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Gender and the Burden of Disease Attributable to Obesity

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Abstract and Introduction

Abstract

Objectives: We estimated the burden of disease in the United States attributable to obesity by gender, with life expectancy, quality-adjusted life expectancy, years of life lost annually, and quality-adjusted life years lost annually as outcome measures.

Methods: We obtained burden of disease estimates for adults falling into the following body-mass index categories: normal weight (23 to <25), overweight (25 to <30), and obese (30). We analyzed the 2000 Medical Expenditure Panel Survey to obtain health-related quality-of-life scores and the 1990–1992 National Health Interview Survey linked to National Death Index data through the end of 1995 for mortality.

Results: Overweight men and women lost 270 000 and 1.8 million quality-adjusted life years, respectively, relative to their normal-weight counterparts. Obese men and women lost 1.9 million and 3.4 million quality-adjusted life years, respectively, per year. Much of the burden of disease among overweight and obese women arose from lower health-related quality of life and late life mortality.

Conclusions: Relative to men, women suffer a disproportionate burden of disease attributable to overweight and obesity, mostly because of differences in health-related quality of life.

Introduction

Between 1990 and 2000, the age-adjusted prevalence of obesity increased from 22.9% to 30.5% and the age-adjusted prevalence of overweight increased from 55.9% to 64.5%.^[1] If similar trends continue, obesity may result in a decline in life expectancy in the United States.^[2] This mortality risk arises from a higher risk of numerous comorbidities, including type 2 diabetes, hypertension, hypercholesterolemia, osteoarthritis, gallbladder disease, and some cancers.^[3] However, obesity may also produce psychological morbidity, especially among women.^[4]

A number of studies have examined the burden of disease attributable to obesity and overweight with measures of mortality, such as annual years of life lost.^[5] Although mortality data provide a common comparable endpoint for all diseases, they provide little information about the suffering caused by diseases while people are alive. Morbidity studies typically capture the association between obesity and a subset of conditions with which it is associated.^[6–11] For instance, the burden of disease has been measured with the prevalence of high blood pressure, heart disease, and other conditions thought to be associated with obesity.^[9] However, analyses based on attributable risk typically exclude diseases with a psychological dimension and those that are less prevalent.^[4]

To provide a more comprehensive assessment of morbidity, recent analyses have been conducted using preference-based health-related quality-of-life (HRQL) measures of overweight and obese people.^[12–14] The advantage of preference-based measures over other quality-of-life measures is that they can be used to calculate quality-adjusted life years (QALYs).^[15] The recent inclusion of an HRQL measure (the EuroQoL [EQ-5D]) into a

large national survey makes it possible to capture the health states of people in the United States and convert them into QALYs.

We examined the burden of disease in the US adult general population by body mass index (BMI). Specifically, we examined: (1) the distribution of sociodemographic variables and selected chronic conditions; (2) the distribution of average HRQL scores by sociodemographic variables and conditions; (3) the annual number of deaths, years of life lost to death, and QALYs in men and women; and (4) life expectancy and quality-adjusted life expectancy for men and women.

Methods

Overview and Definitions

We calculated BMI from self-reported height and weight. Persons with a BMI of less than 23 kg/m² were excluded to avoid confounding by underlying medical conditions unrelated to body weight.^[16,17] Although the ideal comparison group has not been defined, we chose the group with the lowest morbidity and mortality to form a "normal-weight" comparator. The use of the group with the lowest morbidity and mortality maximizes the burden of disease estimated with national datasets, but does not completely eliminate confounding by diseases and conditions unrelated to overweight and obesity. We used the following definitions: BMI 23 to <25 kg/m² = normal weight; BMI 25 to <30 kg/m² = overweight; BMI ≥30 kg/m² = obese.

Datasets

We obtained HRQL values from the Household Component of the 2000 Medical Expenditure Panel Survey (MEPS), and mortality ratios from the 1990–1992 National Health Interview Surveys (NHIS) linked to the National Death Index through the end of 1995.^[18–20] Both the MEPS and the NHIS are nationally representative samples of the civilian noninstitutionalized population.

