

CDC estimates of smoking-related deaths do not add up.

Calculating the 'Big Kill'

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In 1985, the British Medical Association and Health Education Council published *The Big Kill*, a series of booklets estimating the number of people killed by smoking in England and Wales. Assigning a “precise” number of deaths to a risky behavior provided opponents with a powerful and often persuasive weapon. For two decades, the U.S. Centers for Disease Control and Prevention (CDC) has regularly produced an American version of the booklets. The CDC tallies (estimates, actually) are available on the Internet, where visitors can also review other consequences of smoking such as years of life lost, medical expenditures, and productivity losses.

Today, there are mountains of statistics about the health effects of smoking, but the purported mortality figures form the cornerstone of the global campaign against tobacco. The figures provide the justification for tobacco policy at all levels of American government — and for the massive tobacco regulation scheme now being crafted in Congress. A May 2007 *New York Times* editorial typifies the spin that is put on the numbers: “[T]he death toll from cigarette smoking remains disturbingly high.... Tobacco kills 440,000 smokers every year in the United States, and secondhand smoke inhaled by bystanders claims another 50,000.... [T]here is no doubt that the panel’s report strengthens the case for granting the F.D.A. power to rein in one of the most dangerous products ever marketed.”

The *Times* was quoting Big Kill numbers published and heavily publicized by the Institute of Medicine, a part of the prestigious National Academy of Sciences. The problem is that the Institute’s numbers are wrong. For one thing, the CDC had reported that smoking kills 440,000 Americans, including 50,000 from secondhand smoke. The Institute mistaken-



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ly counted the secondhand smoke deaths twice, inflating the numbers by more than 11 percent.

I brought this error to the attention of the Institute report's authors. The essence of their response: Oops, you're right; we'll make the correction in the final, bound report. Never mind that we've generated global headlines with our false data; we're not issuing a corrective press release.

The Institute had issued its report just as Congress began considering a proposal to give the Food and Drug Administration primary regulatory authority for all tobacco products — a move that would likely cost billions and dilute the agency's primary mission of safeguarding the nation's food and drugs. Given the stakes, one would assume the Institute of Medicine would have wanted legislators to have accurate information on the health consequences of smoking.

But how accurate is the underlying CDC estimate of smoking-related deaths? The agency's yearly estimates are rarely disputed, primarily because the supporting data and computations cannot be accessed by anyone outside the CDC or its collaborator, the American Cancer Society. The specifics of the agency's work are shrouded in secrecy. In 1992, a *Detroit*

News reporter documented her quest to understand how the CDC arrives at its estimates. Stymied, she offered this summary: "The computer is fed raw data and... employs various complex mathematical formulas to determine how many people in various age groups, locations, and heaven knows what other categories are likely to get sick or die from what diseases and how many of these can be assumed to be smoking related." In short, the estimate is marginally informative and utterly unsatisfactory.

Americans deserve more disclosure from federal agencies. In a recent study published in *Nicotine and Tobacco Research*, Philip Cole and I developed estimates for America's mortality rate from smoking in 1987 and 2002. Our research shows that the CDC's Big Kill estimates are inflated and that the concept itself is outdated.

This article, which is based on our research, attempts to demystify the secretive CDC process. We provide alternative estimates and propose a dramatic change in how the CDC evaluates the impact of smoking on American society.

SMOKING IS DOWN BUT DEATHS ARE UP?

In addition to its mortality estimates, the CDC regularly reports how many Americans smoke. U.S. smoking rates have been declining almost continuously since the mid-1960s, when 42 percent of American adults smoked. The rate dropped to 28 percent in 1988 and has now declined to 21 percent. Put simply, the proportion of Americans who smoke has been cut in half over the past 40 years.

With smoking rates having declined so dramatically, you would expect that deaths attributable to smoking would have dropped as well. Looking at the CDC reports, it is hard to tell if that has happened. For example, in 1984 when smoking rates had been declining for about two decades, the CDC estimated that 300,000 people suffered smoking-related deaths. Smoking continued to decline, but mortality figures rose, peaking in the late 1980s at 426,500. As of 2001 (the latest estimate available from the CDC), the Big Kill stood at 394,500, only an 8 percent decline from its peak.

