The Direct Health Care Costs of Obesity in the United States

David B. Allison, PhD, Raffaella Zannolli, MD, and K. M. Venkat Narayan, MD

ABSTRACT

Objectives. Recent estimates suggest that obesity accounts for 5.7% of US total direct health care costs, but these estimates have not accounted for the increased death rate among obese people. This article examines whether the estimated direct health care costs attributable to obesity are offset by the increased mortality rate among obese individuals.

Methods. Data on death rates, relative risks of death with obesity, and health care costs at different ages were used to estimate direct health care costs of obesity from 20 to 85 years of age with and without accounting for increased death rates associated with obesity. Sensitivity analyses used different values of relative risk of death, given obesity, and allowed the relative costs due to obesity per unit of time to vary with age.

Results. Direct health care costs from 20 to 85 years of age were estimated to be approximately 25% lower when differential mortality was taken into account. Sensitivity analyses suggested that direct health care costs of obesity are unlikely to exceed 4.32% or to be lower than 0.89%.

Conclusions. Increased mortality among obese people should be accounted for in order not to overestimate health care costs. (*Am J Public Health.* 1999;89:1194–1199)

Obesity is increasingly prevalent in the United States and in much of the developed world.[1] It is associated with a variety of morbidities[2] and reduced longevity.[3] Twenty years ago in the Journal, in the midst of an energy crisis, Hannon and Lohman[4] creatively expressed the costs of obesity in terms of energy expressed in fossil fuel units. In today's economic climate, economic costs have come to the fore. Because of the associated morbidities, obesity is also costly in economic terms.[5] Quantitative cost estimates are of interest to health care policymakers who need information to make appropriate policy decisions and to advocates who would influence the decision making of such policymakers. Therefore, such estimates have received substantial attention in both the professional[6] and lay[7,8] literatures.

Perhaps the most thorough and up-to-date estimates are from Wolf and Colditz,[9] who estimated that 5.7% (i.e., approximately $52 billion annually) of direct health care costs in the United States are attributable to obesity. These costs were estimated on the basis of data from published secondary sources (the Nurses' Health Study and the Health Professionals Follow Up Study), inflated to 1995 dollars by means of the medical component of the consumer price index.[9] Direct health care costs incorporated included personal health care, physician services, allied health care services, and medications. Although a recent editorial on this topic offered a number of caveats regarding the methods used to derive current total cost estimates, it suggested that they are probably "at least in the ballpark."[10]

However, obese people, on average, die earlier than nonobese people.[3] This differential mortality rate has been accounted for in computing indirect costs through lost productivity,[9] but not in estimating direct health care costs. Because people with health-compromising conditions such as obesity have higher mortality rates than people without such conditions, they have a shorter period of time in which to accrue health care expenditures, although their health care expenditures per unit of time when alive may be higher. The extent to which a health-impairing condition causes increased expenditures during life and the extent to which it decreases overall life span will determine the net economic effect of the condition over the course of the life span. Some authors have even stated that "[p]reventing fatal diseases increases health-care costs."[11] For example, it was estimated that eliminating smoking would initially reduce overall health care expenditures but that after 15 years, health care expenditures would increase owing to the increased survival rate of a population composed solely of nonsmokers.[12]

In the context of the "prevalence-based" estimates of obesity-related health care costs provided by other authors,[9,13,14,15] the statement "x% of total health care costs are due to obesity" is equivalent to saying "in any given year, if the population of the United States consisted solely of an equal number of nonobese individuals (i.e., if in the place of every obese person there were a nonobese person), then total health care expenditures would be x% lower." A key phrase in the previous statement is "an equal number of nonobese

David B. Allison and Raffaella Zannolli are with the Obesity Research Center, St. Luke's/Roosevelt Hospital, Columbia University College of Physicians and Surgeons, New York, NY. Raffaella Zannolli is also with the Department of Pediatrics, Policlinico LeScotte, University of Siena, Siena, Italy. K. M. Venkat Narayan is with the Division of Diabetes Translation, Centers for Disease Control and Prevention, Atlanta, Ga.

Requests for reprints should be sent to David B. Allison, PhD, Obesity Research Center, St. Luke's/Roosevelt Hospital, Columbia University College of Physicians and Surgeons, 1090 Amsterdam Ave, 14th floor, New York, NY 10025 (e-mail: dba8@columbia.edu).

