Current Estimates of the Economic Cost of Obesity in the United States

Anne M. Wolf, Graham A. Colditz†*

Abstract

WOLF, ANNE M., GRAHAM A. COLDITZ. Current estimates of the economic cost of obesity in the United States. *Obes Res.* 1998;6:97–106

This study was undertaken to update and revise the estimate of the economic impact of obesity in the United States. A prevalence-based approach to the cost of illness was used to estimate the economic costs in 1995 dollars attributable to obesity for type 2 diabetes mellitus, coronary heart disease (CHD), hypertension, gallbladder disease, breast, endometrial and colon cancer, and osteoarthritis. Additionally and independently, excess physician visits, work-lost days, restricted activity, and bed-days attributable to obesity were analyzed cross-sectionally using the 1988 and 1994 National Health Interview Survey (NHIS). Direct (personal health care, hospital care, physician services, allied health services, and medications) and indirect costs (lost output as a result of a reduction or cessation of productivity due to morbidity or mortality) are from published reports and inflated to 1995 dollars using the medical component of the consumer price index (CPI) for direct cost and the all-items CPI for indirect cost. Population-attributable risk percents (PAR%) are estimated from large prospective studies. Excess work-lost days, restricted activity, bed-days, and physician visits are estimated from 88,262 U.S. citizens who participated in the 1988 NHIS and 80,261 who participated in the 1994 NHIS. Sample weights have been incorporated into the NHIS analyses, making these data generalizable to the U.S. population. The total cost attributable to obesity amounted to $99.2 billion dollars in 1995. Approximately $51.64 billion of those dollars were direct medical costs. Using the 1994 NHIS data, cost of lost productivity attributed to obesity (BMI≥30) was $3.9 billion and reflected 39.2 million days of lost work. In addition, 239 million restricted-activity days, 89.5 million bed-days, and 62.6 million physician visits were attributable to obesity in 1994. Compared with 1988 NHIS data, in 1994 the number of restricted-activity days (36%), bed-days (28%), and work-lost days (50%) increased substantially. The number of physician visits attributed to obesity increased 88% from 1988 to 1994. The economic and personal health costs of overweight and obesity are enormous and compromise the health of the United States. The direct costs associated with obesity represent 5.7% of our National Health Expenditure in the United States.

Key words: obesity, economics

Introduction

Obesity is a well-established risk factor for coronary heart disease (CHD), type 2 diabetes, breast, endometrial and colon cancer, and certain musculo-skeletal disorders such as knee osteoarthritis and low back pain. Obesity also exacerbates many chronic conditions (e.g., hypertension, dyslipidemia) (4,17,34,43,52). Weight loss has been associated with improvement in risk factors associated with CHD (i.e., blood pressure, serum cholesterol, triglycerides) (6), hypertension (24,36), insulin sensitivity, and other risk factors associated with diabetes mellitus (hepatic glucose production, insulin secretion (22,32). More than one third of U.S. adults are overweight and the prevalence of overweight has increased during the past two decades (25). The prevalence and absolute number of persons who are overweight and obese in the United States ranks among the highest in the world (46).

The Netherlands, Australia, France, and the United States have estimated the economic impact of obesity. Seidell and Deerenberg (46) reported that the overweight (body moss index [BMI] 25–29.9 kg/m^2) and obese (BMI>30 kg/m^2) Dutch population consult their physician 20% and 40% more, respectively, than the average-weight Dutch population. In addition, obese men and women were

Submitted for publication December 30, 1996.
Accepted for publication November 19, 1997.
*Director of Nutrition, The Women's Place, University of Virginia Health Systems, Charlottesville, VA; †Associate Professor of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA.
Reprint requests to Anne Wolf, MS, RD, 626 Flordon Drive, Charlottesville, VA 22901.

5 times more likely to use diuretics and 2.5 times more likely to take drugs prescribed for cardiovascular and circulation disorders. Overall, they estimated that the health care costs associated with overweight and obesity corresponded to approximately 4% of the Netherlands total health care costs (46). In Australia, Segal et al. (45) estimated the cost attributable to obesity (BMI>30 kg/m^2) between 1989 and 1990. The direct cost of obesity (associated with type 2 diabetes, CHD, gallstones, colon and postmenopausal breast cancer, and weight-control efforts) amounted to $394.7 million (Australian) dollars and was approximately 2% of Australia's total health care costs (45). More recently, Levy et al. (30) reported the direct and indirect costs associated with obesity in France. The direct cost of obesity at a BMI>27 kg/m^2 was $12 billion French francs (FF) and for BMI≥30 kg/m^3, FF $5.8 billion. The direct cost of obesity (BMI>27 kg/m^2) in France corresponded to about 2% of their health care costs (30).

In the United States, Gorsky et al. (20), using an incidence-based model, estimated the direct care costs of a hypothetical cohort of 10,000 women aged 40 years who were followed up for 25 years. Compared with the reference group (BMI<25 kg/m^2), the health care cost of the moderately overweight group (BMI 25–28.9 kg/m^2) was an additional $22 million, whereas the cost for the severely overweight group (BMI≥29 kg/m^2) was $53 million. The authors, extrapolating the costs to the U.S. population, estimated that the 25-year cost of obesity for women in the 40 to 64 year age range was approximately $16.1 billion or $4,132 per individual for a woman with a BMI≥25 kg/m^2. We have previously reported the direct and indirect cost of obesity in 1986 (12) and 1990 (56) dollars for type 2 diabetes, cardiovascular disease, gallbladder disease, postmenopausal breast cancer, and colon cancer. We also have reported the cost associated with weight gain and obesity using different definitions of overweight (BMI 25–28.9 kg/m^2 and ≥29 kg/m^2) (57). The aim of this study is to update the estimates to 1995 dollars (using more recently published estimates of the costs of several diseases) and to provide additional data and estimates regarding endometrial cancer and osteoarthritis. Further, we have estimated the impact that BMI has on health-related variables (e.g., lost productivity, restricted activity) from the 1988 and 1994 National Health Interview Survey.

