Lifetime Health and Economic Consequences of Obesity

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Background: Obesity is an established risk factor for several chronic diseases. The lifetime health and economic consequences of obesity for individual patients have not been documented.

Objective: To estimate the lifetime health and economic consequences of obesity.

Methods: We developed a dynamic model of the relationship between body mass index and the risks and associated costs of 5 obesity-related diseases: hypertension, hypercholesterolemia, type 2 diabetes mellitus, coronary heart disease, and stroke. The model was estimated using data from the Third National Health and Nutrition Examination Survey, the Framingham Heart Study, and other secondary sources. We used this model to estimate (1) risks of hypertension, hypercholesterolemia, and type 2 diabetes mellitus at future ages; (2) lifetime risks of coronary heart disease and stroke; (3) life expectancy; and (4) expected lifetime medical care costs of these 5 diseases for men and women aged 35 to 64 years with body mass indexes of 22.5, 27.5, 32.5, and 37.5 kg/m² (nonobese and mildly, moderately, and severely obese, respectively).

Results: Disease risks and costs increase substantially with increased body mass index. The risk of hypertension for moderately obese 45- to 54-year-old men, for example, is roughly 2-fold higher than for their nonobese peers (38.1% vs 17.7%), whereas the risk of type 2 diabetes mellitus is almost 3-fold higher (8.1% vs 3.0%). Lifetime risks of coronary heart disease and stroke are similarly elevated (41.8% vs 34.9% and 16.2% vs 13.9%, respectively), whereas life expectancy is reduced by 1 year (26.5 vs 27.5 years). Total discounted lifetime medical care costs for the treatment of these 5 diseases are estimated to differ by $10 000 ($29 600 vs $19 600). Similar results were obtained for women.

Conclusions: The lifetime health and economic consequences of obesity are substantial and suggest that efforts to prevent or reduce this problem might yield significant benefits.

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During the past 2 decades, the prevalence of obesity has increased dramatically among US adults. Between 1976 and 1980, 24.1% and 26.5% of men and women, respectively, were reported to be overweight; between 1988 and 1991, these figures were estimated to have increased to 31.7% and 34.9%, respectively.1 The potential health implications of these trends are ominous, as results of several large-scale epidemiological cohort studies2 have established that obesity is a major risk factor for several chronic disease conditions, including coronary heart disease (CHD), type 2 diabetes mellitus, hypertension, selected cancers, and musculoskeletal disorders, as well as all-cause mortality.

In the Nurses’ Health Study,3 for example, which prospectively followed up more than 100 000 women, the 14-year mortality rate for those with body mass indexes (BMIs or Quetelet indexes; calculated as weight in kilograms divided by the square of the height in meters: weight (kg)/[height (m)]²) greater than 32 was more than double that for women with BMIs less than 19. In another analysis4 based on this study, relative risks of type 2 diabetes mellitus were 40.3, 54.0, and 93.2 for women with BMIs of 31.0 to 32.9, 33.0 to 34.9, and 35.0 or greater, respectively, relative to those with BMIs less than 22.0. In the Health Professionals Follow-up Study,5 which followed up 29 000 men for 3 years, subjects who were mildly obese (BMI, 25.0-28.9) had a 50% higher risk of CHD than those with BMIs less than 23.0; moderate obesity (BMI, 29.0-32.9) and severe obesity (BMI, ≥33.0) were associated with nearly 2-fold and more than 3-fold increases, respectively, in CHD risk.
METHODS

MODEL DESCRIPTION

We developed a dynamic model of the relationship between BMI and 5 diseases for which obesity is an established risk factor: hypertension, hypercholesterolemia, type 2 diabetes mellitus, CHD, and stroke. Our model is composed of a set of interrelated equations that estimate the lifetime risks and costs of these diseases for men and women in relation to their current age and BMI, and it is similar to models previously used by 2 of us in analyses of the lifetime risks and economic costs of smoking.7,8

