

# The Clinical and Economic Burden of Obesity in a Managed Care Setting

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## Abstract

**Objective:** To estimate the clinical and economic burden of obesity in a managed care setting.

**Study Design:** Prevalence-based cost-of-illness evaluation using modeling techniques and data from secondary sources.

**Patients and Methods:** The health and economic burden of obesity was estimated for a hypothetical health plan with 1 million members between the ages of 35 and 84 years, based on projections of the numbers of cases of 8 diseases for which obesity is an established risk factor (coronary heart disease, hypertension, hypercholesterolemia, gallbladder disease, stroke, type 2 diabetes, osteoarthritis of the knee, and endometrial cancer), obesity-attributable "etiologic fractions," and estimates of associated medical care costs. Our analysis was based on data from a variety of secondary sources, including a large managed care plan in the Pacific Northwest region of the United States.

**Results:** In a population of 1 million persons aged 35 to 84 years, it was estimated that obesity would account for approximately 132,900 cases of hypertension (45% of all cases), 58,500 cases of type 2 diabetes (85%), 51,500 cases of hypercholesterolemia (18%), and 16,500 cases of coronary heart disease (35%). Healthcare costs attributable to obesity were estimated to total \$345.9 million

annually (or 41% of the total for the 8 diseases of interest).

**Conclusion:** The clinical and economic burden of obesity in a managed care setting is substantial.

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The prevalence of obesity in the United States has increased dramatically over the past 2 decades. Data from the National Health and Nutrition Examination Surveys indicate that about one quarter of US adults were overweight during the period from 1976 to 1980 (based on a body mass index [BMI] threshold of 27.8 kg/m<sup>2</sup> for men and 27.3 kg/m<sup>2</sup> for women); by 1988-1994, this figure had risen to more than one third.<sup>1,2</sup> (Body mass index is calculated by dividing a person's weight in kilograms by the square of their height in meters.) Recently, in light of emerging evidence that even lesser degrees of overweight pose significant health risks, the National Institutes of Health have lowered the threshold BMI to 25.0 kg/m<sup>2</sup>; based on this criterion, more than one half of all US adults are overweight or obese.<sup>2</sup>

As the problem of obesity has become more widespread, so too have efforts to understand its health and economic consequences. A number of large-scale epidemiologic cohort studies have established obesity as a major risk factor for several chronic disease conditions, including coronary heart disease (CHD), type 2 diabetes, hypertension, selected cancers, and musculoskeletal disorders, as well as all-cause mortality.<sup>3</sup> For example, in the Health Professionals Follow-up Study, which followed

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29,000 men over a period of 3 years, subjects who had BMIs between 25 and 28.9 kg/m<sup>2</sup> were reported to have a 50% higher risk of CHD than those with BMIs of less than 23 kg/m<sup>2</sup>; subjects with BMIs of 29 to 32.9 kg/m<sup>2</sup> and 33 kg/m<sup>2</sup> or higher had nearly 2-fold and more than 3-fold increases, respectively, in CHD risk.<sup>4</sup> With increased disease risks come higher medical care costs: a recent study reported that total US healthcare expenditures attributable to obesity were \$51.6 billion in 1995.<sup>5</sup>

Although this body of recent research has undoubtedly led to an increased awareness on the part of healthcare providers of the health and economic consequences of obesity, available information may be too general in scope to be useful to administrators and decision makers in managed care settings. A managed care organization, for example, may be considering treatment algorithms, disease management programs, or other such initiatives for the treatment of obesity. Decision making may be compromised, however, by a lack of information on the clinical and economic burden of obesity in this setting. We address this issue in our study.

## ...METHODS...

### Overview

We estimated the health and economic burden of obesity to a hypothetical health plan with 1 million members between the ages of 35 and 84 years. We classified persons according to their BMI as nonobese (BMI of <25 kg/m<sup>2</sup>), mildly obese (BMI = 25-28.9 kg/m<sup>2</sup>), or moderately to severely obese (BMI of ≥29 kg/m<sup>2</sup>). We estimated the prevalence and associated annual medical care costs of 8 diseases for which obesity is an established risk factor: CHD, hypertension, hypercholesterolemia, gallbladder disease, stroke, type 2 diabetes, osteoarthritis of the knee, and endometrial cancer. We then estimated the number of cases of each disease attributable to obesity, as well as their associated medical care costs.