This paper was accepted March 10, 1999.

individuals." This assumption is implicit in the calculations of those who use the prevalence-based approach.[9,13,14,15] This approach does not take into account the fact that if obesity were eliminated, a larger total population would exist owing to the lower mortality rate.

The purpose of this article is to examine the extent to which the estimated direct health care costs attributable to obesity are offset by the increased mortality rate among obese individuals. We also estimate the direct health care costs at each year of life from 20 to 85 years of age and cumulatively across those ages.

TABLE 1—Age-Specific Probability (Prevalence) of Obesity, Relative Risk of Death Associated With Obesity, and Relative Per Capita Direct Health Care Costs for US Residents Aged 20 to 85 Years

Age, y	$P(O_i)$, %[a]	RR[b]	M_i^c
20–24	14	1.69	1
25–29	19	1.69	2.36
30–34	25	1.69	2.36
35–39	26	1.69	3.46
40–44	32	1.69	3.46
45–49	30	1.54	3.98
50–54	41	1.54	3.98
55–59	36	1.37	4.11
60–64	35	1.37	4.11
65–69	33	1.20	5.63
70–74	30	1.20	5.63
75–79	27	1.10	5.77
80–84	18	1.10	5.77
>85	18	0.98	5.77

[a]Probability (prevalence) of obesity (body mass index ≥ 29) at specific age *i*. Estimates of prevalence are from the third National Health and Nutrition Examination Survey.[16]
[b]Relative risk of dying associated with obesity, from Stevens et al.[18]; the relative risks for ages 20–29 were derived as described in the text.
[c]Ratio of per capita direct health care costs at specific age *i* to per capita direct health care costs at age 20. Values are from *Statistical Abstract of the United States, 1997*.[20]

Methods

The "annual" costs of obesity from a prevalence-based approach (that is, not accounting for differential mortality) are a function of (a) the relative direct health care cost per unit of time alive for an obese person vs a nonobese person and (b) the prevalence of obesity in the population. The costs of obesity accounting for differential mortality can be estimated from the above quantities and (c) the base rate of death in the population, (d) the relative risk of dying within a defined period of time for an obese person vs a nonobese person, and (e) the relative per capita health care costs at different ages during the life span. The estimation of these costs can take place over the entire life span or some portion of it. We chose the period of adult life from 20 to 85 years of age because we believed there was insufficient information to compute confident estimates outside that range. The exact formulas we used to compute costs of obesity in each year of life from 20 to 85 and cumulatively during this period are shown in detail in an appendix that may be obtained from the authors. Below, we describe the derivation of estimates for the quantities in items (a) to (e) above.

Relative Costs Per Unit of Time

The relative direct health care costs per unit of time alive for an obese person vs a nonobese person (R_c) can be shown to be

$$R_c = 1 + \frac{1}{P(O)}\left(\frac{1}{1-\delta} - 1\right),$$

where δ denotes the proportion of direct health care costs that are attributable to obesity from a prevalence-based approach and $P(O)$ is the probability of obesity in the overall population on which δ was estimated. We used the value of δ (0.057, i.e., 5.7%) offered by Wolf and Colditz, who derived this estimate by considering individuals with a body mass index (BMI) of 29 or greater as obese.[9] We chose the estimate of Wolf and Colditz because it is based on a very recent and comprehensive analysis. However, it is worth noting that it is quite consistent with estimates reported by other authors.[10]

We chose to use a BMI cutoff of 29 to denote obesity for the following reasons: (1) Wolf and Colditz used that value, and that study is where we obtained the required data; (2) for the purpose of presentation, it is easier and more pertinent to model obesity as a categorical variable; and (3) modeling BMI as a continuous variable is much more complex and the required inputs were not available. According to data from the third National Health and Nutrition Examination Survey (NHANES III),[1] approximately 27% of the US adult population has a BMI greater than or equal to 29, so we set $P(O)$ at 0.27. This gives a value of 1.224 for R_c, which is fairly consistent with estimates obtained from another study. For example, Quesenberry et al. obtained an R_c value of 1.21 for outpatient costs when considering moderately obese individuals and a value of 1.37 when considering severely obese individuals.[15]

Probability (Prevalence) of Obesity

The probability (or prevalence) of obesity (defined as BMI ≥ 29 for consistency with Wolf and Colditz[9]) at each age between 20 and 85 years and above was estimated from the raw NHANES III data,[16] with the appropriate weighting factor. To reduce sampling variation, we calculated these estimates in 5-year intervals. We denote the probability of obesity at age *i* as $P(O_i)$ (see Table 1, column 2).