Because some diseases for which obesity is a risk factor (ie, hypertension, hypercholesterolemia, and type 2 diabetes mellitus) are themselves risk factors for CHD and stroke, our model is structured in 2 stages to embody the complex nature of these relationships (Figure 1). In stage 1 we generate predicted risks of hypertension, hypercholesterolemia, and type 2 diabetes mellitus for men and women in each future year of life in relation to BMI. In stage 2 we estimate the risks of CHD, stroke, and death during each future year of life, based on BMI and the predicted risks of hypertension, hypercholesterolemia, and type 2 diabetes mellitus from the first stage of the model. Our analysis therefore reflects obesity’s direct effects on future cardiovascular disease risks and its indirect effects on these risks as a result of changes in blood pressure, serum cholesterol level, and glucose metabolism.

Expected medical care costs are generated and tallied in both stages of the model. In stage 1, the expected costs of hypertension, hypercholesterolemia, and type 2 diabetes mellitus in each future year of life are calculated based on the estimated risks of these diseases and corresponding estimates of medical care costs; to avoid double counting, cardiovascular disease costs (eg, heart attack and stroke) attributable to these 3 diseases are not included in this stage. In stage 2, the expected costs of CHD and stroke in each future year of life are calculated in similar fashion, based on future risks of these diseases and their associated medical care costs.

In our calculations, we hold BMI constant at its initial value as we “age” persons over time; all other risk factors are adjusted to age-appropriate values. Our model accordingly generates a stream of annual BMI-specific disease risks and economic costs running from current age to age 99 years. We translate this lifetime stream of costs into a summary measure of economic burden by discounting and summing these annual estimates, after adjustment for the likelihood of survival to each future year.

We conservatively assumed that all obesity-attributable mortality results from elevated CHD and stroke risks. Hence, in our model, persons can die from CHD, stroke, or causes unrelated to these diseases, but not directly from any other complications of hypertension, hypercholesterolemia, or type 2 diabetes mellitus (eg, kidney disease). The probability of survival to any given future age is therefore calculated as the sum of 3 conditional probabilities: (1) survival given previous onset of CHD, (2) survival given previous onset of stroke, and (3) survival free of these diseases. Life expectancies are calculated by summing annual probabilities of survival, from current age through age 99 years.

A technical appendix that sets forth all model equations is available on request.

MODEL ESTIMATION

We estimated our model using data from a variety of secondary sources, which we describe in detail below. All costs were estimated at 1996 price levels; the Medical Care Component of the Consumer Price Index for All Urban Consumers was used to adjust prices, where necessary. Future costs were discounted to present values using a real annual rate of 3%, consistent with recent recommendations of the US Public Health Service Task Force on Cost-Effectiveness in Health and Medicine.11

Stage 1: Risks of Hypertension, Hypercholesterolemia, and Type 2 Diabetes

We used data from NHANES III12 to estimate risks of hypertension, hypercholesterolemia, and type 2 diabetes mellitus (and mean levels of diastolic blood pressure and total serum cholesterol) for men and women in relation to age and BMI. The variables of interest were expressed as a function of age, age squared, and BMI, and techniques of regression analysis (logistic for dichotomous measures and linear for continuous measures) were used to estimate these equations separately for men and women. We then used the estimated β coefficients of these regressions to predict mean values of the variables of interest in each age-sex-BMI stratum. Because of sample size limitations, we limited our attention to persons aged 35 to 84 years. In the model, we accordingly assumed that the risks of hypertension, hypercholesterolemia, and type 2 diabetes mellitus would remain constant at the levels prevailing at age 84 years throughout all remaining years of life (ie, to age 99 years).

