.

The relatively smaller impact of smoking on female expenditures is consistent with lower cigarette smoke exposure among females in the past. Lower exposure results in lower mortality (U.S. Department of Health and Human Services 1989) and lower medical care use (Rice et al. 1986) relative to neversmokers among females. Lower relative mortality and medical care use in turn produce a smaller proportionate increase in lifetime medical expenditures of smokers compared with neversmokers for females. As female exposure approaches that of males, we can expect lifetime expenditures of female smokers to increase relative to neversmokers.

Excess Medical Care Versus Excess Mortality

Thus far we know smokers use more medical care at all ages when they are alive than neversmokers, whereas neversmokers live longer and use medical care over a greater number of years. The impact of higher medical care use while alive outweighs shorter life expectancy and, on balance, male and female smokers have higher lifetime medical expenditures than neversmokers. The ratio of smoker expenditures to neversmoker expenditures in table 3 shows how smoker expenditures exceed neversmoker expenditures during each age interval up to age 75, whereas neversmokers incur higher expenditures after age 75.

The separate contributions of excess medical care and excess mortality can be appreciated by comparing lifetime expenditures of smokers with lifetime expenditures of two hypothetical groups: (a) smokers with medical care use of neversmokers (smoker expenditures adjusted for medical care) and (b) smokers with mortality rates of neversmokers (smoker expenditures adjusted for mortality). Comparing smoker lifetime expenditures with expenditures adjusted for medical care, we observe the contribution of higher medical care use to smoker expenditures. For males and females, excess expenditures due to higher medical care use are highest in the middle years of the life span and fall off rapidly during the later years. Excess medical care use of smokers increases their lifetime medical expenditures by 43 percent for males and by 29 percent for females.

The impact of higher mortality rates on lifetime medical expenditures is observed from the comparison of smoker expenditures with expenditures adjusted for mortality. Up to age 65 for males and age 75 for fe-

TABLE 3
Expected Medical Expenditures of Smokers Relative to Neversmokers, Smokers Adjusted for Excess Medical Care Use, and Smokers Adjusted for Excess Mortality, by Age and Sex

Age	Ratio of smoker expenditures to[a]		
	Neversmoker	Smoker adjusted for medical care	Smoker adjusted for mortality
Males			
Lifetime	1.32	1.43	0.95
17–34	1.27	1.27	1.00
35–44	1.65	1.64	1.01
45–54	1.55	1.51	1.04
55–64	2.27	2.21	1.06
65–74	1.32	1.33	0.98
75–84	0.74	1.02	0.73
85 and over	0.48	1.01	0.47
Females			
Lifetime	1.24	1.29	0.97
17–34	1.31	1.31	1.00
35–44	1.67	1.66	1.00
45–54	1.56	1.54	1.02
55–64	1.20	1.15	1.04
65–74	1.12	1.08	1.04
75–84	0.92	1.01	0.90
85 and over	0.69	1.08	0.64

[a] Smoker expenditures adjusted for excess *medical care* are expenditures of smokers assuming neversmoker medical care use. Smoker expenditures adjusted for excess *mortality* are expenditures of smokers assuming neversmoker mortality rates. Discount rate is 3 percent.

males, smokers have as high or higher expenditures as the hypothesized smoker with neversmoker mortality rates. This can be attributed to the high cost of dying, which, for this period of the life cycle, outweighs the smoker's lower probability of surviving to each age and incurring expenditures. At older ages, however, the cumulative effect of higher smoker mortality rates has so reduced the probability that a smoker will survive to these ages that expected expenditures are much lower for smokers. Smoker expenditures decline rapidly with advancing age relative to ex-

penditures adjusted for smoker excess mortality. The net effect of excess smoker mortality, given by the result for all ages, is to reduce male smoker lifetime expenditures by 5 percent and female smoker lifetime expenditures by 3 percent.

Up to age 75, smoker expenditures exceed neversmoker expenditures almost solely because of higher smoker medical care use; excess mortality and the high cost of dying make a small contribution. After age 75, expected smoker expenditures are much less than neversmoker expenditures. At the older ages excess smoker medical care use makes a positive but greatly reduced contribution to smoker expenditures, and this is outweighed by the reduction in expenditures resulting from the impact at these ages of the cumulative effect of excess smoker mortality in prior years. The net effect is higher lifetime expenditures for medical care for smokers.

Population Expenditures

In the preceding sections I examined individuals' medical care expenditures. These results enable us to assess the aggregate burden imposed by cigarette smoking. Each year, more than one million young persons in the United States start smoking (Pierce et al. 1989). And each year, applying the results in table 2, decisions by young people to take up smoking commit the health care system to extra medical care expenditures totaling $9.4 billion (discounted at 3 percent), spread out over the lifetimes of each new crop of smokers.

Medical expenditures expected over the remaining lifetime have been estimated by smoking status and sex for each age group, from 25 to 34 years of age to 85 years and older. Applying these profiles of remaining lifetime expenditures per person to the civilian noninstitutionalized population 25 years of age and older residing in the United States in 1985 gives future expenditures attributed to the baseline population. The baseline population will generate medical expenditures for 65 years, at which time the last surviving members will be at least 90 years old and the process is truncated. In addition to future expenditures attributed to the baseline cohort of smokers, we also calculate excess smoker expenditures or the amount by which smoker expenditures exceed expenditures that would be incurred if smokers had the medical care use and mortality of neversmokers. From these calculations we derive the results that follow.

The Next Five Years

Figure 6 shows the aggregate excess medical expenditures, in 1990 dollars, generated by the baseline population of smokers. In the first five years, excess expenditures attributed to male smokers are $113.5 billion, equal to $2,525 per smoker. Female smokers are estimated to have $73.1 billion of excess medical expenditures, averaging $2,069 per smoker. Medical expenditures for hospital care, physicians' services, and nursing-home care for the total baseline population (smokers and never-smokers) during these five years is estimated at $1,026.5 billion, $420.5 billion for males and $605.9 billion for females. Thus, excess expenditures associated with cigarette smoking account for $186.6 billion, 18 percent of medical expenditures required by all persons (smokers and neversmokers) aged 25 and over in the first five years from baseline. The corresponding figures are 27 percent for males and 12 percent for females.

