Excess Deaths Associated With Underweight, Overweight, and Obesity

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AS THE PREVALENCE OF OBE-sity increases in the United States,[1,2] concern about the association of body weight with excess mortality has also increased. However, estimating deaths attributable to overweight and obesity in the US population raises complex methodologic issues.[3,4] In several previous studies,[5-7] relative risk estimates from epidemiologic cohort studies were combined with estimates of the prevalence of overweight and obesity from national surveys to calculate the fraction of deaths attributable to overweight and obesity. It is important to adjust relative risk estimates for confounding factors such as age and smoking that are associated with obesity and mortality.[8,9] When relative risks are adjusted for confounding factors, the use of properly adjusted estimators of attributable risk is necessary to avoid bias.[8,9]

Previous estimates[5,7] of deaths associated with obesity in the United States used adjusted relative risks in an attributable fraction formula appropriate only for unadjusted relative risks and thus only partially adjusted for confounding factors, did not account for variation by age in the relation of body weight to mortality, and did not include measures of uncertainty in the form of SEs or confidence intervals (CIs). Previous estimates used data from a variety of studies to estimate relative risks, but

See also pp 1868 and 1918.

Context As the prevalence of obesity increases in the United States, concern over the association of body weight with excess mortality has also increased.

Objective To estimate deaths associated with underweight (body mass index [BMI] <18.5), overweight (BMI 25 to <30), and obesity (BMI ≥30) in the United States in 2000.

Design, Setting, and Participants We estimated relative risks of mortality associated with different levels of BMI (calculated as weight in kilograms divided by the square of height in meters) from the nationally representative National Health and Nutrition Examination Survey (NHANES) I (1971-1975) and NHANES II (1976-1980), with follow-up through 1992, and from NHANES III (1988-1994), with follow-up through 2000. These relative risks were applied to the distribution of BMI and other covariates from NHANES 1999-2002 to estimate attributable fractions and number of excess deaths, adjusted for confounding factors and for effect modification by age.

Main Outcome Measures Number of excess deaths in 2000 associated with given BMI levels.

Results Relative to the normal weight category (BMI 18.5 to <25), obesity (BMI ≥30) was associated with 111 909 excess deaths (95% confidence interval [CI], 53 754-170 064) and underweight with 33 746 excess deaths (95% CI, 15 726-51 766). Overweight was not associated with excess mortality (−86 094 deaths; 95% CI, −161 223 to −10 966). The relative risks of mortality associated with obesity were lower in NHANES II and NHANES III than in NHANES I.

Conclusions Underweight and obesity, particularly higher levels of obesity, were associated with increased mortality relative to the normal weight category. The impact of obesity on mortality may have decreased over time, perhaps because of improvements in public health and medical care. These findings are consistent with the increases in life expectancy in the United States and the declining mortality rates from ischemic heart disease.

the studies had some limitations. Four of 6 included only older data (2 studies ended follow-up in the 1970s and 2 in the 1980s), 3 had only self-reported weight and height, 3 had data only from small geographic areas, and 1 study included only women. Only 1 data set, the National Health and Nutrition Examination Survey (NHANES) I, was nationally representative.

The objective of this study was to estimate deaths associated with underweight, overweight, and obesity in the United States in 2000 by using all available mortality data from the NHANES

and to offer an assessment of the uncertainty of those estimates.

We used a different approach from that used previously. Our method was derived from the methods used with the

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Gail model[10,11] for predicting breast cancer risk. This method allows us to account for confounding and effect modification, and we provide SEs for the estimates. We also use only data from nationally representative samples with measured heights and weights. We use this approach to make estimates of excess deaths associated with different levels of body weight in the United States in 2000.

METHODS

All data in this report come from the series of NHANES surveys conducted by the National Center for Health Statistics. In each survey, a different nationally representative cross-sectional sample of the US population was interviewed and examined. To estimate relative risks, we used baseline data from NHANES I (1971-1975), NHANES II (1976-1980), NHANES III (1988-1994), and the subsequent mortality data through 1992 for NHANES I and NHANES II and through 2000 for NHANES III.[12-18] Data from NHANES 1999-2002 were used to estimate the current distribution of body mass index (BMI) and other covariates. In each survey, height and weight were measured with standardized procedures. Body mass index was calculated as weight in kilograms divided by the square of height in meters.