We considered NHANES III respondents to be hypertensive if (1) their mean diastolic blood pressure exceeded 90 mm Hg, (2) their mean systolic blood pressure exceeded 160 mm Hg, or (3) they responded “yes” to a question concerning current use of drug therapy to control blood pressure. We similarly considered survey respondents to be hypercholesterolemic if (1) their total cholesterol level exceeded 240 mg/dL, or (2) they responded “yes” to a question concerning current use of drug therapy to reduce their cholesterol level. In NHANES III, blood pressure was measured up to 6 times; we used the average of all available readings for both systolic and diastolic blood pressures. Because treatment would mask the true biologic relationships between BMI and both blood pressure and total cholesterol level, we excluded from the regression analyses of diastolic blood pressure those persons who were currently receiving antihypertensive medications, and from the analyses of total cholesterol level those who were currently receiving cholesterol-lowering therapy.

In NHANES III, persons with diabetes were not specifically identified as having type 2 or type 1 diabetes mellitus. Accordingly, to identify cases of type 2 diabetes mellitus, we used published criteria15 for the diagnosis of this condition to develop an algorithm that was compatible with NHANES III. We considered all persons who reported having diabetes (other than those with gestational diabetes) to have type 2 diabetes mellitus if (1) they were at least 30 years old at onset, (2) they were between the ages of 19 and 29 years at onset and were not taking insulin, or (3) they were between the ages of 19 to 29 years at onset and were currently taking insulin, but did not begin taking insulin for at least 12 months following disease onset.
Stage 1: Costs of Hypertension, Hypercholesterolemia, and Type 2 Diabetes

We estimated the annual cost of treating patients with hypertension ($670) by averaging the costs of pharmacologic therapy and provider services in the first, second, and all subsequent years after diagnosis, as reported by Odell and Gregory. Unpublished data from NHANES III indicate that 80.9% of all persons with elevated blood pressure receive antihypertensive therapy. In the model, we accordingly estimated the annual cost of hypertension to be $542 (or $670 × 0.809).

Our estimate of the annual cost of treating patients with hypercholesterolemia ($705) was based on a recent study by Oster and colleagues. Unpublished data from NHANES III indicate that only 22.0% of all persons with hypercholesterolemia receive cholesterol-lowering medications. Hence, in the model, we assumed that the annual cost of hypercholesterolemia would be $153 (or $705 × 0.22%).

Stage 2: Risks of CHD, Stroke, and Mortality

Using data from the Framingham Heart Study, we estimated logistic functions to predict the risks of CHD and stroke for 2 years as a function of age, age squared, BMI, diastolic blood pressure, total cholesterol level, presence of type 2 diabetes mellitus, and current smoking habit. Separate logistic functions were estimated for men and women aged 35 to 64 and 65 to 99 years; only primary events were considered. Coronary heart disease was defined as in previous research to include sudden death, nonsudden death, myocardial infarction, cardiac arrest, and end-stage renal disease were included in this estimate. Diabetes-attributable costs of CHD and stroke were excluded to avoid double counting. The annual costs of type 2 diabetes mellitus for men aged 35 to 64 and 65 to 99 years were $2025 and $2806, respectively. Corresponding estimates for women were $2374 and $4454.

Stage 2: Costs of CHD and Stroke

As with survival after onset of CHD or stroke, we assumed that these diseases would give rise to medical care costs during a 10-year period (or up to age 99 years for events occurring after age 90 years). Age-at-onset-specific estimates of the annual cost of CHD for men and women in each of the 10 years after onset were obtained from the CHD Policy Research Institute (Karen Kuntz, ScD, written communication, August 1997). These estimates represent a weighted average of the expected costs of myocardial infarction, cardiac arrest, and angina pectoris. Costs included hospital care, prescription drugs, physician services, laboratory tests and rehabilitation services for the diagnosis and treatment of acute myocardial infarction, coronary revascularization (ie, bypass graft surgery and percutaneous transluminal coronary angioplasty), annual maintenance therapy after acute myocardial infarction, cardiac arrest (fatal or nonfatal), and congestive heart failure. Estimates also include the expected costs of secondary events occurring in the 10 years after onset.

