Obesity-Related Quality-Adjusted Life Years Lost in the U.S. from 1993 to 2008

Haomiao Jia, PhD, Erica I. Lubetkin, MD, MPH

Background: Although trends in the prevalence of obesity and obesity-attributable deaths have been examined, little is known about the resultant burden of disease associated with obesity.

Purpose: This study examined trends in the burden of obesity by estimating the obesity-related quality-adjusted life years (QALYs) lost—defined as the sum of QALYs lost due to morbidity and future QALYs lost in expected life years due to premature deaths—among U.S. adults along with differences by gender, race/ethnicity, and state.

Methods: Health-related quality-of-life data were taken from the 1993–2008 Behavioral Risk Factor Surveillance System to calculate QALYs lost due to morbidity. Age-specific mortality data were used to calculate QALYs lost due to mortality.

Results: QALYs lost due to obesity in U.S. adults have more than doubled from 1993 to 2008. Black women had the most QALYs lost due to obesity, at 0.0676 per person in 2008. This number was 31% higher than the QALYs lost in black men and about 50% higher than the QALYs lost in white women and white men. A strong and positive relationship between obesity-related QALYs lost and the percentage of the population reporting no leisure-time physical activity at the state level ($r = 0.71$) also was found.

Conclusions: This analysis enables the overall impact of obesity on both morbidity and mortality to be examined using a single value. The overall health burden of obesity has increased since 1993 and such increases were observed in all gender-by-race subgroups and in all 50 states and the District of Columbia.

Introduction

In formulating the overarching goals of Healthy People 2020, the Secretary’s Advisory Committee on Health Promotion and Disease Prevention recommended that Healthy People 2020 primarily focus on health determinants. Obesity has been associated with a range of health determinants (i.e., personal, social, economic, and environmental) and, because the prevalence of obesity continues to increase, associated modifiable behavioral risk factors, such as poor diet and physical inactivity, may soon be the leading causes of death in the U.S. Healthy People 2010 listed obesity as a leading health indicator and included an objective of decreasing the prevalence of adults who are obese from 23% to 15%. However, these percentages mask the disparities in population subgroups, as obesity prevalence varies according to gender, race/ethnicity, and geographic area.

Although data on the prevalence of obesity and obesity-attributable deaths have been commonly collected, such data fail to provide information on the health-related quality of life (HRQOL) of people with obesity and the resultant burden of disease experienced by individuals in terms of lost health. In analyzing the impact of modifiable behavioral risk factors, mortality or morbidity statistics commonly have been used as outcome measures. For example, with regard to mortality, an earlier study calculated life expectancy according to BMI using the Framingham Heart Study data and found that female and male nonsmokers aged 40 years lost 7.1 years and 5.8 years due to obesity, respectively. Viewing morbidity, another study determined that adults with obesity had significantly lower HRQOL scores than people without
obesity, even in the absence of chronic obesity-associated diseases. However, both types of studies fail to quantify the impact of obesity associated with both morbidity, or nonfatal diseases, and mortality, or premature deaths, through a single number, such as the quality-adjusted life year (QALY).\(^8\) Understanding the contribution of both morbidity and mortality is important, given the steadily increasing prevalence of obesity and its associated conditions, such as diabetes mellitus, and the variability of results of investigations that examine the extent of obesity’s impact on life expectancy and disability.\(^6\) In addition, the contribution of morbidity and mortality attributed to obesity may vary according to gender and race/ethnicity.\(^14,15\)

Prior to 2000, the lack of a data set that contained preference-based HRQOL measures for a representative sample of the population precluded the ability to conduct burden of disease analyses using QALYS in the U.S. During 2000–2003, the Medical Expenditure Panel Survey (MEPS) included the EQ-5D, a preference-based and QALY-compatible instrument.\(^16,17\) Using EQ-5D scores from the 2000 MEPS, an earlier study\(^18\) estimated the burden of disease attributable to obesity/overweight and found that obese men and women lost 270,000 and 1.8 million QALYs, respectively, relative to their normal-weight counterparts (which was defined as a BMI between 23 and <25 kg/m\(^2\)). However, because the MEPS included only the EQ-5D between 2000 and 2003 and was not primarily designed to facilitate state- or local-level estimation, trends over time and comparisons among states were unable to be examined.\(^16\)

