Estimating Deaths Attributable to Obesity in the United States

Estimates of deaths attributable to obesity in the United States rely on estimates from epidemiological cohorts of the relative risk of mortality associated with obesity. However, these relative risk estimates are not necessarily appropriate for the total US population, in part because of exclusions to control for baseline health status and exclusion or underrepresentation of older adults.

Most deaths occur among older adults; estimates of deaths attributable to obesity can vary widely depending on the assumptions about the relative risks of mortality associated with obesity among the elderly. Thus, it may be difficult to estimate deaths attributable to obesity with adequate accuracy and precision. We urge efforts to improve the data and methods for estimating this statistic. (*Am J Public Health.* 2004;94:1486–1489)

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The increasing prevalence of obesity over the last 2 decades has generated considerable concerns about its health burdens. It is frequently stated in scientific and lay literature that obesity causes about 300 000 deaths per year in the United States.[1–5] It has been suggested that obesity is second only to smoking as a preventable cause of death.[1,3]

Many methodological and conceptual difficulties arise in attempting to estimate the number of deaths in the United States that are attributable to obesity. The concept of a death being "attributable" to obesity generally relies on a statistical excess of deaths among people who are obese, relative to people who are nonobese, rather than on identifying obesity as the specific cause of death for an individual. Obesity itself may not be the only contributing factor to this statistical excess, but rather a marker for other factors such as sedentary behavior or adverse body fat distribution. Existing estimates of deaths attributable to obesity[5] are based on body mass index (BMI; defined as weight in kilograms divided by height in meters squared). BMI is correlated with body fat and is the measure recommended by a National Heart, Lung, and Blood Institute expert committee for use in clinical practice and epidemiological studies.[6] In this article, we restrict our discussion to the context in which obesity is defined by BMI and relative risk estimates from epidemiological cohorts are used to generate estimates of the number of deaths owing to obesity. We discuss some of the issues involved in finding appropriate relative risks to apply to the US population. Attempts to control for confounding by baseline health status affect estimates of the relative risk associated with obesity and thus estimates of deaths attibutable to obesity. Estimates of deaths owing to obesity are particularly sensitive to the precision and accuracy of estimates of relative risk in the elderly.

THE EPIDEMIOLOGICAL APPROACH

Epidemiologists make probabilistic estimates of the risks of death attributable to obesity. Observational prospective cohort studies estimate the relative risk of mortality associated with obesity by comparing the mortality rate in the obese group to the mortality rate in a nonobese referent group. Excess deaths in the obese group are considered to be attributable to obesity. Obesity is generally defined as a BMI of 30 or higher, although a variety of BMI categories may be used.

By combining estimates of the prevalence of obesity with estimates of the relative risk of mortality associated with obesity, the population attributable fraction (PAF)—that is, the proportion of deaths attributable to obesity in the population—can be calculated by the formula

$$(1) \qquad PAF = P(E) \times (RR-1) / [1+P(E) \times (RR-1)]$$

where P(E) is the prevalence of exposure (in this case, obesity) and RR is the unadjusted relative risk of mortality associated with obesity.[7] The number of deaths attributable to obesity in the population in a specified time period is then calculated by multiplying the population attributable fraction by the total number of deaths in the population in that time period. Division into finer categories of BMI and more complex methods of estimating relative risk can be used, but the general principles remain the same.

Estimating annual deaths attributable to obesity in the US population requires information on the number of deaths in a given year, the prevalence of obesity, and the relative risk of mortality associated with obesity in the US population. The total number of deaths can be obtained from US vital statistics data.[8] The prevalence of obesity can be estimated from National Health and Nutrition Examination Survey (NHANES) data,[9] at least for the civilian noninstitutionalized population. The major source of uncertainty arises in the choice of appropriate relative risks for the US population.