Discounting at 5 percent instead of 3 percent decreases aggregate excess expenditures by about 6 percent among males and females, but the

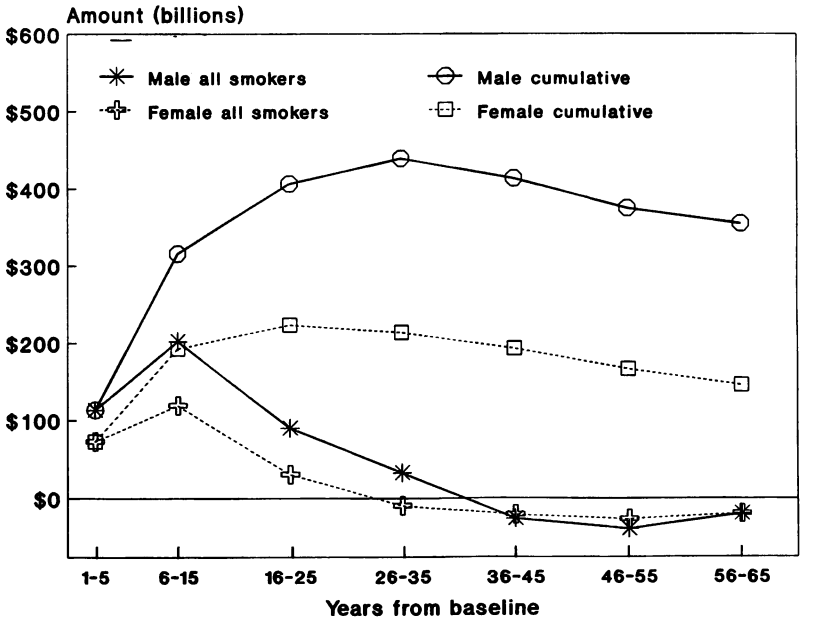

FIG. 6. Aggregate excess medical expenditures for the population of smokers 25 and older during successive time intervals and cumulatively according to sex, discounted at 3 percent.

proportion of total expenditures required for smokers' excess medical care does not change with the discount rate.

This scenario will continue, more or less uninterrupted, at least in the short term, in the absence of significant changes in important parameters. That is, about one fifth of medical expenditures for persons aged 25 and over will go to pay for additional medical care required by smokers. Gradual changes in important parameters over a period of years can have a cumulative, and ultimately significant, impact as well, and such changes are being recorded. In addition to general demographic changes in the population, smoking habits have changed: fewer males take up smoking, although the proportion of neversmokers among females was essentially unchanged between 1976 and 1987 (National Center for Health Statistics 1989). And larger proportions of smokers have been quitting; in the 20 years from 1965 to 1985 there were steady increases in the proportions of both males and females who were former smokers, although this trend slightly reversed itself between 1985 and 1987 (National Center for Health Statistics 1988, 1989). There have also been changes in the number of cigarettes smoked per day: the percent of current smokers smoking 25 or more cigarettes per day increased greatly between 1965 and 1980, but then declined in 1985 and 1987, although still above the levels reached in 1976 (National Center for Health Statistics 1988; Schoenborn and Boyd 1989).

In addition to changes in the rates at which young people take up smoking and smokers quit, the number of cigarettes smoked and the nature of cigarettes, a host of other factors could influence the health effects of smoking and attendant medical expenditures. These are very difficult to predict and have the potential either to increase or decrease expenditures. 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 with smoking to the extent that there are synergistic relations among risks for diseases like cancer, coronary heart disease, and pulmonary disease. Advances in medical therapy may improve survival rates or lessen the severity of the condition and affect medical care expenditures. Medical treatment has changed significantly over the years and changes will continue into the future. For some conditions considerable change in medical care utilization occurs in a short period of time (Hodgson 1988). The cost of treating an illness may increase or decrease as the method of treatment changes (Scitovsky 1967, 1985; Scitovsky

and McCall 1977). Although methods of treatment are certain to change, the effect of these changes, coupled with changes in financing mechanisms that also impact on medical care utilization and costs, is uncertain.

The future medical costs of the health effects of smoking depend on many diverse factors including smoking behavior, the incidence or prevalence of smoking-induced diseases, and methods and costs of treatment. Projecting the divergence of the future values of many of these parameters from currently observed values, and the net effect of changes in several factors, would be speculative. However, research is planned that will take account of the changing prevalence of smoking in projecting expenditures, and will also assess the impact of decisions to quit smoking on individual and aggregate medical expenditures.

The Current Cohort of Smokers

The remainder of figure 6 shows, in ten-year intervals and cumulatively, projected aggregate excess medical expenditures attributed to the current cohort of smokers 25 years of age and older over the remainder of their lifetimes. For the first 25 years for females and 35 years for males, the average smoker in the cohort is expected to incur medical expenditures exceeding what he or she would incur as neversmokers. As a result, the cumulative total rises steadily, especially for males. In subsequent years, as the cohort ages, the shorter life expectancy of smokers relative to neversmokers exerts a dominant influence, excess expenditures turn negative, and the cumulative excess declines.

For the civilian noninstitutionalized population of cigarette smokers in 1985, expected excess expenditures over their remaining lifetimes for hospital care, physicians' services, and nursing-home care total $501 billion in 1990 dollars, $355 billion for males and $146 billion for females. This is an average of $7,888 per male smoker and $4,143 per female smoker. These are averages for smokers of all ages; the remaining lifetime excess is higher for the younger smokers. Discounting at 5 percent instead of 3 percent reduces total expected excess expenditures by 5.6 percent, from $500.9 billion to $473.0 billion.

Source of Funds for Health Care

Health care expenditures in the United States are funded by a variety of sources. Annually, private funding accounts for 60 percent of total per-

sonal health care expenditures, consisting mostly of payments from private health insurance plans and directly from patients, with a small amount from philanthropy and industry. Public payments through Medicare, Medicaid, and other government programs, including the Veterans' Administration, Department of Defense, Indian Health Service, worker's compensation, and maternal and child health, finance 40 percent of personal health care (Letsch, Levit, and Waldo 1988). The distribution of health expenditures among funding sources varies markedly by patient age. Private health insurance and direct payments by consumers of health care account for almost three-fourths of expenditures for persons under 65 years of age, whereas public funds, especially Medicare, contribute almost two-thirds of the health expenditures of the elderly (Waldo et al. 1989).

Given the greater use of health care and higher lifetime medical care expenditures by smokers, albeit shorter life expectancy, how does the burden of financing smokers' excess medical care fall upon the various funding sources? Is the burden evenly distributed among sources, or do one or more sources bear inordinate shares? Does the burden fall more heavily on either the public or private sector? In addressing this issue, payments from consumers directly out of pocket, other private sources (almost entirely from private health insurance), Medicare, and Medicaid are analyzed. These sources account for 90 percent of all personal health care expenditures (Letsch et al. 1988). The remaining 10 percent of expenditures is paid by a variety of sources for health conditions not generally related to smoking. These include workers' compensation medical payments for work-related injuries and illnesses; Veterans Administration medical expenditures, which are heavily weighted by medical care for mental conditions; Department of Defense medical expenditures, over 90 percent of which are for younger persons; maternal and child health and school health programs.