The CDC numbers seem out of line with other evidence. U.S. heart disease death rates have been plummeting for decades. A recent study published in the *New England Journal of Medicine* estimated that 35,000 fewer smokers died from heart disease in 2000 than in 1980. The unprecedented drop in American cancer deaths since 1991 has been fueled by declining rates of lung cancer, the sentinel disease of smoking.

ESTIMATING THE BIG KILL

Did 426,000 people suffer smoking-related deaths in 1987 as the CDC says, or was the number really 402,000 — more than five percent less? And did the CDC inflate the total to 400,000 in



2002, when it actually dropped to 322,000 — nearly 20 percent less?

Cole and I reported the lower estimates in our *Nicotine and Tobacco Research* article. While we used methods similar to those of the CDC, there are some obvious differences in our approach that account for differences in our estimates. We did much more than merely count dead smokers; we demonstrated that smoking as a cause of death in American society declined about 35 percent between 1987 and 2002.

Most Americans do not understand how Big Kill numbers are generated. Some might think that every time someone dies in the United States (2.5 million times a year), the CDC searches for the “smoking gun.” In fact, each death is certified by a physician who lists an underlying cause of death on the death certificate. While there are hundreds of specific causes to choose from, cigarette smoking is not one of them. So how does the CDC determine that smoking kills 400,000 Americans a year?

The number of smoking-related deaths is an estimate because smokers die from cancer, heart attacks, car accidents, and every other cause on the big list, just like nonsmokers. The estimate is derived using data from the National Health Interview Survey, the American Cancer Society, and the CDC. There are two important steps — counting current and former smokers, and developing a model that attributes deaths among smokers to smoking as opposed to all other causes.

Table 1

Current Smokers, Former Smokers, and Lifelong Nonsmokers (In millions)

Age 35+ years in the United States, 1987 and 2002

| 1987 | | | |
|-----------------------|------|-------|-------|
| Smoking status | Men | Women | Both |
| Current smokers | 15.1 | 14.2 | 29.3 |
| Former smokers | 20.1 | 11.7 | 31.8 |
| Years since quitting: | | | |
| 0–4 | 4.6 | 3.5 | 8.1 |
| 5–14 | 5.9 | 4.0 | 9.9 |
| 15+ | 9.6 | 4.2 | 13.8 |
| Lifelong nonsmokers | 15.0 | 32.6 | 47.6 |
| All | 50.2 | 58.5 | 108.7 |
| 2002 | | | |
| Smoking status | Men | Women | Both |
| Current smokers | 15.5 | 14.1 | 29.6 |
| Former smokers | 22.5 | 17.4 | 39.9 |
| Years since quitting: | | | |
| 0–4 | 3.6 | 3.1 | 6.7 |
| 5–14 | 5.4 | 4.7 | 10.1 |
| 15+ | 13.5 | 9.6 | 23.1 |
| Lifelong nonsmokers | 31.6 | 46.1 | 77.7 |
| All | 69.6 | 77.6 | 147.2 |

COUNTING SMOKERS In order to estimate how many smokers died in 1987 and 2002, the first task is to determine how many Americans smoked during those years. We counted current and former smokers using the same method as the CDC — using information provided annually by the National Health Interview Survey. The survey, which is designed to be representative of the U.S. population, defines current smokers as those who have smoked at least 100 cigarettes in their lifetime and who were smoking at the time they completed the survey. It is important to count men and women smokers separately because men are heavier smokers than women and therefore have higher risks of dying. Additionally, it is important to group smokers by age because older smokers have accumulated more risk from smoking than younger smokers. We used 10-year age groups starting with 35–44 years (the last group was 85+ years). We did not consider younger smokers because the risk of death from smoking-related causes for people under age 35 is negligible.

Because former smokers are also at risk of dying from a smoking-related illness, it is important to estimate their number accurately. We used the survey definition: former smokers had smoked 100 cigarettes, or five packs, in their lifetime, and were not smoking at the time of the survey. But counting former smokers is more complicated than counting current smokers. In addition to grouping them by gender and age, it is important to know how much time had passed since former smokers quit. For example, those who quit recently have risks similar to those of current smokers, whereas those who quit long ago have risks similar to those of lifelong nonsmokers. There are now more former smokers in the United States than current smokers, so how they are managed heavily influences mortality estimates.

