■ REPORT ■

The Clinical and Economic Consequences of Obesity

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Abstract

Obesity and its many serious comorbidities exert a heavy toll in both human and economic terms. More than one-third of adults in the United States are obese and, therefore, subject to elevated rates of diabetes, hypertension, dyslipidemia, and other cardiovascular disease risk factors. The negative effect on the quality of life (QoL) of these individuals is enormous. Among the severely obese, QoL scores are comparable to QoL scores associated with diabetes and laryngeal cancer. The medical costs of obesity-related illnesses in the United States have been estimated at $209.7 billion annually (in 2008 dollars). For example, with regard to impact on pharmaceutical costs, obesity is associated with a more than 13-fold increase in the cost of antidiabetic medications. The cost of absenteeism to employers has been estimated to exceed $4.3 billion annually. Successful and cost-effective short-term treatments for obesity are available, and have been shown to reduce cardiovascular risk factors. Intensive lifestyle intervention with the goal of losing 7% of baseline body weight, for example, resulted in a 58% reduction in the risk of diabetes in patients with prediabetes. In clinical trials, improvements in other cardiovascular risk factors, such as elevated triglycerides and high blood pressure, have also been seen with a modest weight loss of 5% to 10% of baseline body weight. As obesity becomes an ever greater public health problem, additional interventions with long-term efficacy are needed to reduce body weight and maintain weight loss.

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For author information and disclosures, see end of text.

Obesity as a category is defined as the possession of a body mass index (BMI) of 30 or more, whereas "overweight" is the term used to describe an individual with a BMI greater than or equal to 25 but less than 30.[1] The prevalence of obesity among adults in the United States, according to a Centers for Disease Control study using data from the National Health and Nutrition Examination Survey, was 35.7% during 2009 to 2010, amounting to more than 78 million people over the age of 20 years.[2] More than two-thirds of US adults (68.5%) aged 20 to 74 years had a BMI of at least 25 during 2007 to 2010.[3] Worldwide, it is estimated that nearly half a billion adults are obese, while overweight and obesity constitute the fifth-most common cause of death globally.[1] The situation is worsening each year. A recently published forecast for obesity estimated that over the next 20 years, the prevalence of obesity in the United States will increase by 33%, and that the prevalence of a BMI of 40 or higher will increase by 130%.[4] In this article, we will review the clinical and economic consequences of obesity and related comorbidities, including impact on quality of life (QoL); discuss the cost-effectiveness of interventions to treat obesity; and examine the impact of weight loss on health outcomes, costs, and QoL.

Obesity-Related Comorbidities

The consequences of obesity can be understood, in part, by examining the many comorbidities with which obesity is linked, an understanding of which necessarily precedes a discussion of the clinical and economic consequences of obesity. Obesity is associated with numerous cardiovascular risk factors, including diabetes, hypertension, and dyslipidemia.[5,6] Types of dyslipidemia include elevated low-density lipoprotein (LDL) cholesterol, decreased high-density lipoprotein (HDL) cholesterol, and elevated triglycerides.[7] Table 1 shows the overall prevalence in the general US population of diabetes, hypertension, and elevated LDL cholesterol, along with the total number of persons with these conditions.[8-11] In addition to being associated with several cardiovascular risk factors, obesity is associated with an increased risk of all-cause mortality.[12]

Field et al provided a sense of the scale of the relationship between excess weight and comorbid diseases by determining the effect of having a BMI over 25 on the risk of experiencing 7

■ **Table 1.** Prevalence of and Total Number of Persons With Diabetes, Hypertension, and Dyslipidemia in the General Population of the United States[8-11,a]

Condition	Year(s)	Prevalence	Total Number of Persons
Diabetes	2010	8.3% (all ages)	25.8 million
Hypertension	2005-2008	30.9% (aged 18 y and over)	68 million
Elevated LDL cholesterol	2005-2008	33.5% (aged 20 y and over)	71 million
Elevated triglycerides	2007-2010	27% (aged 20 y and over)	(not available)

LDL indicates low-density lipoprotein.
[a]Overlap between populations is possible.