Expenditures over the Smoker's Lifetime

Table 4 shows male smokers' lifetime medical expenditures according to smoking status and sources of funds. As expected because of their shorter life expectancy, a larger share of smokers' medical care is paid for by private health insurance (50 percent versus 44 percent), the predominant payer for persons under 65 years of age, whereas 25 percent of neversmokers' medical care compared with 21 percent for smokers is funded

TABLE 4
Lifetime Medical Expenditures for Males by Smoking Status and Source of Funds[a]

Smoking status	Source of funds				
	Total	Direct	Other private	Medicare	Medicaid
	Amount and percent[b] of total				
Neversmokers	$27,276	$5,815	$11,910	$6,852	$2,675
	(100.0)	(21.3)	(43.7)	(25.1)	(9.8)
All smokers	$35,914	$6,920	$17,964	$7,417	$3,597
	(100.0)	(19.3)	(50.0)	(20.7)	(10.0)
Moderate smokers	$32,891	$6,516	$16,174	$6,904	$3,279
	(100.0)	(19.8)	(49.2)	(21.0)	(10.0)
Heavy smokers	$40,187	$7,627	$20,278	$8,311	$3,956
	(100.0)	(19.0)	(50.5)	(20.7)	(9.8)
	Ratio of smoker to neversmoker				
All smokers	1.32	1.19	1.51	1.08	1.34
Moderate smokers	1.21	1.12	1.36	1.01	1.23
Heavy smokers	1.47	1.31	1.70	1.21	1.48
	Excess smoker expenditures and percent of total				
All smokers	$8,638	$1,105	$6,054	$565	$922
	(1.00)	(0.13)	(0.70)	(0.07)	(0.11)
Moderate smokers	$5,615	$701	$4,264	$52	$604
	(1.00)	(0.12)	(0.76)	(0.01)	(0.11)
Heavy smokers	$12,911	$1,812	$8,368	$1,459	$1,281
	(1.00)	(0.14)	(0.65)	(0.11)	(0.10)

[a] Values are in 1990 dollars. Numbers and percents may not add to totals because of rounding. Discount rate is 3 percent.
[b] Percents are in parentheses.

by Medicare, the most important source of funds for the elderly. Out-of-pocket payments are a slightly larger proportion of neversmokers' medical expenditures, accounting for 21 percent of the total, and Medicaid pays 10 percent of expenditures for both smokers and neversmokers. The distribution of expenditures by source of funds varies hardly at all between heavy smokers and moderate smokers.

Smokers' excess medical care is largely financed by private health insurance; 70 percent of excess payments is by private insurance. On aver-

age, lifetime medical payments per person by private insurance are 51 percent higher for male smokers than neversmokers (36 percent higher for moderate and 70 percent higher for heavy smokers). Heavy smokers also require larger lifetime medical payments from Medicare and Medicaid and pay more out of pocket than neversmokers. Moderate smokers also benefit substantially more from Medicaid and pay more out of pocket than neversmokers, but receive only slightly more from Medicare. Shorter life expectancy among smokers does not save the Medicare program money. Although neversmokers live longer, moderate and heavy smokers require substantially greater expenditures for medical care than neversmokers at ages 65 to 74, largely funded by Medicare. Medicare expenditures are 21 percent higher for heavy smokers and 1 percent higher for moderate smokers than for neversmokers, and on average 8 percent higher for smokers. (Of course, the average for all smokers depends on the relative numbers of moderate and heavy smokers in the population.)

Females use more medical care, incur higher expenditures, and generally receive more funds from each source than males (table 5). The distribution of female medical expenditures by source of funds is very much like that of males with respect to out-of-pocket and private payments, whereas Medicare pays relatively less for females and Medicaid pays relatively more. Female smokers' excess medical care is also largely financed by private health insurance (72 percent of the excess, on average); and private health insurance payments range from 23 percent higher for moderate smokers to 64 percent higher for heavy smokers than neversmokers. Female smokers also pay more out of pocket and receive more from Medicaid, but Medicare pays a little less for female smokers than neversmokers.

If expenditures are discounted at 5 percent instead of 3 percent, the share of lifetime expenditures paid by private insurance increases and that paid by Medicare decreases. Because these changes are somewhat larger for neversmokers, there is a resulting decrease in the proportion of excess smoker expenditures paid by private insurance, from 70 to 65 percent among males and 72 to 67 percent among females. The contributions of out-of-pocket payments and Medicare to excess smoker medical expenditures increase modestly as the discount rate increases.

Wright (1986) investigated the net effect on Medicare's hospital insurance fund of the decision to quit smoking at age 45 by a male light smoker. Although the issues that Wright and I address are quite differ-

TABLE 5
Lifetime Medical Expenditures for Females by Smoking Status and Source of Funds[a]

Smoking status	Source of funds				
	Total	Direct	Other private	Medicare	Medicaid
	Amount and percent[b] of total				
Neversmokers	$42,783	$9,302	$19,766	$7,483	$6,232
	(100.0)	(21.7)	(46.2)	(17.5)	(14.6)
All smokers	$52,902	$10,958	$27,029	$7,163	$7,751
	(100.0)	(20.7)	(51.1)	(13.5)	(14.7)
Moderate smokers	$48,918	$10,286	$24,393	$7,013	$7,226
	(100.0)	(21.0)	(49.9)	(14.3)	(14.8)
Heavy smokers	$60,347	$12,205	$32,438	$6,989	$8,717
	(100.0)	(20.2)	(53.8)	(11.6)	(14.4)
	Ratio of smoker to neversmoker				
All smokers	1.24	1.18	1.37	0.96	1.24
Moderate smokers	1.14	1.11	1.23	0.94	1.16
Heavy smokers	1.41	1.31	1.64	0.93	1.40
	Excess smoker expenditures and percent of total				
All smokers	$10,119	$1,656	$7,263	−$320	$1,519
	(1.00)	(0.16)	(0.72)	(−0.03)	(0.15)
Moderate smokers	$6,135	$984	$4,627	−$470	$994
	(1.00)	(0.16)	(0.75)	(−0.08)	(0.16)
Heavy smokers	$17,564	$2,903	$12,672	−$494	$2,485
	(1.00)	(0.17)	(0.72)	(−0.03)	(0.14)

[a] Values are in 1990 dollars. Numbers and percents may not add to totals because of rounding. Discount rate is 3 percent.
[b] Percents are in parentheses.

ent, it is important to comment on Wright's study lest the conclusions of the two analyses appear to be contradictory. Wright asks the following question: for quitters, who live longer, how do additional contributions into the hospital insurance fund compare with additional reimbursements for Medicare-covered medical services? On the other hand, our study considers only Medicare reimbursements and compares payments to smokers with payments to neversmokers. Within Wright's framework, an analysis more closely related to ours would be to ascertain

whether Medicare reimbursements to quitters are higher or lower than reimbursements to nonquitters.

Wright finds that for male light smokers who quit at age 45, reimbursements from the hospital insurance fund during additional years of life exceed payments into the fund by $934 to $1,495 (in 1980 dollars discounted at 3 percent) depending on alternative assumptions about the investment return on contributions. However, the added Medicare reimbursements for quitters are overstated for two reasons. First, these are based upon average annual reimbursement per enrollee, which is a weighted average of reimbursements to smokers and nonsmokers. It is expected that average annual reimbursement would be lower for nonsmokers, who not only live longer because they are more healthy, but also use less medical care per year. Second, quitters can be expected to enjoy better health and require less medical care not only in the extra years added to their life span, but also in the years between quitting at age 45 and the expected age of death for smokers. Wright does not take into account the reduced Medicare payments in these years and credit them against payments during the extra years of life. Correcting for these two sources of overstatement in Wright's estimate of additional Medicare reimbursements to quitters would substantially reduce the amount by which additional reimbursements exceed contributions to the insurance fund and quite possibly turn a net expense into a net gain.