Methods

The primary analysis focuses on the annual economic impact of obesity, using a prevalence-based approach, and estimates the proportion of a disease that was attributable to obesity in 1995. Secondary data sources were used for cost estimates. Economic costs represent the overall economic burden that disease place on a nation, so this analysis takes a societal perspective. Other perspectives that could have been taken, but were not, include a health systems perspective or a patient perspective. Each perspective would yield a different cost estimate because they would include different components of care or patient populations. The burden of disease is categorized into two components: *direct* medical costs, and *indirect* morbidity and mortality costs. Direct costs are the costs of preventive, diagnosis, and treatment services related to the disease (e.g., hospital and nursing home care, physician visits, medications). The current estimate does not include the cost of weight loss programs or the cost people spend on over-the-counter weight loss aids. Nor does the cost estimate include nonmedical expenses incurred due to transportation, food, and lodging when visiting the physician or hospital, or to caregiver time. Indirect costs are the value of lost output because of cessation or reduction of productivity caused by morbidity and mortality. Morbidity costs are wages lost by people who are unable to work because of illness and disability. Mortality costs are the value of future earnings (translated into the current monetary value) lost by people who die prematurely.

To estimate the proportion of disease in a population that could have been prevented by eliminating obesity, we calculated the population-attributable risk percent (PAR%, also referred to as the attributable case percent) which was the maximum proportion of disease (e.g., type 2 diabetes, CHD) in the population that was attributable to a specific exposure (e.g., obesity). The PAR% was based on the incidence of disease in the exposed (i.e., obese) as compared with the nonexposed group (i.e., nonobese) using a method that controls for potential confounding factors (e.g., age, smoking, dietary intake, physical activity). Obesity was defined as a BMI≥29 kg/m^2. The PAR% was calculated using P(RR−1)/1+P(RR−1), where P was the prevalence of obesity in the study population and RR was the relative risk for contracting the disease comparing the obese with the lean subjects. The PAR% was estimated using data primarily from two large epidemiological studies (Nurses' Health Study and the Health Professionals Follow Up Study) to ensure consistency in study methodology and definitions of obesity.

Direct and indirect costs are presented for each disease state, and disease-specific assumptions are presented below. For direct and indirect costs, we assumed a similar proportion attributable to obesity. Dollar equivalency has been inflated to 1995 dollars using the medical component of the consumer price index (CPI) for direct costs and the all items CPI for indirect costs (9).

National Health Interview Survey

An independent analysis was completed using the 1988 NHIS (37) and 1994 NHIS (38). Physician visits, work lost, restricted activity, and bed-days (other surrogates of morbidity) were estimated by calculating the number of excess days (e.g., bed-days) among overweight (BMI≥25 kg/m^2 or the NCHS definition of BMI≥27.3 kg/m^2 for women and

Table 1. Relative risk and proportions of diseases attributable to obesity (PAR%) as used by Wolf,* Levy et al. (30), Segal et al. (45), and the American Health Foundation (1)

		PAR%			
Disease	Relative risk	Wolf et al.	Levy et al.	Segal et al.	American Health Foundation
Type 2 diabetes	27.6	61%	24.1%	66%	38.5%
CHD	3.5	17.3%	13.9%	22%	25%
Hypertension	3.9	17%	24.1%	29%	25%
Gallbladder disease	3.2	30%	14.3%	52%	–
Breast cancer	1.3	11%	3.2%	6%	9–21%
Endometrial cancer	2.0	34%	4.7%	4%	–
Colon cancer	1.48	11.3%	9.1%	–	34–56%
Osteoarthritis	2.07	24%	11.8%	–	21–33%

*Estimates used within this paper. Obese is defined as BMI≥29 kg/m^2. Lean is defined as a BMI<20kg/m^2 for gallbladder disease, <21 kg/m^2 for CHD, <22 kg/m^2 for NIDDM and colon cancer, and <23 kg/m^2 for hypertension.

27.8 kg/m^2 for men) and obese (BMI≥30 kg/m^2) compared with nonoverweight people (BMI<25 kg/m^2). All variables were stratified by gender and 10-year age ranges. The excess number of days or visits attributable to body weight (above the referent group) was multiplied by the number of overweight or obese individuals that sample represented in the population. Work days lost were multiplied by gender- and age-specific median daily wages for 1995 (10). For bed-days, restricted activity, and physician visits, data for persons between the ages of 17 and 84 years were included, for work days lost, data were included for persons between the ages of 17 and 64 years.

Results

Type 2 Diabetes

The incidence of type 2 diabetes increased with increasing BMI (13,14). In 1992, the American Diabetes Association (ADA) estimated the direct and indirect cost of diabetes in America (44). Inflating these estimates to 1995 dollars, the direct cost of diabetes mellitus in 1995 was approximately $53.2 billion and the indirect cost was approximately $50.4 billion.

In a recent report, 63.5% of the cases of type 2 diabetes were diagnosed among women with BMI≥29 kg/m2 (44). Among these cases, 96.4% of type 2 diabetes was attributable to obesity (44). Thus, 61% (0.635×0.964) of the costs of type 2 diabetes was attributable to obesity (Table 1). Therefore, the direct and indirect costs of type 2 diabetes attributable to obesity were $32.4 billion and $30.74 billion, respectively, in 1995 (Table 2).

Coronary Heart Disease

The association between adiposity and lipid abnormalities is well established (58). Although controversial, there is substantial agreement that obesity increases the risk of CHD (5,35,40). The cost of CHD has been updated recently since the initial estimate in 1980. Hodgeson estimated that the direct cost of CHD in 1995 was approximately $40.4 billion (Hodgeson T, NCHS unpublished data, personal communication, May 1997).