different obesity-associated comorbidities during a 10-year period of follow-up (1986-1996). Data for this study were derived from 77,690 women participating in the Nurses' Health Study and 46,060 men participating in the Health Professionals Follow-Up Study, offering robust data from 2 large-scale studies.[5] **Table 2** shows the adjusted odds ratios for men and women with a BMI of 30.0 to 34.9 and those with a BMI of 35.0 or greater experiencing these 7 comorbidities compared with men and women with a BMI between 18.5 and 24.9. The elevation in diabetes risk is most notable, with obese women having a 10- to 17-fold increased risk of the disease, and obese men having an 11- to 23-fold increased risk. Hypertension and gallstones were also seen at significantly higher rates in obese men and women, while heart disease was 2 to 2.2 times more likely in obese men.[5]

These data are consistent with the results of a meta-analysis by Guh et al of studies examining the relationship between obesity and selected comorbidities, which found that obesity was associated with increased risk for a variety of diseases and disease risk factors. The relative risk (RR) for congestive heart failure in obese subjects was 1.79 for men and 1.78 for women, while the RR for stroke was 1.51 among obese men and 1.49 among obese women. Risk of pulmonary embolism was notably high, with an RR of 3.51 for both men and women. Like the study by Field et al, the meta-analysis by Guh et al found that obesity was strongly associated with the incidence of type 2 diabetes, with obese men having an RR for diabetes of 6.74 and women an RR of 12.41. The meta-analysis also observed an increased risk of several types of cancer among obese patients, including colorectal, endometrial, renal, ovarian, and pancreatic cancers.[13]

Results from a German study of 7124 adults representing a nationally representative sample (the German National Health Interview and Examination Survey) similarly found significantly increased risks among obese compared with non-obese subjects for cardiovascular diseases, cardiometabolic risk factors, osteoarthritis, and, among women, diabetes and gallbladder disease.[14]

The association between obesity and stroke risk was the subject of a 2010 systematic literature review, which comprised 25 studies and over 2 million subjects. The results of the review showed that among obese subjects the RR for ischemic stroke was 1.64 (95% confidence interval [CI], 1.36-1.99; P <.0001), and the RR for hemorrhagic stroke was 1.24 (95% CI, 0.99-1.54; P = .059).[15]

The link between obesity and osteoarthritis—in addition to data previously cited—was well illustrated in a British cohort study evaluating risk of knee osteoarthritis in 3035 men and women who had been followed from the time of their birth, in 1946, as part of a larger long-term health study. A strong association between BMI and knee osteoarthritis was observed, and the association between BMI earlier in life and knee osteoarthritis later in life could be detected in men as early as age 20 years, continuing uninterrupted to age 53 years, while for women, the effects of BMI were observed as early as age 15 years and going forward.[16]

Excess weight is also associated with nonalcoholic fatty liver disease (NAFLD), a chronic disease that may progress to end-stage liver disease.[17] An analysis of data from the National Health and Nutrition Examination Study from 1988 to 1994 showed that NAFLD was more common in overweight and obese individuals compared with normal-weight individuals.[18] Based on the same analysis, NAFLD was estimated to affect 19% of the US population (95% CI, 17.5-20.6).[18]

With regard to the relationship between sleep and obesity, in adults, sleep deprivation has been associated with risk for overweight and obesity, with an association generally being made between a lack of sufficient sleep and a consequent increase in caloric intake (mainly from between-meal snacking) that promotes weight gain.[19,20]

Obesity is also a strong risk factor for sleep apnea, as evidenced by study data showing associations between newly diagnosed sleep apnea and recent weight gain, as well as data showing increasing sleep apnea severity over time in patients with increasing BMI.[21,22] Obese patients who have

Table 2. Ten-Year Risk of Developing an Obesity-Related Comorbidity Among 77,690 Women in the Nurses' Health Study and 46,060 Men in the Health Professionals Follow-up Study[5]