Our analysis is based on obesity-attributable "etiologic fractions." The etiologic fraction (sometimes referred to as "population-attributable risk") is a measure of the proportion of cases of a given disease (eg, CHD) that are due to a risk factor of interest (eg, obesity).<sup>6</sup> Etiologic fractions are proportional to the prevalence of the risk factor and the relative risk of disease conferred by it. When estimates of the prevalence of the risk factor and the relative risk

conferred by it are available, an etiologic fraction may be calculated according to the following formula:

$$E = \frac{P(RR - 1)}{1 + P(RR - 1)}$$

For example, if the prevalence of obesity is 0.3 in a population and the relative risk of CHD among obese persons is 3.0, then the etiologic fraction of CHD attributable to obesity is  $[0.3(3.0 - 1)]/[1 + 0.3(3.0 - 1)] = .375$ ; in other words, 37.5% of all cases of CHD in the population would be attributable to obesity. To estimate the number of cases of each disease that are attributable to obesity, we multiplied the total prevalence of each disease by obesity-attributable etiologic fractions. To estimate medical care costs attributable to obesity, we multiplied the numbers of cases of each disease attributable to obesity by corresponding estimates of annual medical care costs.

A technical appendix that sets forth the equations used in our analysis is available from the authors upon request.

### Data Sources

*Characteristics of Health Plan Membership.* We obtained data on the distribution of health plan members by age, sex, and BMI from a large managed care organization in the Pacific Northwest region of the United States. Data on the characteristics of the health plan's membership were obtained from enrollment records (containing demographic information), as well as a 1996 survey conducted on a random sample of approximately 3400 adult plan members. Questions addressing height and weight were among the items contained in the survey; we used these data to calculate BMI.

*Prevalence of Obesity-Related Diseases.* We used data from a variety of sources to estimate age- and sex-specific prevalence rates (ie, cases per 100 persons) for each of the 8 obesity-related diseases of interest. Coronary heart disease prevalence rates for persons 45-84 years of age were obtained from a study of the incidence and prevalence of CHD among persons participating in the US National Health Interview Survey.<sup>7</sup> As information was unavailable in this report on the prevalence of CHD among persons 35-44 years of age, we estimated these rates using unpublished data on the incidence of this disease from the Framingham Heart Study.

We used unpublished data from the Third National Health and Nutrition Examination Survey

(NHANES III) to estimate prevalence rates for hypertension, type 2 diabetes, hypercholesterolemia, and stroke for each age-sex group (Public Use Data File, National Center for Health Statistics). NHANES III respondents were considered to be hypertensive if they met any 1 of 3 conditions: 1) mean diastolic blood pressure of 90 mm Hg or higher; 2) mean systolic blood pressure of 160 mm Hg or higher; or 3) response of “yes” to a question concerning current use of drug therapy to control their blood pressure. NHANES III respondents who had diabetes were not specifically identified as having type 1 or type 2 diabetes; we used published criteria for the diagnosis of type 2 diabetes to develop an algorithm that was compatible with NHANES III.<sup>8</sup> We considered all persons who reported having diabetes to have type 2 diabetes if they 1) were at least 30 years of age at onset; or 2) were between the ages of 19 and 29 years at onset and were not taking insulin; or 3) were between the ages of 19 and 29 years at onset and were currently taking insulin, but did not begin taking insulin for at least 12 months after disease onset; and 4) did not have gestational diabetes only. NHANES III respondents were considered to be hypercholesterolemic if they had a total cholesterol level of 240 mg/dL or higher or responded “yes” to a question concerning current use of drug therapy to reduce their cholesterol level. Finally, survey respondents were identified as having had a stroke if they answered “yes” to a question that asked if they had been told by a doctor that they had had a stroke.