The Behavioral Risk Factor Surveillance System (BRFSS), the largest ongoing state-based health survey of U.S. adults,\(^19,20\) has been collecting health-related data such as BMI at the national, state, and substate levels and tracking trends over time.\(^20\) The BRFSS has included a set of survey instruments, called the Healthy Days measures, for monitoring respondents’ perceived physical and mental health and activity limitation.\(^21\) In recent years, methods have been developed and validated to convert the Healthy Days measures to EQ-5D scores.\(^22\) Therefore, QALYs can be calculated for burden of disease studies and cost-effectiveness analyses using legacy data, such as the BRFSS, which did not contain performance-based HRQOL questions. Such an analysis allows the overall health impact of modifiable risk factors to be examined at multiple levels and over time and is particularly important in public health practice given that interventions tend to be implemented at the state and local levels.

The present study focuses on trends in the burden of obesity due to morbidity and mortality by using the annual state-based BRFSS data and calculated the QALYs lost per person contributed by obesity in the general U.S. population according to gender and race/ethnicity and for the individual states between 1993 and 2008. In addition, the association of QALYs lost contributed by obesity with the proportion of the population who reported no leisure-time physical activity was examined across the states.

### Methods

#### Data and Measurements

Population HRQOL scores were estimated from the 1993–2008 BRFSS, which sampled non-institutionalized civilian adult residents aged \(\geq 18\) years from each of the 50 states and the District of Columbia.\(^20\) The total sample size was 3,590,540, with the annual sample sizes ranging from 102,263 in 1993 to 406,749 in 2008.

Since 1993 the BRFSS asked respondents the number of days in the past 30 days when their physical health was not good, when their mental health was not good, and when their activity was limited as a result of physical or mental conditions (with the exception of 2002, when only 22 states asked these questions).\(^21\) In order to calculate QALYS, these unhealthy days measures were converted to EQ-5D index scores, using a previously constructed formula for all BRFSS healthy days measures.\(^22\) The respondents’ EQ-5D scores were calculated based on the three Healthy Days questions, self-rated general health, and age.

The obesity-attributed premature deaths were estimated based on the annual mortality data compiled by the CDC (available at http://wonder.cdc.gov) and the 1997–2000 cohort of the National Health Interview Survey (NHIS)–linked mortality files produced by the National Center for Health Statistics.\(^23\) The NHIS contains sociodemographics and health behavior questions similar to the BRFSS.

#### Obesity-Related Quality-Adjusted Life Years Lost

The total QALYs lost contributed by a risk factor is the sum of the QALYs lost in the current year due to the risk factor and the future QALYs lost in the expected life years due to premature deaths (mortality).\(^18\)\(^24\) The QALYs lost due to morbidity contributed by a risk factor is defined as the potential annual QALYs that would be gained if those at risk (obese) had a mean EQ-5D index score that was equal to the score of the reference group (not obese).

The future QALYs lost in the expected life years due to excess deaths is the product of obesity-related excess deaths and the potential quality-adjusted life expectancy (QALE) that would be gained if those at risk had a mean EQ-5D index score that was equal to the score of the reference group. The QALE was defined as the mean EQ-5D index score multiplied by each corresponding expected life year.\(^18\)\(^24\)

#### Statistical Analyses

The statistical analyses were conducted in 2009 and are described in detail elsewhere.\(^24\) The following is a short summary: (1) estimate hazard ratios of obesity from the NHIS Linked Mortality Files through the Cox’s proportional hazards model; (2) apply the estimated hazard ratio to the state-level mortality data and use the obesity prevalence estimated from the BRFSS to calculate age-
specific death rate by obesity status; (3) apply the EQ-5D mapping algorithm to the BRFSS to estimate mean EQ-5D scores by obesity status; (4) calculate QALE by obesity status using results from Steps 2 and 3; and (5) use results from Steps 3 and 4 to estimate obesity-related QALYs lost due to mortality and morbidity.