Population Expenditures

In the first five years from baseline, excess use of medical care by smokers 25 years of age and older in 1985 costs $186.6 billion in 1990 dollars (figure 6 and table 6). More than half of this, $100.9 billion, is paid by private insurance, while Medicare pays 16 percent ($29.9 billion), Medicaid pays 12 percent ($21.7 billion), and smokers contribute 18 percent ($34.1 billion) directly out of pocket. Male smokers were estimated to generate excess medical expenditures of $113.5 billion in the first five years from baseline. Female smokers have excess medical expenditures totaling $73.1 billion, with somewhat larger proportions than males paid out of pocket, by private insurance, and by Medicaid, and relatively less by Medicare. The five-year profile shows the short-run experience of the health sector in financing smokers' health care. This continues as long as a steady or near steady state obtains. All sources of funds, public and private, share in the burden of financing smokers' excess medical care, but the predominant payer is private health insurance.

TABLE 6
Excess Medical Expenditures for the Population of Smokers 25 and Older by Years from Baseline and Sex[a]

Sex and years from baseline	Source of funds				
	Total	Direct	Other private	Medicare	Medicaid
	Amount (billions) and percent[b] of total				
All smokers					
1–5 years	$186.6	$34.1	$100.9	$29.9	$21.7
	(100.0)	(18.3)	(54.1)	(16.0)	(11.6)
65 years	$500.9	$26.7	$395.1	$54.4	$25.3
	(100.0)	(5.3)	(78.9)	(10.9)	(5.1)
Male smokers					
1–5 years	$113.5	$20.4	$58.6	$22.7	$11.8
	(100.0)	(18.0)	(51.6)	(20.0)	(10.4)
65 years	$354.6	$33.4	$253.7	$42.0	$26.1
	(100.0)	(9.4)	(71.6)	(11.8)	(7.4)
Female smokers					
1–5 years	$73.1	$13.7	$42.3	$7.2	$10.0
	(100.0)	(18.7)	(57.8)	(9.9)	(13.6)
65 years	$146.3	−$6.7	$141.4	$12.4	−$0.8
	(100.0)	(−4.6)	(96.6)	(8.5)	(−0.5)

[a] Values are in 1990 dollars. Numbers and percents may not add to totals because of rounding. Discount rate is 3 percent.
[b] Percents are in parentheses.

The current population has certain smoking habits, including, for example, amount smoked and rates of quitting at various ages. If these patterns were to continue into the future, the net financial impact on medical care expenditures by the baseline cohort of smokers would be the excess expenditures after 65 years shown in table 6. Total excess expenditures over the remaining lifetime of the baseline cohort of smokers are $500.9 billion, including $354.6 billion for males. For females the long-run excess is much less, $146.3 billion, one reason being that there are many fewer female smokers.

As during the first five years, all payment sources contribute to the excess medical care required by smokers in the long run, although the share paid by private insurance is higher while the proportions paid by other sources are lower. Of the total excess medical expenditures of $501

billion required by all smokers over the lifetime of the cohort, 79 percent is paid by private insurance, 11 percent by Medicare, and 5 percent each by smokers out of pocket and Medicaid. The shift in the burden of funding excess medical expenditures to private insurance is greater for females, with the additional funds paid by private insurance being 97 percent of the net excess required. Medicare provides a small but significant portion while out-of-pocket and Medicaid expenditures are less for female smokers than neversmokers.

Increasing the discount rate from 3 percent to 5 percent decreases population excess medical expenditures by 6.5 percent to $174.5 billion after five years from baseline and by 5.6 percent to $473.0 billion after 65 years from baseline. The distribution of excess expenditures by source of funds does not change with the discount rate in the first five years. Because of the greater impact of discounting on expenditures for neversmokers who live longer, however, after 65 years there is a shift in payment for smokers' excess medical care from private insurance to the other sources of funds. Private insurance payments decrease from 79 percent of the total to 67 percent, while out-of-pocket payments increase to 11 percent, Medicare's share increases to 14 percent, and Medicaid pays 8 percent. The change is greatest among females whose expenditures are most affected by discounting because of their longer life expectancy. At a 5 percent discount rate, the distribution of excess expenditures for females is 75 percent private insurance, 8 percent out-of-pocket, 11 percent Medicare, and 7 percent Medicaid.

Summary and Conclusion

The cumulative impact of excess medical care required by smokers at all ages while alive outweighs shorter life expectancy, and smokers incur higher expenditures for medical care over their lifetimes than neversmokers. This accords with the findings by Manning et al. (1989) of positive lifetime medical care costs per pack of cigarettes, but disagrees with the results found by Leu and Schaub (1983, 1985) for Swiss males. The contradictory conclusions of the analyses are undoubtedly due to a large difference in the amount of medical care used by smokers relative to neversmokers in the United States and Swiss data. Excess expenditures increase with the amount smoked among males and females so that lifetime medical costs of male heavy smokers are 47 percent higher than for

neversmokers when discounted at 3 percent. Each year more than one million young people start to smoke and add an extra $9 to $10 billion (in 1990 dollars discounted at 3 percent) to the nation's health care bill over their lifetimes.

Given the smoking behavior, medical care utilization and costs of care, and population size embedded in the data used in this analysis, I have concluded that in the first five years from baseline the population of smokers aged 25 and over incurs excess medical expenditures totaling $187 billion, which is $2,324 per smoker. The excess cost of medical care associated with cigarette smoking is 18 percent of expenditures for hospital care, physicians' services, and nursing-home care required by all persons (smokers and neversmokers) aged 25 and over. In the absence of large and rapid changes in the values of the underlying parameters, $187 billion, 18 percent of medical expenditures, can be taken as the premium currently being paid every five years to provide medical care for the excess disease suffered by smokers.

Even without the addition of any new smokers, the present value of the bill that will be incurred for excess medical care required by the current population of smokers over their remaining lifetimes is high. The civilian noninstitutionalized population of cigarette smokers in 1985 who are age 25 and older is expected to incur over its remaining lifetime excess medical expenditures of $501 billion, or $6,239 per smoker. It is possible that future changes beyond recent historical trends in the habits of those who currently smoke, such as reductions in the amount smoked, higher rates of quitting, whether occurring fortuitously or brought about by design, may result in lower costs of smoking than estimated. Such an analysis is beyond the scope of this study.

A smoker's lifetime excess medical care is largely financed by private health insurance, with more than 70 percent of the excess paid by this source. But each funding source helps pay for the extra medical care for smokers, except for Medicare's contribution to female expenditures. Medicare pays about 4 percent less for female smokers than neversmokers when expenditures are discounted at 3 percent.

