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Direct medical cost of overweight and obesity in the United States: a quantitative systematic review

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Abstract

Objectives—To estimate per-person and aggregate direct medical costs of overweight and obesity and to examine the effect of study design factors.

Methods—PubMed (1968–2009), EconLit (1969–2009), and Business Source Premier (1995–2009) were searched for original studies. Results were standardized to compute the incremental cost per overweight person and per obese person, and to compute the national aggregate cost.

Results—A total of 33 U.S. studies met review criteria. Among the 4 highest quality studies, the 2008 per-person direct medical cost of overweight was $266 and of obesity was $1723. The aggregate national cost of overweight and obesity combined was $113.9 billion. Study design factors that affected cost estimate included: use of national samples versus more selected populations; age groups examined; inclusion of all medical costs versus obesity-related costs only; and BMI cutoffs for defining overweight and obesity.

Conclusions—Depending on the source of total national health care expenditures used, the direct medical cost of overweight and obesity combined is approximately 5.0% to 10% of U.S. health care spending. Future studies should include nationally representative samples, evaluate adults of all ages, report all medical costs, and use standard BMI cutoffs.

Keywords

Obesity; health care costs; costs and cost analysis

The increased prevalence of obesity that has occurred in the U.S. during the last 30 years[1] has been accompanied by a substantial increase in the literature on the direct medical cost of

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Conflict of interest

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obesity. Although debate exists about the usefulness of quantifying the cost of illness in general and specifically the cost of overweight and obesity,[2, 3] cost of illness estimates are routinely cited in the medical and health services literature. For example, the American Diabetes Association estimated that the annual cost of diabetes in medical expenditures and lost productivity climbed from $132 billion in 2002 to $174 billion in 2007.[4] Similarly, the Centers for Disease Control and Prevention and the American Heart Association estimated the direct and indirect cost of cardiovascular disease to be $403.1 billion in 2006.[5] Although some cost estimates for overweight/obesity, diabetes, and heart disease may double count one another, it is important to understand the magnitude of costs that could potentially be saved by better prevention and treatment of obesity.

To our knowledge, there has been no systematic attempt to quantitatively summarize the growing literature on the direct medical cost of overweight and obesity. In this paper, we identify reports of the U.S. cost of overweight and obesity published between 1992 and 2008; we translate these estimates into 2008 dollars ($Y2008); and we summarize the resulting estimates and report per-person cost and aggregate cost. We also evaluate the impact of variation in study design on cost estimates.

METHODS

Literature Search

We searched the PubMed (1968–2009), EconLit (1969–2009), and Business Source Premier (1995–2009) databases to identify studies that reported on the cost of obesity (search last updated September, 2009). The search strategy combined the terms “obesity” or “obesity, morbid” with any of the following terms: “costs and cost analysis”, “health care costs”, “cost of illness”, and “employer health costs”. A total of 935 titles and/or abstracts were reviewed. Bibliographies of relevant articles, including several qualitative reviews,[6–10] were searched for additional titles. Only studies conducted in the U.S. were included, for two reasons. First, use of only U.S. studies allowed us to standardize cost estimates, as described below. Second, the U.S. is unique in having both the highest rates of overweight and obesity and the highest health care spending among developed nations. Thus, we believed that cost estimates for obesity-related spending might be higher in the U.S. compared to other countries.

Fifty U.S. studies were identified.[11–60] Seventeen studies were excluded for the following reasons: duplicate dataset (n = 7);[44–50] median, rather than mean, cost reported (n = 1);[51] unable to calculate annual cost from data reported (n = 1);[52] no body mass index (BMI) cutoff given for overweight/obesity (n = 4);[53–56] only inpatient or outpatient costs included (n = 3);[57–59] direct and indirect costs were combined (n = 1).[60] Table 1 provides details about the 33 studies we included in our analysis.

Three general study designs were encountered in the conduct of this review. First were studies that used patient-level data, either nationally representative (e.g., from federal surveys) or from employers or health plans. Studies with patient-level data are able to capture the cost of all conditions, whether associated with obesity or not. The second type of study was “attributable risk” analysis. These studies start with estimates of aggregate cost for weight-related conditions and then assign a fraction of the cost to obesity. The formula most commonly used to estimate this fraction is P(RR-1)/(1+P(RR-1)), where P is the prevalence of obesity and RR is the relative risk of the disease among obese persons as compared to normal weight individuals.[61] The third type of study design was modeling analysis, in which various inputs from the literature are combined with mathematical models to predict costs for a hypothetical cohort of individuals over time.