We calculated relative risks (hazard ratios) using Cox proportional hazard models with age as the time scale.[19] Because the proportional hazards assumption was not met across age, for each survey we divided the data into 3 age strata: 25 to younger than 60 years, 60 to younger than 70 years, and 70 years or older and fit models separately within each age stratum. According to federal guidelines,[20] a normal weight for adults is defined as a BMI from 18.5 to less than 25, overweight as a BMI 25 to less than 30, and obesity as a BMI of 30 or greater, divided into grade 1 (BMI 30 to <35), grade 2 (35 to <40) and grade 3 (BMI 40 or greater) obesity. For analysis, we grouped BMI as follows: less than 18.5, 18.5 to less than 25 (reference category), 25 to less than 30, 30 to less than 35, and 35 or greater. In this report, we use the term *underweight* for BMI less than 18.5. The final model included BMI categories, sex (male, female), smoking status (never, former, current), race (white, black, other), and alcohol consumption categories (0, <0.07, 0.07 to <0.35, ≥0.35 oz/d). Race and ethnicity were assessed by interviewer observation or self-report in NHANES I and II and by self-report in NHANES III and NHANES 1999-2002. For NHANES 1999-2002, no separate race variable was available, and for analytic purposes non-Hispanic whites, Mexican Americans, and other Hispanics were grouped together as "white," non-Hispanic blacks were considered "black," and all others, including multiracial participants, were grouped as "other."

To calculate the proportion of deaths in 2000 attributable to each BMI level, we first calculated the relative risks from the NHANES I, NHANES II, and NHANES III mortality studies and from a data set that combined data from all 3 surveys. Estimates were made from the combined data to obtain more precision and to represent the US population during the 20-year period covered by these surveys. We then applied each set of relative risks in turn to the current distribution of the covariates (BMI group, sex, smoking status, race, and alcohol consumption) in the general population, which was estimated from the NHANES 1999-2002 cross-sectional survey data.

Within each survey and age group, we calculated the relative risk r_i corresponding to each combination, i, of BMI level and the levels of the other covariates. From the NHANES 1999-2002 cross-sectional survey data, we estimated the corresponding prevalence of the risk-factor combination, p_i. The mortality rate for a given age group is $R = I\Sigma r_i p_i$, where I is the population baseline mortality rate and the sum is over all risk-factor combinations. We calculated r_i^* as the "counterfactual" relative risk in which the BMI level is set to the reference level but all other risk factors for each participant are left unchanged. The hypothetical counterfac-

tual mortality rate from moving all participants to the reference-weight category is $R^* = I\Sigma r_i^* p_i$. The proportion of deaths attributable to non–reference-weight categories was calculated as $(R–R^*)/R$. Because the factor I cancels out, the attributable fraction depends only on the relative risks and prevalences of the covariates. R and R^* were adjusted to represent the general population parameters by taking the sample weighting into account. This approach accounts for confounding by all covariates in the model.

The estimated number of excess deaths associated with a given BMI level and age group was then calculated by multiplying the total number of deaths for that age group in 2000 by the attributable fraction for that BMI level. In 2000, there were 397 341 deaths in the 25- to 59-year-old group, 315 834 deaths in the 60- to 69-year-old group, and 1 618 086 deaths in the 70 years and older group.[21] Standard errors for estimates of number of attributable deaths were calculated by applying a delta method for complex sample designs.[22,23] This method takes into account uncertainties in the relative risks, the distribution of BMI, the distribution of covariates, and the estimated effects of covariates and accounts for the added variability caused by the complex sample designs of the NHANES surveys. Two-sided 95% CIs were computed according to normal theory approximation.

Data were analyzed using the SAS System for Windows (release 9.1; SAS Institute Inc, Cary, NC) and SUDAAN (release 9.0; Research Triangle Institute, Research Triangle Park, NC) software programs. All analyses included sample weights that account for the unequal probabilities of selection because of oversampling and nonresponse. All variance calculations incorporate the sample weights and account for the complex sample design. We replicated the main analyses with 2 separate SAS programs written independently by 2 of us (K.M.F., B.I.G.). Variance calculations were checked using jackknife resampling.