We estimated that 24% of CHD was diagnosed among women with BMI≥29 kg/m^2, and that among the obese, 72% of CHD was attributable to obesity (54). Thus, 17% (0.24×0.72) (Table 1) of the $40.4 billion direct cost of CHD was attributable to obesity; this amounted to $6.99 billion dollars in 1995 (Table 2). No updated indirect cost estimate exists for CHD. The estimate for CHD is independent of stroke.

Hypertension

Obesity is a recognized risk factor for hypertension. In the United States and Europe, an increase in BMI is associated with increased blood pressure (2,24). Obese persons have an approximately five to six times greater risk of developing hypertension than lean people (47). The direct cost of hypertension was estimated to be approximately $18.9 billion in 1995 (Hodgeson T, NCHS unpublished data, personal communication, May 1997). Current estimates of the indirect costs associated with hypertension are unavailable.

Twenty-three percent of the cases of hypertension were diagnosed among women with BMI≥29 kg/m^2. Among these cases, 74% of hypertension was attributable to obesity (55). Thus, 17% (0.23×0.74) of the costs of hypertension was attributable to obesity (Table 1). Given that 17% of hypertension was caused by obesity, the direct health care cost attributable to obesity was $3.23 billion in 1995 (Table 2).

Table 2. Annual direct and indirect costs attributable to obesity in the United States (1995 dollars)

	Direct cost (billions)	Indirect cost (billions)
Type 2 diabetes	$32.4	$30.74
Coronary heart disease	$6.99	$–
Hypertension	$3.23	$–
Gallbladder disease	$2.59	$.151
Breast cancer	$.840	$1.48
Endometrial cancer	$.286	$.504
Colon cancer	$1.01	$1.78
Osteoarthritis	$4.3	$12.9
Total	$51.64	$47.56

Economic Costs of Gallbladder Disease

The incidence of clinically symptomatic gallstones rose continuously with increasing BMI (48). Approximately 33% of cholecystectomies in the Nurses' Health Study population were performed on women whose BMI≥29 kg/m^2 (Stampfer M, personal communication, 1991). An estimated 90% of these cases were attributable to obesity (48), hence, approximately 30% of the costs of gallbladder disease were attributable to obesity. The relative risk and PAR% are presented in Table 1.

The direct and indirect costs of gallbladder disease were calculated in 1985 (39). Inflating to 1995 dollars, the estimated cost of gallbladder disease in the United States was approximately $8.6 billion in direct costs and $504.4 million in indirect costs. Thus, the direct and indirect costs of gallbladder disease attributable to obesity in 1995 dollars were approximately $2.59 billion and $151.3 million, respectively (Table 2).

Cancer

Prospective data from a 12-year follow-up of 750,000 U.S. men and women who were free from cancer at baseline indicated that mortality from total cancer increased monotonically with increasing weight among women and that among men of desirable weight, the risk of mortality increased with body weight (31). Mortality ratios were elevated for colon and prostate cancer among obese men and for breast, endometrial, cervical, ovarian, and gallbladder cancer among obese women (31). Site-specific direct health care costs of cancer were obtained from Brown and Fintor (8) and were adjusted to 1995 dollars using the medical care component of the CPI (9). Site-specific indirect costs were not available. In 1990, the estimated indirect cost of cancer was approximately $68.68 billion per year (7). Adjusting the indirect cost to 1995 dollars and assuming no increase in the diagnosis of cancer from 1990 to 1995, the indirect cost of cancer was approximately $80.07 billion. We estimated the indirect site-specific cost of cancer by taking the proportion of direct costs of cancer from a given site and applying that proportion to the updated indirect cost for cancer. For instance, breast cancer accounted for 20% of direct care costs of all cancers. We therefore assumed that breast cancer accounted for approximately 20% of indirect costs of all cancers as well. We present cost estimates for breast, endometrial, and colon cancer only.

Breast Cancer. Obesity was related to increased risk of breast cancer among postmenopausal women (3,50). Breast cancer accounted for 32% of all new cancer diagnoses in women (11). In 1990 the direct cost of breast cancer was estimated to be $6.9 billion or 20% of all cancer cost for that year (7). Inflating this amount to 1995 dollars, the direct cost of breast cancer was approximately $9.09 billion. If 84% of all breast cancer was post-menopausal, then the cost of post-menopausal breast cancer was $7.6 billion in 1995. If we assume the same percentage of cancer's indirect cost from breast cancer as the direct cost (20%), then the indirect cost of breast cancer in 1990 was $16.01 billion and the inflated indirect cost of post-menopausal breast cancer was $13.45 billion in 1995. Among post-menopausal women we estimated that 48% of breast cancers were diagnosed among obese women and that 23% of these breast cancers were attributable to obesity given a relative risk of 1.3 (3). Thus, 11% (0.23x0.48) of breast cancer among post-menopausal women was attributable to obesity. Therefore, the direct cost of post-menopausal breast cancer attributable to obesity was approximately $840 million and the indirect cost was approximately $1.48 billion per year (1995 dollars).

Endometrial Cancer. Positive associations have been shown between BMI and the incidence of endometrial cancer (18,29,49). The increased risk of endometrial cancer comparing women who have BMIs between 28 and 30 kg/m^2 with lean women ranges who have BMIs between 2.0 and 3.5 (3). The direct cost of endometrial cancer in 1995 dollars was approximately $840.6 million, which represented 1.85% of all cancer costs. Assuming 1.85% of the indirect costs of cancer were from endometrial cancer, the indirect cost of endometrial cancer was $1.48 billion in 1995. Ballard-Barbash and Swanson (3) estimated that 34–56% of endometrial cancer is attributable to obesity. Using a conservative estimate that 34% of endometrial cancer was attributable to obesity, the cost of endometrial cancer attributable to obesity in 1995 was $286 million and the indirect cost amounted to $504 million (Table 2).