**Table 1.** Relative Risks of Selected Obesity-Related Diseases, by Sex, Disease, and BMI

Obesity-Related Disease	Relative Risk, by BMI (kg/m <sup>2</sup> )*		
	<25	25-28.9	≥29
Men			
Hypertension <sup>††</sup>	1.0	1.9	2.6
Hypercholesterolemia <sup>§</sup>	1.0	—	1.8
Type 2 diabetes <sup>†</sup>	1.0	2.6	10.4
Coronary heart disease <sup>†</sup>	1.0	1.4	2.4
Stroke <sup>  </sup>	1.0	1.2	1.3
Gallbladder disease <sup>‡</sup>	1.0	2.0	3.5
Osteoarthritis of the knee <sup>##</sup>	1.0	1.0	2.8
Women			
Hypertension <sup>††</sup>	1.0	2.3	3.8
Hypercholesterolemia <sup>§</sup>	1.0	—	1.8
Type 2 diabetes <sup>†</sup>	1.0	4.4	48.9
Coronary heart disease <sup>†</sup>	1.0	1.7	3.0
Stroke <sup>  </sup>	1.0	1.4	1.9
Gallbladder disease <sup>‡</sup>	1.0	2.0	3.5
Osteoarthritis of the knee <sup>##</sup>	1.0	1.7	1.6
Endometrial cancer <sup>††</sup>	1.0	1.0	2.0

BMI = body mass index.

\*Patients with a BMI of <25 kg/m<sup>2</sup> were designated as nonobese; 25-28.9 kg/m<sup>2</sup> as mildly obese; and ≥29 kg/m<sup>2</sup> as moderately to severely obese.

<sup>†</sup>BMI categories in reference 14 were used: <26 for <25 kg/m<sup>2</sup> and 26-28 for 25-28.9 kg/m<sup>2</sup>.

<sup>‡</sup>Relative risks were adjusted by weighted averaging to be consistent with BMI categories in this study.

<sup>§</sup>Combined relative risk was reported for men with a BMI of >27.8 kg/m<sup>2</sup> and women with a BMI of >27.3 kg/m<sup>2</sup> in 2 age groups in reference 19; we obtained a weighted average of these risks and report it in the ≥29 kg/m<sup>2</sup> category.

<sup>||</sup>Subjects were classified by metropolitan relative weight (MRW) in reference 16. We used an MRW of <115 to define the reference group, an MRW of 115-129 to define the mild obesity group, and an MRW of 130+ for the moderate to severe obesity group. (An MRW of 115 corresponds to a BMI of 24.7 in women and 25.3 in men, and an MRW of 130 corresponds to a BMI of 28.0 in women and 28.6 in men.) We took weighted averages of the rates for men and women aged 45-54 and 55-64 years.

<sup>‡</sup>Because we could find no adequate study of the relative risk of gallbladder disease in relation to BMI, we used relative risks for women as surrogates for those among men.

<sup>##</sup>Risk in reference 20 was calculated on the basis of quintiles of MRW, with the first 3 quintiles used as the reference category. We used the relative risks of symptomatic osteoarthritis for the fourth and fifth quintiles for our mild and moderate to severe categories, respectively.

<sup>††</sup>The fourth and fifth quintiles of MRW corresponded to BMIs of 26.6-28.1 kg/m<sup>2</sup> and >28.4 kg/m<sup>2</sup>, respectively.

<sup>††</sup>The fourth and fifth quintiles of MRW corresponded to BMIs of 25.2-27.3 kg/m<sup>2</sup> and >27.5 kg/m<sup>2</sup>, respectively.

<sup>††</sup>We estimated no increased risk in the mild obesity group due to equivocal data on the risk of endometrial cancer for this BMI range. For the moderate to severe obesity group, we used the lowest reported relative risk from 3 recent studies reviewed in reference 21.

**Table 2.** Estimated Annual Medical Care Costs per Case of Selected Obesity-Related Diseases, by Sex and Disease

Obesity-Related Disease	Men	Women
Hypertension*	\$542	\$542
Hypercholesterolemia <sup>†</sup>	\$155	\$155
Type 2 diabetes <sup>‡</sup>	\$2026	\$2374
Coronary heart disease <sup>§</sup>	\$5085	\$5085
Stroke <sup>  </sup>	\$5664	\$5928
Gallbladder disease <sup>¶</sup>	\$6097	\$6097
Osteoarthritis of the knee <sup>#</sup>	\$2282	\$2282
Endometrial cancer <sup>**</sup>	—	\$10,375

\*Costs were estimated from reference 23 and include the costs of office visits, laboratory tests, and medications. The costs reported were averaged and adjusted downward on the basis of unpublished data from the Third National Health and Nutrition Examination Survey, in which 80.9% of survey respondents who had elevated blood pressure reported that they were receiving drug therapy for this condition.