Base Rate of Death

We obtained base rates of death for each year of life from 20 to 85 from Table 6–2 of *Vital Statistics of the United States, 1993*.[17] These values ranged from 0.0010 for 20-year-olds to 0.0908 for persons 85 years (a complete list of values is presented in the appendix available from the authors).

Relative Risk of Death Associated With Being Obese

The relative risk of death within a defined period of time can be obtained from published studies. A recent study that is large, well analyzed, and based on a national sample of both men and women is that of Stevens et al.[18] This study graphically presented the relative risk separately for each decade of life from 30 to 85 on. Although the relative risks were presented separately by sex, we averaged these to produce a single estimate for each age interval because the relative risks did not differ markedly by sex and because our intent was not to derive separate cost estimates by sex. The specific relative risks we used are shown in Table 1, column 3. These values were taken as the relative risk for individuals with a BMI greater than or equal to 29 relative to individuals with a BMI of less than 29. The exact relative risks on which the published figures of Stevens et al. were based were provided to us by Stevens for 30 years and older. Because Stevens et al.[18] did not provide relative risks for persons aged 20 to 30 years, we assumed the relative risk was the same as that for persons aged 30 to 44 years.

Relative Per Capita Costs by Age

Because, all other things being equal, people tend to use more health care at older ages,[19] it is important to account for this difference in the analysis. We denote the ratio of per capita direct health care costs at age *i* to per capita direct health care costs at age 20 as M_i. Values of M_i (see Table 1, column 4) were taken from Table 170 of the *Statistical Abstract of the United States, 1997*.[20]

Analysis

For the primary analysis, the estimated quantity of interest is the percentage of the cumulative direct health care costs from 20 to 85 years of age that are attributable to obesity after accounting for differential mortality. We denote this quantity as φ_{20}^{85}. (Formulas for its calculation are given in the appendix.)

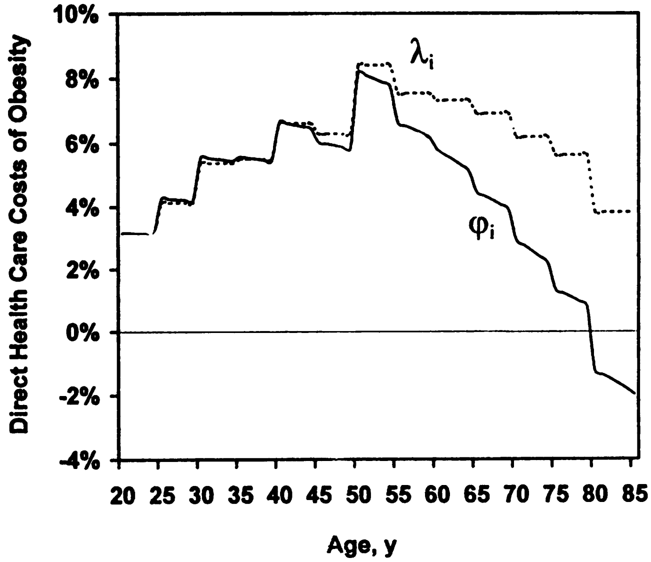
As in any modeling endeavor, the results obtained depend on the input parameters. It is important, therefore, to evaluate the sensitivity of the results obtained to varying input parameters that may be known with lesser confidence. Of our input parameters, the values of age-specific relative per capita costs (M_i), the prevalence of obesity [$P(O_i)$], and the base rate of death [$P(D_i)$] are probably known with relatively high confidence. In contrast, values of the relative risk of death (RR_i) and the relative costs per unit of time (R_{ci}) are probably known with lesser confidence. We therefore conducted 2 sensitivity analyses.

In the sensitivity analysis of RR_i, we assumed that RR_i was constant for all values of *i*, as some authors (e.g., Manson et al.[21]) conclude that it is. We used 2 different values for the constant RR_i. The first was the relatively high value of 2.15, which is the unweighted arithmetic average of the relative risk values for BMIs between 29 and 31.9 and BMI greater than or equal to 32 relative to BMI less than 19.0 from Manson et al.[21] The second was the relatively low value of 1.35, which is the average risk of the same 2 higher BMI categories relative to the more average BMI category of 25.0 to 26.9.

