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**United States General Accounting Office**
**Washington, DC 20548**

July 17, 2003

The Honorable Richard Burr
House of Representatives

Subject: *CDC's April 2002 Report On Smoking: Estimates of Selected Health Consequences of Cigarette Smoking Were Reasonable*

Dear Mr. Burr:

Despite a recent decline in the population that smokes, smoking is considered the leading cause of preventable death in this country. According to the Centers for Disease Control and Prevention (CDC), over 2 million deaths in the 5-year period from 1995 through 1999 were attributable to cigarette smoking. CDC, part of the Department of Health and Human Services (HHS), is a primary source of information on the health consequences of smoking tobacco. CDC reported its most recent estimates of selected health consequences of cigarette smoking in an April 2002 issue of its publication *Morbidity and Mortality Weekly Report.*[1] CDC reported that, on average, over 440,000 deaths, 5.6 million years of potential life lost, $82 billion in mortality-related productivity losses, and $76 billion in medical expenditures were attributable to cigarette smoking each year from 1995 through 1999. (See enclosures I and II.)

CDC and others tasked with making such estimates face challenges. They build estimates on a set of assumptions and make choices about the data sources and methods used, each of which may have limitations that must be weighed against its advantages. Policymakers at both the state and federal levels have relied on estimates like these in considering bans on smoking in public places, taxes on cigarettes, litigation to recoup medical expenditures, and other matters concerning tobacco. Thus it is essential that the estimates CDC provides are sound and that their limitations are clear. In recognition of this, you asked us to review CDC's April 2002 report and determine whether its estimates of selected health consequences of cigarette smoking were reasonable. Specifically, we examined CDC's estimates of (1) deaths and years of potential life lost and (2) mortality-related productivity losses and medical expenditures attributable to cigarette smoking.

[1]Centers for Disease Control and Prevention (CDC), "Annual Smoking-Attributable Mortality, Years of Potential Life Lost, and Economic Costs – United States, 1995-1999," *Morbidity and Mortality Weekly Report*, vol. 51, no. 14 (2002): 300-303. *Morbidity and Mortality Weekly Report* is a CDC publication for dissemination of information about the public health issues in which CDC is involved.

To determine whether CDC's estimates were reasonable, we reviewed CDC's approach and alternative approaches to developing them. Specifically, we reviewed CDC's assumptions, methods, and data sources; the choices CDC made about how to best estimate the number of deaths, years of potential life lost, productivity losses, and medical expenditures attributable to cigarette smoking; and CDC's attempts to deal with the limitations inherent in analyses of this kind. We examined CDC's choices in the context of the alternatives available and determined whether the alternatives would have resulted in more reasonable estimates. In reviewing CDC's approach and the available alternatives, we searched the scientific literature using the electronic databases MEDLINE and EconLit and reviewed over 200 studies on the consequences of tobacco and approaches to estimating them. In addition, we reviewed CDC's documentation of its methods and interviewed CDC officials involved in the report about their approach and their rationale for choices made in deriving these estimates. We conducted our work from December 2002 through July 2003 in accordance with generally accepted government auditing standards.

In summary, CDC's estimates of the average number of deaths and years of potential life lost each year due to cigarette smoking were reasonable. The estimates were based on the increases in deaths from 23 causes that were linked to cigarette smoking. The linkages of cigarette smoking to increased mortality due to the included causes, such as lung cancer or cardiovascular disease, had been well established by the Surgeon General. CDC used the method generally accepted among epidemiologists for estimating the increased deaths attributable to cigarette smoking. The data sources CDC used were the best available and included: the largest study of smoking behavior and health status available for data on the risk of death in smokers relative to nonsmokers; the National Health Interview Survey (NHIS) of over 97,000 persons for data on the prevalence of smoking; and death certificates compiled from all states for mortality data. CDC recognized and handled appropriately the limitations in the data from these sources.

CDC's estimates of the annual mortality-related productivity losses and medical expenditures due to cigarette smoking also were reasonable. CDC estimated productivity losses associated with the years of potential life lost using assumptions about employment and earnings that are generally accepted among economists, well-established methods for extrapolating from present earnings to earnings that would be made in the future, and large federal data sources on earnings. The assumptions that CDC made and the methods it used to estimate medical expenditures were also generally accepted among health care economists. CDC relied on the most comprehensive data available on medical expenditures, the federally sponsored National Medical Expenditure Survey (NMES) of over 38,000 persons. For both productivity losses and medical expenditures, CDC recognized and handled appropriately the limitations in the data.

In its comments on a draft of this report, CDC said that this report, in general, accurately represents the intent, methods, and decision-making processes of its April 2002 report.

## Background

The Surgeon General's first report on smoking and health was published in 1964. This report was the first of many to describe the links between tobacco smoking and health. Since then, several federal agencies have issued reports on tobacco and health.[2] In the last four decades, the Office of the Surgeon General has published dozens of reports on the health consequences of smoking. CDC's Office on Smoking and Health originated as the National Clearinghouse for Smoking and Health in the Office of the Surgeon General and became part of CDC in 1986. Through this office, CDC has become a chief source of information on the health consequences of smoking.