Estimates of the annual costs of stroke were obtained from a study of the cost-effectiveness of stroke prevention in high-risk patients. First-year costs ($12,634) included inpatient hospital and professional services and inpatient rehabilitation. Age-specific costs of stroke in years 2 through 10 after onset were obtained by annualizing the monthly costs of nursing home care; all visits to physicians, physical therapists, and speech therapists; home health care; and inpatient acute and rehabilitation care for recurrent strokes. These costs were estimated to be $3171, $3356, and $9421 annually for persons aged 35 to 74, 75 to 84, and older than 84 years, respectively.

ANALYSES

We used our model to examine the risks at given ages of hypertension, hypercholesterolemia, and type 2 diabetes mellitus; the lifetime risks of CHD and stroke; life expectancy; and expected lifetime medical care costs of the 5 obesity-related diseases. We estimated these measures for men and women aged 35 to 44, 45 to 54, and 55 to 64 years with BMIs of 22.5 to 37.5 (in increments of 5.0). We designated persons at the lowest level of BMI (ie, 22.5) as “nonobese” and used this group as a benchmark against which to assess excess risks and costs among those with higher levels of BMI. Persons with BMIs of 27.5, 32.5, and 37.5 were designated “mildly obese,” “moderately obese,” and “severely obese,” respectively.
and other studies underscore the far-reaching health consequences of obesity. The economic burden of obesity is also substantial. Health care expenditures attributable to obesity were estimated to total $51.6 billion in the United States in 1995, or almost 6% of total health care spending; indirect costs (reflecting the value of lost productivity attributable to obesity-related morbidity and mortality) were reported to be $47.6 billion. Although this and similar studies provide valuable information on the aggregate economic burden of obesity, they do not address the lifetime consequences of this condition for individual patients. Although estimates have been reported of the impact of other risk factors such as cigarette smoking on lifetime medical care costs, to the best of our knowledge, no study has yet examined obesity from this perspective.

In this study, we address these issues using a model of the lifetime health and economic consequences of obesity. We focus attention on the relationship between obesity and 5 major chronic disease conditions: hypertension, hypercholesterolemia, type 2 diabetes mellitus, CHD, and stroke. Results of previous research suggest that these 5 diseases account for approximately 85% of the total economic burden of obesity. We estimated our model using data from the Third National Health and Nutrition Examination Survey (NHANES III), the Framingham Heart Study, and other secondary sources, and used it to examine how a variety of clinical and economic outcomes vary in relation to BMI for men and women aged 35 to 64 years.

### RESULTS

#### RISKS OF HYPERTENSION, HYPERCHOLESTEROLEMIA, AND TYPE 2 DIABETES

Estimates of the risks of hypertension (Figure 2), hypercholesterolemia (Figure 3), and type 2 diabetes mellitus (Figure 4) in relation to BMI are presented for men and women aged 35 to 44, 45 to 54, and 55 to 64 years. The relationship between BMI and risk of hypertension is strong (Figure 2). For example, among men aged 45 to 54 years, the risk of hypertension rises from 17.7% for those with a BMI of 22.5 to 26.7%, 38.1%, and 50.9% for those with BMIs of 27.5, 32.5, and 37.5, respectively. The risk of hypercholesterolemia also increases across the range of BMIs considered, although the effect of obesity is smaller than of hypertension (Figure 3). Among men aged 45 to 54 years, the risk of hypercholesterolemia rises from 17.7% for those with a BMI of 22.5 to 26.7%, 38.1%, and 50.9% for those with BMIs of 27.5, 32.5, and 37.5, respectively. Among nonobese persons aged 45 to 54 years (BMI, 22.5), the risk of this disease is 3.0% for men and 3.2% for women. Among men, risk increases to 5.0%, 8.1%, and 12.9% for those with BMIs of 27.5, 32.5, and 37.5, respectively; among women, risk increases to 4.9%, 7.5%, and 11.2%, respectively.