	Adjusted Odds Ratios (95% CI)[a]						
	Diabetes	Gallstones	Hypertension	High Cholesterol Level	Colon Cancer	Heart Disease	Stroke
Women							
BMI between 30.0 and 34.9	10.0 (8.4-11.8)	2.5 (2.3-2.7)	2.1 (1.9-2.2)	0.9 (0.9-1.0)	1.3 (1.0-1.7)	1.5 (1.3-1.7)	1.0 (0.8-1.4)
BMI ≥35.0	17.0 (14.2-20.5)	3.0 (2.7-3.3)	2.3 (2.1-2.6)	0.7 (0.6-0.7)	1.8 (1.3-2.6)	1.5 (1.3-1.8)	1.1 (0.8-1.7)
Men							
BMI between 30.0 and 34.9	11.2 (9.3-13.6)	2.3 (1.9-2.7)	2.7 (2.4-3.0)	1.2 (1.1-1.3)	1.7 (1.2-2.4)	2.0 (1.7-2.3)	2.0 (1.5-2.7)
BMI ≥35.0	23.4 (19.4-33.2)	2.9 (2.1-4.1)	3.0 (2.3-3.9)	1.3 (1.1-1.6)	1.3 (0.5-3.2)	2.2 (1.5-3.1)	2.3 (1.2-4.4)

BMI indicates body mass index; CI, confidence interval.
[a]Adjusted for age, smoking status, and race.
Adapted from Field AE, Coakley EH, Must A, et al. *Arch Intern Med.* 2001;161(13):1581-1586.

Obesity Hypoventilation Syndrome (OHS), also known as Pickwickian Syndrome—a condition characterized by obesity, daytime hypoventilation, and sleep-disordered breathing or sleep apnea—experience even greater health risk, and OHS patients have generally higher mortality rates than similarly obese individuals with sleep apnea alone.[23,24]

In addition to its substantial effects on physical comorbidities, obesity has been shown to exert a deleterious effect on psychological health. Results from a meta-analysis by Luppino et al showed that persons with a BMI of 30 or greater at baseline had a 55% (95% CI, 22%-98%; P <.001) greater risk of developing depression during the follow-up period compared with persons with a BMI between 18.5 and 24.9.[25]

As discussed in this section, excess body weight is associated with negative effects in terms of physical comorbidities and psychological health. In particular, obesity is associated with increased risk of type 2 diabetes, hypertension, dyslipidemia, cardiovascular diseases, osteoarthritis, sleep apnea, and several cancers.[5,13,14,21,22,26]

Economic Burden of Obesity

Estimating the cost of obesity is challenging because obesity is related to numerous other comorbidities, many of which are associated with high medical expenditures. For example, in 2010, based on Medical Expenditure Panel Surveys (MEPS) data, the total cost of treatment for patients with diabetes mellitus was $51.3 billion, 48% of which was due to medication costs; the total cost of treatment for patients with hypertension was $42.9 billion, 47.4% of which was due to medication costs; and the total cost of treatment for patients with hyperlipidemia was $37.2 billion, 69.1% of which was due to medication costs.[27]

Capturing the full economic impact of obesity is a complex task. One approach to the study of obesity-related expenditures, conducted by Finkelstein et al, applied data from the 2006 MEPS and the National Health Expenditures Accounts to identify total annual medical costs.[28] The authors compared expected costs among people of normal weight with the costs observed in obese subjects to arrive at a relative increase in per capita spending related to obesity. They found that in 2006, medical expenditures in obese patients were 41.5% higher than expenditures in patients of normal weight, amounting to an annual per capita difference of $1429 (in 2008 dollars). When broken down by type of insurer, the annual costs associated with obesity were 58.1% higher ($1140) for those who were privately insured, 36.4% higher ($1723) for Medicare patients, and 46.7% higher ($1021) for Medicaid patients. The authors further broke down that expenditure data by type of insurer and type of service. Among those covered by private insurance, the annual inpatient costs were 90.3% higher ($443) for obese patients, the non-inpatient costs were 37.9% higher ($398), and the prescription drug costs were 81.8% higher ($284), compared with normal-weight individuals. The relative difference for inpatient expenditures among private insurers was far higher than differences seen in Medicare and Medicaid inpatient costs. By contrast, although prescription drug and non-inpatient costs were higher in obese patients for all insurer types, these differences were less marked between private insurers, Medicare, and Medicaid (Table 3).[28]

MEPS data were also used by Cawley et al, who estimated the total US annual expenditures attributed to obesity-related illness to be as high as $209.7 billion annually (in 2008 dollars), which is equivalent to 20.6% of US health