<sup>†</sup>Costs were estimated from reference 25 and include the costs of medication, provider services, and laboratory and diagnostic tests. The resulting estimate (\$705) was adjusted downward on the basis of unpublished data from the Third National Health and Nutrition Examination Survey, in which 22.0% of survey respondents who had elevated cholesterol levels reported that they were receiving drug therapy for this condition.

<sup>‡</sup>Cost estimates were obtained from reference 24 and include hospital costs, physician costs, drug costs, costs of nursing home care, and costs of other professional healthcare services. They also include the costs of related diseases that are attributable to type 2 diabetes (eg, visual disorders, peripheral vascular disease); to avoid double-counting, however, the costs of coronary heart disease and stroke attributable to type 2 diabetes were excluded from the estimates.

<sup>§</sup>Cost estimates were obtained from the Coronary Heart Disease Policy Institute (unpublished data) and include the costs of hospital care, prescription drugs, physician services, laboratory tests, and rehabilitation services for diagnosis and treatment of acute myocardial infarction, coronary revascularization, annual maintenance therapy after acute myocardial infarction, cardiac arrest (fatal or nonfatal), congestive heart failure, and the expected costs of secondary coronary events. First-year costs were assigned to all incident cases, and the average of the annual costs in the subsequent 9 years was assigned to all prevalent cases. The weighted-average estimates were based on the ratio of incident to prevalent cases, which were estimated using unpublished logistic risk functions from the Framingham Heart Study and mortality data from the Coronary Heart Disease Policy Institute and US Vital Health Statistics.<sup>29</sup>

<sup>||</sup>Cost estimates were obtained from reference 22. Costs in the first year after onset include those of inpatient hospital and professional services and expected costs of inpatient rehabilitation. Costs in the subsequent 9 years after onset were estimated by annualizing the monthly costs of nursing home care; all visits to physicians, physical therapists, and speech therapists; home healthcare; and inpatient acute and rehabilitation care for recurrent strokes. The weighted-average estimates were based on the ratio of incident to prevalent cases, which were estimated using unpublished logistic risk functions from the Framingham Heart Study, as well as mortality data from US Vital Health Statistics.<sup>29</sup> and the published literature.<sup>30</sup>

<sup>¶</sup>Cost estimates were obtained from references 27 and 28 and include hospital charges and physician fees associated with treating the disease based on the average Medicare payments for the relevant diagnosis-related groups (195, 196, 197, 198, 207, 208, 493, 494) and Medicare resource-based relative value scale physician payments for cholecystectomy (56340), removal of gallbladder (47600), and other relevant procedures (76700, 99204, 99222, 99231, 99238). Costs were adjusted to reflect the fact that 81% of patients receive surgical treatment for gallbladder disease, based on data from the Nurses' Health Study.<sup>11</sup> It was assumed that one half of the patients who did not receive surgery would not be hospitalized.

<sup>#</sup>Cost estimates were obtained from reference 26 and represent the average annual cost of all forms of osteoarthritis; it was assumed that these have similar average costs.

<sup>\*\*</sup>Cost estimate was obtained from references 27 and 28 and includes hospital charges and physician fees associated with treating the disease based on the average Medicare payments for the relevant diagnosis-related groups (354, 355) and Medicare resource-based relative value scale physician payments for total (58150) and extensive (58210) hysterectomy procedures. The costs of these procedures were multiplied by the corresponding percentages of women receiving them as reported by the American Cancer Society in the National Cancer Database<sup>31</sup> to adjust for patients who receive surgery for this condition. Added to these costs was the cost of radiotherapy at a large Boston hospital for the proportion of patients who receive this treatment according to data reported in the National Cancer Database.