Translating the Study Results to $Y2008

Our goal in translating all study results to $Y2008 was not limited to a single adjustment to reflect changes in inflation over time. Rather, where possible, it was to additionally adjust for changes in age, gender, and BMI distribution of the U.S. population between the time when the study conducted and the present. We were not able to adjust for changes in ethnicity of the U.S. population, as none of the studies presented results stratified by ethnic group. We also adjusted for variations in several design decisions made by the authors of the original studies. Table 2 lists these design decisions, including issues that limited our ability to synthesize the results.

Adjustment for changes in gender, age, and weight distribution—For studies that reported cost estimates stratified by age, gender, or obesity class, we used data from the U.S. Census and national estimates (National Health and Nutrition Examination Surveys [NHANES]) of the proportion of overweight and obese individuals to adjust the studies' results. We made an initial adjustment to 2004 because of the availability of published tables with rates of overweight and obesity stratified by age group, gender, and obesity class.[62, 63]

Standard vs nonstandard BMI definitions of obesity—Current definitions of normal weight, overweight, and obesity are BMI 18.5 to < 25 kg/m^2, 25 to < 30 kg/m^2, and ≥ 30 kg/m^2, respectively. Twelve studies used nonstandard definitions of obesity that differed from the current definition. These -- generally older -- studies commonly used BMI cutoffs to define obesity that ranged between 27 and 29 kg/m^2. For studies that used nonstandard BMI definitions, we adjusted cost estimates by using NHANES data containing the BMI distribution by unit between 18.5 and 30 kg/m^2 (data provided by Dr. Yi-Ling Chen, Centers for Disease Control and Prevention). When studies used a BMI of ≤ 27 kg/m^2 as the lower bound for identifying individuals as obese, we included these data as estimates of the combined cost of overweight and obesity.

Estimates based on cost vs expenditure vs charge—Six studies reported average charge rather than average cost or expenditure. Charges represent fees from health care providers (hospitals, physicians) for a service, while costs represent the actual amount required to provide the service. We adjusted charges to costs by use of a cost-to-charge ratio of 0.5185, estimated by the Medicare program in the U.S.[64]

Translate national cost estimates to per-person estimates—For studies that reported national cost estimates rather than per-person cost estimates, we used census data and data on the distribution of weight to estimate the number of people who were overweight or obese in the year the data were reported. We then divided the cost totals by the number of overweight/obese individuals.

Year in which cost is expressed—Per-person cost estimates were initially inflated to $Y2004 by use of the Consumer Price Index (CPI) Medical Care segment (http://www.bls.gov/data), for reasons described above. Estimates were then re-inflated to $Y2008, again using the Medical Care CPI. We further inflated cost estimates by 3% per year, starting in the year that the study reported cost data. This additional inflation factor was based on two studies by Finkelstein et al,[13, 15] in which obesity-related costs increased over 24% during an eight-year period above and beyond the medical care CPI.

Unadjusted and adjusted estimates—A majority of the studies included in our review made some adjustment for participant characteristics, including alcohol and tobacco use, as well as physical activity. A subset of these studies also controlled for medical diagnoses associated with overweight and obesity, such as blood pressure, diabetes, or coronary heart

disease. Because several of these variables might fall within the causal pathway between obesity and health care spending, we used unadjusted estimates for our primary analysis. Variables adjusted for in individual studies are listed in Table 1.

Sample calculation—A sample calculation is available online as Appendix 1 to the manuscript and also is available on request from the authors.

Analysis

Where available, we report study-specific estimates of the $Y2008 health care cost of normal weight individuals, as well as the incremental cost of overweight, obesity, and the combined cost of overweight and obesity. In studies that reported both a normal weight cost and an incremental cost, we report the incremental cost expressed as a proportion of the normal weight cost. To address differences in study design which could not be completely adjusted for in our translation of cost estimates (e.g., inclusion of all adults versus age-limited subgroups), we report means stratified by these design variables. Finally, we report the un-weighted arithmetic mean of the incremental cost estimates for overweight and obesity, and we report aggregate national cost by multiplying our estimates of per-person cost by the number of overweight and obese adults in the U.S.

RESULTS

Description of Studies

We identified 33 studies that were published between 1992 and 2008 and that met our inclusion criteria.[11–43] Of these, 24 reported on the cost of overweight, 30 on the cost of obesity, and 26 on the cost of overweight and obesity combined. Most studies did not provide estimates of the variance in incremental cost, precluding formal meta-analysis. Table 1 provides the studies' details.

Cost Estimates

High quality studies—Only four studies[12, 13, 15, 20] met all criteria we designated for a "high quality" study – use of nationally representative samples, analysis of adults of all ages, use of standard BMI cutoffs, and reporting cost or expenditure. In these four studies, the cost for overweight was $266, for obesity $1723, and for overweight and obesity combined $1023.