Table 3. Additional Per Capita Spending in Obese Adults in 2006 by Insurance Category and Service Type (2008 dollars)[28]

Insurance Category	Type of Service	Spending Increase ($)	Percent Increase
Medicare	Inpatient	95[b] (296)	4.4[b] (13.0)[a]
	Non-inpatient	693[c] (128)	40.1[c] (8.4)
	Prescription drug	608[c] (65)	72.7[c] (10.3)
Medicaid	Inpatient	213[b] (153)	39.2[b] (34.2)
	Non-inpatient	175[b] (172)	14.8[b] (12.8)
	Prescription drug	230[b,c] (80)	60.6[b,c] (24.2)
Private	Inpatient	443[c] (85)	90.3[c] (23.9)
	Non-inpatient	398[c] (60)	37.9[c] (6.6)
	Prescription drug	284[c] (41)	81.8[c] (12.4)
All payers	Inpatient	420[c] (93)	45.5[c] (12.0)
	Non-inpatient	444[c] (76)	26.9[c] (4.7)
	Prescription drug	568[c] (59)	80.4[c] (8.3)

[a]Bootstrapped standard errors are shown in parentheses.
[b]Relative standard error is greater than 0.3, indicating that the estimate is unstable.
[c]Increased spending estimate is significantly greater than zero ($P < .05$).

expenditures. The medical costs of obesity-related illness impacted all healthcare sectors and payers.[29]

Wang et al evaluated the increase in healthcare costs per unit increase in BMI by analyzing medical and pharmaceutical claims data from 35,932 employees and spouses from various manufacturing companies. Based on their analysis, annual medical costs increased $119.7 (4%) and pharmaceutical costs increased $82.6 (7%) per BMI unit within the BMI range of 25 to 45 (adjusted for age and gender; in 2004 US dollars). Medical costs related to heart disease and diabetes increased by $20.3 and $6.2, respectively, per BMI unit (adjusted for age and gender).[30]

The impact of obesity on medical costs was further seen in a study by Thompson et al, which showed higher rates of pharmaceutical expenditures incurred by obese versus non-obese subjects belonging to the Kaiser Permanente Northwest Division health maintenance organization. Members with a BMI of 30 or greater were found to have 84% more pharmaceutical dispenses than non-obese patients, and overall pharmacy costs that were 105% higher. With regard to diabetes medications alone, obese members had 6 times as many dispenses and incurred costs more than 13-fold greater than non-obese subjects.[31]

As described in this section, obesity exacts a heavy economic burden, with total US annual expenditures attributed to obesity-related illness estimated to be as high as $209.7 billion annually (in 2008 dollars), which is equivalent to 20.6% of US health expenditures. The medical costs of obesity-related illness impact all healthcare sectors and payers.[29] These costs are mainly due to the treatment of obesity-related diseases, rather than the treatment of obesity itself.[28]

Impact of Obesity on Employers

The effect of obesity on employer-incurred healthcare costs as well as lost productivity is substantial and has been the subject of several different analyses. Finkelstein et al looked at the impact of obesity on full-time employees and their employers, drawing data from 2 public data sets: the US National Health and Wellness Survey for 2008, and MEPS for 2006. The data sets included subjects 18 to 64 years old stratified by obesity grades (grade I = BMI 30-34.9; grade II = BMI 35-39.9; grade III = BMI 40+).[32] Medical expenditures, absenteeism, and presenteeism (ie, reduced productivity among workers on-site) were calculated. Total annual expenditures attributable to obesity, including both medical costs and lost productivity, for obese males ranged from $1143 for grade I obesity to $6087 for grade III. Among women, grade I obesity was associated with total annual costs of $2524, while grade III obesity total annual costs were estimated at $6694. Subjects with a BMI of 35 or higher (37% of all subjects in the study) accounted for 61% of excess costs. The Finkelstein study also showed that presenteeism represented the largest contributor to obesity-related cost for employers.[32]