The risk of type 2 diabetes mellitus also increases across the range of BMIs considered, although the effect of obesity is smaller than of hypertension (Figure 4). Among men aged 45 to 54 years, the risk of type 2 diabetes mellitus rises from 3.0% for those with a BMI of 22.5 to 26.7%, 38.1%, and 50.9% for those with BMIs of 27.5, 32.5, and 37.5, respectively.

#### LIFETIME RISKS OF CHD AND STROKE

Age- and sex-specific estimates of lifetime risks of CHD and stroke in relation to BMI are displayed in Table 1. Risks of CHD increase substantially with increasing BMI. For example, among men aged 45 to 54 years with a BMI of 22.5, the lifetime risk of CHD is 34.9%; risk increases...
to 38.0%, 41.8%, and 46.4% for those with BMIs of 27.5, 32.5, and 37.5, respectively. A similar pattern of increasing CHD risk prevails among women: among those aged 45 to 54 years, lifetime risk increases from 25.5% for the nonobese (BMI, 22.5) to 28.6%, 32.4%, and 37.1% for those with BMIs of 27.5, 32.5, and 37.5, respectively.

Although lower in absolute terms, the lifetime risks of stroke for men exhibit a pattern of increase in relation to BMI similar to that of CHD; the gradient for women, however, is less pronounced. Among men aged 45 to 54 years, the lifetime risk of stroke rises from 13.9% for those with a BMI of 22.5 to 15.0%, 16.2%, and 17.4% for those with BMIs of 27.5, 32.5, and 37.5, respectively. Among 45- to 54-year-old women, total expected costs rise from $18 800 at a BMI of 22.5 to $23 200, $28 700, and $35 300 at each of the higher BMIs.

Among men, CHD accounts for about half of the total expected medical care costs of the 5 diseases in all age groups except 75- to 84-year-olds, in whom CHD and stroke are similar and together account for roughly two thirds of the total cost (disease-specific data not shown). Among women who are mildly, moderately, or severely obese, type 2 diabetes mellitus is the most costly disease in all age groups, generally followed by CHD and hypertension. However, in the 75- to 84-year-old age group, the costs of stroke exceed those of these diseases.

LIFE EXPECTANCY

Table 2 summarizes our estimates of life expectancy for men and women by current age and BMI. Life expectancy among nonobese (BMI, 22.5) men and women aged 45 to 54 years is 27.5 and 32.2 years, respectively. Higher BMIs are associated with reduced life expectancies: among men, life expectancy is estimated to be 27.0, 26.5, and 25.8 years for those with BMIs of 27.5, 32.5, and 37.5, respectively; among women, corresponding estimates are 31.9, 31.4, and 30.9 years.

LIFETIME MEDICAL CARE COSTS

Increases in BMI are associated with substantial increases in total (discounted) expected lifetime medical care costs for the treatment of hypertension, hypercholesterolemia, type 2 diabetes mellitus, CHD, and stroke (Table 3). Among men aged 45 to 54 years, for example, costs rise from $19 600 among those who are nonobese (BMI, 22.5) to $24 000, $29 600, and $36 500 among those with BMIs of 27.5, 32.5, and 37.5, respectively. Among 45- to 54-year-old women, total expected costs rise from $18 800 at a BMI of 22.5 to $23 200, $28 700, and $35 300 at each of the higher BMIs.

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COMMENT

Our findings suggest that the lifetime health and economic consequences of obesity are substantial. For
example, relative to persons who are nonobese (BMI, 22.5), the risk of hypertension is 40% to 60% higher for those mildly obese (BMI, 27.5), 2-fold higher for those moderately obese (BMI, 32.5), and nearly 3-fold higher for those severely obese (BMI, 37.5). Similarly, in most age-sex groups, the risk of type 2 diabetes mellitus is 50% to 60% higher, more than 2-fold higher, and 3- to 4-fold higher among those who are mildly, moderately, and severely obese, respectively. Cardiovascular disease risks also increase considerably with increasing BMI. These differences in disease risk translate into substantial differences in medical care costs. Mild obesity increases the expected lifetime medical care costs for the 5 diseases of interest by approximately 20%, while moderate obesity increases them by about 50%, and severe obesity nearly doubles them.