For the population of smokers in 1985, more than half of the $187 billion in excess expenditures in the next five years ($101 billion) is paid by private insurance. All sources of funds share in the burden, however. In addition to private insurance, 18 percent ($34 billion) is paid out of pocket, 16 percent ($30 billion) by Medicare, and 12 percent ($22 billion) by Medicaid. In the long run, over the remaining lifetime of this

cohort of smokers excess medical care costs $501 billion, with 79 percent, or $395 billion, paid by private insurance and lesser but significant amounts funded by Medicare (11 percent or $54 billion), Medicaid (5 percent or $25 billion), and out of pocket (slightly more than 5 percent or $27 billion).

Our analysis employs a 3 percent discount rate, supplemented with brief descriptions of the impact on key results of discounting at 5 percent. A 3 percent rate is at the low end of rates observed in the literature and rates above 5 percent give too little weight to expenditures far in the future. The present value of expenditures decreases as the discount rate increases. More important, however, is the impact on the relationships between smoker and neversmoker medical expenditures. Discounting at 3 percent is conservative in that the ratio of smoker to neversmoker lifetime expenditures increases with the discount rate. Aggregate excess expenditures for the population of smokers are less at the higher discount rate, but the decrease is only around 6 percent. Most sensitive to the discount rate is the contribution of various sources of payment to excess smoker medical expenditures. At higher discount rates less of the excess is paid by private insurance and more by other sources of funds. Yet even this difference is quantitative rather than qualitative. Private insurance remains the primary payer, with Medicare, Medicaid, and out-of-pocket payments providing smaller but important contributions.

This study has not controlled for certain factors such as alcohol consumption, other lifestyle attributes, income, and education. To the extent that there is a correlation between these and smoking resulting in increased medical care use among smokers, not all of the observed differences in lifetime expenditures between smokers and neversmokers are due to smoking. Nevertheless, the analysis by Manning et al. (1989) indicates that 87 percent of the differences would remain after controlling for important confounding variables.

Adjusting the key results to reflect only 87 percent of the observed differences between smoker and neversmoker lifetime medical expenditures produces the following for a 3 percent discount rate. Expected lifetime medical expenditures of the average smoker exceed those of the average neversmoker by 28 percent ($7,515) for males and 21 percent ($8,804) for females. Each year, decisions by more than one million young people to take up smoking commit the health care system to $8.2 billion in extra medical expenditures over their lifetimes. At current

rates, the population of smokers 25 years and older incurs $162 billion in excess medical expenditures every five years. The population of smokers at least 25 years of age in 1985 is expected to incur excess medical expenditures of $436 billion over their remaining lifetimes, $6,863 per male smoker and $3,604 per female smoker.

It is reasonable to conclude that the results in our study reveal the qualitative nature of the impact of smoking on medical care expenditures, both for individuals and in the aggregate, and are reasonably close quantitatively. Smoking both raises medical care expenditures over the smoker's lifetime, with costs rising the more one smokes, and increases society's expenditures for medical care as well as the burden on public and private sources of funds. Reductions in the number of persons who ever smoke and the amounts smoked will benefit all payers of medical care, decreasing the financial obligations of both public and private sources of funding.

This study estimates the lifetime expenditures of eversmokers and neversmokers, thus assessing the impact of becoming a smoker. It does not assess the impact of quitting smoking. Former smokers can be expected to consist of two groups: those who quit while in apparent good health to avoid future consequences of smoking, and those who quit to prevent or reduce further exacerbation of an existing smoking-related health problem. Health care use and mortality of the former group would likely decline over a period of time from at or below the levels of all current smokers and approach levels experienced by neversmokers. Health care use and mortality of the latter group could be expected to be higher than levels observed among all current smokers, possibly for a few years, and also decline with time to levels between current and neversmokers.

The impact of quitting on an individual smoker's lifetime medical expenditures will depend on the type of former smoker (whether he or she quits when in good or failing health), amount smoked, number of years of smoking, and age at quitting. From the time of quitting, we would expect annual medical expenditures of former smokers to fall to a level between expenditures incurred by current and neversmokers, but to continue for more years than expenditures for current smokers, possibly as long as neversmokers. The key factor may be age at quitting. Quitting at earlier ages not only increases the number of years of reduced medical expenditures, but may also result in a lower level of annual expenditures and further increase life expectancy if, by quitting

earlier, fewer deleterious health effects result from prior tobacco exposure. The amount of savings depends on the tradeoff between the separate impacts on lifetime expenditures of lower annual medical costs after quitting and added years of expenditures due to a longer lifetime. The aggregate reduction in expenditures for the population will depend on how many smokers quit, at what ages, and in what state of health. The effect of quitting on lifetime medical expenditures of smokers is a complex issue to which we hope to contribute some analysis in a future publication.

References

Bradstock, M.K., J.S. Marks, M.R. Forman, E.M. Gentry, G.C. Hogelin, and F.L. Trowbridge. 1985. The Behavioral Risk Factor Surveys: III. Chronic Heavy Alcohol Use in the United States. *American Journal of Preventive Medicine* 1(6):15–20.

Cohen, M.A., E.J. Tell, and S.S. Wallack. 1986. The Lifetime Risks and Costs of Nursing Home Use Among the Elderly. *Medical Care* 24(12):1161–72.

Graham, D. 1988. Detailed Diagnoses and Procedures for Patients Discharged from Short-stay Hospitals: United States, 1986. *Vital and Health Statistics*, series 13, no. 95. DHHS pub. no. (PHS) 88-1756. Hyattsville, Md.: National Center for Health Statistics.

Graves, E.J. 1987. Expected Principal Source of Payment for Hospital Discharges: United States. 1985. *Advance Data*, no. 144. DHHS pub. no. (PHS) 88-1250. Hyattsville, Md.: National Center for Health Statistics.

Hatziandreu, E.J., J.P. Pierce, M.C. Fiore, V. Grise, T.E. Novotny, and R.M. Davis. 1989. The Reliability of Self-reported Cigarette Consumption in the United States. *American Journal of Public Health* 79(8):1020–3.

Hing, E. 1989. Nursing Home Utilization by Current Residents: United States, 1985. *Vital and Health Statistics*, series 13, no. 102. DHHS pub. no. (PHS) 89-1763. Hyattsville, Md.: National Center for Health Statistics.

Hing, E., E. Sekscenski, and G. Strahan. 1989. The National Nursing Home Survey: 1985 Summary for the United States. *Vital and Health Statistics*, series 13, no. 97. DHHS pub. no. (PHS) 89-1758. Hyattsville, Md.: National Center for Health Statistics.

Hodgson, T.A. 1988. Annual Costs of Illness Versus Lifetime Costs of Illness and Implications of Structural Change. *Drug Information Journal* 22(3):323–41.

Letsch, S.W., K.R. Levit, and D.R. Waldo. 1988. National Health Expenditures, 1987. *Health Care Financing Review* 10(2):109–22.

Leu, R.E., and T. Schaub. 1983. Does Smoking Increase Medical Care Expenditure? *Social Science and Medicine* 17(23):1907–14.