Durden et al studied costs related to overweight, obesity, and BMI of 35 or higher incurred by self-insured employers using health claims data, self-reported health risk assessment data from employees, and productivity data from 2003 to 2005. Regression models were used to estimate incremental direct and indirect costs in a study population that included nearly 89,000 employees. Direct medical costs associated with overweight, obesity, and BMI of 35 or higher were found, during the study period, to be $147, $712, and $1977, respectively, while indirect medical costs (due to paid absence) associated with overweight, obesity, and BMI of 35 or higher were $1404, $1511, and $1414, respectively.[33]

Finally, Cawley et al sought to determine the nationwide scope of absenteeism cost related to obesity using data from the MEPS for 2000 to 2004. The authors estimated the total annual cost due to obesity-related absenteeism to be $4.3 billion (in 2004 dollars).[34]

In summary, healthcare spending and rates of absenteeism and presenteeism (with associated impact on workplace productivity) are higher among obese workers compared with normal-weight workers, and costs increase with increasing BMI.[32,33]

QoL Burden of Obesity

Individuals who are obese have an elevated risk of experiencing poorer QoL compared with non-obese individuals both as a direct result of being obese and as a consequence of the many comorbidities associated with obesity. The European Male Ageing Study (EMAS), which included 3369 men (aged 40-79 years) drawn from 8 European countries, is perhaps the most comprehensive examination of the effects on QoL in the male population.[35] A total of 814 (25%) of the study subjects were obese and 1629 (49%) were overweight; the study subjects' QoL was assessed using 3 instruments: the Short Form-36 (SF-36), the Beck Depression Inventory, and the EMAS sexual function questionnaire. Obesity was found to be associated with a significant increase in risk of performing poorly in a variety of physical function subdomains, including ability to perform vigorous activity, to climb stairs, or to walk more than 1 km, while also being associated with impairment of 1 or more, 2 or more, or 3 or more physical functions. Several psychological elements were additionally significantly impacted in obese patients, including loss of energy, sleep changes, and various measures of tiredness. Sexual function subdomains were also, in most cases, significantly lower in obese men.[35]

The negative effect of obesity on QoL manifests in patients of all ages. Among older patients, this fact is confirmed not only by the EMAS data but also by a study from the University of California, San Diego, involving 1326 adults with a mean age of 72 years, which showed significantly poorer "Quality of Well Being" scores among obese subjects compared with those who were overweight or who had normal BMI.[36] A Swedish study of younger women, aged 18 to 34 years, meanwhile, found that compared with normal-weight women, obese women in this age group were more likely to be unemployed, less likely to be engaged in academic studies, more likely to possess limited emotional support, more likely to have lower self-reported physical health, and more likely to smoke.[37] The relative severity of impact of obesity on QoL was evaluated in a recently published study of very obese patients awaiting weight loss surgery; the results showed that the QoL of these patients was similar to the QoL of patients living with diabetes or laryngeal cancer.[38]

As discussed in this section, excess body weight is associated with negative effects on QoL, and the negative impact of obesity on QoL affects both male and female patients of all ages.[35-38]

Cost-Effectiveness of Interventions to Treat Obesity

Studies of interventions to treat obesity are fairly consistent in observing cost-effectiveness across a spectrum of different treatment modalities. A systematic literature review and meta-analysis conducted by the UK's Health Technology Assessment program and published by Ara et al examined the clinical effectiveness and cost-effectiveness of pharmaceutical therapies for obesity in primary care, and included 94 studies comprising 24,808 subjects. With regard to efficacy, drug interventions (in addition to lifestyle interventions) were shown to reliably reduce weight and BMI in obese patients in the short term (up to 12 months). In terms of cost-effectiveness, 16 pharmacoeconomic studies were reviewed, comparing 3 drugs (orlistat, sibutramine, and rimonabant) then available in the United Kingdom for obesity treatment; the authors' analysis demonstrated high degrees of cost-effectiveness associated with all of the studied agents.[39] It should be noted that the literature review and manuscript preparation for the Ara et al publication occurred in 2009 to 2011, and thus the meta-analysis does not include pharmaceutical therapies that were more recently approved by the US Food and Drug Administration. These results are consistent with the results of another literature review, which included 14 studies evaluating cost-effectiveness or cost-utility with the same 3 drugs. This review also found these agents to be cost-effective, although the sustainability of weight loss was uncertain.[40]