RESULTS

Descriptive data for the 3 survey cohorts are shown in **TABLE 1**. The numbers of deaths in the 3 cohorts were 3923, 2133, and 2793, for a total of 8849 deaths. Estimated relative risks are shown in **FIGURE 1** by BMI category, age group, and survey, and relative risks from the combined data set and their SEs are shown in **TABLE 2**. Obesity (BMI ≥30) was associated with increased risk, particularly at the younger ages; the relative risks were lower in the oldest group. The relative risk in the overweight category (BMI 25 to <30) was low, often below 1. Relative risks in the underweight category usually exceeded unity (1.00). Relative risks were generally modest, in the range of 1 to 2 in most cases. The prevalence of BMI levels in NHANES 1999-2002 is shown in **TABLE 3**.

Estimated numbers of excess deaths in 2000 in the United States, relative to the reference BMI category of 18.5 to less than 25, are shown by survey and BMI category (**FIGURE 2**). All estimates are based on the covariate distribution from NHANES 1999-2002 and the number of deaths in 2000 from US vital statistics data.[21]

Estimates based on relative risks from each of the 3 surveys showed a similar pattern, with excess deaths greater than zero for the underweight category, less than zero for the overweight category,

and increasing at higher BMI levels. Although the prevalence of BMI 35 or greater is low (Table 3), that category accounted for the largest absolute number of estimated excess deaths in 2000, regardless of which survey served as the source of relative risks.

The estimates of excess deaths associated with obesity (BMI ≥30) were calculated from the distribution of BMI and other covariates in NHANES 1999-2002; however, these estimates vary according to the source of the relative risk estimates. Excess deaths associated with obesity (BMI ≥30) were calculated as 298 808 according to the NHANES I relative risks, 26 917 according to the NHANES II relative risks, or 43 650 according to the NHANES III relative risks. In all 3 cases, however, the ma-

jority of deaths associated with obesity were associated with BMI 35 and above: 186 498, 21 777, or 57 515 deaths, respectively. (NHANES III relative risks produced a negative estimate for BMI 30 to <35.) For overweight (BMI 25 to <30), the data consistently suggested no excess deaths overall: −14 354, −171 945, or −99 979 excess deaths according to the relative risks from each of the 3 surveys. For underweight (BMI <18.5), the relative risks from all surveys suggested a slight increase in risk. The estimated excess deaths associated with underweight were 41 930, 19 618, or 38 456.

Using relative risks from the combined survey data, we estimated that 111 909 excess deaths in 2000 (95% CI, 53 754 to 170 064) were associated with

Table 1. Surveys Providing Mortality Data

	NHANES I	NHANES II	NHANES III
Survey baseline years	1971-1975	1976-1980	1988-1994
Unweighted sample size*	12 655	9219	14 985
Mortality follow-up through study year	1992	1992	2000
Deaths, No.	3923	2133	2793
Person-years of follow-up	210 563	122 772	124 245
Prevalence of BMI level, %			
<18.5	3.0	2.5	2.2
18.5 to <25	46.9	45.7	40.7
25 to <30	34.1	35.1	33.8
30 to <35	11.6	11.6	15.0
≥35	4.4	5.1	8.3

Abbreviations: BMI, body mass index (measured as weight in kilograms divided by the square of height in meters); NHANES, National Health and Nutrition Examination Survey.
*After exclusions for missing BMI data.

