# The Lifetime Medical Cost Burden of Overweight and Obesity: Implications for Obesity Prevention

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**This study quantifies age-specific and lifetime costs for overweight (BMI: 25–29.9), obese I (BMI: 30–34.9), and obese II/III (BMI: >35) adults separately by race/gender strata. We use these results to demonstrate why private sector firms are likely to underinvest in obesity prevention efforts. Not only does the existence of Medicare reduce the economic burden that obesity imposes on private payers, but, from the perspective of a 20-year-old obese adult, the short-term costs of obesity are small. This suggests that legislation that subsidizes wellness programs and/or mandates coverage for obesity treatments might make all firms better off. Ironically, Medicare has a greater incentive to prevent obesity because when an obese 65 year old enters the program, his/her costs are immediate and higher than costs for normal weight individuals.**

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## INTRODUCTION

The prevalence of obesity has increased dramatically over the past several decades, from 15% of the adult population in 1980 to ~32% in 2003–2004 (ref. 1). The rising prevalence of obesity and obesity-related diseases and treatment complications has exacerbated health-care cost inflation. Thorpe *et al.* estimate that increases in the proportion of and spending on obese people relative to people of normal weight account for >27% of the rise in inflation-adjusted per capita spending since 1987 (ref. 2). Current estimates reveal that total annual medical expenditures would be 9% lower in the absence of overweight and obesity (3).

Although overwhelming evidence exists that obesity increases annual medical expenditures, the effect of obesity on lifetime medical spending remains an open question. This ambiguity exists because, although obesity increases the likelihood of diseases and treatment that results in higher annual medical spending, for the same reasons it also results in a shorter life expectancy, especially for high BMI values (4–6). Depending on which effect is larger, the expenditure effect or the mortality effect, some levels of obesity may actually reduce lifetime medical spending.

Given that the high costs of obesity have been the driving motivation behind many obesity-prevention efforts, it is important to quantify the magnitude of these costs over the life cycle to determine whether they are indeed positive and, if so, to quantify the present value of these costs over the life cycle. This value represents an upper bound of the medical costs that could be saved through successful obesity-prevention efforts.

From a public policy perspective, another important question concerns the magnitude and percentage of total costs attributable to obesity that occur beyond 65 years of age, when most individuals become eligible for Medicare. It is likely that private sector firms (i.e., employers and insurers) will ignore these costs when thinking about how much to invest in obesity-prevention efforts. Moreover, it is possible that successful obesity-intervention efforts may improve health and decrease obesity-attributable costs while increasing costs to Medicare via longer survival and thus more time in the program.

A few papers have attempted to quantify lifetime costs of obesity (7–11). However, the published literature suffers from significant shortcomings. Early papers on the lifetime costs of obesity used an attributable fraction approach. This approach, employed by Allison *et al.* (7) and Thompson *et al.* (8), has been criticized for including a limited number of diseases and because it fails to account for confounding and effect modification fully (12). Tucker *et al.* (9) estimate lifetime costs via a semi-Markov model. The model relies on a series of assumptions that are difficult to verify with existing data, and for some BMI values, their results are markedly different from those reported in the other published studies.

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Lakdawalla *et al.* (10) and Daviglus *et al.* (11) focus on quantifying costs from Medicare's perspective. Although informative, neither of these studies quantify separate estimates by race. Moreover, Daviglus *et al.* quantify costs for only one category of obesity (BMI >30). There is evidence that both medical costs and mortality vary systematically by race and BMI class (6,9).

Our approach is an improvement over previous studies. We estimate the lifetime costs from various starting ages, including age 65 when individuals first become eligible for Medicare, using a common econometric approach combined with age, gender, race/ethnicity, and obesity-specific life tables generated from nationally representative samples. This approach avoids the shortcomings associated with the etiologic-fraction approach by allowing the model to estimate the annual increase in medical costs without having to identify a comprehensive list of obesity-attributable diseases. Unlike Tucker *et al.* (9), this approach also allows for uniquely quantifying these costs for each age and BMI class. Moreover, because obesity has been shown to affect longevity and medical costs differentially by race and gender, unlike Daviglus *et al.* (11) and Lakdawalla *et al.* (10), we estimate costs separately for race/gender strata and three classes of excess weight. Using two starting ages, discounting future costs, and identifying the percentage of lifetime costs that occur beyond age 65, we quantify lifetime costs from a societal perspective, a private employer or insurer's perspective, and from a Medicare perspective. These results will allow for a greater understanding of private and public sector motivations for engaging in obesity-prevention efforts. Finally, unlike previous studies, we also conduct sensitivity analyses to gauge the precision of our estimates.