The MEPS includes approximately 25000 persons.^[18] Although 15438 adults provided questionnaire data for the EQ-5D, 12% were proxy responders and were excluded. Also excluded from our sample were adults with missing height or weight information (4.3% of the sample). These persons had slightly lower self-rated health than those with BMI information, but were otherwise similar sociodemographically. The final sample consisted of 13646 subjects. All EQ-5D scores were generated with recently published US preference weights.^[21] The EQ-5D self-classifier included in the MEPS enables the respondent to categorize his/her health according to 3 levels (no problem, moderate, severe) for 5 dimensions of health.^[22]

The 1990–1992 NHIS included similar sociodemographic, height, and weight variables to those in MEPS.^[19] The NHIS can be linked to the National Death Index through the end of 1995, allowing for prospective mortality analyses of subjects in the original sample. The sample included 256900 persons whose vital statuses were obtained during the 6 years of follow-up, over which time 11214 persons died. We eliminated the subjects missing height or weight information (11.7% of the sample); these persons were older and tended to have higher mortality (6% vs 4% died) than those with complete BMI information. After also excluding persons aged younger than 18 years and those with a BMI <23, 84375 subjects remained in the analysis.

Calculations

Analyses were conducted using SAS version 8.2 (SAS Institute Inc, Cary, NC) and SUDAAN version 8.0.1 (Research Triangle Institute, Research Triangle Park, NC). These statistical packages permit adjustment for the complex sampling design used in the MEPS and NHIS. Both MEPS and NHIS data incorporated sampling weights and poststratification weights.

Spline regressions were employed to derive smoothed age-specific EQ-5D scores for persons aged 18 years and older.^[23] Spline regressions correct for bias, particularly at boundary regions, when independent variables are skewed or have outliers. We generated HRQL values for persons aged younger than 25 years, 25 to 44 years, 45 to 64 years, 65 to 74 years, and 75 years and older.

Cox proportional hazard survival models were used to generate the hazard ratios for overweight and obese relative to normal-weight individuals. Hazard ratios were generated from NHIS for the same intervals used to generate HRQL scores. Each analysis was adjusted for age and age squared.

Abridged life tables were generated for the general US population for the year 2000 with age intervals of 5 years (or fewer) to age 90 and older, and mortality data obtained from the National Center for Health Statistics.^[24] We calculated quality-adjusted life expectancy for each subgroup by first generating reference abridged life tables for normal-weight persons of each gender and then by multiplying age- and gender-specific mortality probabilities in the table by age-specific HRQL scores. Further details pertaining to the general construction of our life tables have been published elsewhere.^[25,26]

Overweight- and obesity-related deaths were calculated as:

(1)

$$(1) \quad \sum_{x=1}^5 M_x e_x / (1 - p_x)$$

where M = the total number of deaths in age interval x , e = the proportion of M excess deaths because of overweight and obesity in age interval x , and p = the proportion overweight or obese in age interval x . Total deaths were obtained from death certificate data.^[24] In 2000, there were 2403351 deaths, of which 356 (0.01%) were excluded because no information on subjects' ages was available. The derivation of this formula is available from the corresponding author.

Total years of life lost were calculated as:

(2)

$$(2) \quad \sum_{x=1}^5 D_x \cdot L_x$$

where x = the age interval (<25, 25–44, 45–64, 65–74, and ≥75 years), D_x is the number of weight-related deaths within age interval x , and L_x is the life expectancy for persons above the 2 thresholds at the midpoint of age interval x . L_x was obtained from life table values for the reference group (e.g., 23.0 kg/m² ≤BMI<25) to reflect the full potential life lost.

The QALYs lost to morbidity were calculated as:

(3)

$$(3) \quad \sum_{x=1}^5 (H_{Ax} - H_{Bx}) \cdot P_x$$

where H_{Ax} is the HRQL score for normal-weight persons in age interval x , H_{Bx} is the HRQL score for persons either overweight or obese in age interval x , and P_x is the population that is either overweight or obese in age interval x .

Total QALYs (because of both morbidity and mortality) were calculated as:

(4)

$$(4) \quad \sum_{x=1}^5 Q_{Mx} + H_x \cdot Y_x$$

where Q_{Mx} is the total number of QALYs because of morbidity in age interval x , H_x is the HRQL score for persons in

the BMI category of interest in age interval x , and Y_x is the number of years of life lost in age interval x .