———. 1985. More on the Impact of Smoking on Medical Care Expenditures. *Social Science and Medicine* 21(7):825–7.

Lippiatt, B.C. 1990. Measuring Medical Cost and Life Expectancy Impacts of Changes in Cigarette Sales. *Preventive Medicine* 19(5): 515–32.

Liu, K., and K.G. Manton. 1983. The Length-of-stay Pattern of Nursing Home Admissions. *Medical Care* 21(12):1211–22.

Lubitz, J., and R. Prihoda. 1984. The Use and Costs of Medicare Services in the Last 2 Years of Life. *Health Care Financing Review* 5(3):117–31.

Manning, W.G., E.B. Keeler, J.P. Newhouse, E.M. Sloss, and J. Wasserman. 1989. The Taxes of Sin: Do Smokers and Drinkers Pay Their Way? *Journal of the American Medical Association* 261(11): 1604–9.

Mattson, M.E., E.S. Pollack, and J.W. Cullen. 1987. What Are the Odds That Smoking Will Kill You? *American Journal of Public Health* 77(4):425–31.

National Center for Health Statistics. 1988. *Health, United States, 1987.* DHHS pub. no. (PHS) 88-1232. Hyattsville, Md.

———. 1989. *Health, United States, 1988.* DHHS pub. no. (PHS) 89-1232. Hyattsville, Md.

———. 1990. Vital Statistics of the United States, 1987 Life Tables. DHHS pub. no. (PHS) 90-1104. Hyattsville, Md.

Novotny, T.E., K.E. Warner, J.S. Kendrick, and P.L. Remington. 1988. Smoking by Blacks and Whites: Socioeconomic and Demographic Differences. *American Journal of Public Health* 78(9):1187–9.

Oster, G., G.A. Colditz, and N.L. Kelly. 1984a. The Economic Costs of Smoking and Benefits of Quitting for Individual Smokers. *Preventive Medicine* 13(4):377–89.

——— 1984b. The Economic Costs of Smoking and Benefits of Quitting. Lexington, Mass.: Lexington Books.

Pearson, D.C., L.C. Grothaus, R.S. Thompson, and E.H. Wagner. 1987. Smokers and Drinkers in a Health Maintenance Organization Population: Lifestyles and Health Status. *Preventive Medicine* 16(6):783–95.

Pierce, J.P., M.C. Fiore, T.E. Novotny, E.J. Hatziandreu, and R.M. Davis. 1989. Trends in Cigarette Smoking in the United States—Projections to the Year 2000. *Journal of the American Medical Association* 261(1):61–5.

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

Riley, G., and J. Lubitz. 1986. Use and Cost of Medicare Services in the Last 5 Years of Life by Cause of Death. Paper presented at the Annual Meeting of the American Public Health Association, Las Vegas, September 28–October 2.

Roos, N.P., P. Montgomery, and L.L. Roos. 1987. Health Care Utilization in the Years Prior to Death. *Milbank Quarterly* 65(2):231–54.

Schoenborn, C.A., and V. Benson. 1988. Relationships Between Smoking and Other Unhealthy Habits: United States, 1985. *Advance Data*, no. 154. DHHS pub. no. (PHS) 88-1250. Hyattsville, Md.: National Center for Health Statistics.

Schoenborn, C.A., and G.M. Boyd. 1989. Smoking and Other Tobacco Use: United States, 1987. *Vital and Health Statistics*, series 10, no. 169. DHHS pub. no. (PHS) 89-1597. Hyattsville, Md.: National Center for Health Statistics.

Scitovsky, A.A. 1967. Changes in the Costs of Treatment of Selected Illnesses, 1951–1965. *American Economic Review* 57(5):1182–95.

———. 1985. Changes in the Costs of Treatment of Selected Illnesses, 1971–1981. *Medical Care* 23(12):1345–57.

Scitovsky, A.A., and N. McCall. 1977. Changes in the Costs of Treatment of Selected Illnesses 1951–1964–1971. DHEW pub. no. (HRA) 77-3161. Rockville, Md.

Shoven, J.B., J.O. Sundberg, and J.P. Bunker, 1987. The Social Security Cost of Smoking. Presented at the National Bureau of Economic Research Conference on the Economics of Aging, New Orleans, March 19–22.

Social Security Bulletin. 1991. Medical Care Component of the Consumer Price Index. 54(2):52. (Tables)

Stellman, S.D., and L. Garfinkel. 1986. Smoking Habits and Tar Levels in a New American Cancer Society Prospective Study of 1.2 Million Men and Women. *Journal of the National Cancer Institute* 76(6): 1057–63.

U.S. Department of Health and Human Services. 1980. *The Health Consequences of Smoking for Women. A Report of the Surgeon General.* Washington.

———. 1989. *Reducing the Health Consequences of Smoking: 25 Years of Progress. A Report of the Surgeon General.* DHHS pub. no. (CDC) 89-8411. Washington.

——— 1990. *The Health Benefits of Smoking Cessation. A Report of the Surgeon General.* DHHS pub. no. (CDC) 90-8416. Washington.

Vicente, L., J.A. Wiley, and R.A. Carrington. 1979. The Risk of Institutionalization Before Death. *Gerontologist* 19(4):361–7.

Waldo, D.R., and H.C. Lazenby. 1984. Demographic Characteristics and Health Care Use and Expenditures by the Aged in the United States, 1977–1984. *Health Care Financing Review* 6(1):1–29.

Waldo, D.R., S.T. Sonnefeld, D.R. McKusick, and R.H. Arnett III. 1989. Health Expenditures by Age Group, 1977 and 1987. *Health Care Financing Review* 10(4):111–20.

Warner, K.E. 1978. Possible Increases in the Underreporting of Cigarette Consumption. *Journal of the American Statistical Association* 73(362):314–18.

———. 1987. Health and Economic Implications of a Tobacco-free Society. *Journal of the American Medical Association* 258(15):2080–6.

Wright, V.B. 1986. Will Quitting Smoking Help Medicare Solve Its Financial Problems? *Inquiry* 23(1):76–82.

Acknowledgments: Appreciation and thanks are due Eugene Lewit, Dorothy Rice, Kenneth Warner, and anonymous reviewers for reviewing drafts of this article and making many suggestions that improved the content and presentation of the analysis.

The author gratefully acknowledges the assistance of Lawrence Garfinkel and the American Cancer Society for unpublished data from Cancer Prevention Study II; Robert Wright of the National Center for Health Statistics (NCHS) and Marvin Dicker, formerly of NCHS and now with the National Institute on Drug Abuse, for providing tabulations of data from the National Medical Care Utilization and Expenditure Survey; Christine Cox, Dawn Scott, and Ildy Shannon of NCHS for tabulations, respectively, from the National Health and Nutrition Examination Survey Epidemiologic Followup Study, linked NCHS mortality and Health Care Financing Administration Medicare files, and the National Health Interview Survey.

The views expressed in this paper are those of the author and no official endorsement by the National Center for Health Statistics is intended or should be inferred.