In the sensitivity analysis of R_c, we allowed the relative cost per unit of time alive (R_c) to vary with age. Although the results of Wolf and Colditz[9] imply that the *average* value of R_c over the whole population is 1.224, the exact value may vary from age to age. It is possible that as individuals age and begin to use more health care regardless of their weight, the value of R_c decreases. Indeed, Quesenberry et al. found that "[a]lthough the BMI and outpatient cost association did not vary by age using traditional levels of significance as criteria (test for age × BMI interaction, $P = .61$), there was evidence that the association was somewhat stronger in the 2 youngest groups."[15] We therefore derived a set of R_c values that varied with age but maintained the average R_c over the life span of the cohort from age 20 to 85 at 1.224. For the *i*th year of age, R_{ci} was calculated as

$$R_{ci} = (R_{ci-1})^K \text{ for } i > 20$$
$$R_{ci} = R_{c20} = 1.430 \text{ for } i = 20$$
where k was 0.9796.

The values of R_{c20} and K were obtained iteratively such that R_{ci} slowly descended toward 1.0 as *i* approached 85 and maintained the overall weighted average R_c at 1.224.



Note. λ_i (dotted line) represents the cost during the *i*th year of life without taking into account the higher mortality of obese persons (i.e., the age-specific prevalence-based cost). φ_i (solid line) represents the cost during the *i*th year of life taking into account the higher mortality of obese persons.

FIGURE 1—Percentage of direct health care costs attributable to obesity in the United States.

Results

Primary Analysis

The results of the primary analysis are shown in Figures 1 and 2. The line in Figure 1 labeled λ_i is the proportion of direct health care costs attributable to obesity calculated from a prevalence-based annual perspective. At each year of age, these values indicate the proportion by which the direct health care costs would be reduced if instead of obese people there were an equal number of nonobese people. As can be seen, although this quantity varies over the adult life span, it remains positive and relatively stable. It fluctuates only because the proportion of the cohort that is obese fluctuates with age. In contrast, the line labeled φ_i shows the proportion of direct health care costs in each year that are attributable to obesity, taking differential mortality into account. This value changes dramatically with age and becomes negative by approximately age 79 years. This implies that if obesity were eliminated, direct health care costs would be lower during each year of life from 20 to about 79. Thereafter, owing to the larger number of people who would live to older ages, costs would actually be higher than they would be if obesity were not eliminated.

In Figure 2, the line labeled λ_{20}^{i} indicates the proportion of cumulative direct health care costs from age 20 to the *i*th year of age that are attributable to obesity if differential mortality is not taken into account. As is evident in the figure, by 85 years of age the 5.7% estimate that we began with has essentially been recovered. This serves as a check on the validity of our calculations. Finally, the line labeled φ_{20}^{i} indicates the proportion of the cumulative direct health care costs from 20 years to the *i*th age that are attributable to obesity after accounting for differential mortality. This value drops steadily after about 55 years of age. It reaches its lowest point (over the range examined) at 85 years, where the value obtained is 4.32%. This value indicates that 4.32% of cumulative direct health care costs over the period of life from 20 to 85 can be attributed to obesity.

Sensitivity Analyses

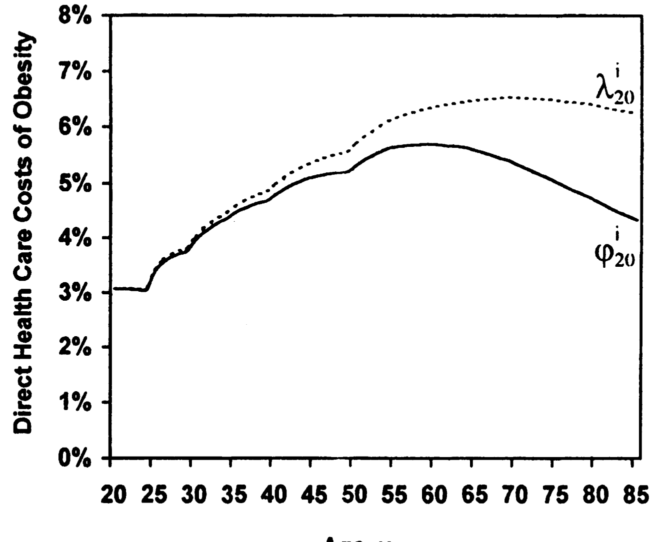
Figure 3 shows the results of the sensitivity analysis in which the relative risk of death for obese persons vs nonobese persons was allowed to vary. As might be expected, the results depend strongly on the relative risks assumed. The larger the relative risk of death for an obese person vs a nonobese person, the lower the net costs attributable to obesity over the course of a lifetime. With a constant relative risk of 2.15, from 20 to 85 years of age the costs attributable to obesity are only 0.89%. Although they are much higher (4.32%) if one assumes a relative risk of only 1.35, the direct health care costs attributable to obesity remain below the prevalence-based estimate of 5.7%.