Pooled estimates—Among all studies, the incremental cost of overweight was $498. Six of the 24 studies reported incremental cost savings for overweight. Among the 23 studies that reported estimates of both the cost of normal weight and the incremental cost of overweight, the incremental cost of overweight was 9.9% greater than the cost of normal weight. Among all studies, the incremental cost of obesity was $1662. None of the 30 studies reported cost savings associated with obesity. Among the 24 studies that reported estimates of both the cost of normal weight and the incremental cost of obesity, the cost of obesity was 42.7% greater than the cost of normal weight. Table 3 shows, for all studies, $Y2008 estimates of the costs of normal weight, overweight, and obesity, overweight and obesity combined, plus the latter figures expressed as a percentage of the cost of normal weight. Appendix 2 (published online and also available from the authors upon request) lists costs as reported in the individual manuscripts, in the year in which they were originally quantified.

Morbid obesity—Five studies reported cost estimates for morbid obesity (BMI ≥ 40 kg/m^2).[11, 12, 14, 16, 43] Among these five studies, the average incremental cost was $3012,

which represented a 68% increase over the cost of normal weight. The cost of morbid obesity accounted for 35% of the total cost of obesity (range, 25–49%).

Stratified Estimates—Table 4 shows our estimates of average cost stratified by variations in study design. Studies that used nationally representative sample, standard BMI cutoffs, reported cost or expenditure, and included all health care spending reported higher estimates. The cost of overweight and of obesity was generally higher in women than in men. Studies that used age-limited subsamples of the adult population -- usually near-elderly or elderly individuals -- reported higher costs compared to studies that used employed populations (< 65) or samples of all adults.

National cost estimates—When we multiplied our estimates (from high-quality studies) of $266 and $1723 for overweight and obesity by the number of overweight and obese persons in the U.S., the $Y2008 aggregate (national) costs of overweight and obesity were $15.8 billion and $98.1 billion, or 113.9 billion total, equal to 4.8% of health care spending in 2008.[65] When pooled estimates from all 33 studies were used to compute aggregate costs, the total costs of overweight and obesity were 29.9 billion and $91.0 billion, respectively ($120.1 billion, or 5.0% of total health care spending). When pooled results from only the 29 studies not classified as high-quality studies were used, incremental costs were $531 (overweight) and $1615 (obesity). Thus, total costs among these 29 studies were $38.4 billion for overweight and $110.5 billion for obesity ($148.9 billion, or 6.2% of health care spending).

DISCUSSION

In this quantitative review of 33 studies, we estimated that the annual direct medical cost of overweight is approximately $266 higher, and the incremental cost of obesity $1723 higher, than that of normal weight persons. These results were based on the four highest quality studies. Our pooled estimates (n = 33 studies) show per-person costs to be $498 (overweight) and $1630 (obesity). Based on our estimates of incremental cost from the four highest quality studies and using a recently published estimate of national health expenditures,[65] the aggregate national cost of overweight and obesity was 4.8% of U.S. health spending in 2008, or 5.0% if pooled estimates are used. Estimates of the incremental cost of obesity were similar, whether only the highest quality studies were used or whether all studies were pooled. (The incremental cost of overweight was, in fact, lower for the highest quality studies.) Because the characteristics of high-quality studies were generally associated with larger cost estimates (Table 4), the finding of similar estimates in the pooled analysis and for the subset of high-quality studies was surprising. We believe that this result reflects the small number of high-quality studies.

We found substantial heterogeneity in costs among the studies. An important source of heterogeneity was study design (e.g., national samples versus health plan or employer samples). If only “nationally representative” studies had been used for this analysis, the aggregate national cost of overweight would be $48.2 billion and obesity would be $122 billion (i.e., $170.2 billion total, or 7.1% of health care spending in 2008). This latter estimate is closer to estimates from two recent studies that estimated current and future costs of obesity.[15, 50] However, some national samples in the current analysis included only subpopulations by age, which led to a wide range of cost estimates.

Finkelstein et al, using recent Medical Expenditure Panel Survey data, reported that the incremental cost of obesity to be $1429 and that the cost of overweight was not significantly different than the cost of normal weight.[15] Our cost estimate for obesity of $1723 is higher than Finkelstein’s, and we estimated a cost of $266 for overweight. We estimated that total

spending was 4.8% of national expenditures, while Finkelstein estimated total spending to be 9.1%. The difference in percentage of health care spending occurs because Finkelstein et al used aggregate spending from the Medical Expenditure Panel Survey (MEPS) which is lower than aggregate spending from the National Health Expenditure Accounts (NHEA) which we used.[65] Had we used MEPS aggregate expenditures, costs would be estimated at 10.4% (obesity alone) or 12.1% (obesity and overweight combined) of total health care spending. It is unclear whether aggregate spending from MEPS or from the NHEA is preferred. In another study, Wang and colleagues estimated future obesity-related health care costs for the U.S. health care system. They concluded that obesity-related expenditures would increase to 16–18% of health care spending by 2030. They also pointed out that the proportion of total health care expenditures attributable to obesity would be lower if MEPS was used and higher if NHEA was used.[50] We did not attempt to project future obesity costs in this manuscript.