We obtained age- and sex-specific estimates of the prevalence of osteoarthritis of the knee for persons less than 65 years of age from a published study on the epidemiology of hip and knee osteoarthritis.<sup>9</sup> Corresponding rates for men and women over the age of 65 years were obtained from a study of the prevalence of osteoarthritis of the knee in elderly patients enrolled in the Framingham Heart Study.<sup>10</sup>

In the absence of available data on the prevalence of gallbladder disease and endometrial cancer, we used estimates of the incidence of these diseases. The incidence of gallbladder disease for women less than 65 years of age was obtained from a report of data from the Nurses' Health Study.<sup>11</sup> In the absence of a comparable data source for men, we assumed that men less than 65 years of age have an incidence of gallbladder disease equal to one half that of women, based on differences between men and women in the frequency of cholecystectomy procedures reported in the National Hospital Discharge Survey.<sup>12</sup> Similarly, based on National Hospital Discharge Survey data, we assumed that the incidence of gallbladder disease for persons more than 65 years of age was 70% higher than that for those younger than 65 years of age. Age-specific incidence rates of endometrial cancer were based on data from the Surveillance, Epidemiology, and End Results Program (unpublished data, National Cancer Institute), which collects data from designated population-based cancer registries in various areas of the United States.

**Relative Risks of Disease.** Relative risks of the 8 diseases for persons who are mildly or moderately to severely obese versus persons who are nonobese were estimated using published reports from major US epidemiologic studies of



obesity.<sup>4,11,13-21</sup> Because the BMI categories were not consistent across all studies, relative risk estimates were adjusted where necessary to be consistent with the BMI categories used in our analysis. Relative risks for each disease are displayed in Table 1 by sex and BMI category. Any adjustments made to the reported estimates are noted.

**Annual Medical Care Costs.** Estimates of annual medical care costs for each of the 8 diseases of interest are expressed in 1996 US dollars and were obtained from a variety of secondary sources. Age- and sex-specific estimates were used whenever available and appropriate. We estimated the annual cost of CHD as a weighted average of medical care costs in the first and subsequent 9 years after onset of the disease. Cost estimates specific to the year past onset were obtained from the CHD Policy Institute (Karen Kuntz, ScD, written communication, August 1997) and represent a weighted average of the expected costs of myocardial infarction, cardiac arrest, and angina pectoris. The annual cost of stroke was estimated in a manner similar to that used for CHD, based on data from a cost-effectiveness study of stroke prevention in high-risk patients.<sup>22</sup> Data from the published literature were used to estimate the annual costs of hypertension,<sup>23</sup> type 2 diabetes,<sup>24</sup> hypercholesterolemia,<sup>25</sup> and osteoarthritis of the knee.<sup>26</sup> We estimated the annual cost per case of gallbladder disease and endometrial cancer based on the average Medicare payments for the appropriate diagnosis-related groups and Medicare resource-based relative value scale physician payments for relevant procedures.<sup>27,28</sup>

Estimates of expected annual medical care costs per case of each disease are summarized in Table 2, and additional methodologic details are noted.

## ... RESULTS ...

### Prevalence of Obesity

In a health plan with 1 million members between the ages of 35 and 84 years, we estimated that 174,400 men and 132,900 women (38% and 25%, respectively) would be mildly obese (BMI = 25-28.9 kg/m<sup>2</sup>); corresponding estimates for moderate to severe obesity (≥29 kg/m<sup>2</sup>) were 149,300 and 168,800 (32% for both) (Table 3). As in the general US population, the prevalence of obesity increased with age up to 65 years.

### Obesity-Attributable Cases of Disease

A total of 132,900 cases of hypertension (45% of all cases), 58,500 cases of type 2 diabetes (85%), 51,500 cases of hypercholesterolemia (18%), and 16,500 cases of CHD (35%) were estimated to be attributable to obesity in a 1-million member health plan (Table 4). Moderate to severe obesity

**Table 3.** Estimated Distribution of Plan Membership in a Managed Care Organization With 1 Million Members Aged 35-84 Years, by Age, Sex, and Degree of Obesity