Figure 1. Relative Risks of Mortality by BMI Category, Survey, and Age
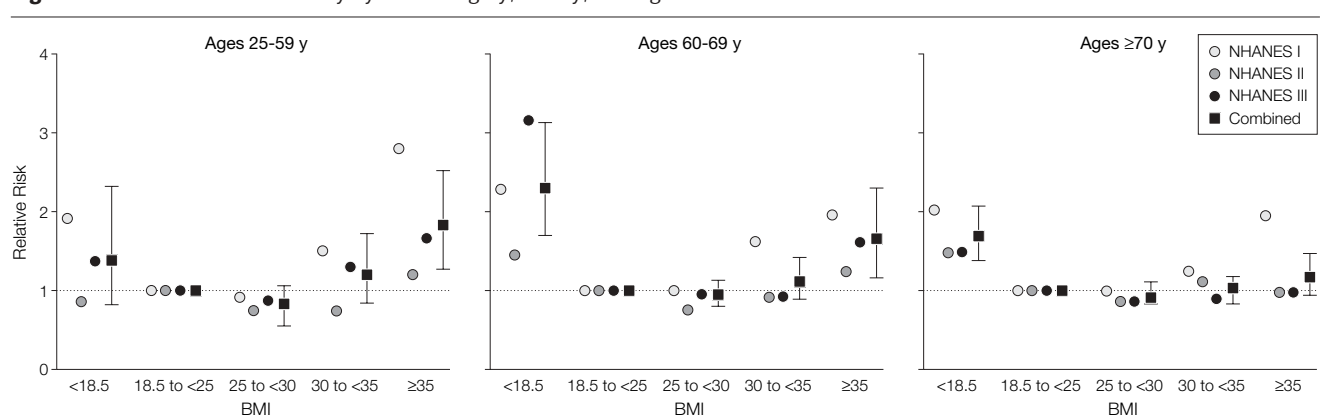
BMI indicates body mass index, measured as weight in kilograms divided by the square of height in meters. The reference category with relative risk 1.0 is BMI 18 to <25. Error bars indicate 95% confidence intervals.

obesity (BMI ≥30) (Figure 2). Of the excess deaths associated with obesity, the majority (82 066 deaths; 95% CI, 44 843 to 119 289) occurred in individuals with BMI 35 or greater. Overweight was associated with a slight reduction in mortality (−86 094 deaths; 95% CI, −161 223 to −10 966) relative to the normal weight category. Thus, for overweight and obesity combined (BMI ≥25), our estimate was 25 814 excess deaths (95% CI, −86 284 to 137 913) in 2000, arrived at by adding the estimate for obesity to the estimate for overweight. Underweight was associated with 33 746 excess deaths (95% CI, 15 726-51 766).

Of the 111 909 estimated excess deaths associated with obesity (BMI ≥30), the majority, 84 145 excess deaths, occurred in individuals younger than 70 years. In contrast, of the 33 746 estimated excess deaths associated with underweight, the majority, 26 666 excess deaths, occurred in individuals aged 70 years and older.

We explored the effect of using different models with additional terms and interaction terms. Models with only sex, BMI, and smoking were fitted, as were models that used, in addition, race, alcohol, educational level, and height, as well as interactions of BMI group with sex, race, or smoking. Although some of these terms had coefficients that were statistically significantly different from zero within 1 or more subgroups, the effect on the parameter of interest (excess deaths) was not large, and the broad pattern of results did not change. The highest number of deaths associated with BMI 30 or greater was 137 696

Table 2. Relative Risks by Age Group and BMI Level From the Combined NHANES I, II, and III Data Set

| BMI Level	Relative Risk (95% Confidence Interval) by Age Category		
	25-59 y	60-69 y	≥70 y
	Overall		
<18.5	1.38 (0.82-2.32)	2.30 (1.70-3.13)	1.69 (1.38-2.07)
18.5 to <25	1.00	1.00	1.00
25 to <30	0.83 (0.65-1.06)	0.95 (0.80-1.13)	0.91 (0.83-1.01)
30 to <35	1.20 (0.84-1.72)	1.13 (0.89-1.42)	1.03 (0.91-1.17)
≥35	1.83 (1.27-2.62)	1.63 (1.16-2.30)	1.17 (0.94-1.47)
	Never-Smokers Only		
<18.5	1.25 (0.29-5.49)	2.97 (1.17-7.54)	1.50 (1.11-2.02)
18.5 to <25	1.00	1.00	1.00
25 to <30	0.66 (0.38-1.16)	0.81 (0.56-1.16)	0.90 (0.79-1.04)
30 to <35	0.77 (0.46-1.28)	1.21 (0.83-1.77)	1.13 (0.96-1.31)
≥35	1.25 (0.76-2.06)	2.30 (1.47-3.59)	1.12 (0.87-1.45)

Abbreviations: BMI, body mass index (measured as weight in kilograms divided by the square of height in meters); NHANES, National Health and Nutrition Examination Survey.