It is interesting to compare our estimates of the lifetime costs of obesity with those attributable to cigarette smoking, which is the No. 1 modifiable risk factor for morbidity and mortality in the United States. In a study using a similar method, excess lifetime medical care costs (discounted 3% annually) of CHD, lung cancer, and chronic obstructive pulmonary disease were $5500 among 45- to 54-year-old men who were light smokers (<1 pack/day), $9200 among moderate smokers (1-2 packs/day), and $14 100 among heavy smokers (>2 packs/day) (estimates were updated to 1996 dollars). These cost estimates are similar in magnitude to ours for 45- to 54-year-old men who are mildly, moderately, and severely obese.

Although our findings suggest that the lifetime health and economic consequences of obesity are substantial, we believe them to be conservative for several reasons. First, modeling complexity prevented us from examining the relationship between BMI and other diseases that have been linked to obesity, including gallbladder disease, osteoarthritis of the knees, and endometrial cancer. It is unknown to what extent our omission of these diseases led us to underestimate the impact of obesity on medical care costs and life expectancy. In addition, although available evidence suggests that average body weight (and hence BMI) among US adults increases with age, in our analysis, we assumed that BMI would remain constant from each person’s current age through all remaining years of life. This assumption was necessitated by the lack of data characterizing average weight gain with increasing age in relation to initial BMI. Hence, possible future increases in BMI, and their attendant effects on disease risks and costs, are not reflected in our estimates of the lifetime health and economic consequences of obesity.

Additional limitations of our analysis should be noted. Because of the complexity of the interrelationships between degree of obesity and the 5 obesity-related diseases on which we focused attention, we made several simplifying assumptions to prevent the model calculations from becoming intractable. We assumed that obesity impacts mortality only via its role as a risk factor in the development of CHD and stroke. In the model, mortality rates for persons who do not

| Table 1. Lifetime Risks of Coronary Heart Disease and Stroke by Sex, Age Group, and BMI* |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Age Group, y    | Lifespan, %, by BMI, kg/m² | Coronary Heart Disease | Stroke |
| Men             | 22.5 | 27.5 | 32.5 | 37.5 | 22.5 | 27.5 | 32.5 | 37.5 |
| 35-44           | 35.2 | 35.6 | 35.4 | 35.5 | 16.0 | 16.2 | 16.5 | 16.7 |
| 45-54           | 35.5 | 35.8 | 36.1 | 36.3 | 16.4 | 16.6 | 16.9 | 17.1 |
| 55-64           | 35.8 | 36.1 | 36.4 | 36.6 | 16.8 | 17.0 | 17.3 | 17.5 |
| Women           | 22.5 | 27.5 | 32.5 | 37.5 | 22.5 | 27.5 | 32.5 | 37.5 |
| 35-44           | 35.0 | 35.4 | 35.6 | 35.8 | 15.9 | 16.1 | 16.4 | 16.7 |
| 45-54           | 35.3 | 35.7 | 35.9 | 36.2 | 16.3 | 16.5 | 16.8 | 17.0 |
| 55-64           | 35.6 | 35.9 | 36.2 | 36.5 | 16.7 | 16.9 | 17.2 | 17.4 |

* In persons assumed initially free of coronary heart disease and stroke. BMI indicates body mass index.