Although the health consequences of cigarette smoking are numerous, CDC's April 2002 report provided four estimates—number of deaths, years of potential life lost, mortality-related productivity losses, and annual medical expenditures attributable to cigarette smoking. The estimate of number of deaths is the foundation for both the years of potential life lost and mortality-related productivity loss estimates. Number of deaths and years lost are two different ways of measuring mortality attributable to cigarette smoking, and mortality-related productivity loss is a way of measuring lives and years of life lost in economic terms. All three of these estimates are limited to mortality and do not measure morbidity attributable to cigarette smoking, such as disability, diminished quality of life, and reduced productivity associated with diseases linked to cigarette smoking. Unlike the other three estimates, CDC's estimate of annual medical expenditures attributable to cigarette smoking includes the additional medical expenses attributable to cigarette smoking of all smokers in a given year, not those who died in that year. Thus, CDC's estimate is of annual medical expenditures for morbidity attributable to cigarette smoking. CDC labels as economic costs attributable to cigarette smoking the sum of its estimates of mortality-related productivity losses and medical expenditures. However, this summary estimate of economic costs does not include such costs as time lost in the workplace due to sick leave and disability.

## CDC's Estimates of Number of Deaths and Years of Potential Life Lost Due to Cigarette Smoking Were Reasonable

CDC's estimates of an average of over 440,000 premature deaths and 5.6 million years of potential life lost each year attributable to cigarette smoking were reasonable. CDC relied on well-established criteria for the causes of death to include and used

[2]See for example, U.S. Department of Health, Education, and Welfare, National Institutes of Health, National Cancer Institute, and National Heart, Lung, and Blood Institute, *Smoking and Health: A Program to Reduce the Risk of Diseases in Smokers*, *Status Report* (Bethesda, Md.: December 1978); U.S. Department of Agriculture, Economic Research Service, *Tobacco: Situation and Outlook* (Washington, D.C.: April 1995); U.S. Department of the Treasury, *The Economic Costs of Smoking in the U.S. and the Benefits of Comprehensive Tobacco Legislation* (Washington, D.C.: March 1998); and U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute, *Strategies to Control Tobacco Use In the United States: A Blueprint for Public Health Action In the 1990's*, Smoking and Tobacco Control Monograph 1 (Bethesda, Md.: December 1991).

the standard method for attributing deaths to cigarette smoking. In addition, it used the best data sources available and recognized and handled appropriately the limitations in the data on which the estimates are based.

Total Number of Deaths Attributable to Cigarette Smoking

CDC's estimate of the average total number of deaths attributable to cigarette smoking annually is the sum of deaths in four categories that reflect differences in how the estimates are obtained: adult deaths from diseases causally linked to cigarette smoking, infant deaths from conditions causally linked to maternal cigarette smoking during pregnancy, adult deaths from diseases causally linked to exposure to secondhand cigarette smoke, and deaths from residential fires caused by smoking. (See table 1.) CDC generated the estimates of adult deaths from diseases linked to cigarette smoking and infant deaths from conditions linked to maternal cigarette smoking and relied on the estimates of others for secondhand smoke and fire deaths.

**Table 1: CDC's Estimates of Average Annual Deaths Attributable to Cigarette Smoking and Years of Potential Life Lost (1995 to 1999)**

| | Deaths | Percentage of total deaths | Years of potential life lost (YPLL) | Percentage of total YPLL |
|---|---|---|---|---|
| **Adult deaths from diseases causally linked to cigarette smoking[a]** | | | | |
| Cancer of lip, oral cavity, pharynx | 5,137 | 1.2 | 85,521 | 1.5 |
| Cancer of esophagus | 7,893 | 1.8 | 120,045 | 2.1 |
| Cancer of pancreas | 6,480 | 1.5 | 98,593 | 1.8 |
| Cancer of larynx | 3,127 | 0.7 | 48,616 | 0.9 |
| Cancer of trachea, lung, bronchus | 124,813 | 28.2 | 1,869,786 | 33.3 |
| Cancer of cervix uteri | 522 | 0.1 | 13,606 | 0.2 |
| Cancer of urinary bladder | 4,752 | 1.1 | 53,498 | 1.0 |
| Cancer of kidney, other urinary | 3,035 | 0.7 | 46,039 | 0.8 |
| Hypertension | 6,060 | 1.4 | 87,577 | 1.6 |
| Ischemic heart disease | 81,976 | 18.5 | 1,172,699 | 20.9 |
| Other heart diseases | 29,368 | 6.6 | 371,083 | 6.6 |
| Cerebrovascular disease | 17,445 | 3.9 | 280,728 | 5.0 |
| Atherosclerosis | 2,527 | 0.6 | 22,802 | 0.4 |
| Aortic aneurysm | 9,624 | 2.2 | 116,223 | 2.1 |
| Other arterial disease | 1,605 | 0.4 | 20,894 | 0.4 |
| Pneumonia, influenza | 15,576 | 3.5 | 156,133 | 2.8 |
| Bronchitis, emphysema | 17,696 | 4.0 | 216,376 | 3.9 |
| Chronic airways obstruction | 64,735 | 14.6 | 732,189 | 13.0 |
| **Adult smoker deaths from disease** | **402,373** | **91.0** | **5,512,405** | **98.1** |
| **Infant deaths from conditions causally linked to maternal cigarette smoking during pregnancy[b]** | | | | |
| Short gestation/low birthweight | 402 | 0.09 | 30,556 | 0.54 |
| Respiratory distress syndrome | 109 | 0.02 | 8,198 | 0.15 |
| Other respiratory—newborn | 117 | 0.03 | 8,793 | 0.16 |
| Sudden infant death syndrome | 377 | 0.09 | 28,677 | 0.51 |
| **Infant deaths from maternal smoking** | **1,007** | **0.23** | **76,224** | **1.36** |
| **Adult deaths from diseases causally linked to exposure to secondhand cigarette smoke[a]** | | | | |
| Lung cancer | 3,000 | 0.7 | - | - |
| Ischemic heart disease | 35,053 | 7.9 | - | - |
| **Adult deaths from secondhand smoke** | **38,053** | **8.6** | - | **-** |
| **Deaths from residential fires caused by smoking** | **966** | **0.2** | **27,756** | **0.5** |
| **Total deaths attributable to cigarette smoking** | **442,398** | **100.0** | **5,616,385** | **100.0** |

Source: CDC, "Annual Smoking-Attributable Mortality, Years of Potential Life Lost, and Economic Costs – United States, 1995-1999."