Results

Table 1 highlights the sociodemographic and clinical profile of adults in the MEPS sample according to the 3 categories of BMI. Although there were more overweight men (57%) than women (43%), there were more obese women (54%) than men (46%). Adults who were obese compared with normal-weight persons were more likely to report fair or poor health, having diabetes, and having hypertension. All comparisons across rows are statistically significant at $P < .05$.

We found that HRQL scores declined with increasing category of weight with a few notable exceptions (data not shown). In particular, overweight non-Hispanic African Americans and overweight Hispanics had scores that were similar to the scores of normal-weight non-Hispanic African Americans and Hispanics. Overweight men had scores that were similar to the scores of normal-weight men.

Table 2 presents weight-related deaths, years of life lost, QALYs because of morbidity, and overall QALYs for overweight and obese persons by age. In the United States, relative to the normal-weight persons, there were 15000 additional deaths for overweight men and 37000 additional deaths for overweight women. Similarly, relative to normal-weight persons, there were 42000 additional deaths for obese men and 70000 additional deaths for obese women. Young, overweight women had fewer deaths than young, overweight men.

Overweight men in the United States had 47000 additional years of life lost annually whereas overweight women had 1 million additional years of life lost annually relative to normal-weight persons. Obese men had 1.21 million years of life lost to disease annually whereas obese women had an additional 1.89 million years of life lost to disease annually relative to normal-weight persons.

In addition to measuring QALYs as a summary measure capturing both HRQL and mortality, we examined QALYs attributable to HRQL decrements alone. Health-related quality-of-life decrements because of being overweight were nearly 4 times higher among women than among men (960000 QALYs and 243000 QALYs, respectively). Differences in HRQL among obese women were slightly greater than 2 times higher than among obese men (1.95 million QALYs and 912000 QALYs, respectively).

Overweight women had a 6.6-times higher burden of disease in total QALYs relative to overweight men (1.78 million QALYs relative to 270000 QALYs). The burden of disease among obese women was 1.8 times higher than among obese men (3.4 million QALYs relative to 1.94 million QALYs).

Figure 1 shows the total years of life and QALYs lost to overweight and obesity by gender per 100000 persons. Here, we see that the rate (per 100000 persons) of QALYs lost to morbidity for obese and overweight men remained relatively steady by age, whereas years of life lost by men generally increased with age. For both obese and overweight women, the rate of years of life lost was lower than the rate of QALYs lost to morbidity at young ages and then crossed around age 35 to 45 years before converging again later in life.