Figure 4 displays the results of the sensitivity analysis that allowed the values of R_c to vary with age, as described previously. Using the steadily decreasing values of R_c produces a markedly lower estimate of the costs (2.77%) by 85 years of age.

Discussion

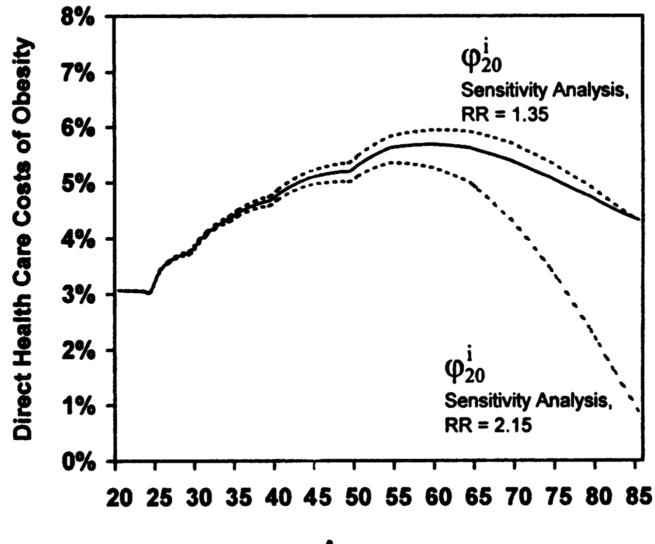
Wolf and Colditz estimated the direct health care costs attributable to obesity to be 5.7% of the total direct health care costs.[9] This is equivalent to saying "If there were a treatment that made all obese people nonobese and equivalent in health to people who had never been obese, and if this treatment cost nothing to apply, and if it were given to all obese people, then in the immediately subsequent time period, direct health care costs would be reduced by 5.7%." However, this prevalence-based approach does not take into account the differential mortality rates of obese and nonobese people. When we took this differential mortality into account, retaining all other assumptions and calculations of Wolf and Colditz, we estimated the percentage of lifetime costs (from 20 to 85 years of age) attributable to obesity to be only 4.32%. This is equivalent to saying "If obesity were prevented (at no charge) before 20 years of age and the cohort remained nonobese throughout life, then, in the subsequent 65 years, direct health care costs would be reduced by 4.32%." Sensitivity analyses suggested that given plausible variations in the input parameters, the actual value is unlikely to be higher than 4.32% or lower than 0.89%.

Bonneux et al. stated that preventing fatal diseases will not save money.[11] Although obesity does increase death rates, it may not merit the appellation "fatal" because it increases the death rate only moderately (relative to, for example, certain forms of cancer[22]). It is for this reason that a "lifetime" perspective shows the costs between 20 and 85 years of age to be lower than the annual prevalence-based approach but still returns a positive value. That is, even after the increased death rates among obese persons are taken into account,