Note: Individual entries may not sum to totals because of rounding.

[a]For adults 35 years old and older.

[b]For infants 1 year old and younger.

In deciding which causes of death to include in its analysis, CDC relied on the Surgeon General's determination of the causes of death linked to cigarette smoking.[3] These determinations are based on extensive reviews of scientific literature and are widely regarded as valid. When new data become available, the Surgeon General's determination changes accordingly. An alternative method of estimating deaths attributable to cigarette smoking that does not depend on decisions about which causes of death to include has been employed by some researchers. Rather than including only those deaths due to diseases or conditions that the Surgeon General considers linked to cigarette smoking, this method estimates deaths attributable to cigarette smoking regardless of the specific cause of death. CDC officials told us that they explored this approach, which yielded an estimate of over 540,000 deaths attributable to cigarette smoking during 1999, but chose not to use it because it would have resulted in inflated estimates.[4]

The method that CDC used to estimate adult and infant deaths and that others used to estimate secondhand smoke deaths is generally accepted among epidemiologists as appropriate for attributing deaths to cigarette smoking.[5] Use of this method is necessary because it is not possible to definitively attribute an individual case of disease to smoking—deaths from a disease can only be attributed to smoking on a population basis.[6] For example, in the case of lung cancer, not all cigarette smokers develop lung cancer, and not all people who develop lung cancer are cigarette smokers. Thus, counting the lung cancer deaths in cigarette smokers and attributing them to cigarette smoking would not be accurate because some of those deaths would have occurred even in the absence of cigarette smoking. Instead, the generally accepted approach attributes to cigarette smoking only the lung cancer deaths among

[3]The Surgeon General's determinations are based on the application of standard criteria for establishing causality to information from comprehensive reviews of the scientific literature. For standard causality criteria, see A. B. Hill, "The Environment and Disease: Association or Causation?" *Proceedings of the Royal Society of Medicine*, vol. 58, no. 5 (1965): 295-300.

[4]This method was also applied to 1993 data and produced an estimate of 569,000 deaths attributable to cigarette smoking in 1993. D.M. Burns, L. Garfinkel, and J.M. Samet, "Introduction, Summary, and Conclusions," *Changes in Cigarette-Related Disease Risks and Their Implication for Prevention and Control*, Smoking and Tobacco Control Monograph 8 (Bethesda, Md.: U.S. Department of Health and Human Services, 1997).

[5]See, for example, P. Bruzzi et al., "Estimating the Population Attributable Risk for Multiple Risk Factors Using Case-control Data," *American Journal of Epidemiology*, vol. 122, no. 5 (1985): 904-914.

[6]It was not necessary to use this method to estimate deaths from fires because, unlike deaths from disease, an individual death in a fire can be definitively attributed to smoking if the fire department determines that smoking was the cause of the fire.

smokers that are in excess of those expected among nonsmokers. Estimates of deaths attributable to cigarette smoking using this approach are based on three components: (1) estimates of the risk for smokers[7] relative to nonsmokers of dying from each specific disease or condition linked to cigarette smoking, (2) estimates of the prevalence of cigarette smoking, and (3) the number of deaths from each disease and condition. The estimate of deaths attributable to cigarette smoking derived from these three components for lung cancer, for example, represents the excess number of lung cancer deaths that occurred because of cigarette smoking.

*Adult Deaths from Diseases Causally Linked to Cigarette Smoking*

CDC's estimate of deaths in adult smokers due to diseases causally linked to cigarette smoking accounted for about 91 percent of its estimate of total deaths attributable to cigarette smoking. The data sources that CDC used for each of the three components of the estimate of the number of deaths attributable to cigarette smoking all had limitations that potentially could have affected the estimate. However, each was the best data source available for each particular purpose, and CDC recognized and dealt appropriately with the limitations so that their effects on the estimate were minimal.

For the first component of its estimate of adult deaths—estimating the risk of death for smokers relative to nonsmokers—CDC used the American Cancer Society's second Cancer Prevention Study (CPS-II).[8] This study gathered data on individuals' demographic traits, medical history, and behavior (such as alcohol use) and reported on the relationship between cigarette smoking and death. CPS-II, with a sample of about 1.2 million individuals, had a size advantage over other studies that have similar information. Smaller samples are not sufficient to produce estimates of cigarette smoking risks that have margins of error as small as those obtained using CPS-II.

Although the CPS-II sample was not representative of the national population—for example, nonwhites were underrepresented—adjustments can be made for the nonrepresentativeness of the overall sample by estimating cigarette smoking risks taking account of other factors, such as race. The size of the CPS-II sample enabled CDC to isolate the increase in risk that was directly attributable to cigarette smoking and adjust for the effect that multiple factors can have on a person's risk of death.