Table 1 shows the number of current and former smokers and lifelong nonsmokers in the United States in 1987 and 2002. Although the number of current smokers is virtually unchanged between the two years, the age distribution is different. In 1987, 36 percent of current smokers were older (55+ years), but this group declined to 28 percent of the total by 2002. In short, there were almost 2.1 million fewer smokers age 55+ in 2002 than in 1987. This is important because fewer smokers at older ages means fewer deaths attributable to smoking.

The number of former smokers increased moderately from 31.8 million in 1987 to 39.9 million in 2002. However, the distribution of the former smokers, with respect to their age and how long ago they quit, changed considerably. The number of former smokers quitting less than five years ago actually declined from 8.1 million in 1987 to 6.7 million in 2002. The proportion of this group who were older declined from 43 percent to 41 percent, a decrease of 770,000. There was little change in the number of former smokers who quit from five to 14 years ago (9.9 million in 1987, 10.1 million in 2002) and the proportion of this group who were older increased slightly from 45 percent to 48 percent. However, the biggest changes occurred among former smokers who quit 15 years ago or more. Their numbers increased from 13.8 million in 1987 to 23.1 million in 2002. The proportion of this group who were older increased marginally from 65 percent in 1987 to 68 percent in 2002.

ESTIMATING DEATHS The next step is to develop a system for estimating how many smokers die each year. First, we have to know how much more likely it is that any given smoker or former smoker will die, compared to a nonsmoker, when other factors are mostly comparable. The best way to get information on the relative risk of dying is to prospectively collect information about diet, lifestyle, education, and other factors on a large number of Americans and wait for them to die. In 1982, the American Cancer Society did just that, gathering information on some one million Americans in its second cancer prevention survey, called CPS-II. In 1988, the Cancer Society determined how many participants in their survey had died. They calculated the rate at which deaths occurred (depending on gender and age) among current and former smokers compared with the rate among lifelong nonsmokers. Those death rates among current and former smokers are used by the CDC to estimate the number of deaths attributable to smoking each year. The Cancer Society provided us with the relative risk numbers in 1999 but later refused to give us additional information.

Although the CDC does not provide specific information about how the agency estimates deaths among smokers, our model is conceptually straightforward. For each group of smokers (e.g., men age 45–54), the number of deaths is calculated twice: first by applying the lifelong nonsmoker death rate, then by applying the smoker death rate. The number of “excess” deaths among smokers at the smokers’ rate, compared to the number of deaths that would have occurred if they had been lifelong nonsmokers, is the number of smoking-attributable deaths.

The same general approach can be used to estimate smoking-attributable deaths among former smokers, but the specific process is much more complicated. The CDC counts people who smoked at least 100 cigarettes (and are not currently smoking) as former smokers, but this definition is rather unrestrictive because it includes even transient or experimental smokers who quit decades ago (their risks are very low to nonexistent) as well as those who are older and quit recently (their risks are still high).

We designed a solution to this problem using information from the national survey about how recently former smokers had quit. We assumed that former smokers who quit less than five years ago had the death rates of current smokers. People who quit smoking 15 or more years ago probably died at rates similar to those of lifelong nonsmokers. Hence, our model categorized “former smokers” as those who quit smoking between five and 14 years ago. Our approach was based on risk estimates from other studies.

We estimated that there were 402,000 deaths attributable to smoking in 1987, of which 266,000 involved current smokers and 136,000 involved former smokers (Table 2). The CDC estimate for that year was about 426,000. By 2002, our smoking mortality estimate declined by 20 percent to 322,000, including 212,200 deaths among current smokers and almost 90,000 among former smokers. Yet the CDC estimate remained close to 400,000.