Sex and Age (y)	Nonobese (BMI of <25 kg/m <sup>2</sup> )	Mildly Obese (BMI of 25-28 kg/m <sup>2</sup> )	Moderately to Severely Obese (BMI of ≥29 kg/m <sup>2</sup> )	Total
<b>Men</b>				
35-44	46,800	54,300	43,000	144,100
45-54	40,300	48,300	50,500	139,100
55-64	21,300	35,000	31,500	87,800
65-74	19,600	23,700	17,800	61,100
75-84	13,300	13,100	6,500	32,900
Total (men)	141,300	174,400	149,300	465,000
<b>Women</b>				
35-44	82,800	37,300	47,100	167,200
45-54	62,900	37,500	54,500	154,900
55-64	34,700	25,000	37,100	96,800
65-74	29,100	20,500	20,700	70,300
75-84	23,800	12,600	9,400	45,800
Total (women)	233,300	132,900	168,800	535,000
<b>Total (men and women)</b>	<b>374,600</b>	<b>307,300</b>	<b>318,100</b>	<b>1,000,000</b>

BMI = body mass index.

is far more consequential than mild obesity, as it accounts for the vast majority of obesity-attributable cases of the diseases of interest (data not shown).

#### Obesity-Attributable Medical Care Costs

Annual medical care costs attributable to obesity were estimated to total \$345.9 million (or 41% of the total costs for the 8 diseases) (Table 5). Expenditures related to the treatment of type 2 diabetes comprised nearly 40% of the total economic burden of obesity, followed by CHD (24%), hypertension (21%), and stroke (7%) (Figure).

#### ... DISCUSSION ...

Our results suggest that the burden of obesity in a managed care setting is substantial. We estimate that mild and moderate to severe obesity combined account for 85% of all cases of type 2 diabetes, almost one half of all cases of hypertension and gallbladder disease, and more than one third of all cases of CHD. Annual healthcare costs attributable to obesity in a health plan of this size (1 million members between the ages of 35 and 84 years) are estimated to total more than \$345.9 million, or 41 cents of every healthcare dollar spent on the 8 dis-

**Table 4.** Total and Obesity-Attributable Cases of Selected Diseases in a Managed Care Organization With 1 Million Members Aged 35-84 Years, by Age, Sex, and Disease

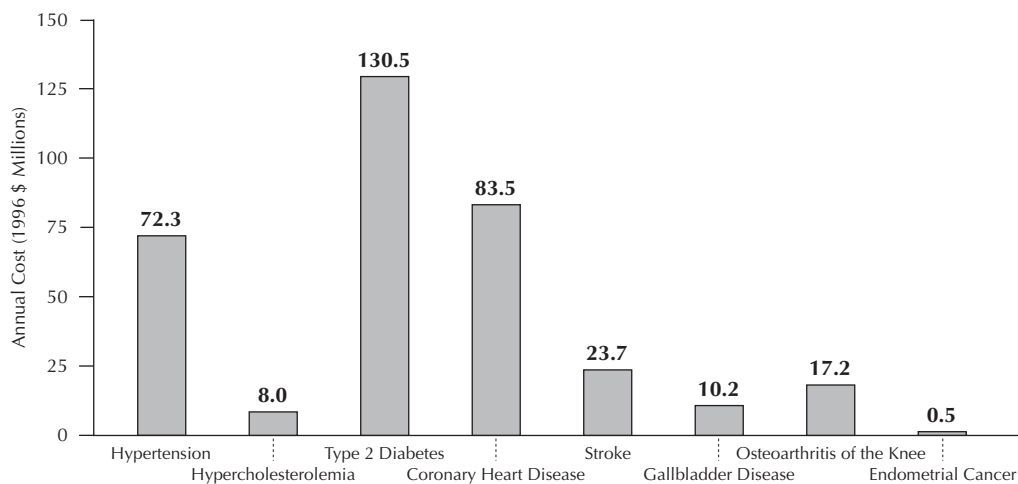
Sex and Age (y)	Cases, Obesity Attributable/Total							
	Hypertension	Hypercholesterolemia	Type 2 Diabetes	Coronary Heart Disease	Stroke	Gallbladder Disease	Osteoarthritis of the Knee	Endometrial Cancer
<b>Men</b>								
35-44	10,600/23,600	5600/30,900	2000/2600	300/900	100/600	200/300	300/700	—
45-54	18,300/39,900	8500/42,700	6400/8100	1,900/5,000	400/2300	200/300	400/1000	—
55-64	14,300/31,200	5600/26,900	7800/9800	4,000/10,100	400/2800	100/200	400/1100	—
65-74	9400/26,200	2700/16,800	4900/6600	2,800/8,200	300/3100	41/200	1300/3800	—
75-84	4200/14,500	1000/8,300	3400/4900	1,700/5,800	200/4000	16/100	800/2300	—
<b>Total (men)</b>	56,800/135,400	23,400/125,600	24,500/32,000	10,700/30,000	1400/12,800	557/1100	3200/8900	—
<b>Women</b>								
35-44	9500/18,600	3900/22,000	4400/4800	100/200	200/600	400/800	200/800	3/14
45-54	20,900/38,800	8500/42,400	5400/5700	800/1,800	500/1700	400/700	500/1700	13/50
55-64	20,300/37,000	9200/43,800	10,300/11,000	2100/4400	900/2900	200/400	600/2200	19/68
65-74	14,900/34,600	4700/31,400	8200/8800	1600/5000	700/4000	100/500	1500/5400	12/52
75-84	10,500/28,300	1800/19,500	5700/6300	1200/5800	400/4900	44/300	1700/6100	6/35
<b>Total (women)</b>	76,100/157,300	28,100/159,100	34,000/36,600	5800/17,200	2700/14,100	1144/2700	4500/16,200	53/219
<b>Total (men and women)</b>	<b>132,900/292,700</b>	<b>51,500/284,700</b>	<b>58,500/68,600</b>	<b>16,500/47,200</b>	<b>4100/26,900</b>	<b>1701/3800</b>	<b>7700/25,100</b>	<b>53/219</b>