Sibutramine was the subject of a US study published in 2005, comparing its use versus non-use in a group of 501 patients participating in a weight management program. The authors determined that sibutramine did help subjects achieve significantly greater weight loss and BMI decrease, but that its use was not associated with cost savings. It should be noted, however, that subjects receiving sibutramine were significantly older and had a higher BMI than subjects not receiving sibutramine.[41]

Also recently published was a study evaluating the efficacy and costs of a stepped-care weight loss intervention (STEP) and a standard behavioral weight loss intervention (SBWI) in 363 overweight and obese adults randomized to 1 of the 2 interventions for 18 months.[42] Both interventions resulted in significant weight reductions after 18 months (both P <.001 vs baseline), with reductions in the SBWI group being greater, but not significantly so, than reductions in the STEP group (–8.1% vs –6.9%). Patients in both treatment groups experienced significant reductions in resting heart rate and blood pressure as well as increases in fitness. Although the study did not include a cost-effectiveness analysis, the costs associated with treatment were, in both the STEP group and the SWBI group, notably lower than medical expenditures associated with obesity, with a significant financial advantage for the STEP intervention over the SWBI intervention. Combined payer and participant costs were $1357 (95% CI, $1272-$1442) for the SBWI group versus $785 (95% CI, $739-$830) for the STEP group (P <.001).[42]

Bariatric surgery may be used in patients with a BMI of 40 or greater or patients with a BMI of 35 or greater who have an obesity-related comorbidity (eg, hypertension, hyperlipidemia, obstructive sleep apnea). Additionally, bariatric surgery is FDA approved for use in patients with a BMI between 30 and 35 who have type 2 diabetes mellitus. Bariatric surgery has become more common and more diverse in its modalities, comprising techniques such as Roux-en-Y gastric bypass, sleeve gastrectomy, and adjustable gastric banding.[43] The decision to undertake bariatric surgery must involve a balanced view of the medical risks associated with obesity versus the short- and long-term risks of complications related to surgical intervention.[43] In the Swedish Obese Subjects study, for example, 0.25% of subjects died within 90 days of surgery compared with 0.10% of matched controls who did not have surgery. However, cumulative mortality, based on 16-year follow-up, found that 101 patients in the surgery group had died compared with 129 patients in the control group (hazard ratio = 0.76; 95% CI, 0.59-0.99; P = .04).[44]

A systematic review by the Health Technology Assessment program assessed the clinical effectiveness and cost-effectiveness of bariatric surgery in obese subjects and concluded, with some degree of ambivalence, that for people with a BMI of 30 or greater but less than 40, bariatric surgery is, overall, more effective than non-surgical management and, with somewhat less ambivalence, cost-effective in the same patient group.[45] Other studies have tended to confirm the cost-effectiveness of bariatric surgery. Two US studies in managed care organization populations—one from a large-scale managed care database and the other from an independent practice association—both found laparoscopic bariatric surgery to be cost-effective; the former study observed particular cost benefits in patients with diabetes and the latter in women, non-white subjects, and more obese subjects.[46,47]

A recent US study applied a simulated cost-effectiveness model using an average Medicare reference case of a 53-year-old female patient with a BMI of 44. The authors found all 3 of the surgical methods they examined to be cost-effective, with Roux-en-Y gastric bypass being the most cost-effective, followed by laparoscopic gastric bypass and adjustable gastric banding, the latter 2 methods yielding similar savings.[48]

In summary, a wide variety of interventions—pharmacologic, behavioral/lifestyle, and surgical—offer effective and economically sound options for weight loss in obese patients.

Impact of Weight Loss on Health Outcomes, Costs, and QoL

To reduce the increased morbidity and mortality associated with obesity, and reduce risk factors for diabetes and cardiovascular disease, the National Heart, Lung, and Blood Institute, in its Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults, recommends an initial goal of a 10% reduction in body weight, and maintenance of a lower body weight over the long term.[49] The American Association of Clinical Endocrinologists recently published an algorithm for the management of diabetes which advocates the treatment of the whole spectrum of cardiometabolic disease with an initial and ongoing focus on achieving weight loss to address the underlying pathophysiology of obesity-related diseases. The guidelines advocate lifestyle interventions augmented with obesity pharmacotherapy, as needed, to achieve target weight loss and improvement in comorbidities and disease biomarkers for hypertension, prediabetes and diabetes, and dyslipidemia (ie, blood pressure, glycemic measures, and lipid changes).[50]