Relative risk estimates vary from study to study, depending on the characteristics of the study population and on the reference and exposure categories chosen. Estimates of the relative risk of total mortality associated with obesity tend to fall in the range of approximately 1.0 to 2.0. However, within this range of relative risks the exact values

and even the precision of the estimate can make a considerable difference in estimated numbers of deaths attributable to obesity. For example, in the large Nurses Health Study of 115 195 women, the 95% confidence interval for the multivariate mortality relative risk for obesity (BMI ≥ 32 relative to BMI < 19.0) was 1.3 to 1.7.[10] Within this narrow confidence interval, the number of deaths attributable to obesity for a relative risk of 1.7 would be approximately double the number for a relative risk of 1.3, regardless of the prevalence of obesity.

CONTROL FOR CONFOUNDING BY BASELINE HEALTH STATUS

Most epidemiological studies of obesity and mortality attempt to isolate the effects of obesity by controlling for the effects of smoking and baseline health status on mortality. Such studies often exclude deaths that occur early in the follow-up period, which are thought to be potentially owing to preexisting illnesses, and exclude participants with specific health conditions at baseline.[5,10–12] Most studies exclude from analysis those with conditions such as heart disease or cancer at baseline, and they often exclude current smokers and sometimes former smokers. Many studies, including NHANES I and II, also exclude from sample selection people who are hospitalized or in nursing homes or who are older than a specified age. Persons excluded from epidemiological studies are often those at highest risk of death and may also be those most likely to die of factors unrelated to obesity.

Ironically, efforts to control for health status as a confounder of the relationship between obesity and mortality are at odds with a key assumption in estimating the number of deaths attributable to obesity in the United States: that the mortality relative risk for obesity is an appropriate estimate for the *entire* US population. Excluding those at highest risk of death may be appropriate to obtain internally valid estimates of the mortality relative risk for obesity in *otherwise healthy persons*. However, such exclusions result in estimates of the relative risk associated with obesity that apply only to a subgroup of the population and cannot necessarily be extrapolated to deaths in the entire population.

Empirical data suggest that the net effect of such exclusions may be to change the apparent relative risk of mortality in the obese. For example, in the Nurses Health Study, the age-adjusted relative risk of death among the obese (BMI = 29.0–31.9), relative to those with a BMI of less than 19, was 1.1 in the total study sample, but after current and former smokers were excluded the relative risk rose to 1.8.[10] Similarly, in the Cancer Prevention Study II, "limiting the primary analyses to subjects who had never smoked and who had no history of disease at enrollment. . . increased the risk [of death] among heavy persons."[11(p1103)] The exclusions may also make the mortality experience of the sample different from the mortality experience of the population. For example, in the Health Professionals Follow-Up Study, after exclusions, only 18% of the deaths in the study sample are attributable to cardiovascular disease, although nationally about 40% of deaths are attributable to cardiovascular disease.[12]

TABLE 1—Proportion of Population, Number of Deaths, and Prevalence of Obesity, by Age Group: United States, 1991

Age Group, y	% of Population Aged ≥ 25[13]	No. (%) of Deaths Among Adults[8]	Prevalence of Obesity, %[a]
25–64	73.6	516 484 (24.8)	23.6
65–79	21.9	780 458 (37.5)	24.2
≥ 80	4.5	783 069 (37.6)	12.7
Total (≥ 25)		2 080 011	

[a]Calculated from National Health and Nutrition Examination Survey III data.[9]

AGE AND MORTALITY RELATIVE RISK

Most deaths in adults occur in older persons. As shown in Table 1, of the more than 2 million deaths among US adults aged 25 and older in 1991, approximately 1.6 million deaths occurred among persons aged 65 years and older. This represents 75% of all deaths among adults. Almost 800 000 deaths, 37.5% of all deaths among adults, occurred in those aged 80 years and older.[8] Because of the large number of deaths among older persons, the estimates of relative risks for older persons will have a major impact on any estimate of the number of deaths associated with obesity.