Another important source of variability in cost estimate was the age groups selected for analysis. The studies by Sturm et al and Daviglus et al were limited to near-elderly or elderly adults[18, 26] and reported the incremental cost of obesity to be 2–3 times greater than the average that we calculated. Higher obesity-related health care spending for older age groups may reflect greater cumulative exposure to overweight/obesity (i.e., “pound-years”). The recent study by Wolf et al also reported large incremental costs.[21] This study included spending for weight loss, a category not usually included in cost analyses.

A third important source of variability was BMI cutoff used. Some studies used non-standard definitions for obesity, in which BMI cutoffs were lower than the standard of 30 kg/m^2. This difference in classification, by including overweight individuals in the obese class, has the effect of lowering the incremental cost for both the overweight and obese groups.[66] (Both means are lowered because those who are reclassified from overweight to obese represent the heaviest and most costly among overweight individuals, but their weight and cost is lower than that of the obese individuals with whom they are now classified.)

Several important limitations apply to this review. The most important limitation is the use of pooled analysis to summarize a heterogeneous group of studies. To overcome this limitation, we presented data from only four high-quality studies as the primary results. Second, although the review was quantitative, lack of variance estimates for cost precluded formal meta-analysis. Third, we were unable to adjust for some of the design decisions made by authors of the original reports. Fourth, we were not able to control for the type or number of medical conditions that individual studies counted as weight-related. For example, among the 4 attributable risk studies, the study that counted fewer medical diagnoses as obesity-related[37] reported lower estimates of incremental cost. Lastly, the review does not provide information about the cost-effectiveness of weight loss programs or other interventions intended to reduce the direct medical cost of overweight and obesity.

Despite the limitations noted, our work has several implications. First, the results suggest that the financial burden of obesity is at least 2–3 times greater in the U.S. than in other developed countries. Obesity-related spending as a percentage of total health care spending is approximately 1–2.5% in Canada and in the European Union.[67–70] The difference between the U.S. and the EU/Canada is likely a combination of higher obesity rates and higher per capita health care spending in the U.S. Higher obesity-related spending in the United States, a country that already has the largest expenditures in the world, provides support for those who advocate for greater attention to obesity prevention and treatment.[71, 72] Second, as described above, our results indicate that study methodology potentially makes a large difference in estimates of cost. Third, although these results do not provide an estimate of cost-effectiveness for obesity treatment, they do provide data that can be used,

together with economic analyses of interventions, to estimate how much of the cost of weight-related illness could be saved. For example, the sub-analysis examining the cost of morbid obesity (n = 5 studies) suggests that this subgroup incurs costs that are disproportionate to their numbers (i.e., 35% of the total cost of obesity, whereas morbidly obese individuals make up approximately 15% of all obese persons.[62]) Disproportionately higher costs among the morbidly obese, in combination with studies showing that bariatric surgery can produce a return on investment (i.e., a cost savings),[73, 74] suggests that surgical treatment of obesity, while costly, may be more cost-effective than lifestyle or pharmacologic treatment for the morbidly obese.

In conclusion, we found that a BMI ≥ 30 kg/m^2 was associated with approximately $1723 of additional medical spending per year, while overweight (BMI 25 to 29.9 kg/m^2) was associated with a more modest incremental cost of $266. Our review suggests that in the future, more accurate estimates of the cost of overweight and obesity will be obtained in studies that use nationally representative samples, report cost or expenditure, use standard BMI cutoffs, include all direct medical costs, and analyze adult subjects of all ages.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of the 33 studies included in the review