## METHODS AND PROCEDURES

### Data

The primary source of cost data for this analysis is the Medical Expenditure Panel Survey (MEPS), which is a nationally representative survey of the civilian noninstitutionalized population administered by the Agency for Healthcare Research and Quality (http://www.meps.ahrq.gov/mepsweb). The MEPS sample is drawn from a subset of the households who participate in the National Health Interview Survey. Individuals enrolled in MEPS are followed for 2 years, although the Agency for Healthcare Research and Quality releases sampling weights that allow each year to be treated as an independent cross-section. We used MEPS data for the years 2001–2004.

MEPS includes data on participants' health services utilization and corresponding medical costs. The data also include sociodemographic characteristics, including age, race/ethnicity, gender, socioeconomic status (relative to the poverty level), insurance status, education, and self-reported BMI. The analysis sample was restricted to non-Hispanic white and African-American adults ≥18 years of age with valid BMI ($N$ = 66,161), of whom 11% were black women, 8% were black men, 41% were white women, and 39% were white men. We did not include additional racial/ethnic groups because there were no available life tables that could be matched with the cost estimates.

### Methods

Our estimation strategy consisted of three steps. First, we used regression analysis to determine annual age-specific obesity-attributable medical expenditures for each demographic group using the MEPS data. All medical expenditures were inflated to 2007 dollars using the medical component of the consumer price index. Because MEPS is a data set of survivors, these data quantify obesity-attributable costs at each age conditional on survival to that age. Second, to quantify unconditional costs, we applied these expenditure estimates to race-, gender-, age-, and BMI-specific survival estimates available in a recent paper (13). This allowed us to calculate expected medical expenditures for each year of life and each obesity class separately by race and gender. We then discounted (at 3% annually) and summed these costs to quantify lifetime medical expenditures from the perspective of a 20- and a 65-year-old adult in each BMI class. The difference in the present value of lifetime costs between normal-weight adults and those in each BMI class provided an estimate of the lifetime costs for someone who remains in that BMI class from the starting age throughout their adult life. Third, we conducted sensitivity analyses to gauge the stability of the estimates. Each step is described in detail below.

*Regression analysis.* We estimated age-specific medical costs using regression-based econometric techniques. Because medical cost data are highly skewed, simple linear regressions often fit the data poorly (14). We followed the procedures in Manning and Mullahy (14) and Buntin and Zalavsky (15) by testing the distribution of the cost data and selected the most appropriate model. A two-part generalized linear regression model with a gamma distribution and a log link was found to be most appropriate for the cost analysis. The first part of the two-part model used logit analysis to predict the probability of positive expenditures. The second part of the two-part model used a generalized linear regression model with log link and gamma distribution to analyze positive expenditures (unlike ordinary least squares on log-transformed expenditures, predictions from generalized linear regression models do not have to be retransformed from the log scale). Predicted medical expenditures were generated by multiplying the probability of positive expenditures (part 1) by expected expenditures conditional on having positive expenditures (part 2).

Each regression included the same set of independent variables. These included one of six BMI categories: underweight (BMI: <18.5), low/normal (BMI: 18.5–19.9), normal (BMI: 20–24.9, omitted in specification for reference), overweight (BMI: 25–29.9), obese I (BMI: 30–34.9), obese II/III combined (BMI: >35) (the categories for obese II and III were combined because of small sample considerations), educational level (less than college graduate, college graduate, master's or doctoral degree), current smoker, insurance status (insurance status was given the following priority classification: private insurance, Medicaid, Medicare, other public insurance, and uninsured), marital status (married, widowed, divorced/separated, single), binary variables for each Census region (northeast, midwest, south, west), population density, and age, age$^2$, and age$^3$.

To estimate the effect of obesity separately for each age, the regressions included interaction terms between each BMI class and age. We ran separate regressions for each of the four demographic groups (white/black; men/women). Using the two-part model, we predicted expenditures for the average individual (i.e., using mean values for independent variables) separately for each age and BMI class. These estimates were calculated separately for average individuals of each race/gender strata. We refer to these estimates as conditional expenditures because they are costs conditioned on living to a certain age.