**Table 5.** Total and Obesity-Attributable Annual Costs of Selected Diseases in a Managed Care Organization With 1 Million Members Aged 35-84 Years, by Age, Sex, and Disease

	Annual Medical Care Costs, Obesity Attributable/Total \$ (in millions)								
Sex and Age (y)	Hypertension	Hypercholesterolemia	Type 2 Diabetes	Coronary Heart Disease	Stroke	Gallbladder Disease	Osteoarthritis of the Knee	Endometrial Cancer	Total*
Men									
35-44	5.8/12.8	0.9/4.8	4.1/5.4	1.7/4.7	0.5/3.3	1.1/2.0	0.6/1.6	—	14.7/34.6
45-54	9.9/21.6	1.3/6.6	12.9/16.3	9.7/25.6	2.0/12.7	1.1/1.9	0.8/2.2	—	37.7/86.9
55-64	7.8/16.9	0.9/4.2	15.9/19.9	20.1/51.5	2.5/15.6	0.7/1.2	0.9/2.4	—	48.8/111.7
65-74	5.1/14.2	0.4/2.6	9.9/13.4	14.1/41.5	1.9/17.5	0.3/1.5	3.0/8.6	—	34.7/99.3
75-84	2.3/7.8	0.2/1.3	6.9/9.9	8.6/29.7	1.4/22.8	0.1/0.8	1.8/5.4	—	21.3/77.7
Total (men)	30.9/73.3	3.7/19.5	49.7/64.9	54.2/153.0	8.3/71.9	3.3/7.4	7.1/20.2	—	157.2/410.2
Women									
35-44	5.2/10.1	0.6/3.3	10.5/11.3	0.5/1.2	0.9/3.6	2.2/4.6	0.5/1.9	0.03/0.1	20.4/36.1
45-54	11.4/21.0	1.3/6.6	12.8/13.6	4.2/9.4	2.8/10.2	2.3/4.2	1.0/3.9	0.1/0.5	35.9/69.4
55-64	11.0/20.0	1.4/6.8	24.5/26.1	10.6/22.5	5.1/17.1	1.5/2.6	1.4/4.9	0.2/0.7	55.7/100.7
65-74	8.1/18.8	0.7/4.9	19.4/20.8	8.1/25.5	4.3/23.8	0.6/3.3	3.4/12.3	0.1/0.5	44.7/109.9
75-84	5.7/15.4	0.3/3.0	13.6/15.0	5.9/29.6	2.3/29.0	0.3/2.1	3.8/14.0	0.1/0.4	32.0/108.5
Total (women)	41.4/85.3	4.3/24.6	80.8/86.8	29.3/88.2	15.4/83.7	6.9/16.8	10.1/37.0	0.5/2.2	188.7/424.6
Total (men and women)	72.3/158.6	8.0/44.1	130.5/151.7	83.5/241.2	23.7/155.6	10.2/24.2	17.2/57.2	0.5/2.2	345.9/834.8

\*Total for all 8 diseases.