Address correspondence to: Thomas A. Hodgson, Ph.D., Chief Economist, Office of Analysis and Epidemiology, National Center for Health Statistics, 6525 Belcrest Road, Room 1000, Hyattsville, MD 20782.

Methodology and Data Appendix

In this appendix the variables and data for estimating lifetime medical expenditures are explained in detail. The model defines medical care expenditures during age interval t as:

$$E_t = E_{at}P_{at} + E_{dt}P_{dt}$$

Lifetime expenditures from age 17 are given by:

$$\sum_{t=17-34}^{85 \text{ \& over}} (E_{at}P_{at} + E_{dt}P_{dt})(1 + i)^{-(t-17)}$$

where

E_{at} = expenditures during age interval t if the individual survives through t

P_{at} = probability of surviving through age interval t

E_{dt} = expenditures during age interval t if the individual dies in t

P_{dt} = probability of dying during age interval t

t = age 17–34, 35–44, 45–54, 55–64, 65–74, 75–84, 85 and over

i = discount rate

The components of E_t are described below.

Survivor Expenditures

$$E_{at} = H_t C_{Ht} N_t + D_t C_{Dt} N_t + NH_{at}$$

Hospital Care Expenditures—$H_t C_{Ht} N_t$. H_t = number of days in the hospital per year by age, sex, and amount smoked derived from the National Center for Health Statistics' (NCHS) National Health Interview Survey (NHIS) in the three years from 1978 to 1980. Combining three successive years of data increases the sample size, reduces the standard errors, and improves the stability of the estimates. Comparing data from NHIS in 1974 and 1985 shows that during the decade age-adjusted relative risks of hospital care and physician services for smokers increased except for a very small decrease among females in the relative risk of hospital use. The data used in this study thus somewhat underestimate more recent use of medical care by smokers relative to nonsmokers and, consequently, conservatively estimate the amount by which lifetime medical expenditures of smokers exceed those of persons who never smoked.

NHIS hospital days and physician visits per capita in a year are biased measures of use by survivors in our model; that is, persons who live to the end of an age interval. The bias derives from the influence of decedents in subsequent years on per capita use observed in NHIS in a base

year. Decedents are known to have higher than average medical care use several years prior to their deaths. Consequently, per capita use in the NHIS is the overall per capita use of two groups: (1) long-term survivors—those who will be alive at least several years after the base period, and (2) short-term survivors—those who will die within a few years following the base period. Thus, in the base year, observed per capita use in NHIS is likely to be higher than per capita use of long-term survivors and lower than that of short-term survivors. Per capita use by long-term survivors is the appropriate measure of use by survivors in the model in our analysis.

Even if the factor by which base period utilization exceeds long-term survivor utilization is the same for smokers and neversmokers, the difference in use between long-term surviving smokers and neversmokers is overstated if measured by base period per capita rates. Furthermore, because smokers have higher mortality rates than neversmokers, a larger proportion of smokers in the base year are short-term survivors and a smaller proportion are long-term survivors than among neversmokers. The impact of short-term survivors on per capita medical care use in the base period is greater among smokers than neversmokers. This results in additional overstatement of long-term survivor smoker use compared with neversmoker use measured by base period per capita rates. The overstatement increases with age, as do mortality rates, and short-term survivors become a larger proportion of the base year population.

To estimate more accurately expenditures for survivors, decedents, smokers, and neversmokers over their lifetimes, long-term survivor hospital and physician use is estimated from NHIS base period utilization. This is accomplished as follows:

1. Mortality rates for smokers and neversmokers from the American Cancer Society's Cancer Prevention Study II are applied to the NHIS base period population to estimate the number of short- and long-term survivors by smoking status. Short-term survivors die within three years and long-term survivors live to at least the fourth year following the base year.
2. Known relationships between per capita medical care charges (for hospital care and physicians' services, respectively) of the base year population of Medicare beneficiaries, short- and long-term survivors, are used to estimate the relationships between per capita medical care use of the NHIS base year population, short- and long-term

survivors. For example, the ratio of average hospital charges per short-term surviving Medicare beneficiary, 65 to 74 years of age, to average hospital charges per long-term surviving Medicare beneficiary of the same age is assumed to estimate the ratio of per capita hospital days for short- and long-term NHIS survivors 65 to 74 years old. Ratios for 65 and older are assumed to apply to persons under 65 years of age.

3. The results in (1) and (2) are used to derive long-term survivor medical care use from NHIS base period utilization.

C_{Ht} = average charge per day in the hospital by age and sex from NCHS's National Medical Care Utilization and Expenditure Survey (NMCUES), in 1990 dollars. This includes the total charge for the hospital stay, with any charges for X rays, laboratory tests, and diagnostic procedures, and charges from doctors or surgeons who provided treatment in the hospital.

N_t = number of years in the period.

Physicians' Services Expenditures $-D_t C_{Dt} N_t$

D_t = number of doctor visits by age, sex, and amount smoked derived from the NHIS. Included are visits in doctors' offices, hospital clinics and emergency rooms, patients' homes, and by telephone. NHIS doctor visits are also adjusted as described above for hospital days.

C_{DT} = average charge per doctor visit by age and sex from the NMCUES for visits in doctors' offices, hospital clinics and emergency rooms, and patients' homes, in 1990 dollars.

Nursing-home Care Expenditures $-NH_{at}$

$$NH_{at} = 1.5 L_{at} C_{NHt} W_{at}$$

L_{at} = average length of stay for live discharges in 1985 by age and sex from the NCHS's National Nursing Home Survey (NNHS), inflated by 30 percent. The correct variable to use here is the expected length of stay at admission and Liu and Manton (1983) estimated expected length of stay at admission to be 30 percent higher than length of stay for discharges. The fac-

tor 1.5 reflects that one-half of discharges in 1985 had previously had another nursing-home stay (Hing, Sekscenski, and Strahan 1989).

C_{NHt} = average daily charge to nursing-home residents in 1990 dollars by age and sex from the NNHS.

W_{at} = percent of the population surviving through age t who had a nursing-home stay in the period by age, sex, and smoking status from NCHS's first National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Followup Study (NHEFS). Because NHEFS does not provide an estimate of W for ages 85 and over, it is necessary to assume some value. Sensitivity analysis shows the ratio of lifetime expenditures of all smokers to those who never smoked is quite insensitive to reasonable assumptions for the value of W at 85 and over. Therefore, it is assumed W at 85 and over is twice W at 75 to 84. The values for W employed in this analysis are consistent with the risks of nursing-home use among the elderly estimated from a survey of Medicare beneficiaries by Cohen, Tell, and Wallack (1986).

Decedent Expenditures

$$E_{dt} = H_t C_{Ht} K_{Ht} + D_t C_{Dt} K_{Dt} + NH_{dt}$$

Medical expenditures for hospital care and physicians' services for decedents are estimated from expenditures for survivors by means of the relationship of expenditures of decedents relative to survivors observed in several populations. Thus, average annual hospital and physician expenditures for survivors are multiplied by K_{Ht} and K_{Dt}, respectively, to obtain hospital and physician expenditures for decedents.