Study	* Data Sources	Sample Size	Year(s) of Data Collection	Year of Cost Reporting	** BMI Cutoff	Cost Reporting	† Age (Age Range)	Gender	Obesity Class	‡ Type of Cost	# Adjusted Results	Variables Adjusted for in Analysis
Cohort/Cross Sectional Studies (Nationally Representative)												
Andreyeva (2004)[11]	HRS	8,762	1996–2000	2002	Standard	Expenditure	Subsample: (54–69)	Stratified	Stratified	All HC	Adjusted	Age; gender; race/ethnicity; education; household income; health insurance status; marital status; tobacco use; alcohol use; region of U.S.; survey wave
¶ Arterburn (2005)[12]	MEPS	16,262	2000	2000	Standard	Expenditure	All adults (≥ 18)	Aggregated	Stratified	All HC	Adjusted	Age; gender; race/ethnicity; education; household income; health insurance status; marital status; tobacco use
¶ Finkelstein (2003)[13]	MEPS	9,867	1998	1998	Standard	Expenditure	All adults (≥ 18)	Aggregated	Aggregated	All HC	Adjusted	Age; gender; race/ethnicity; educational level; household income; marital status; region of U.S.
Finkelstein (2005)[14]	MEPS	20,329	2000–2001	2004	Standard	Expenditure	Employed (18–65)	Stratified	Stratified	All HC	Adjusted	Age; gender; race/ethnicity; education; household income; tobacco use; region of U.S.
¶ Finkelstein (2009)[15]	MEPS	10,597 (1998); 21,877 (2006)	1998, 2006	2008	Standard	Expenditure	All adults (≥ 18)	Aggregated	Aggregated	All HC	Adjusted	Age; gender; race/ethnicity; education; household income; marital status; tobacco use; region of U.S.
Heithoff (1997)[16]	NMES	16,217	1987	1993	Standard	Expenditure	Employed (18–65)	Stratified	Stratified	All HC	Adjusted	Age; gender; race/ethnicity; household income; tobacco use; health insurance status
Sturm (2002)[17]	HCC	10,000	1997–1998	1998	Standard	Expenditure	Employed (18–65)	Aggregated	Aggregated	All HC	Adjusted	Age; tobacco use; alcohol use
Sturm (2004)[18]	HRS; BRFSS	9,825	2000	1992	Standard (50–69)	Cost	Subsample	Stratified	Stratified	All HC	Adjusted	Age; gender; race/ethnicity; education; household income; marital status; health insurance status; tobacco use; alcohol use; region of U.S.; survey wave
Thorpe (2005)[19]	NMES; MEPS	13,974	1987; 2002	2002	Standard	Mixed	Employed (18–65)	Aggregated	Aggregated	All HC	Adjusted	Age; gender; race/ethnicity; education; household income; marital status; tobacco use; region of U.S.

Study	* Data Sources	Sample Size	Year(s) of Data Collection	Year of Cost Reporting	** BMI Cutoff	Cost Reporting	† Age (Age Range)	Gender	Obesity Class	‡ Type of Cost	# Adjusted Results	Variables Adjusted for in Analysis
¶ Wang G (2002)[20]	MEPS	9,872	1996	1996	Standard	Expenditure	All adults (≥ 25)	Stratified	Aggregated	All HC	Adjusted	Age; gender
Wolf (2008)[21]	Harris online poll volunteers; HCUP	1,067	2004–2005	2004	Standard	Cost	Subsample (35–75)	Aggregated	Aggregated	All HC	Adjusted	Age; gender, education; tobacco use; alcohol use; health insurance status; waist circumference; co-morbid conditions
Cohort/Cross Sectional Studies (Less Representative)												
Anderson (2005)[22]	Health Partners, Minnesota	8,000	1996–1999	1997	Standard	Charge	Subsample (≥ 40)	Aggregated	Aggregated	All HC	Unadjusted	Age; gender; tobacco use; physical activity; chronic disease burden
Bungum (2003)[23]	Claims data from a southwestern U.S. city	266	1993–1998	1995–6	Standard	Charge	Employed (19–68)	Aggregated	Aggregated	OR HC	Unadjusted	No adjustments
Burton (1998)[24]	First Chicago/National Bank of Detroit	3,066	1989–1995	1996	Nonstandard Men: ≥ 27.8 kg/m^2 Women: ≥ 27.3 kg/m^2	Charge	@ Employed (Mean: 35)	Stratified	Aggregated	All HC	Unadjusted	No adjustments
Cornier (2002)[25]	Denver Health Medical Center	424	1998	1997–8	Nonstandard Quartiles: < 25, 25–28.5, 28.5–34, >34 kg/m^2	Charge	All adults (18–84)	Aggregated	Stratified	All HC	Adjusted	Age; gender; race/ethnicity; tobacco use
Daviglus (2004)[26]	CMS; Chicago Heart Association	17,601	1984– 2002; 1967–1973	2002	Standard	Charge	Subsample (≥ 65)	Stratified	Stratified	All HC	Both	Age; race/ethnicity; education; tobacco use
Durden (2008)[27]	MarketScan Research; nine large U.S. employers	88,984	2003–2005	2005	Standard	Cost	@ Employed (Mean: 41)	Aggregated	Stratified	All HC	Both	Age; gender; personal income; health insurance type; union/nonunion status; industry type; region of U.S.; year of study
Long (2006)[28]	61 U.S. employers from 9 sectors	Not provided	2000–2004	2004	Standard	Cost	All adults (≥ 18)	Stratified	Aggregated	OR HC	Adjusted	$ Nine lifestyle health risks other than obesity
Quesenberry (1998)[29]	KP, Northern California	17,118	1993	1994	Standard	Cost	@ All adults (Mean: 52)	Aggregated	Stratified	All HC	Adjusted	Age; gender
Raebel (2004)[30]	KP, Colorado	1,764	1999–2000	1998	Nonstandard: ≥ 27.9 kg/m^2	Mixed	All adults (21–84)	Aggregated	Aggregated	All HC	Adjusted	Age; gender; chronic disease score
Thompson (2001)[31]	KP, Oregon	1,286	1990–1998	1998	Standard	Mixed	Employed (35–64)	Aggregated	Aggregated	All HC	Adjusted	Age; gender
Tucker, L (2002)[32]	Technology company in western U.S.	982	1994–95	1994–5	Nonstandard	Expenditure	Employed (18–68)	Aggregated	Aggregated	All HC	Adjusted	Age; gender
Wang, F (2004)[33]	Employees of four large U.S. corporations	23,490	1996–97	2002	Standard	Expenditure	@ Employed (Mean: 47)	Aggregated	Aggregated	All HC	Both	$$ Age; gender; chronic diseases; physical activity; overall health status