Table 3. Prevalence of BMI Levels in 1999-2002 (From NHANES 1999-2002), by Age Group

BMI Level	Prevalence, % by Age Category		
	25-59 y	60-69 y	≥70 y
<18.5	1.9	0.7	2.4
18.5 to <25	32.8	23.8	31.8
25 to <30	34.8	36.1	40.5
30 to <35	17.3	23.6	17.7
≥35	13.3	15.8	7.6

Abbreviations: BMI, body mass index (measured as weight in kilograms divided by the square of height in meters); NHANES, National Health and Nutrition Examination Survey.

Figure 2. Estimated Numbers of Excess Deaths in 2000 in the United States Relative to the Healthy Reference BMI Category of 18.5 to <25, Shown by Survey and BMI Category
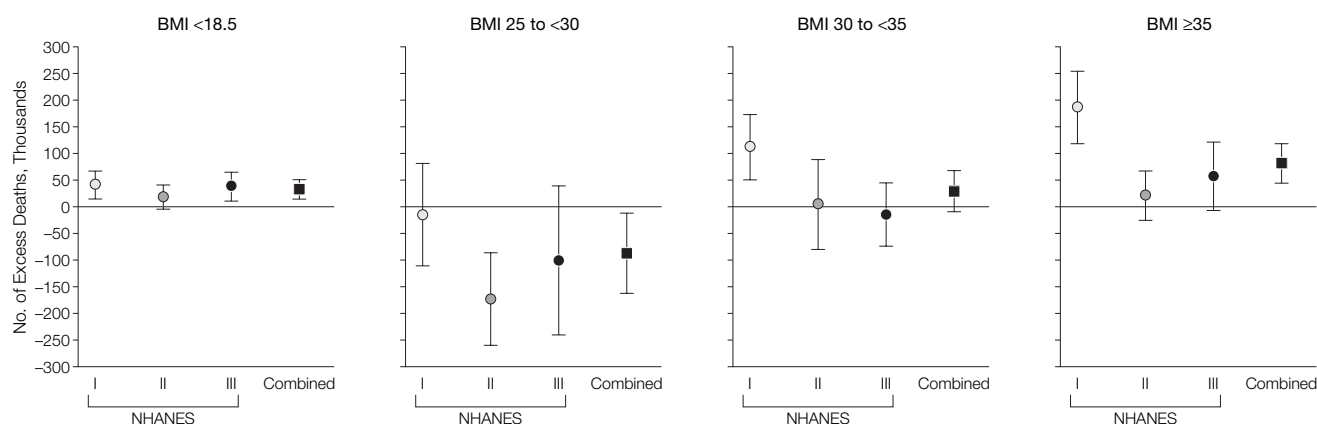
BMI indicates body mass index (measured as weight in kilograms divided by the square of height in meters). All estimates are based on the covariate distribution from NHANES 1999-2002, the number of deaths in 2000 from US vital statistics data, and the relative risks estimated from National Health and Nutrition Examination Surveys (NHANES) I, NHANES II, NHANES III, or the combined NHANES I, II, and III data set. Error bars indicate 95% confidence intervals.

for the simplest model, which included only sex, BMI, and smoking; the lowest number was 79 449 for a more complex model that included all listed variables and an interaction of smoking with BMI group.

We chose to use the NHLBI "normal weight" category of 18.5 to less than 25 as the reference category. The effect of using other reference BMI categories was also explored. Across the reference categories 18.5 to less than 25, 21 to less than 25, and 23 to less than 25, the estimated number of excess deaths associated with BMI 30 or greater was 111 909, 129 148, and 164 836, respectively, and the number of excess deaths associated with a BMI less than the reference category was 33 746, 45 784, and 81 705. Thus, using a reference category of 23 to less than 25 rather than the normal weight category would result in increased estimates of excess deaths for low weight and for obesity.

We undertook additional analyses to examine whether our estimates of excess deaths might have been affected by factors such as length of follow-up, weight stability, weight loss caused by illness, or smoking status. The purpose of these analyses was not to make statistical comparisons between relative risks but to assess the direction and possible magnitude of any effects of these factors on estimated excess deaths. To examine whether the higher relative risks in NHANES I might be due to the longer follow-up in NHANES I, we compared the relative risks from the first phase of NHANES I through the 1982-1984 follow-up with the relative risks from NHANES II and III. Thus, the follow-up period was similar for all surveys (≈10 years for NHANES I, ≈14 years for NHANES II, ≈9 years for NHANES III). The NHANES I relative risks over the first 10 years of follow-up were higher in almost every BMI-age subgroup than were the relative risks from the other surveys (data not shown). Thus, even after controlling for length of follow-up, NHANES I tended to have higher relative risks than the other surveys.