*Adjusting for survival.* To obtain unconditional (on survival) expenditure estimates, we multiplied the age-specific expenditures by the probability of surviving to each age given an individual's BMI, race, and gender. These estimates were available from a recent working paper that reports age-specific survival probabilities by gender, BMI, and race categories for ages 18–85 based on analyses conducted using linked data from the 1986–2000 National Health Interview Survey and the 1986–2002 National Death Index (13). Estimates available from authors upon request.

After the survival adjustment, the age-specific costs were then discounted (based on a starting age of 20 or 65) and summed over subsequent ages. Lifetime obesity-attributable costs from that age forward were calculated as the difference in lifetime costs between the normal-weight individual and the overweight or obese individual for

**Table 1 Baseline characteristics of 2001–2004 MEPS participants**

| Class | Variable | White men (*n* = 26,114) | Black men (*n* = 5,385) | White women (*n* = 27,334) | Black women (*n* = 7,328) |
|---|---|---|---|---|---|
| Age | Age | 46 | 42 | 49 | 45 |
| Expenditures | Medical expenditures | $3,370 | $2,455 | $4,105 | $3,219 |
| BMI categories | Underweight | 1.0% | 1.1% | 3.1% | 1.9% |
| | Low/normal weight | 4.9% | 5.5% | 12.9% | 5.8% |
| | Normal weight | 26.3% | 25.6% | 33.5% | 21.7% |
| | Overweight | 43.8% | 38.3% | 27.7% | 29.2% |
| | Obese I | 16.6% | 18.9% | 13.6% | 22.1% |
| | Obese II/III | 7.4% | 10.7% | 9.4% | 19.3% |
| Insurance | Medicaid | 2.9% | 8.2% | 4.3% | 16.0% |
| | Medicare | 18.7% | 14.3% | 23.9% | 17.5% |
| | Private | 66.6% | 54.9% | 62.8% | 52.1% |
| | Other public insurance | 0.8% | 1.8% | 0.9% | 1.2% |
| | Uninsured | 10.9% | 20.9% | 8.0% | 13.2% |
| Urban | Rural | 21.7% | 12.6% | 21.9% | 12.3% |
| | MSA | 78.3% | 87.4% | 78.1% | 87.7% |
| Region | South | 33.3% | 56.1% | 33.9% | 55.8% |
| | West | 19.6% | 9.1% | 19.5% | 7.7% |
| | Northeast | 20.3% | 16.9% | 20.2% | 18.2% |
| | Midwest | 26.8% | 17.9% | 26.5% | 18.3% |
| Education | More than college | 9.7% | 4.0% | 8.0% | 4.4% |
| | College degree | 26.2% | 13.6% | 25.3% | 17.5% |
| | Less than college | 64.1% | 82.5% | 66.7% | 78.1% |
| Income | High income | 50.7% | 28.4% | 44.4% | 23.0% |
| | Middle income | 30.5% | 34.6% | 30.9% | 30.2% |
| | Low income | 12.3% | 21.1% | 16.1% | 24.3% |
| | Poor | 6.5% | 15.8% | 8.7% | 22.5% |
| Marital status | Single | 24.2% | 40.3% | 17.9% | 37.0% |
| | Widowed | 2.9% | 2.8% | 12.5% | 11.7% |
| | Married | 61.3% | 41.2% | 55.2% | 31.1% |
| | Divorced | 11.6% | 15.7% | 14.3% | 20.1% |
| Smoking status | Smoker | 23.4% | 26.4% | 19.7% | 18.3% |
| | Nonsmoker | 68.2% | 60.4% | 73.4% | 71.4% |
| | Smoking information missing | 8.3% | 13.2% | 6.9% | 10.3% |

Weighted mean statistics presented. Only participants with available BMI displayed.

MEPS, Medical Expenditure Panel Survey; MSA, metropolitan statistical area.

each race and gender combination. To be consistent with the mortality estimates, we assumed that no costs are incurred beyond age 85.

*Sensitivity analysis.* We conducted separate analyses to assess the sensitivity of the lifetime cost estimates due to uncertainty surrounding the parameter estimates for medical expenditures, the life-table adjustments for differential mortality by BMI class, and potential correlation in medical expenditures over time, such as those that would occur through persistent health shocks.