K_{Ht} = the multiple by which hospital expenditures for decedents in the period t exceed average annual hospital expenditures for survivors. For decedents less than 65 years of age, K_{Ht} is derived from hospital care expenditures for decedents and survivors in the year of death in NMCUES and hospital care utilization in the four years prior to death in a probability sample of 60,000 Canadians reported by Roos, Montgomery, and Roos (1987).

For decedents 65 years of age and older, K_{Ht} is derived entirely from expenditures of decedents relative to survivors in the population of Medicare beneficiaries. The Medicare data are described in Lubitz and Prihoda (1984) and Riley and Lubitz (1986).

K_{Dt} = the multiple by which physician expenditures for decedents in the period t exceed average annual physician expenditures for survivors. K_{Dt} is derived from the same data sources and methods as is K_{Ht}.

Nursing-home expenditures, if the individual dies at age t, are estimated by

$$NH_{dt} = 1.5(.25\,L_{at} + .75\,L_{dt})\,C_{NHt}\,W_{dt}$$

L_{at} = average length of stay for live discharges, as described above.

L_{dt} = average length of stay for dead discharges, also from the NNHS and inflated by 30 percent. The average length of stay for decedents is a weighted average of the lengths of stay of live and dead discharges, with the weights reflecting the assumption that 75 percent of those with a long-term stay die in the institution (Vicente, Wiley, and Carrington 1979).

C_{NHt} = average daily charge to nursing-home residents in 1990 dollars by age and sex from the NNHS.

W_{dt} = percent of the population dying in age t who had a nursing-home stay in the period by age, sex, and smoking status from NHEFS.

Probabilities of Surviving and Dying

$$P_{at} = \prod_{n=17\text{–}34}^{t} (1 - p_n) \qquad \text{for a 17–34-year-old.}$$

$$P_{dt} = p_t \prod_{n=17\text{–}34}^{t-1} (1 - p_n) \qquad \text{for a 17–34-year-old.}$$

t = age 17–34, 35–44, 45–54, 55–64, 65–74, 75–84, 85 and over.

For example,

$$P_{a,45\text{-}54} = (1 - p_{17\text{-}34})(1 - p_{35\text{-}44})(1 - p_{45\text{-}54})$$

$$P_{d,45\text{-}54} = p_{45\text{-}54}(1 - p_{17\text{-}34})(1 - p_{35\text{-}44})$$

p_n = the probability of dying in the nth age interval for persons alive at the beginning of the age interval by sex and amount smoked. The p_ns are derived from death rates in the American Cancer Society's (ACS) Cancer Prevention Study II (CPS II). The p_ns are scaled to 1985 U.S. values for all males and females following the methodology employed by Mattson, Pollack, and Cullen (1987).

CPS II is a long-term prospective study. In 1982, more than 77,000 ACS volunteers enrolled 509,000 men and 677,000 women, who provided information on their lifestyles, exposure to certain environmental conditions, and history of disease. In 1984, 1986, and 1988, it was determined which enrollees had died in the two preceding years and death certificates were obtained. Although subjects come from all 50 states, the District of Columbia, and Puerto Rico, the sample is not a probability sample of the U.S. population. Minority groups are underrepresented, institutionalized persons are excluded, and sample persons are more highly educated (Stellman and Garfinkel 1986).

CPS II is more representative of middle-class white Americans and the enrollees' mortality rates are lower than those of the total U.S. population (U.S. Department of Health and Human Services 1989). Longer life expectancy among CPS II enrollees would produce some overstatement of lifetime medical expenditures for the U.S. population. The impact on excess smoker expenditures is not clear. It depends on whether, and by how much, underrepresentation of minorities differs among smokers and neversmokers, and on certain other characteristics that produce different smoker versus neversmoker mortality among minority and nonminority populations. For example, higher proportions of blacks currently smoke, but a higher proportion of whites are former smokers, whereas Hispanics have the highest proportion of neversmokers and the lowest proportion of current smokers (Schoenborn and Boyd 1989). Whites smoke more cigarettes per day (National Center for Health Statistics 1988), whereas black smokers prefer cigarette brands that are high in tar and nicotine and are mentholated (Novotny et al.

1988). The net effect of these competing factors on the relative mortality of smokers and neversmokers is uncertain.

The higher educational level of the CPS II sample is due at least in part to underrepresentation of minorities. A line of reasoning similar to that in the preceding paragraph applies to whether educational differences between the CPS II sample and the U.S. population not caused by minority underrepresentation impact on excess smoker expenditures.

The potential for CPS II to provide reasonable generalizations to the U.S. population is shown by Stellman and Garfinkel (1986). They find that adjusting CPS II data for the educational distribution of the United States by ten-year age groups produces only small changes in the age-specific distributions of smoking habits among men and women. Further encouragement for the use of CPS II is given by the surgeon general, who reports that estimated relative risks for cigarette-related diseases do not change much in response to statistically controlling for confounding and stratifying variables (U.S. Department of Health and Human Services 1989). Even with its limitations, CPS II is the best available data source for this analysis.

Population Expenditures

Expected medical expenditures per individual over the remaining lifetime are estimated for each smoking status, sex, and age group. Each profile of expected expenditures is then multiplied by the corresponding number of persons in the group as estimated by the NHIS for 1985. This produces aggregate expected expenditures for each cohort by age and years from baseline.

Source of Funds

The Health Care Financing Administration (HCFA) annually estimates national health expenditures by source of funds for each type of medical care (Letsch, Levit, and Waldo 1988). From time to time, national health expenditures are disaggregated by age (Waldo and Lazenby 1984; Waldo et al. 1989), usually into three age groups: under 19 years, 19 to 64 years, and 65 years of age or over. The following steps were taken to allocate lifetime medical expenditures of each smoking status group (male neversmokers, for example) according to payment sources.

1. HCFA's personal health expenditures for hospital care and physicians' services were disaggregated by sex according to the distribution of hospital discharges between males and females within each age and source of payment group reported by the National Hospital Discharge Survey (Graves 1987). Expenditures for nursing home care reported by HCFA were distributed by sex according to the proportion of male and female nursing-home residents in each age and source of payment group (Hing 1989).
2. The resulting expenditures by source of payment for each type of medical care (hospitals, physicians, and nursing homes), sex, and age were converted to percentage distributions. The appropriate distributions were applied to corresponding components of estimated lifetime medical expenditures to derive payments by age and source for hospital care, physicians' services, and nursing-home care for each smoking status group. Expenditures were aggregated over types of medical care to obtain lifetime medical expenditures by age and source of funds for each smoking status group.

This methodology accounts for variation in the source of payment for medical care by type of care, sex, and age of the recipient, but with respect to age only distinguishes whether payments are made at ages under 65 years or 65 years or older. The source of funds for medical care for male smokers, for example, differs from that for male neversmokers because of differences in type and amount of medical care used and age at which expenditures are incurred.