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[7]Smokers are generally classified as either current smokers or former smokers, and separate estimates are derived for each group.

[8]M.J. Thun et al., "Trends in Tobacco Smoking and Mortality from Cigarette Use in Cancer Prevention Studies I (1959 through 1965) and II (1982 through 1988)," *Changes in Cigarette-Related Disease Risks and Their Implication for Prevention and Control*, Smoking and Tobacco Control Monograph 8 (Bethesda, Md.: U.S. Department of Health and Human Services, 1997). Study participants self-reported information on their medical history, current health status, and a series of lifestyle factors including smoking behaviors. During the 6-year follow-up period, deaths among participants were recorded along with the cause of death as recorded on the death certificate. Death certificates were obtained for approximately 97 percent of all study participants known to have died.

For example, although the proportion of nonwhites in the sample was less than the proportion in the general population, the sample still contained enough nonwhites to analyze the effect of race on the relative risks. CDC used data from CPS-II and additional studies to evaluate the importance of race and other factors—such as education, alcohol use, and diabetes—and concluded that only age and sex needed to be taken into account in estimating the relative risks.[9]

CPS-II was almost 20 years old at the time of CDC's report. It was initiated in 1982 and follow-up of individuals in the study is ongoing. The relative risk estimates that CDC used were based on follow-up through 1988. Thus, if relative risks had changed over time, those estimated from CPS-II might not have been accurate for estimating deaths during 1995 through 1999. However, CDC and others reviewed studies at different points in time and determined that the relative risks were likely to have remained stable and were still applicable.

For the second component of the estimate of deaths attributable to cigarette smoking—estimates of the prevalence of cigarette smoking among adults—CDC used the National Health Interview Survey (NHIS), which has detailed data on cigarette smoking for the years included in CDC's analysis.[10] CDC chose to use data that capture cigarette smoking prevalence during the same years that the deaths of interest occurred. Using prevalence data from the same years that the deaths occurred underestimates the number of deaths attributable to cigarette smoking because, for example, deaths in 1999 are the result of exposure to cigarette smoke during previous decades and the prevalence of cigarette smoking declined by 25 percent during the 1990s. In addition, former smokers in 1999 may have been different from former smokers in the year that relative risks were estimated—that is, having quit relatively recently, their risk may resemble that of current smokers more closely than that of former smokers. CDC officials said that they accepted this limitation since its result was a lower estimate of the number of deaths attributable to cigarette smoking.

CDC's source for the data needed for the last component of the estimate of deaths attributable to cigarette smoking—the total number of deaths due to each disease each year—was death certificates. CDC obtained these data from the National Center for Health Statistics (NCHS), which is the national repository for information from birth and death certificates. NCHS has determined that death certificates accurately capture the cause of death about 97 percent of the time.

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[9]M.J. Thun, L.F. Apicella, and S.J. Henley, "Smoking vs Other Risk Factors as the Cause of Smoking-Attributable Deaths: Confounding in the Courtroom," *JAMA*, vol. 284, no. 6 (2000): 706-712 and A.M. Malarcher et al., "Methodological Issues in Estimating Smoking-Attributable Mortality in the United States," *American Journal of Epidemiology*, vol. 152, no. 6 (2000): 573-584.

[10]The National Health Interview Survey (NHIS) is a nationally representative survey of health trends in the civilian population. The survey collects basic health and demographic information every year and frequently includes questions on smoking. The 1999 NHIS sample consisted of 37,573 households, which yielded 97,059 persons in 38,171 families. For the adult component, 30,801 persons 18 years or older were interviewed.

*Infant Deaths from Conditions Causally Linked to Maternal Cigarette Smoking during Pregnancy*

Infant deaths from conditions causally linked to maternal cigarette smoking accounted for less than one half of 1 percent of the total deaths attributable to cigarette smoking. CDC's estimate of infant deaths was based on the same three components as for adults, but the data sources were necessarily different because, for example, CPS-II was a study of only adults. CDC's source of data for the first component—estimates of the risk of dying for infants whose mothers smoked cigarettes during pregnancy relative to those whose mothers did not smoke—was a review of studies of the effects of maternal cigarette smoking.[11] For the second component, CDC used data compiled from birth certificates and surveys of new mothers to obtain estimates of cigarette smoking prevalence among pregnant women. As for adult deaths, the source for the last component of the estimate was NCHS data on the number of infant deaths each year from each condition.

*Adult Deaths from Diseases Causally Linked to Exposure to Secondhand Cigarette Smoke*

Deaths associated with secondhand cigarette smoke accounted for about 9 percent of CDC's estimated total number of deaths attributable to cigarette smoking. CDC obtained its estimates of deaths attributable to secondhand cigarette smoke from a National Cancer Institute (NCI) report.[12] CDC used the NCI report's estimate of 3,000 annual lung cancer deaths associated with secondhand cigarette smoke.[13] The NCI report presented a range of estimates (35,000-62,000) for deaths from ischemic heart disease. CDC used the estimate of 35,000 because it was the lowest of the range and relied on the same data source CDC used to develop estimates for adult deaths due to cigarette smoking (CPS-II) and thus would be consistent with those estimates.

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[11]N.I. Gavin, C. Wiesen, and C. Layton, *Review and Meta-Analysis of the Evidence on the Impact of Smoking on Perinatal Conditions Built into SAMMEC II*, (Washington, D.C.: Centers for Disease Control and Prevention, September 2000).