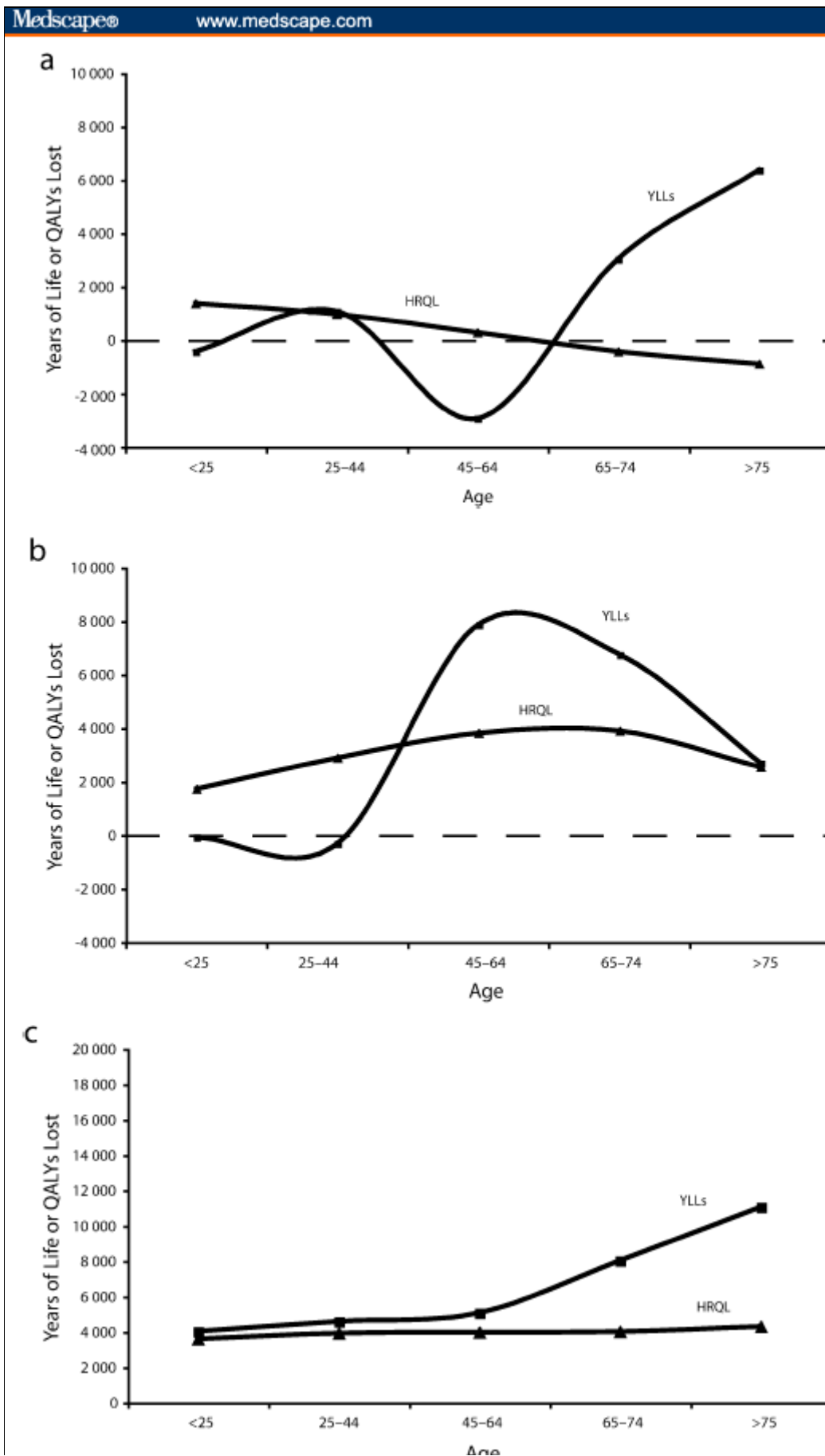


Figure 1.

Total years of life lost and quality-adjusted life years (QALYs) lost to overweight and obesity by gender per 100 000 persons for overweight males (a), overweight females (b), obese males (c), and obese females (d).

Table 3 shows the lifetime burden of disease for the 3 categories of BMI examined. Men aged 18 years in the normal-weight category had a life expectancy roughly equal to men of the same age in the overweight category—both 57 years. Obese men had a life expectancy of 54.3 years. By contrast, overweight women had a shorter lifespan than normal-weight women (62.4 vs 63.5 years). Obese women had a life expectancy of 60.7 years.

Differences in quality-adjusted life expectancy demonstrated larger differences by gender. Normal-weight men lived 0.5 QALY more than overweight men, and 4.4 QALYs more than obese men. Women in the normal-weight range lived 2.9 QALYs more than overweight women and 7.2 QALYs more than obese women. (Differences between these values and those in **Table 3** are because of rounding.)

Discussion

When we looked at data representative of the US adult household population, we found that being overweight or obese had a profound impact on the length and quality of life, and that the interplay of morbidity and mortality produced disparate results for men and women. Being overweight had a small effect on both HRQL and mortality among men (270000 QALYs lost), but a large impact on both outcomes for women (1.78 million QALYs lost). Likewise, obesity had a much greater impact on HRQL and mortality for obese women relative to obese men, producing a total of 1.94 million QALYs lost for men and 3.40 million QALYs lost for women.

However, this is not true across all age groups. Obese women aged younger than 45 years appeared to have lower excess mortality than younger obese men. After age 45, mortality for obese women far surpassed that of men (**Figure 1**). This pattern—a flip in male versus female mortality at age 45—has been observed before.^[17] This previous study used merged data from National Health and Nutrition Epidemiological Follow-Up Study and National Health and Nutrition II Mortality Study, but did not provide HRQL data to contextualize it.