In order to compare QALYs lost among states and in different years, the proportion of the population were used to calculate QALYs lost per person, which can be converted to absolute total QALYs lost by multiplying the adult population in each state/year.

**Results**

From 1993 to 2008, the obesity prevalence for U.S. adults increased from 14.1% to 26.7%, or an 89.9% increase. Such a substantial and progressive climb in obesity prevalence was observed in every gender-by-race/ethnicity subgroup (Figure 1). Compared to whites, blacks had a much higher obesity prevalence whereas Hispanics had a higher obesity prevalence but at a smaller magnitude. When examined by gender, black women had a much higher obesity prevalence than did black men, whereas white women had a slightly lower obesity prevalence than did white men. When examined using combined data from all race/ethnicity groups, obesity prevalence was almost exactly the same between men and women in each study year.

Figure 2 shows the trend of obesity-related QALYs lost. Although obesity prevalence in Hispanics was higher than in whites, the QALYs lost to obesity were almost the same between Hispanics and whites for both genders. Therefore, only results for blacks and whites are presented. Similar to the obesity prevalence, blacks lost more QALYs to obesity than whites did, and of the four gender-by-race subgroups, black women lost the most QALYs, about 31% more than those lost in black men, the second-highest group. For whites, the QALYs lost due to obesity were almost the same between men and women. Like the obesity prevalence, the obesity-related QALYs lost significantly increased during this 16-year period. For the overall U.S. adult population, obesity contributed 0.0204 QALYs lost per person in 1993 and this number increased to 0.0464 QALYs lost per person in 2008, or approximately a 127% increase. Such increases in obesity-related QALYs lost were found for both men and women and among all racial/ethnic subgroups. However, the rise of QALYs lost due to obesity was much smaller for black men (increased 45.5% from 1993 to 2008) compared to other gender–racial/ethnic groups, whose increases were 132%, 121%, and 68% for white men, white women, and black women, respectively.

Figure 3 presents the trends of QALYs lost due to morbidity and to mortality separately. For white men, more than 70% of total obesity-related QALYs lost were due to mortality and the loss due to mortality increased nearly twice as fast as did the loss due to morbidity (slope=1.93). From 1993 to 2008, the QALYs lost due to mortality increased from 0.015 to 0.033 whereas the QALYs lost due to morbidity increased from 0.0045 to 0.013. For white women, more than 50% of the total QALYs lost were due to morbidity, and, over the 16-year period, the QALYs lost due to morbidity increased much faster than did the loss due to mortality (slope=0.61). Specifically, the QALYs lost due to morbidity increased from 0.011 QALYs lost per person in 1993 to 0.026 QALYs lost in 2008, whereas the QALYs lost due to mortality increased from 0.0094 QALYs lost in 1993 to 0.019 QALYs lost in 2008. Black women had a similar trend in QALYs lost due to mortality and to morbidity as did white women. Although more QALYs lost were due
to mortality in 1993 to 2001, more QALYs lost were due to morbidity in recent years because the loss due to morbidity increased more than twice as fast as did the loss due to mortality (slope $= 0.48$). The QALYs lost due to morbidity increased from 0.017 to 0.035 whereas the QALYs lost due to mortality increased from 0.023 to 0.032.

For black men, different trends emerged. Similar to the other three subgroups, the QALYs lost due to mortality continuously increased between 1993 and 2008, or from 0.028 to 0.042 QALYs lost per person. However, the QALYs lost due to morbidity was relatively unchanged (and the smallest among the four demographic subgroups) during this period, ranging from 0.0036 QALYs lost per person in 2003 to 0.0094 QALYs lost in 2008. Black men had the biggest percentage of total obesity-related QALYs lost to mortality, and more than 70% of total QALYs lost were due to mortality.