Colon Cancer. Obesity has been associated with increased risk of colon cancer in several large prospective epidemiologic studies with relative risks in the order of 1.1–1.6 (19,41,42). Inflating to 1995 dollars, direct cost of colorectal cancer was $8.91 billion (8). The direct cost of colorectal cancer accounted for 19.7% of all direct cancer

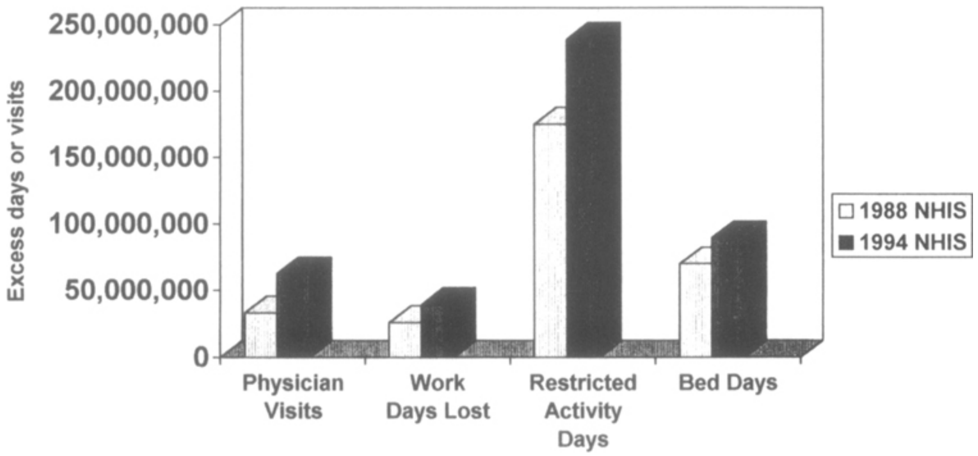

Figure 1: National Health Interview Survey, 1988 and 1994: Excess days or visits in the U.S. population with BMI≥30 kg/m^2.

costs. If we assume the same percentage for indirect cancer costs, the estimated indirect cost of cancer in 1995 was approximately $15.74 billion dollars. We estimated that 35% of colon cancer cases were diagnosed among the obese and that 32% of these were attributable to obesity (19). Therefore, 11% (0.35×0.32) of colon cancer costs were attributable to obesity. Thus, the cost of colon cancer attributable to obesity was approximately $1.01 billion in direct costs and $1.78 billion in indirect costs.

Musculoskeletal Disease

Obesity was a strong predictor for developing mobility disability (i.e., functional loss of ability to walk, carry groceries, run errands) in older women. Obese women had a 2-fold greater risk for becoming physically limited compared with lean women (27). Obesity was associated more strongly with osteoarthritis (OA), specifically knee osteoarthritis, than rheumatoid arthritis and was a greater risk factor for women than men (Felson DT. The epidemiology of knee osteoarthritis: Results from the Framingham Osteoarthritis Study. *Semin Arthritis Rheum.* 1990;20(Suppl 1):42–50.). Felson (Felson DT. Weight and osteoarthritis. *Am J Clin Nutr.* 1996;63:(Suppl):4305–4325.) estimated that 24% of osteoarthritis of the knee was attributable to obesity. Although back pain and mobility disability were associated with obesity (27), no prospective studies had been done to evaluate the risk of developing back pain once obese. Recently, Yelin and Callahan (59) estimated the direct and indirect cost of arthritis. Inflating to 1995 dollars, the direct cost amounted to $17.9 billion and the indirect cost was approximately $53.8 billion per year. Therefore, if we conservatively assume that 24% of the costs of arthritis were attributable to obesity, then the direct and indirect costs in 1995 were $4.3 and 14.01 billion, respectively (Table 2).

National Health Interview Survey

An independent analysis was completed to estimate the number of physician visits, restricted activity, bed-days, and lost productivity attributable to overweight and obesity by using the National Health Interview Study (NHIS) for 1988 and 1994. Although physician visits typically are incorporated into the direct health care cost and work-loss days are incorporated into the indirect morbidity costs, we estimated these numbers using the NHIS to provide further *independent* information about the "costs" of obesity (i.e., the numbers and costs are not incorporated in the costs presented in Table 2).

Physicians Visits

Independent from the estimates given in Table 2, we estimated the absolute number of excess physician office visits attributable to overweight and obesity or factors directly related to obesity using the NHIS. In 1988, an estimated 42.9 million physician office visits were associated with obesity (NCHS definition). In 1994, the estimate increased to 81.2 million visits (Table 3) representing a 88% increase in physician visits from 1988 to 1994. Estimates of physician visits using the WHO criteria for overweight (BMI≥25 kg/m^2) and obesity (BMI≥30 kg/m^2) using the 1988 NHIS criteria are presented elsewhere (57). Regardless of the definition of overweight and obesity, physician visits attributable to obesity were substantially greater in 1994 compared with 1988 (Figure 1). The increase apparently is caused by an increase in the number of obese persons, as well as in the average number of office visits per person. In 1994, 67% of office visits were made by obese (BMI≥30 kg/m^2) women.

Lost Productivity

Although direct costs are immediately relevant to the health care provider in today's health care environment, indirect costs have a substantial impact at the individual and societal level. Lost productivity is particularly important at the societal level. In 1988, a total of 52,591,480 work days were lost because of obesity (NCHS definition) (15) which amounted to approximately $4.9 billion in 1995. Using the

Table 3. Annual number of physician visits,* work-lost days, cost of loss productivity, restricted activity days, and bed-days attributable to body mass index (BMI) as specified

	BMI≥25 kg/m^2	BMI≥27 kg/m^2†	BMI≥30 kg/m^2
Physician visits	80,852,894	81,171,498	62,652,050
Work days lost‡	49,147,290	58,456,780	39,256,085
Cost loss productivity‡ ($ 1995)	$2.77 billion	$5.66 billion	$3.93 billion
Restricted activity days	181,540,000	262,980,000	239,010,000
Bed-days	57,042,177	91,852,767	89,508,700