| Table 2. Life Expectancy by Sex, Age Group, and BMI* |
|-----------------|-----------------|-----------------|-----------------|
| Age Group, y    | Life Expectancy, y, by BMI, kg/m² | Coronary Heart Disease | Stroke |
| Men             | 22.5 | 27.5 | 32.5 | 37.5 | 22.5 | 27.5 | 32.5 | 37.5 |
| 35-44           | 36.2 | 35.7 | 35.1 | 34.4 | 16.0 | 15.6 | 15.2 | 14.8 |
| 45-54           | 37.5 | 37.0 | 36.5 | 35.8 | 16.3 | 15.9 | 15.5 | 15.1 |
| 55-64           | 38.8 | 38.3 | 37.8 | 37.1 | 16.7 | 16.3 | 15.9 | 15.5 |
| Women           | 22.5 | 27.5 | 32.5 | 37.5 | 22.5 | 27.5 | 32.5 | 37.5 |
| 35-44           | 41.4 | 41.1 | 40.6 | 40.1 | 17.0 | 16.6 | 16.2 | 15.8 |
| 45-54           | 42.7 | 42.3 | 41.8 | 41.3 | 17.4 | 17.0 | 16.6 | 16.2 |
| 55-64           | 44.0 | 43.6 | 43.1 | 42.6 | 17.8 | 17.4 | 17.0 | 16.6 |

* In persons assumed initially free of coronary heart disease and stroke. BMI indicates body mass index.

| Table 3. Expected Lifetime Medical Care Costs of Selected Obesity-related Diseases, Discounted 3% by Sex, Age Group, and BMI* |
|-----------------|-----------------|-----------------|-----------------|
| Age Group, y    | Expected Lifetime Costs, $, by BMI, kg/m² | Coronary Heart Disease | Stroke |
| Men             | 22.5 | 27.5 | 32.5 | 37.5 | 22.5 | 27.5 | 32.5 | 37.5 |
| 35-44           | 16 200 | 20 200 | 25 300 | 31 700 | 16 200 | 20 200 | 25 300 | 31 700 |
| 45-54           | 19 600 | 24 000 | 29 600 | 36 500 | 19 600 | 24 000 | 29 600 | 36 500 |
| 55-64           | 22 000 | 26 100 | 31 200 | 37 400 | 22 000 | 26 100 | 31 200 | 37 400 |
| Women           | 22.5 | 27.5 | 32.5 | 37.5 | 22.5 | 27.5 | 32.5 | 37.5 |
| 35-44           | 15 200 | 18 900 | 23 800 | 29 700 | 15 200 | 18 900 | 23 800 | 29 700 |
| 45-54           | 18 800 | 23 200 | 28 700 | 35 300 | 18 800 | 23 200 | 28 700 | 35 300 |
| 55-64           | 21 900 | 26 500 | 32 200 | 39 000 | 21 900 | 26 500 | 32 200 | 39 000 |

* BMI indicates body mass index. In persons assumed initially free of coronary heart disease and stroke. The obesity-related diseases are coronary heart disease, stroke, type 2 diabetes, hypertension, and hypercholesterolemia.
develop 1 of these diseases are accordingly assumed to be equal to those of age- and sex-specific US population averages (with CHD and stroke mortality factored out), irrespective of the degree of obesity. This undoubtedly lent a conservative bias to our life-expectancy estimates because reported differences in mortality rates among obese vs nonobese persons exceed the amount that can be explained by differences in cardiovascular mortality. We also assumed that persons could develop either CHD or stroke but not both, either in the same year or at different points in time. Prediction of the joint risks of CHD and stroke, or of the risk of 1 of these diseases conditional on previous development of the other, would make model estimation impossible with available data. Finally, we did not attribute to obesity the possible savings in lifetime medical care costs that could result from reduced longevity. Although overweight persons who die prematurely of an obesity-related disease are not subject to the costs of medical care (routine and otherwise) incurred in the additional years of life lived by their nonobese peers, it is unlikely that inclusion of such costs in the analysis would have appreciably altered our findings, due to the modest differences in life expectancy according to BMI that we estimated, as well as the effects of discounting on future disease costs.

The health and economic burden of obesity has drawn considerable interest in recent years. To the best of our knowledge, our study is the first to examine its lifetime health and economic consequences. Our findings suggest that these consequences are substantial, and that efforts to prevent or reduce the magnitude of this problem may yield significant health and economic benefits.

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