Viewing the trend of burden of obesity by individual states, the obesity prevalence increased over time for all states (Table 1), whereas the obesity-related QALYs lost tended to follow a similar pattern. However, the disparities among states lessened over time, with less-obese states “catching up” to more-obese states and producing a greater percentage change of QALYs lost.

Finally, the relationship of the proportion of the population reporting no leisure-time physical activity and the obesity-related QALYs lost in the states (Figure 4) was examined. The plot shows a strong and positive relationship between these two measures ($r = 0.71$). Based on regression analysis, it was concluded that for each additional percentage of the adult population reporting no leisure-time physical activity, obesity contributed on average an additional 0.0011 QALYs lost per population.

**Discussion**

From 1993 to 2008, the obesity-related QALYs lost among U.S. adults increased progressively from 0.0204 to 0.0464 QALYs per person and such increases were observed in all gender-by-race subgroups and in all 50 states and the District of Columbia. The increasing prevalence and QALYs lost due to obesity over time highlights the importance of finding effective strategies in the general population. Because the trends of obesity over time and QALYs lost are not uniformly distributed according to gender, race/ethnicity, or geographic area (i.e., statewide level), practitioners and policymakers should ensure that resources and strategies to target obesity are geared to the populations most affected. For example, an earlier study$^{25}$ estimated the progression of obesity and determined that, among all subgroups, black women would be the most affected, with an obesity prevalence of more than 75% in the year 2030.

Despite a higher obesity prevalence in blacks, the trend of QALYs lost for black men initially resembled black women and then bore a closer resemblance to the trends seen in whites. Other investigators have noted that obesity results in a smaller increase in mortality among blacks compared with whites$^{26,27}$ and, for blacks, the optimal BMI associated with the fewest years of life lost was between 23 and 30. Similarity, a prospective study found that black men and women with the highest BMIs had risks of death that were not significantly different from that of the reference category (BMI between 23.5 and 24.9).$^{15}$

Regarding mortality and gender, a high BMI was most predictive of death from cardiovascular disease, but this relationship was more pronounced in men. In addition, compared to obese men, obese women tended to have lower relative risks of death from all causes in the range of BMIs examined.$^{15}$ This relationship also has been noted abroad where, for most age categories, obesity was not related to mortality among women (as opposed to men).$^{28,29}$ By contrast, obesity has been noted to have an impact on morbidity in women,$^{30}$ and the magnitude has been estimated to be greater in women than men.$^{14,18}$

Our finding of a nonlinear trend for black men in terms of QALYs lost due to mortality and morbidity was interesting but difficult to explain. As noted by Fontaine and colleagues,$^{26}$ blacks may be exposed to different competing risks for mortality (i.e., distributions of age, health status, and SES, among other variables) and these other risk factors may have an impact on mortality. In addition, because the percentage of obesity-related QALYs lost due to morbidity was much lower than QALYs lost due to mortality, the morbidity component of the QALYs may be unreliable relative to the mortality component.
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<th>Obese prevalence (%)</th>
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<td>Oregon</td>
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<td>21.0</td>
<td>25.0</td>
<td>25.0</td>
<td>74.2</td>
<td>0.020</td>
<td>0.025</td>
<td>0.032</td>
</tr>
</tbody>
</table>

(continued on next page)
Although an earlier study\textsuperscript{31} illustrated that the increases in the prevalence of obesity did not continue at the same rate between 1999 and 2008, these authors also cautioned that trends in obesity-related health outcomes do not always parallel trends in obesity prevalence, as reflected by the finding that the rate of increase in QALYs lost due to obesity was greater than the rate of increase in the prevalence of obesity. Even though disparities among states have lessened over time, the proportion of obesity and percentage change in QALYs lost increased for every state, with the percentage change in QALYs lost being greater than the percentage change in obesity prevalence. In terms of potential interventions, the scatter plot revealed that at the state level, reporting no leisure-time physical activity was strongly associated with QALYs lost. Similar results were found that failing to meet the physical activity recommendations continued to be the strongest predictor of the state prevalence of obesity, after adjusting for age, gender, race, and median household income.\textsuperscript{32}