Based on the 1994 National Health Interview Study.
*Analyses have been controlled for age, gender, and working status (in lost productivity).
†BMI≥27 more specifically is 27.3 kg/m^2 for women and 27.8 kg/m^2 for men.
‡Work days lost and cost of loss productivity include only ages 17–64 years. Other variables include ages 17–84 years.

same definition of obesity in 1994, there was a total of 58,456,780 work-lost days, amounting to approximately $5.7 billion in 1995 (Table 3). Regardless of the definition of obesity, there were more days of work lost in 1994 than in 1988 (Figure 2). Although 70% of work-lost days were contributed from obese women, obese men contributed 36% of the cost of lost productivity because of their higher wages, on average. Comparing across different definitions of obesity, a greater amount of lost productivity occurred at a BMI≥27 kg/m^2 versus BMI≥25 kg/m^2 because there was greater lost productivity in men among the referent group (BMI<25 kg/m^2) than in the moderately overweight group (BMI 25–29.9 kg/m^2). This was especially evident among the older age groups. This analysis could not control for preclinical disease or smoking.

Restricted Activity and Bed-days

We further evaluated two functional measures of health which primarily affect the individual restricted activity and bed-days (Table 3). At almost every age strata and definition of increased body weight, obesity had a more negative impact on the activity level of women than of men. Obese (BMI≥30 kg/m^2) women accounted for 89% of total restricted activity days and 98% of total bed-days in 1994. Among men, restricted activity only began occurring at a BMI≥27 kg/m^2; for bed-days, days only began occurring at a BMI≥30 kg/m^2. BMI appeared protective for restricted activity and bed-days among men, especially in the older age groups (≥65 years). These analyses, however, may be confounded by smoking status and preexisting disease. Overall in 1988, 229.5 billion restricted activity days and 87.04 billion bed-days were attributable to a BMI≥27 kg/m^2. In 1994, the amount of restricted activity and bed-days were greater (Table 3). From 1988 to 1994, a 36% increase occurred in the number of restricted activity days and a 28% increase in number of bed-days (Figure 2). The number of excess restricted activity and bed-days in 1994 by various definitions of overweight and obesity are presented in Table 3.

Discussion

The economic impact of obesity on the United States was approximately $99.2 billion in 1995. The direct medical costs of disease attributable to obesity were approximately $51.6 billion whereas the indirect costs (excluding CHD and hypertension) amounted to $47.56 billion (Figure 2). The direct costs associated with obesity represent 5.7% of the U.S. Health Expenditure in 1995. Approximately 63% of the direct costs associated with obesity are from type 2 diabetes, 14% from coronary heart disease, 8% from osteoarthritis, 5% from gallbladder disease, 6% from hypertension, and 4% from all cancers (Figure 2).

The direct economic impact of obesity was similar to the impact of diabetes, was approximately 1.25 times greater than the direct cost of coronary heart disease and was 2.7 times greater than the direct cost of hypertension. The indirect economic impact of obesity was similar to the impact of cigarette smoking. In 1990, the lost productivity of persons disabled by disease attributable to cigarette smoking and foregone earnings of those dying prematurely totaled $47 billion (33). In sum, these data indicate that excess body weight or adiposity had a substantial annual burden on the health care system as measured by the economic impact of a range of obesity-related diseases as well as excess physician visits, loss productivity, and restriction in activity level using the NHIS data. These costs largely reflect the impact of weight gain in adult life. These costs therefore could be avoided if the population maintained a healthy weight. This is now a priority recommendation for the U.S. Department of Health and Human Services contained in the dietary guidelines (51).

The economic impact of obesity as defined in this paper may underestimate the true cost of overweight and excess

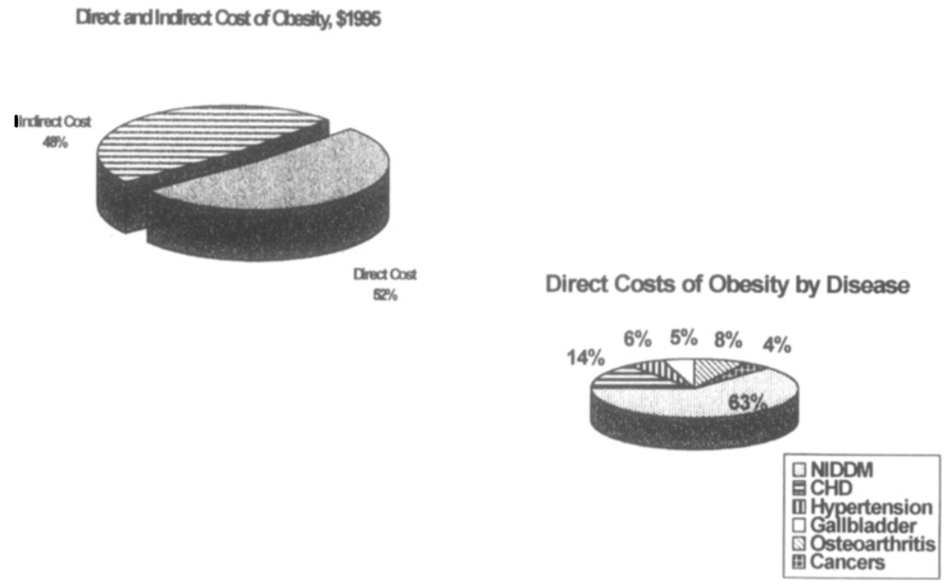

Figure 2: The economic cost of obesity, 1995 dollars.

adiposity. The current estimate of the cost of obesity defines obesity as a BMI≥29 kg/m^2. However, health risks are seen in most diseases associated with obesity at a BMI≥25 kg/m^2. The Dietary Guidelines Advisory Committee (51), the American Institute of Nutrition (26), and an expert panel convened by the American Health Foundation (1) independently recommended that the upper bound limit for BMI should be 25 kg/m^2 because of the increased health risks seen at a BMI≥25 kg/m^2. Therefore, had we used a BMI cutoff of 25 kg/m^2 rather than 29 kg/m^2 the economic toll of excess body weight would be much greater. The definition of obesity which may underestimate the cost of obesity may be offset partially by possible double-counting of costs. Our model assumes that coronary heart disease, hypertension, and diabetes occur independently. However, we know that there is some interdependence among these disease states, especially in the obese patient. Thus, calculating the cost of obesity as it related to these diseases independently would inflate the cost estimate. However, to offset this source of error there clearly may be other additional conditions that are related to obesity but are not included in this analysis.