[12]U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute, *Health Effects of Exposure to Environmental Tobacco Smoke: The Report of the California Environmental Protection Agency*, Smoking and Tobacco Control Monograph 10 (Bethesda, Md.: 1999).

[13]The NCI report cited the Environmental Protection Agency's (EPA) estimate of 3,000 annual lung cancer deaths associated with secondhand smoke (see U.S. Environmental Protection Agency, Office of Research and Development, Office of Health and Environmental Assessment, *Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders* (Washington, D.C.: December 1992)). After the report was published, several tobacco companies filed a lawsuit seeking to have the report withdrawn, claiming that EPA had violated procedural requirements in developing the report. In 1998, a district court invalidated certain chapters of the report, including those on lung cancer. In December 2002, the U.S. Court of Appeals overturned the district court's decision and ordered that the suit be dismissed, concluding that the district court had lacked jurisdiction to hear the suit. (See *Flue-Cured Tobacco Cooperative Stabilization Corporation v. United States EPA*, 313 F.3d 852 (4th Cir. 2002).)

*Deaths from Residential Fires Caused by Smoking*

Deaths from residential fires accounted for less than one half of 1 percent of CDC's estimated total number of deaths attributable to cigarette smoking.[14] CDC obtained its estimates of residential fire deaths from the National Fire Protection Association (NFPA). NFPA national estimates are of the average annual number of deaths due to fires caused by smoking and are based on data reported to the U.S. Fire Administration and NFPA's annual survey of fire departments.[15]

Years of Potential Life Lost

CDC's estimate of the years of potential life lost was built on the estimate of number of deaths attributable to cigarette smoking and provided another perspective on mortality attributable to cigarette smoking. CDC reported that, on average, men and women who died from cigarette smoking-related illness each lost about 13 and 15 years of life, respectively. When mortality attributable to cigarette smoking is measured in terms of the number of deaths, each death contributes equally to the total. In contrast, when mortality is measured in terms of years of potential life lost, each death contributes to the total depending on how premature the death was. This measure takes life expectancy into account, and thus death at a younger age results in a greater loss of potential years of life than death at an older age. For example, an infant who died as a result of maternal cigarette smoking would likely have had a greater life expectancy than an elderly lifetime smoker who died of lung cancer and so would contribute more years of potential life lost to the total. Thus, although infant mortality accounts for .23 percent of the total number of deaths, it accounts for almost six times that percentage (1.36 percent) of the total number of years lost. In contrast, adult lung cancer mortality accounts for about the same proportion of both the total number of deaths and the total number of years lost.

CDC used national life expectancy data published by NCHS to estimate the expected years of life remaining for those who died from cigarette smoking. The expected life

[14]The National Fire Protection Association (NFPA) estimate that CDC cited includes deaths from the 1 to 2 percent of fires caused by cigars and pipes. The estimate does not include deaths from nonresidential and auto-related fires.

[15]The United States Fire Association (USFA) is part of the Federal Emergency Management Agency. The fire reports sent to USFA's voluntary fire reporting system account for about half of the fires each year, and representation of certain regions of the country and communities may not be uniform. To address these issues, NFPA supplements USFA's data with its own annual survey of a sample of fire departments. NFPA assumes that fires with unknown or unreported causes have the same proportional distribution as fires for which the cause is known and reported.

span differs for women and men, by age group, and by year assessed.[16] For example, in 1995, a 65-year old woman was expected to live another 19 years to age 84 and a 65-year old man was expected to live another 16 years to age 81. A 75-year old woman in that year was expected to live another 12 years to age 87. In contrast to life expectancies in 1995, a 65-year old woman in 1950 had an expected life span of 80 years. CDC calculated years of potential life lost by multiplying the estimated remaining life expectancy for each sex and age group in each year from 1995 through 1999 by the number of cigarette smoking-attributable deaths in that group in each year.[17] CDC did not estimate the years lost from secondhand cigarette smoke deaths because the NCI report from which CDC obtained the estimate of secondhand smoke deaths did not have sufficient age-specific data. Thus CDC's estimate of the total number of potential years of life lost did not include the lost years associated with about 9 percent of the total estimated deaths.

## CDC's Estimates of Mortality-Related Productivity Losses and Medical Expenditures Due to Cigarette Smoking Were Reasonable

CDC's estimates of $82 billion annually in productivity losses from mortality attributable to cigarette smoking and $76 billion in additional medical expenditures for all smokers annually were reasonable. CDC arrived at these estimates using approaches that were generally accepted among economists and relied on large federal data sources. CDC recognized and handled appropriately the limitations in the data on which the estimates are based.

### Mortality-Related Productivity Losses

CDC's estimate of mortality-related productivity losses built on its estimates of death and years of potential life lost and measured mortality in economic terms. CDC valued the years of potential life lost in terms of the productivity lost as a result of those lost years. CDC used expected future earnings, calculated in current dollars, to represent mortality-related productivity losses. An alternative approach to estimating mortality-related productivity losses attempts to capture the broader impact on productivity of death by accounting for such factors as time and costs to replace workers and restore productivity levels.[18] CDC did not take this approach because it was not widely accepted.

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[16]Life expectancy also differs by race, with blacks of both sexes and of all ages generally having lower life expectancies than whites for all years. CDC did not estimate cigarette-smoking attributable deaths separately by race and thus did not estimate years of potential life lost by race.

[17]An alternative method for estimating years of potential life lost is to calculate the years of life remaining using life expectancy at birth rather than at the age of death. This method would likely have resulted in a lower estimate of the total years of productive life lost; however, it is not the method generally accepted among public health experts.