The sensitivity analysis consisted of three steps. First, we bootstrapped standard errors around the age, race, and BMI class–specific predicted medical expenditure estimates. Second, we drew a series of random expenditure paths from ages 20 to 85 based on the bootstrapped distributions of age-specific medical expenditures and a model that accounts for correlation of medical expenditures over time. Third, we combined these estimates with two separate life tables: the BMI class–specific life tables that account for differential mortality by weight class and a standard life table from the National Center for Health Statistics that assumes BMI does not affect survival. The details of this analysis are available in **Supplementary Data** online.

## RESULTS

**Table 1** presents demographic characteristics of MEPS participants by race/gender strata. Average age of the adult sample ranged between 42 and 49. There is substantial variation in average annual expenditures, with black men having the lowest annual costs and white women having the highest costs. The prevalence of (self-reported) class I obesity ranged from 13.6% (white women) to 22.1% (black women). Obese II/III ranged from 7.4% (white men) to 19.3% (black women).

Whites are less likely to be on Medicaid and are more likely to live outside of a metropolitan statistical area, live outside of the south, have a college degree, have high income, and be married. These results underscore the need to control for demographic differences in the regression analyses.

**Figure 1** presents age-specific cost estimates for a 20 year old in each BMI class after adjusting for differential survival. For white men and women, regardless of BMI, costs increase annually until individuals reach their early 60s and then begin to decrease dramatically, primarily due to considerable decreases in annual survival. Costs for those who are obese I are slightly higher for young adults and reach their maximal difference of ~$940 for men and $1,150 for women at the peak of the curve. Beyond this level, costs tend to equate across BMI groups, although the pace at which the curves converge occurs more quickly among men.

Results are generally similar for blacks. However, because of greater mortality rates and lower annual expenditures, the height of the expenditure curve peaks at younger ages and at lower expenditure levels. For black men, regardless of BMI, the peak occurs at age 60. For black women, the curve peaks at $3,950 at age 48 for those who are in the obese II/III class and between $2,850 and $3,150 at approximately age 50 for those in the remaining categories. Only for overweight black men and women do the expected costs ever drop below the costs for normal weight. In other words, even after adjusting for differential survival, with the possible exception of overweight, there are no "savings" resulting from excess weight at any age.

**Table 2** displays the lifetime costs, discounted at 3% annually, attributable to overweight and obesity beginning at ages 20 and 65. With the exception of white women, the lifetime costs of overweight are around zero. For 20-year-old overweight white women, these costs are estimated at $8,120, with only 11% occurring beyond age 65. From the perspective of a 65 year old, the costs of overweight are $4,560.

For 20-year-old obese I adults, lifetime costs range from $5,340 for black women to $21,550 for white women. For 20 year olds in the obese II/III class, black men have the lowest lifetime cost estimates, $14,580, and white women again have the highest lifetime cost estimates, $29,460. For men, the costs of obese II/III are similar to those of obese I. From the perspective of an obese 20 year old, the percentage of costs occurring after age 65 ranges from 3% for obese II/III black women to 28% for obese I black men.

From the perspective of a 65 year old, lifetime costs of obese I range from $4,660 (black women) to $19,270 (black men). For obese II/III, these estimates range from $7,590 (black women) to $25,300 (white women). From this perspective, lifetime costs are higher for the obese II/III class than for those who are obese I.

Due to discounting future costs, perhaps surprisingly, in some instances the costs of excess weight are greater from the

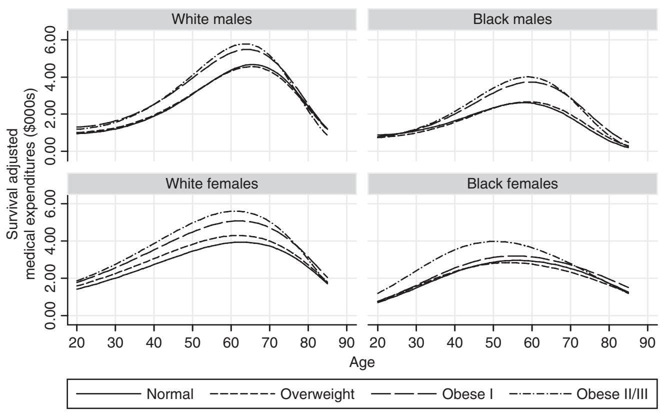


**Figure 1** Survival adjusted annual costs from the perspective of a 20 year old. All estimates are presented in 2007 dollars. Normal is defined as a BMI of 21–25. Overweight is 25–29.9. Obese I is 30–34.9. Obese II/III is >35.