Within the NHIS analysis, we report a substantial increase in the number of physician visits and to a lesser degree, the number of restricted activity, bed-days, and work-lost days during from 1988 to 1994. This increase partly reflects the increase in the prevalence of obesity in the United States (25), particularly with respect to restricted activity and bed-days. The average number of restricted activity and bed-days per obese person actually declined during this period (restricted activity: 1988, 5.3 days per year; 1994, 5.0 days per year; bed-days; 1988, 2.02 days per year; 1994, 1.76 days per year). The increase in the number of physician visits and work days lost from 1988 to 1994 was caused by the increase in the prevalence of obesity and an increase in the utilization of physician services and lost productivity among the obese (physician visits: 1988 1.0 visit per year, 1994 1.6 visit per year; work-lost days; 1988 1.48 days per year, 1994 1.83 days per year). The increase in physician visits and work lost attributable to obesity probably reflects increased early comorbidity. That is, comorbidities that are associated with the early stages of obesity and weight gain such as type 2 diabetes and hypertension. Restricted activity and bed-days, on the other hand, may not have increased as much because they would be associated with comorbidities in which obesity has been present for a longer duration, such as osteoarthritis. If this was the case then we would expect to see an increase in restricted activity and disability associated with obesity in the future.

A limitation of this cost estimate is that it used secondary data sources to estimate the cost of obesity. Therefore, the amount in Table 2 is only an estimate using the most appropriate cost estimates and attributable risks available. However, we are still uncertain about the actual amount of health utilization associated with overweight and obesity. Height and weight are not included in many of the primary data sources (Hospital Discharge Survey, the National Medical Expenditure Survey, and the National Ambulatory Care Survey) from which we estimate health utilization and costs associated with disease. A primary data analysis of the NHANES III would provide a more accurate estimate of the health utilization associated with obesity, but we would not be able to distinguish cost by all of the diseases listed in the current estimate. Analysis of the NHIS, would provide insight in the amount of physician and hospital utilization associated with obesity, but there is limited information on utilization of allied health professionals, laboratory, or medication usage.

Estimates of the prevalence and proportion of disease attributable to obesity were inferred primarily from two large prospective studies (Nurses' Health Study and the Health Professional Follow-up Study). This may lead to some imprecision in our estimates. However, the distribution of body weight for height in these cohorts is similar to the U.S. population. Second, some may argue that the PAR% from these studies (primarily health professionals) were not generalizable to the population or that the different referent groups among the studies would affect the PAR%. We report PAR% used in similar prevalence-based economic analyses evaluating the economic implications of obesity (Table 1). The estimates of Levy et al. (30) were based on epidemiologic studies primarily from France. The lower PAR% values may reflect the lower prevalence of obesity among the French than among the Americans.

We used a prevalence-based approach to estimate the cost of disease. A prevalence-based approach provides important information on the expenditures associated with disease for a given period, usually one year. Almost all cost-of-illness studies have adopted the prevalence-based annual cost approach in deriving their estimates. Estimates generated by this approach, however, have a limited value in the context of cost-benefit and cost-effectiveness analyses in which it is necessary to have information regarding the natural history of disease, such as found in an incidence-based approach. Gorsky et al. (20) used an incidence-based approach to estimate the cost of obesity in women. Because methodological differences, it is difficult to compare the findings of Gorsky et al. with those presented here. Gorsky reported that most costs came from coronary heart disease, hypertension, and diabetes. This finding is similar to ours where most were from diabetes, coronary heart disease, and osteoarthritis. It is possible that the cost of osteoarthritis exceeded the cost of hypertension in our analysis because we used an updated cost for osteoarthritis, but it is difficult to compare the assumptions and costs of these two studies.

A further limitation is that we did not include all obesity-related medical conditions such as sleep apnea, gout, low-back pain, or infertility because we could not account for the cost and/or incidence of these disorders in the obese population. With respect to cancer, we did not consider several cancers that have a lower incidence than post-menopausal breast cancer (i.e., ovary) but which do have a consistent relation with obesity. Regarding colon cancer, we have only addressed obesity as a risk factor in men because it appears to be a stronger risk among men than women. In addition, the cost estimate for gallbladder disease may be underestimated since the cost estimate is from 1985 and gallbladder disease management has changed dramatically within this 10-year period. Nor have we included the cost to the patient for weight loss programs or over-the-counter medications. It has been estimated that Americans spend $33 billion per year on weight loss products and services (16). Alternatively, we have not included the beneficial economic effect that obesity may have on pre-menopausal breast cancer (3) or osteoporosis (53).

A limitation and cause for underestimation in the NHIS analysis of lost productivity may have occurred because we did not account for the working population older than 65 years of age. Among older populations excess body weight may appear beneficial if preclinical disease is present. Disease, leading to weight loss, will make the leaner categories enriched with unhealthy people with higher subsequent mortality. In addition, the NHIS analysis of restricted activity, bed-days, physician visits, and work-lost days may be confounded by smoking status and pre-existing illness, leading to an underestimation of the true magnitude of the burden caused by obesity. In all the variables mentioned, an increased amount of disability occurred in the referent group, especially in the older age groups. As noted previously (23,57), if we look at the amount of disability or loss productivity across a range of BMI, there is a mild J-shaped curve. Once the data are stratified by age and gender, the J-shape becomes more accentuated (U-shaped) in men and in the older population. The greater amount of disability in the older, leaner population suggests that preclinical disease was a major confounding factor. Additional indirect costs not included in these estimates are the impact of obesity on self-esteem, as well as social and personal economic achievement (21). Although these "costs" are not societal or included in the traditional cost-of-illness model, they have a tangible impact on the lives of individuals.