Oster et al estimated the lifetime health and economic benefits of sustained modest weight loss (defined as a 10% reduction in body weight) in persons who are obese, using a model that takes into consideration the connection of BMI to the risks and associated costs of hypertension, hypercholesterolemia, type 2 diabetes, coronary heart disease, and stroke. These diseases were selected because they, along

Table 4. Lifetime and 10-Year Gross Per Capita Medicare Savings From Temporary and Permanent Weight Loss Among 1 Cohort Aged 65 to 70 Years[52]

Baseline BMI at Age 65 y	10% Weight Loss With Weight Regain ("temporary")	15% Weight Loss With Weight Regain ("temporary")	10% Permanent Weight Loss	15% Permanent Weight Loss
BMI ≥27 + comorbidity (2.4 million[a])				
Lifetime	$7556	$9933	$9445	$12,912
10 years	$6456	$7831	$8070	$10,180
BMI ≥30 (5.5 million[a])				
Lifetime	$9112	$10,304	$12,392	$14,116
10 years	$7446	$8911	$9053	$12,208
BMI ≥35 (3.3 million[a])				
Lifetime	$7799	$11,109	$13,496	$15,987
10 years	$7654	$8534	$10,126	$13,474

BMI indicates body mass index.
[a] These numbers reflect the number of Medicare beneficiaries within each BMI category, which can be used to determine the available pool of aggregate savings.
Adapted with permission from Thorpe KE, Yang Z, Long KM, Garvey WT. *Health Econ Rev.* 2013;3(1):7.

with their associated complications, account for a majority of total obesity-attributable medical care costs.[51] Based on their model, with a range of results contingent on baseline variables, the authors showed that sustained modest weight loss would reduce the number of patient years of life with hypertension by 1.2 to 2.9 years, hypercholesterolemia by 0.3 to 0.8 years, and type 2 diabetes by 0.5 to 1.7 years; lifetime incidence of coronary heart disease would be reduced by 12 to 38 cases per 1000 and stroke would fall by 1 to 13 cases per 1000. They further estimated that the expected lifetime medical care costs due to the 5 diseases included in the study would be reduced by $2200 to $5300 (1996 dollars).[51]

Capturing the effects of weight loss among patients earlier in life upon medical expenditures a decade later was the subject of a study published in 2013 that used Medicare data from 1992 to 2001.[52] The study used a model to estimate Medicare spending for 5 patient populations: no weight loss intervention, 10% or 15% weight loss followed by 90% weight regain over 10 years (temporary weight loss), and permanent 10% or 15% weight loss.[52] The authors found that gross per capita savings to the Medicare program ranged from $6456 to $13,474, depending on BMI at baseline, percent weight loss, and whether the weight loss was temporary or permanent. The results by BMI category are presented in Table 4.[52] Weight loss in beneficiaries in the highest BMI category (≥35) was shown to have the greatest impact in terms of cost savings.[52]

Given the increased risk of developing diabetes among persons who are overweight or obese, it is important to establish whether interventions (eg, weight loss) in this population might lessen the risk of progression to diabetes, particularly among those who are at high risk. The Diabetes Prevention Program Research Group evaluated the effects of 2 interventions on the risk of progression to diabetes in a clinical trial that enrolled 3234 adults with a mean BMI of 34.0 (±6.7) and elevated fasting and post-load plasma glucose levels (ie, prediabetes). Participants were randomized to receive a lifestyle modification program, metformin 850 mg twice daily, or placebo. The lifestyle modification program included a low-calorie diet and at least 150 minutes per week of moderate-intensity exercise, with a weight reduction goal of at least 7% of baseline weight.[53] After an average of 2.8 years of follow-up, the incidence of diabetes was 4.8, 7.8, and 11.0 per 100 person-years in the lifestyle modification, metformin, and placebo groups, respectively. The incidence of diabetes was 58% lower among subjects in the lifestyle modification group compared with subjects in the placebo group (P <.001); the incidence of diabetes was 31% lower among subjects in the metformin group compared with subjects in the placebo group (P <.001). Participants in the lifestyle modification group achieved an average weight loss of 12.3 pounds, participants in the metformin group lost an average of 4.62 pounds, and participants in the placebo group lost an average of 0.22 pounds.[53]