**Table 2 Lifetime attributable costs to overweight and obesity**

| | Overweight | | Obese I | | Obese II/III | |
|---|---|---|---|---|---|---|
| | Cost $ (range) | % After 65 | Cost $ (range) | % After 65 | Cost $ (range) | % After 65 |
| Start at Age 20 | | | | | | |
| White men | 630 (–1,460, 2,830) | N/A | 16,490 (14,790, 18,170) | 10 (7, 14) | 16,720 (13,070, 20,410) | 9 (3, 15) |
| Black men | –1,150 (–3,630, 1,230) | N/A | 12,290 (8,160, 16,330) | 28 (20, 44) | 14,580 (9,320, 19,730) | 21 (14, 33) |
| White women | 8,120 (6,900, 9,310) | 11 (9, 15) | 21,550 (19,280, 23,740) | 16 (13, 18) | 29,460 (26,390, 32,460) | 13 (11, 16) |
| Black women | –180 (–1,200, 860) | N/A | 5,340 (3,130, 7,570) | 16 (10, 27) | 23,750 (22,300, 25,140) | 3 (2, 3) |
| Starting at Age 65 | | | | | | |
| White men | –3,790 (–5,380, –2,150) | | 9,940 (7,080, 12,760) | | 20,510 (15,510, 25,380) | |
| Black men | 1,070 (–1,330, 3,540) | | 19,270 (15,610, 23,030) | | 24,830 (19,210, 30,500) | |
| White women | 4,560 (3,850, 5,270) | | 17,640 (15,990, 19,230) | | 25,300 (22,720, 27,860) | |
| Black women | –2,000 (–3,170, –840) | | 4,660 (3,140, 6,180) | | 7,590 (6,700, 8,520) | |

Present value of costs shown, discounted at 3% per year. The 2.5 and 97.5% sensitivity bounds using BMI class–specific life tables are presented in parentheses. All figures represent 2007 dollars. Overweight is defined as BMI 25–29.9, obese I is BMI 30–34.9, and obese II/III is BMI >35. "% After 65" refers to the percentage of costs that occur for a 20 year old after the age of 65.

perspective of an obese 65 year old than from that of an obese 20 year old. For example, the lifetime costs of an obese I adult are $12,290 for black 20-year-old men and $19,270 for black 65-year-old obese men. This result is driven by the small cost differences that occur for young obese black men and the large cost differential between normal and obese black men in their 60s. This latter result drives the high costs from the perspective of a 65 year old, but due to discounting, these costs are significantly reduced from the perspective of an obese 20 year old. Our sensitivity analyses suggest that all costs for obese I and obese II/III are likely to be greater than zero.

## DISCUSSION

Consistent with cross-sectional studies, these results reveal that, with the exception of white women, the costs of overweight are small or nonexistent (16). However, even after adjusting for survival, the lifetime costs of obesity are positive and generally increase with increasing BMI. However, because of the inverse relationship between survival and excess BMI, the difference in costs between those who are obese I and obese II/III is much less than the cross-sectional differences reported in earlier studies (17).

Our estimates of obesity beginning at age 20 are slightly higher than those reported in earlier studies. From the perspective of a 60-year-old obese individual, our estimates are larger than those reported by Tucker *et al.* (9) but much smaller than the estimates reported by Lakdawalla *et al.* (10) and Daviglus *et al.* (11). A large percentage of the difference between our estimates and the studies relying on Medicare claims data may result from their use of charges, as opposed to payments for quantifying costs.

This analysis provides several key results that are relevant for policy makers. It has been suggested that, although the annual costs of obesity are positive, the net lifetime medical costs could be negative if reduced survival more than offsets increased medical expenditures attributable to obesity while alive. As shown in **Table 2**, this hypothesis is false. Even after taking differential survival probabilities into account, costs attributable to obesity are positive for all race and gender strata. Given that approximately one-third of Americans are obese, the lifetime medical costs of excess weight impose a substantial drain on scarce health-care resources, even after accounting for differential survival rates.