In conclusion, obesity represents a major avoidable contribution to the costs of illness in the United States. Programs aimed at avoiding weight gain in middle and later life as well as preventing obesity in childhood are important approaches to containing the rapidly rising health care costs in the United States and improving the quality of life.

Acknowledgment

Dr. Colditz is sponsored by DK 46,200.

References

1. **American Health Foundation Roundtable on Healthy Weight.** Proceedings of an expert panel discussion held in New York, NY (Meisler J, St. Jeor S, Shapiro A, Wynder EI, eds.) *Am J Clin Nutr.* 1996;63(suppl):4095–4775.
2. **Ascherio A, Rimm EB, Giovannucci EL, et al.** A prospective study of nutritional factors and hypertension among men. *Circulation.* 1992;86:1475–1484.
3. **Ballard-Barbash R, Swanson CA.** Body weight: Estimation of risk for breast and endometrial cancers. *Am J Clin Nutr.* 1996;63(suppl):437S–441S.
4. **Beirman EI, Hirsch J.** Obesity. In: Williams RH, ed. *Text-*

book of Endocrinology. Philadelphia, PA: WB Saunders Co; 906–921.

5. **Boe J, Humerfelt S, Wedervang G.** The blood pressure in a population: Blood pressure readings and height and weight determinations in the adult population of the City of Bergin. *Acta Med Scand.* 1957;157:1–336.
6. **Borkon GA, Sparrow D, Wisniewski C, Volkonas PS.** Body weight and coronary disease risk: Patterns of risk factor change associated with long-term weight change. The Normative Aging Study. *Am J Epidemiol.* 1986;124(3):410–419.
7. **Brown ML.** The national economic burden of cancer: An update. *Natl Cancer Inst* 1990;82:1811–1814.
8. **Brown ML, Fintor L.** In: Greenwald P, et al., eds. *Cancer Prevention and Control,* New York: Marcel Dekker; 1995: 69–81.
9. **Bureau of Labor Statistics.** Consumer Price Index. Washington DC: U.S. Department of Labor: 1995.
10. **Bureau of the Census.** Current population survey, 1995 annual median income (Table A-1).
11. **CA.** Cancer Statistics 1995. *Cancer J Clin.* 1995;45:8–30.
12. **Colditz GA.** The economic costs of obesity. *Am J Clin Nutr.* 1992;55:503S–507S.
13. **Colditz GA, Willett WC, Rotnitzky A, Manson JE.** Weight gain as a risk factor for clinical diabetes in women. *Ann Intern Med.* 1995;122:481–486.
14. **Colditz GA, Willett WC, Stampfer MJ, et al.** Weight as a risk factor for clinical diabetes in women. *Am J Epidemiol.* 1990;132:501–513.
15. **Colditz GA, Wolf AM.** The public health impact of obesity. In: Angel A et al., eds. *Progress in Obesity Research.* 7th Int Congress on Obesity. John Libbey & Co.; 1996:517–523.
16. *Costs of weight loss aids.* U.S. Congress, House, 1990. Deception and fraud in the Diet Industry, Part I, pp. 101–150 in hearing before subcommittee on Regulation, Business Opportunity and Energy. Committee on Small Business. 101st Congress, 2nd Session. Washington, DC: GPO.
17. **David MA, Walter H, Neuhaus JM.** Obesity and osteoarthritis of the knee: Evidence from the National Health Examination (NHANES 1). *Semin Arthritis Rheum.* 1990;20(3 Suppl 1):34–41.
18. **Folsom AR, Kaye SA, Potter JD, Prineas RJ.** Association of incident carcinoma of the endometrium with body weight and fat distribution in older women: Early findings of the Iowa Women's Study. *Cancer Res.* 1989;49:6828–6831.
19. **Giovannucci E, Ascherio A, Rimm EB, Colditz GA, Stampfer MJ, Willett WC.** Physical activity, obesity and risk of colon cancer and adenoma in men. *Ann Intern Med.* 1995; 122:327–334.
20. **Gorsky RD, Pamuk E, Williamson DF, Shaffer PA, Koplan JP.** The 25-year health care costs of women who remain overweight after 40 years of age. *Am J Prev Med.* 1996;12: 388–394.
21. **Gortmaker S, Must A, Perrin J, Sobol A, Dietz W.** Social and economic consequences of overweight in adolescence and young adulthood. *N Engl J Med.* 1993;329:1008–1112.
22. **Henry RR, Wallace P, Olefsky JM.** Effects of weight loss on mechanisms of hyperglycemia in obese non-insulin dependent diabetes mellitus. *Diabetes.* 1986;35:990–998.
23. **Hunter DJ, Willett WC.** Diet, body size, and breast cancer. *Epidemiol Rev.* 1993;15:110–132.
24. **Kannel WB, Brand N, Skinner JJ, Dawber TR, McNamara PM.** The relation of adiposity to blood pressure and the development of hypertension. The Framingham study. *Ann Intern Med.* 1967;67:48–59.
25. **Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL.** Increasing prevalence of overweight among U.S. adults. *JAMA.* 1994;205–211.
26. **Kuller LH, St. Jeor ST, Dwyer J, et al.** Report of the American Institute of Nutrition (AIN) Steering Committee on Healthy Weight. Bethesda, MD: American Institute of Nutrition; 1994.
27. **Launier LJ, Harris T, Rumpel C, Madans J.** Body mass index, weight change, and risk of mobility disability in middle-aged and older women: The epidemiologic follow-up study of NHANES I. *JAMA.* 1994;271:1093–1098.
28. **Laurier D, Guiguet M, Chau NP, et al.** Prevalence of obesity: A comparative survey in France, the United Kingdom and the United States. *Int J Obes.* 1992;16:565–573.
29. **La Vecchia C, Parassini F, Negri E, Gasoli M, Gentile A, Franceschi S.** Anthropometric indicators of endometrial cancer risk. *Eur J Cancer.* 1991;27:487–490.
30. **Levy E, Levy P, LePen C, Basdevant A.** The economic cost of obesity: The French situation. *Int J Obes.* 1995;19: 788–792.
31. **Lew FA, Garfinkel L.** Variations in mortality by weight among 750,000 men and women. *J Clin Epidemiol.* 1979;32: 563–576.
32. **Liu GC, Coulston AM, Lardinois CK, Hollenbeck CB, Moore JG, Reaven GM.** Moderate weight loss and sulfonylurea treatment of NIDDM. *Arch Intern Med.* 1985;145: 665–669.
33. **MacKenzie T, Bartecchi C, Schrier R.** The human cost of tobacco use. *N Engl J Med.* 1994;330:975–980.
34. **Mann GV.** The influence of obesity on health. *N Engl J Med.* 1974;291:178–185, 226–232.
35. **Manson JE, Colditz GA, Stampfer MJ, et al.** A prospective study of obesity and risk of coronary heart disease in women. *N Engl J Med.* 1990;322:882–889.
36. **McMahon SW, MacDonald GJ, Bernstein L, Andrews G, Blacket RB.** Comparison of weight reduction with metoprolol in treatment of hypertension in young overweight patients. *Lancet.* 1985:i:1233–1236.
37. **National Center for Health Statistics (1989).** Public use data file documentation. Part I: National Health Interview Survey, 1988 (Machine readable data file and documentation). National Center for Health Statistics, Hyattsville, MD (Producer). National Information Service, U.S. Department of Commerce, Springfield, VA 22161 (Distributor).
38. **National Center for Health Statistics (1995).** Public use data file documentation. Part I: National Health Interview Survey, 1994 (Machine readable data file and documentation). National Center for Health Statistics. Hyattsville, MD (Producer). National Information Service, U.S. Department of Commerce. Springfield, VA 22161 (Distributor).
39. **National Digestive Diseases Data Working Group.** Diges-