Studies that examine age-specific mortality relative risks for obesity have generally found that relative risks decrease with increasing age.[11,12,14–17] For example, in a nationally representative cohort of civilian, noninstitutionalized US adults aged up to 74 years at baseline, Davis and colleagues[14] found that for women aged 45 to 54, 55 to 64, and 65 to 74 years, the mortality relative risks for obesity were 2.0, 1.6, and 0.9, respectively. The corresponding relative risks for men were 1.4, 1.2, and 1.1. A recent systematic review[18] found that of the 7 prospective studies of body weight and mortality in elderly persons that met specified review criteria, only 2 showed a positive association between all-cause mortality and BMI, and of those 2, 1 found no association for those aged 75 years and older. The other 5 studies found no association or a significant negative association. Many other studies suggest that high body weight may not be an important adverse prognostic factor for mortality in the elderly.[19–33]

Although the reasons for the observed reduction in relative risk associated with obesity at older ages are not known, it has been suggested that in old age the protective effects of obesity might counterbalance some negative effects.[19] The potential protective effects of obesity include greater nutritional reserves in times of stress, lower rates of injury from falls, and lower rates of osteoporosis. Another possible explanation is that weight loss occurring in old age masks the lifetime risks of obesity. Since weight loss is itself associated with increased mortality in many studies, the effects of weight change are difficult to disentangle from the effects of previous weight. However, in a cohort of people aged 65 to 100 years at baseline, after excluding those who had lost 10% or more of

their body weight since age 50, there was still no relation between high BMI and mortality.[19] This cannot be attributed to the masking effect of weight loss, since those who lost weight were excluded.

Allison and colleagues[5] estimated the number of deaths attributable to obesity in the United States using data from 6 large prospective cohort studies. For each cohort, they estimated an overall mortality relative risk (hazard ratio), adjusted for age, sex, and smoking. They argued that if the cohort included a cross section of ages, these adjusted risks would generate the same number of attributable deaths as would be obtained by calculating relative risks and attributable fractions separately for each age group and summing across the age groups. However, this approach to calculating deaths attributable to obesity did not fully allow for age as a confounder (associated both with mortality and with obesity) or as an effect modifier (the relative risk varies with age),[7,34,35] and thus it is unlikely to adequately account for the differential effects of age on the mortality relative risk for obesity.

To demonstrate the potential impact of various relative risks on estimates of deaths attributable to obesity in the United States, we used 3 age groups (25–64, 65–79, and ≥80 years) and derived the number of deaths and the prevalence of obesity (BMI≥30) within each age group, using 1991 US vital statistics data and NHANES III data on obesity, shown in Table 1. The "older elderly"—those aged 80 years and older—represent a relatively small proportion of the population (<5%), but they contribute a high proportion of deaths (almost 38%). We arbitrarily varied mortality relative risks over the range of 1.2 to 2.0 for the younger group and the range of 1.0 to 1.8 for the older groups; these relative risks represent a broad range of typical relative risks from the literature. (For example, in the 6 cohorts used by Allison et al.,[5] the adjusted relative risks for a BMI of 30 or above, relative to a lower BMI, ranged from 1.38 to 1.58 when the reference category was a BMI of less than 30, and from 1.41 to 1.60 when the reference category was a BMI of less than 25.) We used the formula for population attributable fraction shown above under "The Epidemiological Approach," calculated the number of deaths attributable to obesity within each age group, and summed the results over age. This approach allows for confounding and effect modification by age group.[34]

We calculated the estimated numbers of deaths associated with obesity for each combination of relative risk estimates (Table 2). The purpose of these calculations is only to provide simplified examples that show how sensitive estimates of obesity-attributable deaths could be to relatively small variations in the estimates of relative risks used, particularly for the elderly. These calculations are not intended to provide estimates for the US population. To arrive at US population estimates would require more complex calculations, taking into account variations in risk associated with other factors, as well as with age, and allowing for more categories of BMI. However, the results suggest how variable the estimated number of deaths attributable to obesity could be, even within a rather narrow range of assumptions. Even within these narrow ranges of relative risk estimates, we observed over a 10-fold difference in the magnitude of the estimates, from 23 313 to 297 835 deaths, depending on the age-specific mortality relative risks. In these examples, variation in the relative risks for the elderly had a greater impact on the estimated numbers of deaths than did variation in the relative risks for younger persons. For any given relative risk among those aged 25 to 64, variation in the relative risks for older people by 0.8 could add or subtract almost 200 000 obesity-attributable deaths.