The results also reveal the differential effect of obesity that results from different race/gender strata. The most pronounced effect occurs for obese I black women, whose costs are <25% of the costs for obese I white women. **Figure 1** reveals that black men also tend to have lower costs than white men, regardless of BMI. The cause of these differences is unclear.

These results allow for estimating the maximum investment that could be spent on effective obesity interventions and still show a positive return on investment. From age 20 until their average predicted life expectancy, an annual investment that eliminated all costs attributable to obese I could cost as much as $740 (for white women) and still be cost saving. For obese II/III white women, this figure increases to $1,040. To put these costs into perspective, an annual membership at a fitness center costs ~$650 (ref. 18). This cost is less than the annualized burden of obesity. However, whether it is cost saving to join a fitness center or participate in other interventions designed to reduce weight remains an open question.

Even if cost-saving interventions were available, this analysis reveals why private sector firms would likely underinvest in them. As shown in **Table 2**, not only does the existence of Medicare reduce the economic burden that obesity imposes on private payers, but, as can be seen in **Figure 1**, from the perspective of a 20-year-old adult, the short-term costs of obesity are relatively modest. This results because many of the diseases that obesity promotes are not prevalent until older ages. As a result, and given that individuals in the current economy switch jobs every 4–5 years, there is unlikely to be a return on investment for obesity interventions among young obese adults, even those whose BMI exceeds 35 (ref. 19,20). Job switching makes it difficult for firms to recoup the fixed cost of investment. Instead, a future firm will reap the benefits. This suggests that legislation that subsidizes wellness programs and/or mandates coverage for obesity treatments might make all firms financially better off. This would result if the mandates result in all firms hiring healthier workers at every age. However, this only holds if the interventions are effective at reducing the medical costs attributable to obesity.

Perhaps surprisingly, Medicare has a much greater financial incentive to prevent obesity than the private sector. This results because when an obese 65 year old enters the program, his/her costs are immediate and substantially higher than costs for those of normal weight. Our analysis suggests that Medicare would be willing to spend up to $2,630 (black men) and $3,460 (white women) annually to prevent the costs of class I and class II/III obesity, respectively. This again hinges on these expenditures being effective in reducing obesity-attributable costs.

The results of this analysis are subject to several limitations. Our cost projections assume that a person who is obese at age 20 (or 65) remains obese until death, and we compare these costs to a person of normal weight and who remains normal weight until death. However, normal weight individuals tend to gain weight over time. As a result, our estimates may overstate the actual lifetime costs attributable to obesity at age 20. Future research should attempt to incorporate weight transitions into the lifetime cost estimates. Moreover, these estimates are based on current medical technology. Introduction of new technologies aimed at treating obesity and related diseases will affect both costs and survival. As a result, the estimates will need to be updated once these new technologies are available.

Due to data limitations, our econometric analysis does not include information on weight history, but rather correlates current weight with current expenditures. Ideally, we would have preferred to have access to expenditure and mortality data on a cohort of 20 and 65 year olds. Unfortunately, these data were not available. However, our sensitivity analysis provides a range of estimates under the assumption that medical expenditures are correlated over time and allows for estimating the variability in the lifetime cost estimates.

Data limitations also force us to rely on self-reported height and weight when calculating BMI categories. Self-reporting may introduce bias because overweight individuals tend to under-report their weight (21). The effect of the bias on the cost estimates is unclear because we do not know how many overweight/obese individuals may have under-reported their weight to the point where they would be included in a different group. Measured BMI, although not available in MEPS or National Health Interview Survey, would have been preferred.

Lastly, our analysis is limited to medical expenditures among the civilian noninstitutionalized population. Obesity is likely to have additional effects that we could not measure, such as effects on the use of nursing home care, absenteeism, presenteeism, disability, worker's compensation, and decreased quality of life. Although beyond the scope of this analysis, a thorough accounting of all lifetime costs of obesity would include these additional costs. It is possible that these costs may prove to be a greater incentive to address obesity in the workplace than the direct medical costs.

*Human participant protection.* IRB approval was not required as all analysis was of publicly available, unidentified data.

### SUPPLEMENTARY MATERIAL
Supplementary material is linked to the online version of the paper at http://www.nature.com/oby

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### DISCLOSURE
The authors declared no conflict of interest.

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