tive diseases in the U.S.: Epidemiology and impact. Everhart JE, ed. 1994. NIH Publication No. 94-1447;57–82.
40. **National Research Council-Committee on Diet and Health.** *Diet and Health: Implications for Reducing Chronic Disease Risk.* Washington, DC: National Academy Press; 1989.
41. **Nomura A, Helbrun LK, Stemmerman DN.** Body mass index as a predictor of cancer in men. *J Natl Cancer Inst* 1985;74:319–323.
42. **Phillips RL, Snowden DA.** Dietary relationships with fatal colorectal cancer among Seventh-Day Adventists. *J Natl Cancer Inst.* 1985;74:307–317.
43. **Pi-Sunyer FX.** Medical hazards of obesity. *Ann Intern Med.* 1993;119:655–660.
44. **Ray NF, Wills S, Thamer M, and Medical Technology and Practice Patterns Institute.** *Direct and Indirect Cost of Diabetes in the U.S. in 1992.* Alexandria, VA: American Diabetes Association; 1993.
45. **Segal L, Carter R, Zimmet P.** The cost of obesity: The Australian perspective. *PharmacoEconomics.* 1994;5(Suppl 1):45–52.
46. **Seidell JC, Deerenberg I.** Obesity in Europe: Prevalence and consequences for use of medical care. *PharmacoEconomics.* 1994;5:38–44.
47. **Stamler R, Stamler J, Riedlinger WF, Alegra G, Roberts RH.** Weight and blood pressure. *JAMA.* 1978;240:1607–1610.
48. **Stampfer MJ, Maclure KM, Colditz GA, Manson JE, Willett WC.** Risk of symptomatic gallstones in women with severe obesity. *Am J Clin Nutr.* 1992;55:652–658.
49. **Swanson CA, Postischman N, Wilbanks GD, et al.** Relation of endometrial cancer risk to past and contemporary body size and body fat distribution. *Cancer Epidemiol Biomarkers Prev.* 1993;2:321–327.
50. **Tretli S.** Height and weight in relation to breast cancer morbidity and mortality. A prospective study of 570,000 women in Norway. *Int J Cancer.* 1989;44:23–30.
51. **U.S. Department of Agriculture.** Report of the dietary guidelines advisory committee on the dietary guidelines for Americans, 1995. To the Secretary of Health and Human Services and the Secretary of Agriculture. Washington, DC: U.S. Department of Agriculture; 1995.
52. **Van Italie TB.** Obesity: Adverse effects on health and longevity. *Am J Clin Nutr.* 1979;32:2723–2733.
53. **Wardlaw GM.** Putting body weight and osteoporosis into perspective. *Am J Clin Nutr.* 1996;63(suppl):4335–4375.
54. **Willett WC, Manson JE, Stampfer MJ, et al.** Weight and weight change in relation to risk of coronary heart disease in women: A 14-year follow-up. *JAMA* 1995;273:461–465.
55. **Witteman JCM, Willett WC, Stampfer MJ, et al.** A prospective study of nutritional factors and hypertension among U.S. women. *Circulation.* 1989;80:1320–1327.
56. **Wolf AM, Colditz GA.** The cost of obesity: The US perspective. *PharmacoEconomics.* 1994;5:34–37.
57. **Wolf AM, Colditz GA.** Social and economic effects of body weight in the United States. *Am J Clin Nutr.* 1996;63(suppl): 466S–469S.
58. **Wood PD, Stefanick ML, Dreon DM, et al.** Changes in plasma lipids and lipoproteins in overweight men during weight loss through dieting as compared with exercise. *N Engl J Med.* 1988;319:1173–1179.
59. **Yelin E, Callahan LF.** The economic cost and social and psychological impact of musculoskeletal conditions. *Arthritis Rheum.* 1995;38:1351–1362.