Across all ages, HRQL was significantly lower among obese women than obese men; women aged younger than 45 years lost 1.5 times as many QALYs to morbidity than did men in the same age group. There are several possible overlapping explanations for these disparate gender findings. First, mortality by BMI may be confounded by muscle mass in very fit men. This hypothesis explains why overweight men have lower mortality than overweight women, but does not explain the distribution of years of life lost by age seen in **Figure 1**. Second, obesity in women may be more strongly associated with morbidity that translates into later mortality than in men. Third, psychological morbidity associated with obesity-related stigma might contribute to both the greater HRQL burden in women than men and the later increase in mortality in women.

This third hypothesis is consistent with other authors' findings that there was a much stronger association between depression and BMI in women than in men.^[4,27] It is also consistent with our finding that obese and overweight women of all ages suffered disproportionately from lower HRQL relative to men. Stress and depression have been linked to increases in the release of cortisol, vasopressors, and oxidative chemicals, which in turn may lead to an increased risk of the metabolic syndrome and heart disease—a process that necessarily takes years to lead to increases in mortality.^[27–30] Conversely, it is plausible that stress, anxiety, and depression could be the cause of obesity and higher mortality in the first place, or that a 2-way causal relationship exists.

When we compared the overweight and obese categories within genders, we found that men experienced slightly less than a 3-fold increase in the number of excess deaths when moving from the overweight to the obese category and a 7-fold increase in QALYs lost. Women, on the other hand, experienced less than a 2-fold increase in deaths and QALYs when moving between these categories. It is possible that men catch up to women in total QALYs lost in the obese category because of the aforementioned physiological differences in body fat versus lean muscle mass distribution by gender. Alternatively, this might happen once BMI is high enough to affect labor market participation among men (thus affecting access to health insurance or other goods and services that might affect survival). Clearly, more research is needed to iron out the pieces of these differences in quality versus quantity of life by age

and gender.

Whereas these annual losses are indicative of the burden of disease to society as a whole, changes in life expectancy and quality-adjusted life expectancy provide information on the burden of disease among individuals (Table 3). We found that being overweight had a modest impact on male quality-adjusted life expectancy: +0.5 QALY relative to normal-weight men. However, overweight had a relatively large impact on female quality-adjusted life expectancy: -2.9 fewer QALYs over a lifespan. Being obese had a large impact on quality-adjusted life expectancy for both sexes: -4 QALYs for men and -7 QALYs for women. Although no other authors have examined quality-adjusted life expectancy by BMI, other authors have examined differences in unadjusted life expectancy by BMI.^[2,31] These authors predict that, if trends continue, life expectancy in the United States will ultimately fall because of high rates of obesity among youngsters.

Likewise, although we did not conduct a trend analysis, it is conceivable that such trends will erase the gender gap in life expectancy. Were all women within the normal-weight category (BMI 23 to <25), life expectancy for women would be 1.8 years longer and 3.9 QALYs longer than it is now.^[24] For men, there would be little change in life expectancy, and just 0.7 QALYs would be added to male quality-adjusted life expectancy.

There are, as of yet, few burden-of-disease analyses that also include quality-adjusted life expectancy or QALYs lost annually as outcome measures from which comparisons can be made to overweight and obesity. One exception is a recent study of poverty.^[32] Because the prevalence of obesity is higher than that of poverty, more QALYs are lost to obesity (5.3 million) every year than to poverty (3.1 million). However, the impact of obesity on quality-adjusted life expectancy is considerably lower than that for poverty. Whereas obese 18-year-olds in the general US population have approximately 47 QALYs ahead of them, those 18-year-olds living under the poverty threshold can expect to live just 43 QALYs. That obesity has a large impact on QALYs lost annually in the population, but a relatively smaller impact on QALYs lost among the average obese person underscores the fact that the burden of disease because of obesity is driven more by its high prevalence than its severity.

Flegal et al. recently released revised estimates of annual deaths because of overweight and obesity.^[5] They used subjects in the BMI from 18.5 to less-than-25 range as a comparison group rather than the BMI from 23 to less-than-25 group we employed. Inclusion of persons with a BMI less than 23 produces a comparison group that is less healthy than the BMI from 23 to less-than-25 group.^[17] This less-healthy reference group may therefore result in an under estimate of the burden of disease attributable to overweight and obesity. If so, the use of this reference group partly accounts for their finding that overweight persons are at lower risk of mortality than normal-weight persons.^[5,33] Subjects within any BMI group will have morbidity unrelated to their body weight. Nonetheless, we felt that the group with the lowest morbidity and mortality serves as the optimal "normal" comparison group and therefore provides a more accurate picture of the relationship between being overweight or obese and health outcomes.