CONCLUSION

To estimate total deaths associated with obesity, it is preferable for mortality relative risks to be based on samples of persons representative of the mortality experience in the United States as a

TABLE 2—Examples of Variation in Estimated Number of Deaths Attributable to Obesity for Different Combinations of Relative Risk Estimates for Different Age Groups

	Estimated No. of Deaths Attributable to Obesity								
RR, Ages 25–64 y	RR = 1.0 for 65–79 y, RR = 1.0 for ≥80 y	RR = 1.2 for 65–79 y, RR = 1.2 for ≥80 y	RR = 1.4 for 65–79 y, RR = 1.4 for ≥80 y	RR = 1.6 for 65–79 y, RR = 1.6 for ≥80 y	RR = 1.8 for 65–79 y, RR = 1.8 for ≥80 y	RR = 1.2 for 65–79 y, RR = 1.0 for ≥80 y	RR = 1.4 for 65–79 y, RR = 1.0 for ≥80 y	RR = 1.6 for 65–79 y, RR = 1.0 for ≥80 y	RR = 1.8 for 65–79 y, RR = 1.0 for ≥80 y
1.2	23 313	78 829	130 215	177 943	222 411	59 397	92 292	122 402	150 068
1.4	44 612	100 128	151 514	199 242	243 710	80 696	113 591	143 701	171 367
1.6	64 147	119 664	171 050	218 777	263 246	100 231	133 126	163 237	190 902
1.8	82 130	137 646	189 032	236 760	281 228	118 214	151 109	181 219	208 885
2.0	98 737	154 253	205 639	253 367	297 835	134 821	167 716	197 826	225 492

Note. RR = relative risk.
Population attributable fraction (PAF) was calculated for each age group by the formula PAF = P(E) × (RR-1)/[1+P(E) × (RR-1)], where P(E) is the prevalence of exposure (in this case, obesity) and RR is the relative risk of mortality associated with obesity for that age group. Number of deaths was calculated by multiplying the number of deaths within each age group in the 1991 US population by the PAF for that group and summing the results.

whole, rather than only the mortality experience of selected subgroups. Exclusions by baseline health status, smoking, age, or other factors may make relative risks derived from epidemiological cohorts inappropriate for the whole population. Because most deaths occur among older adults, estimates of the number of deaths attributable to obesity are sensitive to estimates of relative risk among the elderly. To arrive at an accurate and precise estimate of the number of deaths attributable to obesity is likely to require more accurate and precise age-specific estimates of mortality relative risks for older adults than those presently available. Even from large cohort studies, it is difficult to estimate relative risks in the elderly with sufficient precision to give reliable estimates of the number of deaths. If relative risk estimates are derived from studies of predominantly middle-aged cohorts but then applied to all deaths, the resulting estimate could be biased, because many studies suggest that the relative risk of mortality associated with obesity is lower in the elderly. Methods of estimating deaths attributable to obesity should adequately allow for variation in the relative risks with age.

We have identified important limitations in the data that are currently available to estimate the number of deaths in the United States that are attributable to obesity. Our examination suggests that given present knowledge about the epidemiology of obesity, and especially the impact of age on mortality risks associated with obesity, it may be difficult to develop accurate and precise estimates. We urge caution in the use of current estimates of the number of deaths attributable to obesity and also urge researchers to devote greater efforts to improve the data and methods used to estimate this important public health statistic. ■

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Contributors

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Human Participant Protection

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