Weight loss also has beneficial effects in patients who have diabetes, as shown in a study by Kumar et al, which found that among 50 patients with type 2 diabetes and a mean BMI of 35, the loss of 5% of body weight, resulting from participation in a weight loss program, was associated with a 49% reduction in requirements for antidiabetic medications. Furthermore, 44% (22) of subjects were able to discontinue their anti-diabetic medications altogether, and at the time of discontinuation, a mean weight loss of 11.2% from baseline had been achieved.[54]

Weight loss has also been observed to provide benefits in regard to dyslipidemia and blood pressure, as shown by the results of a 56-week randomized controlled study of 2487 obese patients with cardiovascular risk factors who were treated with a combination of phentermine and topiramate extended-release. A nearly linear relationship between amount of weight lost and degree of improvements in risk factors—including triglycerides, non-HDL cholesterol, systolic blood pressure, and diastolic blood pressure—was observed. For example, subjects who lost between 5% and 10% of body weight experienced a mean 14.5% reduction in triglycerides, and the reduction climbed to 28.7% for subjects who lost between 10% and 15% of body weight. Systolic blood pressure was reduced by 7.5 mm Hg in those losing 5% to 10% of body weight, and was reduced by 10.8 mm Hg among those who lost 10% to 15% of body weight.[55]

Weight loss also benefits patients with sleep apnea. A study of 81 adult patients with sleep apnea and BMI 28 to 40 found that the study intervention (diet and lifestyle changes) reduced the risk of obstructive sleep apnea at follow-up by 65%. The average weight lost was 7.3 kg in the intervention group and 2.9 kg in the control group.[56]

Weight loss also confers benefits in terms of QoL. The immediate and long-term effects of a clinical weight loss program on health-related QoL (HRQoL) in 190 overweight and moderately obese adults were evaluated in a 2-year study conducted by Blissmer et al. HRQoL was evaluated via the SF-36 at baseline, at the conclusion of a 6-month clinical weight loss program, and again at 12 and 24 months post intervention. At 6 months, 144 subjects remained in the study. While baseline scores for bodily pain, vitality, and mental health were poorer among study subjects compared with population norms, after completing the 6-month clinical weight loss program, scores were improved across several domains including physical and mental composite scores as well as subscale scores for physical functioning, general health, vitality, and mental health. Improvements in the mental composite score and the physical functioning, vitality, and mental health subscales were sustained after 24 months.[57]

As described in this section, weight loss can improve many obesity-related cardiovascular risk factors, including type 2 diabetes, dyslipidemia, and hypertension. These effects are also seen in several measures of health-related quality of life. Benefits are seen with modest weight loss of 5% to 10% of baseline body weight, and additional improvements are seen with greater weight loss.[53-55,57]

Summary

Obesity is a multifactorial condition associated with numerous comorbidities that exact a considerable clinical, quality-of-life, and economic toll. Therapeutic interventions to reduce excess body weight, and consequent associated comorbidities and health risks, are available, effective at promoting weight loss, and cost-effective when evaluated over the short term. Weight loss has been shown to have a positive impact on several comorbidities associated with obesity. Relatively modest weight reductions, from 5% to 10% of baseline body weight, are associated with significant reductions in the risk of developing type 2 diabetes among those at high risk for diabetes, as well as significant reductions in the need for antidiabetic medications among those who already have diabetes. Similarly, this degree of weight reduction has been shown to reduce key cardiovascular disease risk factors, including triglycerides, non-HDL cholesterol, and both diastolic and systolic blood pressure. Larger weight reductions result in greater improvement in these risk factors. Treatment options to reduce obesity, and to meaningfully lower its substantial health effects, have been shown to be effective in the short term and should be offered to the increasing number of people who are affected by obesity and who are affected by or are at high risk for its related medical and economic burden. Additional weight loss interventions with long-term efficacy are needed to reduce body weight and maintain weight loss.

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