Study	* Data Sources	Sample Size	Year(s) of Data Collection	Year of Cost Reporting	** BMI Cutoff	Cost Reporting	† Age (Age Range)	Gender	Obesity Class	‡ Type of Cost	# Adjusted Results	Variables Adjusted for in Analysis
Wang, F (2005)[34]	Retirees from General Motors Corporation	42,520	2001–2002	2002	Standard	Charge	Subsample (≥ 65)	Aggregated	Aggregated	All HC	Adjusted	$$ Age; gender; chronic diseases; physical activity; overall health status
Attributable Risk Studies												
Oster (2000)[35]	Managed care organization in northwest U.S.	N/A	Not described	1996	Nonstandard “Mild” ≥ 25 kg/m^2 “Moderate to Severe” ≥ 29 kg/m^2	Mixed	All adults (35–84)	Stratified	Aggregated	OR HC	Unadjusted	No adjustment
Thompson (1998)[36]	Multiple sources††	Not provided	1993–1994	1994	Nonstandard “Mild” ≥ 25 kg/m^2 “Moderate to Severe” ≥ 29 kg/m^2	Mixed	Employed (25–64)	Aggregated	Aggregated	OR HC	Unadjusted	No adjustment
Wolf (1996)[37]	Multiple sources‡‡	Not provided	1988	1993	Nonstandard: ≥ 25 kg/m^2	Cost	All adults (≥ 18)	Aggregated	Aggregated	OR HC	Unadjusted	No adjustment
Wolf (1998)[38]	Multiple sources##	80,261	1988–1994	1995	Nonstandard: ≥ 29 kg/m^2	Cost	All adults (17–84)	Aggregated	Aggregated	OR HC	Unadjusted	No adjustment
Modeling Studies												
Allison (1999)[39]	Multiple Sources@@	N/A	Not described	1995	Nonstandard: ≥ 29 kg/m^2	Cost	All adults (17–84)	Aggregated	Aggregated	OR HC	Adjusted	Age; mortality risk
Gorsky (1996)[40]	Multiple Sources¶¶	N/A	1990	1990	Nonstandard: “Moderate” ≥ 25 kg/m^2 “Severe” ≥ 29 kg/m^2	Mixed	Subsample (40–65)	Stratified	Aggregated	OR HC	Unadjusted	No adjustment
Lakdawalla (2005)[41]	MCBS	N/A	1992–1998	2004	Standard	Expenditure	Subsample (≥ 65)	Aggregated	Aggregated	All HC	Adjusted	Age; gender; race/ethnicity; education; tobacco use; functional status
Thompson (1999)[42]	Multiple sources***	N/A	Not described	1996	Nonstandard Point estimates for BMI of 27.5, 32.5, and 37.5 kg/m^2	Mixed	Employed (35–64)	Stratified	Stratified	OR HC	Unadjusted	No adjustment
Tucker, D (2006)[43]	Multiple Sources†††	N/A	2004	2004	Nonstandard Point estimates for BMI of 24 and 44 kg/m^2	Cost	Employed (20–65)	Stratified	Stratified	All HC	Unadjusted	No adjustment