THE DIFFERENCES

Why have the CDC estimates not fallen? It is difficult to say, primarily because neither the CDC nor the American Cancer

Table 2

Smoking-Related Deaths (1987 and 2002)

Rodu-Cole and CDC estimates

| 1987 | Rodu-Cole | CDC |
|------------------------------|------------------|---------------|
| MEN | 284,800 | 283,100 |
| Current smokers | 182,400 | Not available |
| Former smokers | | |
| Years since quitting: | | |
| 0-4 | 67,700 | Not available |
| 5-14 | 34,700 | Not available |
| WOMEN | 117,100 | 143,400 |
| Current smokers | 83,600 | Not available |
| Former smokers | | |
| Years since quitting: | | |
| 0-4 | 22,600 | Not available |
| 5-14 | 10,900 | Not available |
| MEN AND WOMEN | 401,900 | 426,500 |
| 2002 | Rodu-Cole | CDC |
| MEN | 221,900 | 240,300 |
| Current smokers | 146,800 | Not available |
| Former smokers | | |
| Years since quitting: | | |
| 0-4 | 46,200 | Not available |
| 5-14 | 28,900 | Not available |
| WOMEN | 100,200 | 154,200 |
| Current smokers | 65,400 | Not available |
| Former smokers | | |
| Years since quitting: | | |
| 0-4 | 21,700 | Not available |
| 5-14 | 13,100 | Not available |
| MEN AND WOMEN | 322,100 | 394,500 |

Society will share their underlying data with outside researchers. Instead, the agency takes a black-box approach, filtering mortality information through its online program. This government secrecy is unacceptable.

Table 3 shows the gaps in information about the CDC methodology. As I mentioned previously, there is virtually no information about how the CDC estimates smoking-related death rates among former smokers. The major problem is discrepant definitions of former smokers. The CDC counts people who smoked at least 100 cigarettes (and are not currently smoking) as former smokers, but this definition is rather unrestrictive because, as already noted, it includes even transient or experimental smokers. In contrast, the Cancer Society CPS-II survey — the source of risk estimates for CDC mortality figures — defined former smokers as having smoked at least once daily for a year or more.

This is a vital issue because small variations in the definition of, and in the risk formula for, nearly 40 million former smokers can cause smoking-related mortality estimates to

change by tens of thousands of deaths. In the course of our research we asked the agency to provide us with separate estimates of deaths among current smokers and former smokers. The CDC replied that “data are not available for former or current smokers separately.” It is inconceivable that the CDC does not calculate mortality estimates separately for current and former smokers, so it seems the agency was simply refusing to disclose the information.

Our model is straightforward because it employed a relative risk for all causes of death combined. We applied this risk uniformly so that our estimates from 1987 and 2002 are fully comparable. In sharp contrast, the CDC model is far more complicated because it includes relative risks for as many as 19 individual diseases that the agency considers to be smoking-related. Over time, the CDC has changed both the disease list and the relative risks assigned to most diseases. For example, comparison of CDC relative risks from 1988 with those from its current website reveals that almost all of them have changed. The website also indicates that the current relative risks are “unpublished estimates provided by the American Cancer Society.” Translation: The estimates have never been submitted for peer review by scientists unaffiliated with the Cancer Society or the CDC, and they have not been published in the scientific literature. Some of the risks went up from 1988 to 2007, others went down, but the result is that year-to-year comparisons of CDC estimates are meaningless. In order to report the Big Kill in an accurate and informative fashion, the CDC should have established a model and applied it consistently every year. If the CDC wanted to revise the model, then the agency should have revised it for all years.

Table 3

Big Differences

Why Rodu-Cole estimates differ from CDC estimates

| Steps | Rodu-Cole | CDC |
|-----------------------------------|-----------------------|-----------------------|
| Counting current smokers | | |
| Source | NHIS Survey | NHIS Survey |
| Men and women | Counted separately | Counted separately |
| Age | 10-year age groups | Not specified |
| Counting former smokers | | |
| Source | NHIS Survey | NHIS Survey |
| Men and women | Counted separately | Counted separately |
| Age | 10-year age groups | Not specified |
| Years since quitting | 1-4, 5-14, 15+ | No information |
| Assigning risks | | |
| Source | ACS CPS-II, 1982–1988 | ACS CPS-II, 1982–1988 |
| Measure | All-cause mortality | 19 separate diseases |
| Changes over time | None | Numerous, unclear |
| Computing deaths | | |
| Men and women | Counted separately | Counted separately |
| Age | 10-year groups | Not specified |
| Current vs. former smokers | Specified | Not specified |