In NHANES I, the relative risks through 1992 associated with weights measured in the 1982-1984 follow-up were almost always lower (in 14 of 15 subgroups) than the relative risks from 1971-1975 through the 1982-1984 follow-up, suggesting a possible decrease in relative risks over time, although the differences were small (data not shown). To examine whether the increased relative risks at lower BMI levels might be related to possible weight loss associated with illness and increased mortality, which could also have decreased the relative risks associated with overweight and obesity, we repeated analyses excluding the first 3 or the first 5 years of deaths and found little change in the relative risk estimates (data not shown). We also repeated analyses including only individuals who never smoked and found that the elevated relative risks for the lowest BMI category persisted and that other relative risks were not systematically different (Table 2).

To assess the longer-term effects of a given weight, excluding possible effects of major weight gains or losses, we repeated the NHANES I analyses for a subgroup of participants whose weight had not changed by more than 2 kg between baseline (1971-1975) and 1982-1984, looking at mortality from the 1982-1984 follow-up through 1992. In these analyses, the relative risks did not differ systematically from the whole group (6 higher and 6 lower) and differences were slight (data not shown). Overweight (BMI 25 to <30) that had persisted for at least 10 years was still associated with no excess risk, and underweight was still associated with an increased relative risk. Taken together, these analyses suggest that differences in length of follow-up, weight loss because of underlying illness, or confounding by smoking status did not have a major impact on our estimates of excess deaths.

COMMENT

Our results show increased mortality associated with underweight and with obesity, particularly with higher levels of obesity, relative to the normal weight category. Our results are lower than previous estimates.[5,7] Differences in statistical methods account for some of the differences. Our method of estimation accounts more fully for confounding and for effect modification by age than the partially adjusted method used in previous estimates. When applied either to NHANES I data or to the combined data set, our method yielded results that were more than 20% lower than when the partially adjusted method was applied to the same data with the same reference category and the same covariates. However, the largest difference is due to the inclusion of the mortality data from NHANES II and NHANES III, which decreased estimates by 63% or more relative to NHANES I mortality data alone. It would be useful to know whether similar secular patterns are detectable in other cohorts that span recent decades.

Relative to NHANES I, the more recent data from NHANES II and NHANES III suggest the possibility that improvements in medical care, particularly for cardiovascular disease, the leading cause of death among the obese, and its risk factors may have led to a decreased association of obesity with total mortality. Cardiovascular risk factors have declined at all BMI levels in the US population, but, except for diabetes, the decline appears to be greater at higher BMI levels.[24] These findings are consistent with the increases in life expectancy in the United States and with the declining mortality rates from ischemic heart disease. Life expectancy increased from 73.7 years in 1980 to 75.4 years in 1990 to 77.0 years in 2000 and continues to increase.[25] Age-adjusted death rates (per 100 000 population) for ischemic heart disease declined from 345.2 in 1980 to 249.6 in 1990 to 186.6 in 2000 and continue to decline.[25]

The methods used in our study to estimate deaths attributable to obesity have several strengths. Our method accounts for confounding by all factors included in the Cox proportional hazards model, as well as for modifica-

tion by age of the effect of obesity on mortality. Moreover, the NHANES surveys are nationally representative, and the heights and weights of cohort members were measured, rather than based on self-reports. Our design-based survey methods applied to the NHANES data yielded unbiased population estimates and estimates of SEs.

Our approach for estimating the number of deaths attributable to obesity has important limitations, however. Like earlier estimates, our estimates are based on assumptions that may not hold in practice. The key assumption is that relative risks calculated from past cohorts apply to the current population. The measured values of weight and height in NHANES I, II, and III are more accurate than the self-reported values in some other studies. Nonetheless, our covariate data are subject to measurement error and faulty reporting. Because of errors in confounder measurements, our estimates of relative risks for BMI categories may be subject to residual confounding. As in most studies, our data on smoking were based on self-reports and may be subject to error, especially in NHANES I in which much of the smoking data were gathered retrospectively.[26] Serum cotinine data from NHANES III, however, showed that misclassification by self-reported smoking status was low in that survey.[27] Bias may also result from failure to control for unknown confounders that are associated with body weight and mortality.