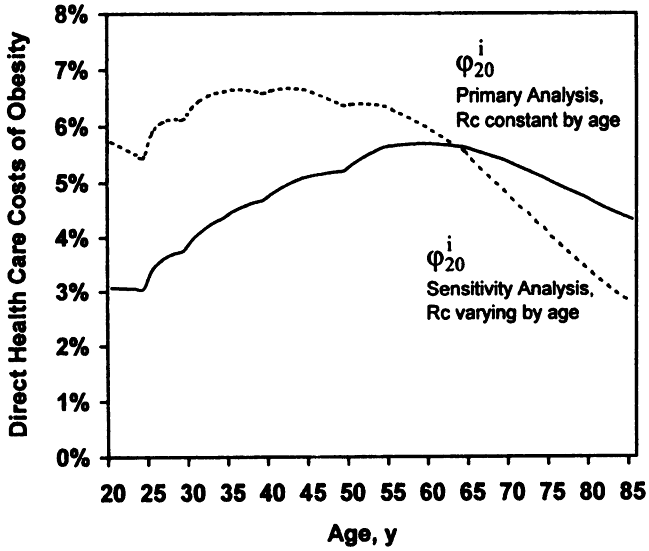
Note. λ^i_{20} (dotted line) represents the cost during the period of life from age 20 to age *i* without taking into account the higher mortality of the obese persons. φ^i_{20} (solid line) represents the cost during the period of life from age 20 to age *i* taking into account the higher mortality of obese persons.

FIGURE 2—Percentage of cumulative direct health care costs attributable to obesity.



Note. Estimates were made on the basis of a primary analysis (solid line) in which values of relative risk (RR) of death associated with obesity varied with age and on the basis of a sensitivity analysis using 2 different relative risk values that remained constant with age, one relatively low (1.35; upper dotted line) and the other relatively high (2.15; lower dotted line).

FIGURE 3—Sensitivity to relative risk assumptions: direct health care costs of obesity, taking differential mortality into account, as a function of the relative risk values chosen.



Note. Estimates were made on the basis of a primary analysis (solid line) in which the value of the relative per capita costs per unit of time alive (R_c) was held constant at 1.224 and on the basis of a sensitivity analysis (dotted line) in which R_c varied with age (see Table 1). Note that the end result at age 85 is substantially altered by this variation of assumption.

FIGURE 4—Sensitivity to assumptions about the relative per capita costs per unit of time alive: direct health care costs of obesity, taking differential mortality into account.

obesity results in a net health care cost during the period from 20 to 85 years of age.

It is important to point out that although the higher mortality rate "decreases" the direct health care costs of obesity, it may "increase" the indirect costs if one accepts the practice of calculating costs due to lost productivity and so forth.[23] In addition, at the risk of stating the obvious, though early mortality may reduce direct health care costs, it is certainly an undesirable concomitant of obesity. Moreover, regardless of the effect on mortality and costs, it is clear that obesity reduces quality of life.[24]

Limitations of the present study include the uncertainty of some of the input parameters, particularly the relative risk of death associated with obesity, and the fact that there was insufficient information available to permit confident predictions beyond 85 years of age. The former limitation was addressed by the sensitivity analysis, and the results suggest that given the uncertainty of the relative risk values, the direct health care costs may be slightly lower or markedly lower than values previously reported but are almost certainly lower. In addition, the results suggest that over the ages of 20 to 85 years, the costs remain positive—that is, obesity is costly. Even at the lowest end of the sensitivity analysis, the estimate was nearly 1% of total direct health care costs, which is a substantial amount of money.

It is also important to acknowledge 3 other limitations. First, our approach to cost-benefits and cost-effectiveness analyses was limited in that it did not consider information about the real-life response to treatment, which may include "cure," temporary alleviation, or even iatrogenesis.[5] Second, the estimates based on information from Wolf and Colditz[9] do not include all obesity-related medical conditions (e.g., sleep apnea, gout, low back pain, and some cancers that have a lower absolute incidence but a possible consistent relation with obesity). Finally, our estimates do not include the cost of weight loss programs and interventions.

We used data from studies that generally had information on individuals' weight at single points in time. Thus, these data are applicable to asking "what if" questions about the effects of differences among cohorts with respect to obesity prevalence. It is not clear how our results might change if we asked "what if" questions about the effects of changes in obesity prevalence within a cohort over time. This represents an interesting topic for future research.

In conclusion, although obesity is clearly costly during the period from 20 to 85 years of age, it appears to be less costly than previously estimated. Future research should endeavor to extend this calculation beyond 85 years of age. At each year of life from 20 to 79, prevention and treatment of obesity could be cost saving, if the costs of the interventions to prevent and treat obesity are less than the costs of obesity itself, but any reduction in costs may be less than earlier reports have suggested. □

Contributors

All three authors contributed to the conception, derivations, and writing of this manuscript.