Table 4

Mortality Rates*

For men and women age 35+ in the United States, 1987 and 2002, according to cause

| Men | | | | |
|---------|-------|-------|------------------------|---------|
| Cause | 1987 | 2002 | 1987–2002 Decline Rate | Percent |
| Smoking | 556 | 329 | 227 | 41 |
| Other | 1,746 | 1,555 | 191 | 11 |
| All | 2,302 | 1,884 | 418 | 18 |
| Women | | | | |
| Cause | 1987 | 2002 | 1987–2002 Decline Rate | Percent |
| Smoking | 175 | 122 | 53 | 30 |
| Other | 1,271 | 1,224 | 47 | 4 |
| All | 1,446 | 1,346 | 100 | 7 |

*Deaths per 100,000 per year, adjusted to the U.S. 2000 Standard population.

MISLEADING AND PRACTICALLY USELESS

Even if the CDC estimates had been fully comparable from year to year, raw death counts themselves are potentially misleading and they should not form the basis of public policy. The National Center for Health Statistics (NCHS) is the federal agency in charge of tracking deaths from various causes. The agency understands that simply counting the number of deaths provides little meaningful information about the pattern of deaths over time because a count does not capture information on the age structure of the population or the age at which the deaths occurred. For example, about 2.1 million Americans died in 1987. By 2002, over 2.4 million died, which appears to be an alarming 14 percent increase. But there were 46 million more Americans living in 2002 than in 1987, and on average they were older. Taking those facts into consideration, the rate at which Americans died in 2002 was actually 13 percent lower than in 1987, indicating an overall improvement in health and life expectancy over the 15-year period.

The NCHS, which is affiliated with the CDC, uses these factors in calculating mortality rates. It is disappointing that the CDC has not adopted this practice in reporting smoking-related mortality. We believe age-adjusted mortality rates, which are reported as the number of deaths among 100,000 persons per year, provide the most accurate information about the effects of smoking on American society. We thus estimated similar rates, which appear in Table 4.

In 1987, the death rate among American men age 35 and older was 2,302 per 100,000 per year. We calculate that smoking was responsible for 556 of those

deaths, about 24 percent. By 2002, the overall death rate had declined by 18 percent to 1,884. But the death rate from smoking had declined by 41 percent to 329, and smoking accounted for only 17 percent of deaths among men. In 1987, the death rate among American women age 35 and older was 1,446 per 100,000 per year, and smoking was responsible for 175 of those deaths, about 12 percent. By 2002 the overall death rate had declined by 7 percent to 1,346. But the death rate from smoking had declined by 30 percent to 122, and smoking accounted for only 9 percent of deaths among women.

CONCLUSION

In the United States, the impact of smoking as a cause of death is waning. Between 1987 and 2002, the contribution of smoking to American deaths declined by 35 percent. The reason is that there are now fewer current and recent former smokers, especially at older ages when smoking takes a higher toll. In

fact, the decline in deaths from smoking is so large that it dwarfs the decline in other causes of death.

The data and methods that the CDC uses to generate Big Kill estimates should no longer be treated like state secrets. In 2003, the National Institutes of Health established a policy that requires university researchers to release and share research data from NIH-supported studies for use by other researchers. According to the policy, "data sharing is essential for expedited translation of research results into knowledge, products, and procedures to improve human health." The same policy should apply to federal agencies. Americans deserve to be fully informed about the health risks related to smoking. In order for that to happen, the CDC must release publicly the data and methods it uses to estimate the Big Kill. **R**

Readings

- "Cigarette Smoking and Mortality Risk: Twenty-Five-Year Follow-Up of the Seven Countries Study," by D.R. Jacobs Jr., H. Adachi, I. Mulder, et al. *Archives of Internal Medicine*, Vol. 159 (1999).
- "Declining Mortality from Smoking in the United States," by Brad Rodu and Philip Cole. *Nicotine and Tobacco Research*, Vol. 9 (2007).
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- "Explaining the Decrease in U.S. Deaths from Coronary Disease, 1980–2000," by E.S. Ford, U.A. Ajani, J.B. Croft, et al. *New England Journal of Medicine*, Vol. 356, (2007).
- "Mortality in Relation to Smoking: 50 Years' Observations on Male British Doctors," by R. Doll, R. Peto, J. Boreham, and I. Sutherland. *British Medical Journal*, Vol. 328 (2004).

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