*HRS = Health and Retirement Study; MEPS = Medical Expenditure Panel Survey; NMES = National Medical Expenditure Survey; HCC = Health Care for Communities; BRFSS = Behavioral Risk Factor Surveillance Survey; HCUP = Healthcare Cost and Utilization Project; CMS = Center for Medicare Services; KP = Kaiser Permanente; NHANES = National Health and Nutrition Examination Survey; MCBS = Medicare Current Beneficiary Survey

**Studies that used standard BMI cutoffs classified adults with a body mass index (BMI) ≥ of 25–29.9 kg/m^2 as overweight and those with a BMI ≥ 30 kg/m^2 as obese. Studies that used nonstandard cutoffs, most of which were older, often used cutoffs of 27–28 kg/m^2 to label subjects as obese.

†Subsample refers to age-restricted adults, in this case usually near-elderly or elderly individuals; all adults refers to all individuals ≥ 18 years old; employed refers to adults < age 65

‡ All HC = all health care spending; OR HC = spending only for putatively obesity-related conditions

Adjusted or unadjusted for participant characteristics such as sociodemographics (age, ethnicity, socioeconomic status), alcohol and tobacco use, physical activity level, and/or medical diagnoses. Variables adjusted for are listed in Table 2.

¶ High quality study

@ Only mean age provided

$ accidents/injuries; alcohol/substance abuse; high cholesterol; high blood pressure; prenatal care; lack of exercise; smoking; stress; dental hygiene

$$ tobacco, alcohol, & seat belt use; blood pressure; cholesterol; self-reported health; stress; quality of life

†† Bureau of Labor Statistics; National Health Interview Survey (1993); others

National Health Interview Survey (1988); Nurses Health Study; others

National Health Interview Survey (1988, 1994); American Diabetes Association; others

@@ Wolf and Colditz (1998); NHANES III; Vital Statistics of the United States; others

¶¶ National Center for Health Statistics, NHANES II; American Heart Association; others

*** NHANES III; Framingham Heart Study; Coronary Heart Disease Policy Research Institute; others

††† Bureau of Labor Statistics; NHANES I–III; NHANES 2 Mortality Study; others

Table 2

Sources of Heterogeneity in Cost of Obesity Studies

Aggregated vs stratified (i.e., multiple) cost estimates
All ages (n = 12) vs age-specific (n= 21)
Both genders (n = 22) vs gender-specific (n = 11)
All obesity (n = 19) vs obesity class-specific (n = 11)*
Standard (n = 21) vs nonstandard (n = 12) BMI levels used to define overweight/obesity
Estimates based on costs (n = 9) vs expenditures (n = 11) vs charges (n = 6) versus mixed reporting (n = 7)
National cost estimates (n = 7) vs per-person estimates (n = 26)
Estimates made for 1 year (n = 20) vs estimates made for multiple years (n = 13)
Year in which cost is expressed
Studies with national samples (n = 11) vs those with less representative samples (n = 13) vs attributable risk design (n = 4) vs decision modeling (n = 5)
Estimates for all adults (n = 12) vs estimates restricted to specific age groups (n = 21)
All health care costs (n = 24) vs costs for putatively obesity-related conditions only (n = 9)
Adjusted (n = 24) or unadjusted (n = 9) for characteristics of study participants

*Among studies reporting costs for obesity (BMI ≥ 30 kg/m^2)

Table 3

Annual Per-Person Cost ($Y2008) of Overweight and Obesity Incremental to the Cost of Normal Weight, Stratified by Study Design

Author	Cost, Normal Weight	Incremental Cost, Overweight	% of Cost, Normal Weight	Incremental Cost, Obesity	% of Cost, Normal Weight	Incremental Cost, Overweight and Obesity	% of Cost, Normal Weight
Cohort/Cross Sectional Studies (Nationally Representative)							
Andreyeva (2004)[11]	5984	757	12.7	2257	37.7	1487	24.9
¶ Arterburn (2005)[12]	4197	416	9.9	1535	36.6	960	22.9
¶ Finkelstein (2003)[13]	3324	482	14.5	1429	43.0	942	28.3
Finkelstein (2005)[14]	2230	398	17.9	1180	52.9	799	35.8
¶ Finkelstein (2009)[15]	3443	--	--	1429	41.5	--	--
Heithoff (1997)[16]	4650	340	7.3	1183	25.5	775	16.7
Sturm (2002)[17]	2915	244	8.4	772	26.5	500	17.1
Sturm (2004)[18]	14584	1754	12.0	5506	37.8	3547	24.3
Thorpe (2005)[19]	3335	328	9.8	1877	56.3	1081	32.4
¶ Wang G (2002)[20]	3889	−99	−2.5	2499	64.3	1166	30.0
Wolf (2008)[21]	2396	3301	138	3836	160	3562	149
Cohort/Cross Sectional Studies (Less Representative)							
Anderson (2005)[22]	4265	1331	31.2	2298	54.0	1802	42.3
Bungum (2003)[23]	129	523	403	577	446	550	425
Burton (1998)[24]	1911	−391	−20.4	986	51.6	279	14.6
Cornier (2002)[25]	5128	−389	−7.6	483	9.4	35	0.7
Daviglus (2004)[26]	7191	1031	14.3	3251	45.2	2086	29.0
Durden (2008)[27]	3528	−53	−1.5	1422	40.3	811	23.0
Long (2006)[28]	--	--	--	92	--	--	--
Quesenberry (1998)[29]	5116	−128	−2.5	1619	31.6	721	14.1
Raebel (2004)[30]	1383	--	--	695	50.2	--	--
Thompson (2001)[31]	3202	320	10.0	1153	36.0	726	22.7