[18]M.A. Koopmanschap, "Estimating the Indirect Costs of Smoking Using the Friction Cost Method," ed. C. Jeanrenaud and N. Soguel, *Valuing the Cost of Smoking: Assessment Methods, Risk Perception and Policy Options* (Boston: Kluwer Academic Publishers, 1999).

In estimating mortality-related productivity losses, CDC used estimates of expected earnings[19] derived from the Bureau of Labor Statistics (BLS), U.S. Census Bureau, and other national sources. They take into account both changes in earnings and the value of money over time. They also include the estimated value of household work that accounts for the productivity losses among individuals who do not earn wages for household services. CDC updated the published earnings estimates using an adjustment factor from BLS so that the estimates would reflect 1995-99 earnings. CDC used a single average estimate of future lifetime earnings for men and women. Because of men's higher average earnings and higher incidence of cigarette smoking-related death compared to women, the productivity loss estimate was likely to be lower than if separate average earnings had been used for men and women.

CDC's estimate of mortality-related productivity losses did not include the expected lost earnings associated with infant or secondhand cigarette smoke deaths (about 9 percent of the total deaths). CDC said that it did not develop an estimate of productivity losses for infants because of a lack of consensus among economists about the best method for estimating the potential future earnings of infants. Similarly, the NCI report from which CDC obtained the estimate of secondhand smoke deaths lacked specific data on the age at which those deaths occurred—information needed to estimate expected lost earnings. CDC informed us that it is working on including these two categories in future estimates of productivity losses when more reliable data become available.

Medical Expenditures

CDC's estimate of $76 billion annually in additional medical expenditures attributable to cigarette smokers was not built on the other three estimates, and its approach to developing this estimate was different from its approach to the others. CDC examined the use of health care services and the cost of those services for smokers compared to nonsmokers independent of the reason—that is, the disease or condition—for the services. Thus, this estimate is not limited to medical expenditures associated with a set of diseases and conditions causally linked to cigarette smoking. CDC's estimate of total medical expenditures was the sum of five estimates by type of health care service for adults—ambulatory care, hospital care, prescription drugs, nursing home,[20] and other (including home health care, nonprescription drugs, and nondurable medical equipment)—and an estimate of expenditures for neonatal health care services. (See table 2.) CDC estimated these expenditures on an annual basis.

[19]CDC's estimates were drawn from A.C. Haddix et al., eds., *Prevention Effectiveness: A Guide to Decision Analysis and Economic Evaluation* (New York: Oxford University Press, 1996).

[20]CDC's nursing home estimate accounts for differences between smokers and nonsmokers in the likelihood of admission to a nursing home but not differences in readmission or length of stay.

**Table 2: CDC's Estimates of Annual Mortality-Related Productivity Losses and Medical Expenditures Attributable to Cigarette Smoking**

| **Dollars in millions** | |
|---|---|
| | Total |
| **Mortality-related productivity losses** | |
| Men | $55,389 |
| Women | 26,483 |
| **Total mortality-related productivity losses** | **$81,872** |
| **Medical expenditures**[a] | |
| Ambulatory care | $27,182 |
| Hospital care | 17,140 |
| Prescription drugs | 6,364 |
| Nursing home | 19,383 |
| Other care | 5,419 |
| Neonatal | 366 |
| **Total medical expenditures** | **$75,854** |

Source: CDC, "Annual Smoking-Attributable Mortality, Years of Potential Life Lost, and Economic Costs – United States, 1995-1999."

[a]CDC's estimate of annual personal medical expenditures for adults attributable to cigarette smoking was derived using 1998 data obtained from the Health Care Financing Administration and is in 1998 dollars. Its estimate of annual neonatal medical expenditures attributable to maternal cigarette smoking was based on 1996 data and is in 1996 dollars.

The data source that CDC used to determine medical expenditures for smokers compared to nonsmokers allowed CDC to adjust for many factors—including certain risk-taking behaviors (e.g., not wearing a seat belt)—that may affect health care expenditures independent of smoking status.[21] However, although the data source was the most comprehensive available, it did not include information on alcohol consumption. CDC used data from another study to assess the importance of drinking alcohol with respect to expenditures attributable to cigarette smoking and concluded that adjusting the data for drinking would not have had an appreciable effect on the results.[22] Expenditures for dental care and mental health care and certain costs

[21]CDC's primary data source for determining medical expenditures for smokers compared to nonsmokers was the 1987 National Medical Expenditure Survey, a population-based survey of over 38,000 individuals in about 14,000 households.

[22]This study assessed utilization of health care services using data from a nationally representative survey of adults that included information on utilization of medical care, smoking, and alcohol consumption. CDC based its conclusion on findings from this study, after an expert panel determined that these findings were applicable to CDC's analysis. V.P. Miller, C. Ernst, and F. Collin, "Smoking-Attributable Medical Care Costs in the USA," *Social Science & Medicine*, vol. 48, no. 3 (1999): 375-391.

associated with the care of infants of cigarette smoking mothers were not included in CDC's estimate.[23] In addition, certain expenditures for health services associated with secondhand cigarette smoke (e.g., care for lung cancer due to secondhand cigarette smoke in a nonsmoker) and care for nonsmokers injured in residential fires caused by smoking are not accounted for in the estimate.