Our study had a number of limitations. First, subanalyses by gender and age resulted in a good deal of random error in our parameter estimates. At the outset of this analysis, we decided to produce estimates that minimized nonrandom error. We thus used age-specific hazard ratios (rather than age-adjusted hazard ratios) and derived EQ-5D scores using spline regression. Though the use of age-specific hazard ratios and HRQL scores increased random error in the analysis, the use of age-adjusted summary values would have introduced non-random error.^[34] The use of age-specific estimates for both HRQL and mortality made the derivation of 95% confidence intervals around our summary outcome indicators computationally prohibitive. Our findings, however, were largely consistent with other estimates of HRQL and mortality.^[13,17]

Second, we calculated age-specific risk ratios for mortality using mortality data from 1990 through 1995; newer data were not readily available via public access. There is evidence that BMI is increasing among persons already categorized as obese.^[33] Therefore, it is possible that our hazards ratios underestimate the burden of disease today.

Third, we assumed that all excess mortality by BMI is attributable to obesity. However, differences may have existed among the groups because of other sociodemographic factors that may have affected the results.

Fourth, height and weight were self-reported. Obese persons have been found to be more likely to underestimate their weights and heights than are nonobese persons, women may be more likely to underestimate their weight, and men may be more likely to overestimate their heights.^[35,36] Thus, the actual number of overweight and obese persons may be higher.

Fifth, because of the limited number of response categories in the EQ-5D for each question, a ceiling effect may

occur when measuring the health status of the US general population, which may limit its sensitivity to mild morbidity effects. Sixth, we eliminated proxy responders to the EQ-5D. Proxy responders tended to be poorer, less educated, and more likely to be African American or Hispanic. Finally, we omitted those with missing height and weight information. While 4.3% of persons were omitted from the HRQL analysis, 11.7% of subjects were omitted from the mortality analysis. These subjects tended to be older and have higher mortality than those for whom height and weight were available.

In conclusion, with MEPS and NHIS data, we examined the burden of disease in the United States because of overweight and obesity separately for men and women. We found that the inclusion of morbidity greatly changed what we know about the distribution of the burden of disease attributable to obesity by gender. Further research is needed to elucidate the factors that drive the gender differences in morbidity and mortality. It is possible that the obesity epidemic will not only shape the overall mortality experience in the future, but also will affect differences in the total burden of disease by gender.

Table 1. Basic Sociodemographic and Clinical Characteristics of the Total MEPS Sample of US Adults, by Body Mass Index (BMI) Category

	n	No. (%)		
		BMI 23.0 to <25	BMI 25.0 to <30	BMI ≥30.0
Total sample	10301 (100)	2174 (16.8)	4798 (35.5)	3329 (23.1)
Age				
18–44	5058 (52.3)	1125 (51.9)	2342 (48.7)	1591 (48.4)
45–64	3465 (30.8)	639 (29.5)	1184 (32.7)	1242 (36.7)
≥65	1778 (16.9)	410 (18.6)	872 (18.6)	492 (14.8)
Race/ethnicity				
White, non-Hispanic	6266 (74.5)	1417 (75.9)	2951 (74.9)	1898 (70.6)
Black, non-Hispanic	1488 (11.1)	245 (9.6)	617 (11.1)	625 (15.7)
Asian, non-Hispanic	183 (3.0)	70 (4.1)	88 (2.3)	25 (1.2)
AIAN, non-Hispanic	53 (0.6)	8 (0.5)	21 (0.5)	24 (0.9)
Hispanic	2311 (10.5)	434 (10.0)	1121 (11.2)	756 (11.7)
Gender				
Male	5099 (47.3)	971 (46.0)	2682 (57.3)	1444 (46.2)
Female	5202 (52.7)	1203 (54.1)	2114 (42.7)	1885 (53.8)
Marital status				
Married	6309 (56.6)	1258 (55.5)	3037 (61.1)	2014 (58.7)
Widowed	757 (7.2)	157 (7.2)	331 (6.9)	269 (7.7)
Divorced	1143 (11.3)	250 (12.2)	522 (11.9)	371 (11.8)
Separated	224 (1.7)	38 (1.3)	103 (1.8)	83 (2.1)
Never married	1868 (23.3)	471 (23.8)	805 (18.3)	592 (19.7)
Insurance				