Author	Cost, Normal Weight	Incremental Cost, Overweight	% of Cost, Normal Weight	Incremental Cost, Obesity	% of Cost, Normal Weight	Incremental Cost, Overweight and Obesity	% of Cost, Normal Weight
Tucker, L (2002)[32]	3540	--	--	--	--	1281	36.2
Wang, F (2004)[33]	2983	426	14.2	1157	38.5	782	26.0
Wang, F (2005)[34]	16007	432	2.7	1072	6.7	743	4.6
Attributable Risk Studies							
Oster (2000)[35]	--	--	--	--	--	1195	--
Thompson (1998)[36]	--	143	--	411	--	273	
Wolf (1996)[37]	197	434	221	894	454	658	334
Wolf (1998)[38]	--	--	--	2207	--	--	--
Modeling Studies							
Allison (1999)[39]	--	--	--	1653	--	--	--
Gorsky (1996)[40]	--	469	--	1152	--	836	--
Lakdawalla (2005)[41]	5727	--	--	733	12.8	--	--
Thompson (1999)[42]	19886	−169	−0.9	3124	15.7	1433	7.2
Tucker, D (2006)[43]	2075	530	25.5	1380	66.5	941	45.3

¶High-quality study

Table 4

Incremental Cost Associated with Overweight and Obesity Stratified by Study Characteristics*

Study Characteristic	Overweight	Obesity	Overweight &Obesity
Study Design			
Nationally Representative Sample	792 (n = 10)	2137 (n = 11)	1482 (n = 10)
Less Representative Sample	310 (n = 10)	1249 (n = 12)	902 (n = 11)
Attributable Risk	288 (n = 2)	1171 (n = 3)	709 (n = 3)
Modeling	180 (n = 2)	1722 (n = 4)	1187 (n = 2)
Body Mass Index (BMI) cutoff			
Standard	612 (n = 19)	1879 (n = 21)	1294 (n = 19)
Nonstandard	65 (n = 5)	1049 (n = 9)	666 (n = 7)
Cost Reporting Method			
Costs	1060 (n = 5)	2016 (n = 9)	1881 (n = 5)
Charges**	423 (n = 6)	1444 (n = 6)	916 (n = 6)
Expenditures	311 (n = 9)	1656 (n = 10)	1013 (n = 10)
Mixed	330 (n = 4)	1103 (n = 5)	843 (n = 5)
Health Care Costs			
Obesity-related costs only	407 (n = 4)	1031 (n = 7)	723 (n = 5)
All health care costs	516 (n = 20)	1812 (n = 23)	1220 (n = 21)
Gender			
Men	403 (n = 8)	1453 (n = 10)	991 (n = 9)
Women	690 (n = 9)	2207 (n = 11)	1679 (n = 10)
Age Groups‡			
Adults	119 (n = 6)	1321 (n = 11)	811 (n = 7)
Employed	255 (n = 11)	1085 (n = 12)	742 (n = 12)
Limited	1205 (n = 7)	3049 (n = 7)	2094 (n = 7)
Characteristics of Participants			
Adjusted†	532 (n = 15)	1817 (n = 18)	1235 (n = 16)
Unadjusted†	441 (n = 9)	1409 (n = 11)	948 (n = 10)

*All estimates are in 2008 USD.

**Charges were adjusted to costs using a single cost-to-charge ratio, as described in the text.

‡"Adults" refers to all adults, "Employed" refers to younger adult populations (approximately ages 18–65), and "Limited" refers to age-restricted samples, usually consisting of near-elderly or elderly adults.

†Includes two studies that report both unadjusted and adjusted cost estimates.