We used the current federal definitions of overweight and obesity, which are based only on BMI, not on body composition. Our estimates give numbers of excess deaths associated with different levels of body weight, but the associations are not necessarily causal. Even if body weights were reduced to the reference level, risks might not return to the level of the reference category. Other factors associated with body weight, such as physical activity, body composition, visceral adiposity, physical fitness, or dietary intake, might be responsible for some or all of the apparent associations of weight with mor-

tality. Additional investigation of the effects of body composition and visceral adiposity on mortality would be of interest.

The attributable fraction is a nonlinear function of relative risk and changes rapidly at low levels of relative risk. For example, in a hypothetical population in which the prevalence of obesity (BMI ≥30) was 30% and there were 2 million deaths per year, the attributable fraction for unadjusted relative risks of 1.2, 1.4, or 1.6 would translate into 113 000, 214 000, or 305 000 deaths per year, a difference of about 100 000 deaths for a slight change in relative risk.

Obesity is associated with a modestly increased relative risk of mortality, often in the range of 1 to 2. In this range, estimates of attributable fractions, and thus numbers of deaths, are very sensitive to minor changes in relative risk estimates.[3] Thus, results are affected by the precision and bias in relative risk estimates. Additional precision might be gained from larger cohort studies, but bias because of nonrepresentative samples and the use of self-reported weight and height could lead to less accurate estimates. Because our goal is to estimate deaths associated with obesity in the US population, rather than in a subgroup, nationally representative data are preferable as a source of relative risk estimates appropriate for the whole population.[3]

Some have argued that it takes 15 years or more for obesity to have its full impact on cardiovascular mortality.[28] We did not examine cardiovascular mortality specifically. However, the relative risks for total mortality in weight-stable individuals in the latter part of the NHANES I follow-up were similar to relative risks in the earlier follow-up period. There is some question as to the optimal length of follow-up: the longer the follow-up, the longer the interval between the event and the BMI measurement and the higher the probability of misclassification.[29] Across the 6 cohorts used by Allison et al,[5] there was no relation between the length of follow-up in a cohort and the

relative risks in that cohort. Thus, this issue requires further study.

Neither analyses of weight-stable participants nor analyses excluding early mortality suggest that illness-induced weight loss had an important impact on estimates of excess deaths. Estimates of relative risks for BMI categories were little changed by such exclusions, and, in particular, there was little change in the relative risk associated with the underweight and overweight categories. More studies are needed to explore the possible impact of baseline health status and other possible confounders.

In our analysis, we did not find overweight (BMI 25 to <30) to be associated with increased mortality in any of the 3 surveys. Our results are similar to those of a previous analysis of NHANES I and II data that found little effect of overweight on life expectancy.[30] Our finding is consistent with other results reported in the literature, although methodologic differences often preclude exact comparisons. In many studies, a plot of the relative risk of mortality against BMI follows a U-shaped curve, with the minimum mortality close to a BMI of 25; mortality increases both as BMI increases above 25 and as BMI decreases below 25,[31] which may explain why risks in the overweight category are not much different from those in the normal weight category. Some studies have found that overweight was associated with a slightly increased risk of total mortality compared with the normal weight category.[32-34] Other studies have suggested that overweight (BMI 25 to <30) is associated with no excess mortality, particularly in older age groups.[35-39] Further investigation of the effects of overweight on mortality, particularly in the elderly, and of the possible role of confounding would be of interest.

We did not examine other health problems caused by obesity. A recent population-based study has found that overweight and obesity have a strong and deleterious impact on important components of health status, including morbidity, disability, and quality of life, and

this impact is disproportionately borne by younger adults.[40] Nor did we examine cause-specific mortality. Overweight and obesity may be more strongly associated with cardiovascular mortality than with total mortality.[41]

The differences between NHANES I and the later surveys suggest that the association of obesity with total mortality may have decreased over time, perhaps because of improvements in public health or medical care for obesity-related conditions. However, such speculation should be tempered by the awareness that these differences between surveys may simply represent chance variation and that small differences in relative risk translate into large differences in the numbers of deaths.

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