Acknowledgments

This research was funded by grants R29DK47256, R01DK51716, and P30DK26687 from the National Institutes of Health.

We are grateful to Theodore Thompson and David F. Williamson for their helpful suggestions and to June Stevens for providing the relative risk information from her study.

References

1. Kuczmarski RJ, Carroll MD, Flegal KM, Troiano RP. Varying body mass index cutoff points to describe overweight prevalence among U.S. adults: NHANES III (1988 to 1994). *Obes Res.* 1997;5:542–548.
2. Pi-Sunyer FX. Health implications of obesity. *Am J Clin Nutr.* 1991;53(6 suppl):1595S–1603S.
3. Troiano RP, Frongillo EA, Sobal J, Levitsky DA. The relationship between body weight and mortality: a quantitative analysis of combined information from existing studies. *Int J Obes Relat Metab Disord.* 1996;20:63–75.
4. Hannon BM, Lohman TG. The energy cost of overweight in the United States. *Am J Public Health.* 1978;68:765–767.
5. Institute of Medicine (Paul R.Thomas, ed.). *Weighing the Options: Criteria for Evaluating Weight-Management Programs.* Washington, DC: National Academy Press; 1995.
6. *Report of the Advisory Committee on the Dietary Guidelines for Americans, 1995.* Washington, DC: US Dept of Agriculture; 1995.
7. Costs of obesity on health [transcript]. "ABC World News Tonight." ABC television. July 18, 1994.
8. Mihill C. Obesity costs early death and pounds 200m. *The Guardian.* July 18, 1994:sect 1:5.
9. Wolf AM, Colditz GA. Current estimates of the economic cost of obesity in the United States. *Obes Res.* 1998;6:97–106.
10. Williamson DF, Venkat Narayan KM, Teutsch SM. The economic impact of obesity in the United States: whither? *Obes Res.* 1998;6:173–175.
11. Bonneux L, Barendregt JJ, Nusselder WJ, Van der Maas PJ. Preventing fatal diseases increases healthcare costs: cause elimination life table approach. *BMJ.* 1998;316:26–29.
12. Barendregt JJ, Bonneux L, Van der Maas PJ. The health care costs of smoking. *N Engl J Med.* 1997;337:1052–1057.
13. Heithoff KA, Cuffel BJ, Kennedy S, Peter J. The association between body mass and health care expenditures. *Clin Ther.* 1997;19:811–820.
14. Swinburn B, Ashton T, Gillespie J, et al. Health care costs of obesity in New Zealand. *Int J Obes Relat Metab Disord.* 1997;21:891–896.

15. Quesenberry CP, Caan B, Jacobson A. Obesity, health service use, and health care costs among members of a health maintenance organization. *Arch Intern Med.* 1998;158:466–472.
16. *National Health and Nutrition Examination Survey, III 1988–94* [CD-ROM]. Hyattsville, Md: National Center for Health Statistics/Centers for Disease Control and Prevention; 1997. Series 11, No. 1.
17. *Vital Statistics of the United States, 1993.* Vol 2, sec 6. Hyattsville, Md: National Center for Health Statistics; 1997.
18. Stevens J, Cai J, Pamuk ER, Williamson DF, Thun MJ, Wood JL. The effect of age on the association between body-mass index and mortality. *N Engl J Med.* 1998;338:1–7.
19. Schneider EL, Guralnik JM. The aging of America. Impact of health care costs. *JAMA.* 1990;263:2335–2340.
20. *Statistical Abstract of the United States, 1997.* Washington, DC: US Bureau of the Census;1998.
21. Manson JE, Willett WC, Stampfer M, et al. Body weight and mortality among women. *N Engl J Med.* 1995;333:677–685.
22. Ramalingam S, Pawlish K, Gadgeel S, Demers R, Kalemkerian GP. Lung cancer in young patients: analysis of a Surveillance, Epidemiology, and End Results database. *J Clin Oncol.* 1998;16:651–657.
23. Gold MR, Siegel JE, Russel LB, Weinstein MC, eds. *Cost Effectiveness in Health and Medicine.* New York, NY: Oxford Press; 1996.
24. Han TS, Tijhuis MA, Lean ME, Seidell JC. Quality of life in relation to overweight and body fat distribution. *Am J Public Health.* 1998;88:1814–1820.