By estimating medical expenditures on an annual basis, CDC avoided limitations associated with the alternative of estimating expenditures over an individual's lifetime. The lifetime approach is based on a series of assumptions and predictions about disease course and duration, survival rates, patterns of medical care, and impact of disease on employment, among other factors. Results using a lifetime approach have varied widely—some studies have concluded that smokers have more medical expenditures than nonsmokers over their lifetimes and other studies have come to the opposite conclusion.[24] Changes in the assumptions underlying the annual approach have less of an effect on the results. CDC's estimates are consistent with other annual estimates of medical expenditures published in the literature.[25]

## Agency Comments

In its comments on a draft of this report (see enclosure III), CDC said that this report, in general, accurately represents the intent, methods, and decision-making processes of its April 2002 report. With respect to our discussion of the relative risks obtained from CPS-II, CDC noted that while the overall prevalence of smoking may have decreased since CPS-II, the relative risks for smokers compared to nonsmokers would not have decreased because smoking behavior was similar. We have incorporated CDC's technical comments as appropriate.

- - - - -

[23]CDC's estimate of costs associated with smoking during pregnancy includes only neonatal hospital expenditures and excludes costs of care throughout infancy (for example, those associated with hospital readmissions in the first year of life) and expenditures associated with treating secondhand smoke-related conditions arising after birth. The estimates were based on data from CDC's Pregnancy Risk Assessment Monitoring System and 1996 private sector claims data from the Medstat MarketScan™ database.

[24]For an example of a study that found greater lifetime expenditures for smokers, see T.A. Hodgson, "Cigarette Smoking and Lifetime Medical Expenditures," *Milbank Quarterly*, vol. 70, no. 1 (1992): 81-125. For an example of a study that found fewer lifetime expenditures for smokers, see B.C. Lippiatt, "Measuring Medical Cost and Life Expectancy Impacts of Changes in Cigarette Sales," *Preventive Medicine*, vol.19, no. 5 (1990): 515-532.

[25]CDC's estimate of annual personal medical expenditures attributable to smoking, $76 billion, represents approximately 8 percent of total personal medical expenditures, an estimate within the range of other annual estimates (from about 6 to about 9 percent). See W. Max, "The Financial Impact of Smoking on Health-related Costs: A Review of the Literature," *American Journal of Health Promotion*, vol. 15, no. 5 (2001): 321-333.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies to the Director of CDC and other interested parties. We will also make copies available to others upon request. In addition, this report will be available at no charge on GAO's Web site at http://www.gao.gov. If you have questions or would like additional information, please call me at (202) 512-7119. Another contact and contributors to this report are listed in enclosure IV.

Sincerely yours,

Janet Heinrich
Director, Health Care—Public Health Issues
Enclosures

Enclosure I

## CDC's Table Presenting Its Estimates of Cigarette Smoking-Attributable Mortality and Years of Potential Life Lost

**TABLE 1. Annual deaths, smoking-attributable mortality (SAM), and years of potential life lost (YPLL), by cause of death and sex — United States, 1995–1999**

| Disease category (ICD-9 code)* | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | Total | SAM | YPLL | Total | SAM | YPLL |
| **Neoplasms** | | | | | | |
| Lip, oral cavity, pharynx (140–149) | 5,180 | 3,873 | 64,022 | 2,645 | 1,264 | 21,499 |
| Esophagus (150) | 8,627 | 6,280 | 94,359 | 2,778 | 1,613 | 25,686 |
| Pancreas (157) | 13,429 | 3,065 | 46,112 | 14,339 | 3,415 | 52,481 |
| Larynx (161) | 3,031 | 2,525 | 37,823 | 816 | 602 | 10,793 |
| Trachea, lung, bronchus (162) | 91,295 | 80,571 | 1,106,117 | 61,593 | 44,242 | 763,669 |
| Cervix uteri (180) | — | — | — | 4,138 | 552 | 13,606 |
| Urinary bladder (188) | 7,778 | 3,699 | 40,208 | 3,772 | 1,053 | 13,290 |
| Kidney, other urinary (189) | 7,066 | 2,799 | 41,867 | 4,537 | 236 | 4,172 |
| **Total** | **136,406** | **102,812** | **1,430,507** | **94,618** | **52,949** | **905,194** |
| **Cardiovascular diseases** | | | | | | |
| Hypertension (401–404) | 17,575 | 3,320 | 51,291 | 25,182 | 2,740 | 36,286 |
| Ischemic heart disease (410–414) | | | | | | |
| Aged 35–64 years | 52,977 | 22,059 | 514,926 | 19,381 | 7,069 | 185,580 |
| Aged ≥65 years | 191,172 | 29,312 | 252,380 | 217,962 | 23,536 | 219,813 |
| Other heart diseases† | 98,088 | 18,822 | 243,327 | 117,645 | 10,546 | 127,756 |
| Cerebrovascular disease (430–438) | | | | | | |
| Aged 35–64 years | 9,726 | 3,898 | 93,903 | 8,103 | 3,586 | 101,493 |
| Aged ≥65 years | 51,369 | 4,697 | 37,751 | 88,452 | 5,264 | 47,581 |
| Atherosclerosis (440) | 6,008 | 1,644 | 14,877 | 10,050 | 883 | 7,925 |
| Aortic aneurysm (441) | 9,971 | 6,489 | 76,568 | 6,201 | 3,135 | 39,655 |
| Other arterial disease (442–448) | 4,716 | 665 | 8,535 | 6,183 | 940 | 12,359 |
| **Total** | **441,602** | **90,906** | **1,293,559** | **499,159** | **57,699** | **778,447** |
| **Respiratory diseases** | | | | | | |
| Pneumonia, influenza (480–487) | 38,295 | 8,802 | 84,878 | 47,420 | 6,774 | 71,255 |
| Bronchitis, emphysema (490–492) | 10,935 | 9,944 | 109,011 | 9,585 | 7,752 | 107,365 |
| Chronic airways obstruction (496) | 42,765 | 34,919 | 353,137 | 39,727 | 29,816 | 379,052 |
| **Total** | **91,996** | **53,665** | **547,026** | **96,731** | **44,342** | **557,672** |
| **Perinatal conditions** | | | | | | |
| Short gestation/low birthweight (765) | 2,198 | 227 | 16,685 | 1,768 | 175 | 13,871 |
| Respiratory distress syndrome (769) | 931 | 85 | 6,273 | 639 | 24 | 1,925 |
| Other respiratory-newborn (770) | 912 | 84 | 6,147 | 645 | 33 | 2,646 |
| Sudden infant death syndrome (798.0) | 1,766 | 202 | 14,805 | 1,197 | 175 | 13,872 |
| **Total** | **5,808** | **599** | **43,910** | **4,249** | **408** | **32,314** |
| **Burn deaths§** | — | 589 | 17,270 | — | 377 | 10,486 |
| **Secondhand smoke deaths¶** | | | | | | |
| Lung cancer | — | 1,110 | — | — | 1,890 | — |
| Ischemic heart disease | — | 14,407 | — | — | 20,646 | — |
| **Overall Total** | | **264,087** | **3,332,272** | | **178,311** | **2,284,113** |