**Figure.** Annual Obesity-Attributable Medical Care Costs of Selected Diseases in a Managed Care Organization with 1 Million Members Aged 35 to 84 Years Old



eases. Assuming stable membership over the year, this represents \$29 per member per month.

We believe that our estimate of the economic burden of obesity is probably conservative. First, our classification of subjects is based on self-reported height and weight. Several studies have demonstrated that self-reported weight is consistently less than measured weight, with a greater absolute difference between the 2 weights for heavier persons. In addition, men tend to slightly overestimate their height, while women underestimate theirs. Although the overall effect of these inaccuracies is fairly small, to the extent that obese persons are misclassified as nonobese in our analysis, we may have underestimated the cost of obesity. Second, some of the data sources that we used to estimate the costs of obesity-related diseases are fairly old. Costs of treatment of type 2 diabetes, for example, are likely to have increased substantially in the last decade due to advances in therapy. The use of cholesterol-lowering medications also has become much more widespread in recent years.

Some additional limitations of our analysis should be noted. For one, we used data from a large managed care plan in the Pacific Northwest region of the United States to estimate the distribution of members by age, sex, and BMI in a typical health plan. Although this distribution may vary by setting, we note that the BMI distribution in the health plan we used is similar to that of the US population as reported in NHANES III. (Among men aged 35 to 84 years, NHANES III reported that 38% had mild obesity and 29% had moderate to severe obesity vs 38% and 32%, respectively, in the health plan we used; among women of this age, NHANES III reported that 24% had mild obesity and 33% had moderate to severe obesity vs 25% and 32%, respectively, in the health plan we used.) Other parameters in our analysis (eg, disease prevalence, medical care costs) also may vary from one setting to the next. The prevalences of several of the obesity-related diseases are known to vary regionally, for instance, and it is quite possible also that prevalences could vary even among health plans in the same region. Annual treatment costs for the diseases included in our analysis vary by region, as well as by a myriad of other factors that may differ from one health plan to the next.

Along the same lines, data limitations prevented us from being able to account for racial differences in the prevalences of obesity and the obesity-related diseases. Among women, at least, the prevalence of obesity is higher among nonwhite populations,<sup>1</sup> and it is well known that the prevalence of hypertension is higher among blacks than whites. The

epidemiologic evidence with respect to racial variations in the role of obesity in the development of selected diseases is scanty, however, and we could not incorporate race into our analysis.

We note also that there is some evidence that the risks of selected diseases not included in our analysis, including breast cancer, colon cancer, and sleep apnea, may be higher among persons who are obese.<sup>3</sup> A review of the epidemiologic data, however, suggests that the research findings are equivocal. Although obesity appears to increase the risk of breast cancer among postmenopausal women, for example, it appears to have a slight protective effect among premenopausal women.<sup>21</sup> To cite another example, although the risk of colon cancer in men clearly increases with adiposity as measured by waist-to-hip ratio, the relationship is equivocal when measured in terms of BMI.<sup>32</sup> For these reasons, we conservatively limited our attention to those diseases for which a firmly established etiologic role for obesity (as measured by BMI) was present.

Finally, although our analysis may improve awareness of the health and economic burden of obesity in the managed care setting, it does not shed light on the potential health and economic benefits of improved weight control among persons who are obese or, for that matter, on the cost effectiveness of specific weight loss interventions. Although these issues clearly are important, they cannot be addressed reliably in the context of a 1-year prevalence-based analysis such as ours, because many of the clinical and economic benefits of weight loss may not accrue for a number of years. Models adopting a lifetime perspective and an incidence-based analytic framework have been developed to address the lifetime health and economic consequences of obesity as well as the benefits of weight loss.<sup>33,34</sup>

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### ... CONCLUSION ...

Recent years have witnessed a dramatic increase in the prevalence of obesity in the United States, as well as growth in research on the health and economic consequences of this condition. Although such research may improve general awareness of the aggregate burden of obesity to the US medical care system, health plan administrators may benefit from data specific to the managed care setting. Our analysis demonstrates that the clinical and economic burden of obesity in a managed care setting is substantial.



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