Any private	7237 (74.4)	1556 (75.3)	3471 (76.5)	2210 (71.4)
Public only	1561 (13.5)	327 (14.7)	664 (12.8)	570 (15.0)
Uninsured	1503 (12.1)	291 (10.0)	663 (10.8)	549 (13.6)
Self-reported health/condition				
Fair or poor health	1798 (15.0)	302 (12.3)	731 (13.3)	765 (21.1)
Diabetes	869 (6.3)	86 (3.2)	352 (6.7)	431 (11.6)
Asthma	938 (9.2)	166 (8.3)	403 (9.1)	370 (11.3)
Hypertension	2396 (19.8)	338 (15.2)	1010 (21.1)	1048 (31.2)
Heart disease	1066 (10.2)	204 (9.6)	456 (10.2)	406 (12.5)
Number of conditions ^a				
0	6580 (67.2)	1561 (72.2)	3192 (66.1)	1827 (55.3)
1	2482 (22.8)	463 (21.0)	1095 (23.2)	924 (28.0)
2 or more	1238 (10.1)	149 (6.8)	571 (10.8)	578 (16.8)

Note. MEPS=2000 Medical Expenditure Panel Survey; AIAN=American Indian/Alaska Native. Column values add to 100% for each sociodemographic category. Subgroup comparisons all differ at $P<.05$; larger differences are highlighted in the text.

^aTotal number of self-reported medical conditions.

Table 2. Annual Overweight- and Obesity-Associated Deaths, Years of Life Lost (YLLs), and Quality-Adjusted Life Years (QALYs) Lost Relative to the Normal-Weight (BMI 23 to <25) Group, by Age Group and Gender in US Adults

Age Group	Men		Women	
	BMI 25 to <30	BMI ≥30	BMI 25 to <30	BMI ≥30
Deaths^a				
<25	-290	1463	-29	85
25-44	4673	10430	-750	3276
45-64	-12204	12187	18587	27243
65-74	6904	8561	10952	23180
≥75	16028	8910	7982	16406
Total	15111	41550	36742	70190
YLLs^a				
<25	-18773	94850	-2015	5962
25-44	203101	453258	-36145	157897
45-64	-422780	422169	718620	1053277
65-74	120237	149093	228580	483801

≥75	165161	91814	93298	191755
Total	46946	1211185	1002337	1892692
QALYs (morbidity)^b				
<25	59435	84543	40573	90175
25–44	184175	387308	332841	627899
45–64	39676	330701	359067	769054
65–74	–17394	74246	138102	274356
≥75	–23245	35545	88999	185140
Total	242647	912343	959583	1946624
QALYs (total)^{a,b}				
<25	41774	171673	38744	95440
25–44	370763	790373	300960	761284
45–64	–329656	683947	959618	1597952
65–74	81452	190207	319260	627206
≥75	105726	102488	161401	317708
Total	270059	1938689	1779983	3399590

Note. BMI=body mass index.

^aValues were calculated using 2000 vital statistics^[24] and National Health Interview Survey data linked to the National Death Index data.^[19,20]

^bBased on 2000 Medical Expenditure Panel Survey data.^[18]

Table 3. Years of Perfect Health, Life Expectancy, and Quality-Adjusted Life Expectancy Among US Adults, by Body Mass Index

Body mass index	Men			Women		
	23 to < 25	25 to < 30	≥30	23 to < 25	25 to < 30	≥30
Life expectancy at birth	74.1	73.8	71.5	80.8	79.6	78
Life expectancy at age 18 y	57	56.7	54.3	63.5	62.4	60.7
Quality-adjusted life expectancy at age 18 y	50.5	50	46.1	55.6	52.7	48.4

Note. BMIs were based on National Health Interview Survey–National Death Index data^[19,20] and 2000 life tables obtained from the National Center for Health Statistics.^[24]

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