* *International Classification of Diseases, Ninth Revision.*
† Other heart diseases include ICD-9 codes 390–398, 415–417, and 420–429. Totals may not equal sums because of rounding.
§ Reference 6.
¶ Reference 7.

Source: CDC.

Note: This table is taken from page 302 of CDC, "Annual Smoking-Attributable Mortality, Years of Potential Life Lost, and Economic Costs – United States, 1995-1999."

Enclosure II

## CDC's Table Presenting Its Estimates of Smoking-Attributable Mortality-Related Productivity Losses and Medical Expenditures

**TABLE 2. Annual smoking-attributable economic costs for adults and infants — United States, 1995–1999**

| Cost component | Total (in millions) | Per smoker* |
|---|---|---|
| **Adult costs** | | |
| Annual smoking-attributable productivity costs, 1995–1999 | | |
| Men | $55,389 | $2,278 |
| Women | $26,483 | $1,193 |
| **Total** | **$81,872** | **$1,760** |
| Smoking-attributable medical expenditures, 1998† | | |
| Ambulatory care | $27,182 | $584 |
| Hospital care | $17,140 | $368 |
| Prescription drugs | $6,364 | $137 |
| Nursing home | $19,383 | $417 |
| Other care | $5,419 | $116 |
| **Total** | **$75,488** | **$1,623** |
| **Total adult costs** | **$157,360** | **$3,383** |
| **Infant costs** | | |
| Smoking-attributable neonatal medical expenditures, 1996 | $366 | $704 |
| **Total costs** | **$157,726** | **$3,391** |

* Approximately 46.5 million U.S. residents aged ≥18 years smoked in 1999 (24,316,033 men and 22,199,233 women), based on the civilian noninstitutional population and respondents from the 1999 National Health Interview Survey. Smoking-attributable neonatal expenditures are per maternal smoker; average costs per adult smoker were approximately $8. Total productivity costs are weighted averages for men and women. Totals may not equal sum because of rounding.

† Data sources: Expenditure smoking-attributable fractions cited in reference 8 and 1998 personal health-care expenditure data obtained from the Centers for Medicare and Medicaid Services.

Source: CDC.

Note: This table is taken from page 303 of CDC, "Annual Smoking-Attributable Mortality, Years of Potential Life Lost, and Economic Costs – United States, 1995-1999."

 Enclosure III

## Comments from the Centers for Disease Control and Prevention

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
and Prevention (CDC)
Atlanta GA 30333

JUL 11 2003

Ms. Janet Heinrich
Director
Health Care – Public Health Issues
U.S. General Accounting Office
441 G Street, N.W., Mail Drop 5A14
Washington, D.C. 20548

Dear Ms. Heinrich:

The Centers for Disease Control and Prevention (CDC) appreciates the opportunity to review and comment on the U.S. General Accounting Office's (GAO) proposed correspondence entitled *CDC's APRIL 2002 REPORT ON SMOKING: Estimates of Selected Health Consequences of Cigarette Smoking Were Reasonable* (GAO-03-942R).

CDC commends GAO for this well-written report which, in general, accurately represents the intent, methods, and decision-making processes of the April 2002 *Morbidity and Mortality Weekly Report* (MMWR) article on the disease burden of smoking.

Enclosed are CDC's general and technical comments. If you or your staff should have any questions regarding these comments, please contact Ms. Jenelda Thornton of CDC's National Center for Chronic Disease Prevention and Health Promotion. Ms. Thornton may be reached by telephone at 770-488-6417 or by email at JThornton@cdc.gov.

Sincerely,

Julie Louise Gerberding, M.D., M.P.H.
Director

## GAO Contact and Staff Acknowledgments

GAO Contact

Michele Orza, (202) 512-6970

Acknowledgments

The following staff members made important contributions to this work: Angela Choy, Chad Davenport, Maria Hewitt, Donald Keller, and Nkeruka Okonmah.

(290254)

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