The ability to collect data at the state and local levels is essential for designing and implementing interventions, such as promoting physical activity, that target the relevant at-risk populations. Although the prevalence of obesity has been well documented in the general population, less is known about the impact on QALYs both in the general population and at the state and local levels. As noted by the current study, both the proportion of obesity and the percentage change in QALYs vary at the statewide level and would be expected to vary locally as well, based on sociodemographic and geographic features.\textsuperscript{33–35}

There are several limitations in this analysis. First, the analysis relies on the validity of EQ-5D estimates from the Healthy Days measures. Different measures of HROQL may not reliably cross over among the full range of health states at the individual level.\textsuperscript{22} However, a validation study demonstrated that estimated EQ-5D scores should have acceptable accuracy in terms of providing estimated mean scores in different subgroups needed for calculating QALYs.\textsuperscript{22} Second, the calculated CI of QALYs would

\begin{table}
\centering
\caption{Obesity prevalence QALYs lost to obesity \textsuperscript{\textit{continues}}}
\begin{tabular}{|l|c|c|c|c|c|c|c|c|c|c|c|}
\hline
\hline
Pennsylvania & 16.9 & 19.6 & 23.5 & 26.4 & 56.5 & 0.0248 & 0.0302 & 0.0325 & 0.0457 & 84.2 \\
Rhode Island & 13.3 & 16.1 & 18.4 & 21.5 & 62.3 & 0.0183 & 0.0251 & 0.0299 & 0.0405 & 121.2 \\
South Carolina & 17.1 & 20.1 & 24.5 & 29.5 & 73.2 & 0.0199 & 0.0288 & 0.0358 & 0.0497 & 149.8 \\
South Dakota & 14.5 & 18.1 & 22.3 & 26.6 & 82.8 & 0.0192 & 0.0247 & 0.0255 & 0.0360 & 87.8 \\
Tennessee & 16.6 & 20.1 & 25.1 & 29.6 & 77.9 & 0.0224 & 0.0236 & 0.0424 & 0.0470 & 109.6 \\
Texas & 16.3 & 20.9 & 25.1 & 27.7 & 69.7 & 0.0189 & 0.0226 & 0.0311 & 0.0418 & 121.4 \\
Utah & 12.5 & 16.8 & 19.5 & 22.2 & 77.3 & 0.0134 & 0.0171 & 0.0161 & 0.0282 & 111.0 \\
Vermont & 13.8 & 16.7 & 18.7 & 21.7 & 57.5 & 0.0186 & 0.0260 & 0.0302 & 0.0357 & 92.2 \\
Virginia & 14.7 & 18.1 & 22.4 & 25.3 & 72.6 & 0.0196 & 0.0206 & 0.0282 & 0.0384 & 95.7 \\
Washington & 14.3 & 17.6 & 21.1 & 24.9 & 74.0 & 0.0190 & 0.0234 & 0.0304 & 0.0385 & 103.1 \\
West Virginia & 18.3 & 23.1 & 27.0 & 31.0 & 69.5 & 0.0244 & 0.0299 & 0.0481 & 0.0518 & 112.1 \\
Wisconsin & 16.6 & 18.7 & 22.0 & 25.6 & 54.6 & 0.0161 & 0.0237 & 0.0254 & 0.0364 & 125.7 \\
Wyoming & 14.4 & 16.2 & 20.0 & 24.3 & 68.6 & 0.0179 & 0.0217 & 0.0255 & 0.0377 & 111.0 \\
\hline
\end{tabular}
\end{table}


QALYs, quality-adjusted life years.
be artificially too small because the EQ-5D scores used in this analysis were based on the model-estimated EQ-5D, not the actual observed EQ-5D. In addition, because the model-estimated QALYs would be biased, interpretation of CIs for biased estimates is difficult. Therefore, CIs or SEs for estimated QALYs lost were not reported. Third, in 2002, a total of 28 states and the District of Columbia did not ask the Healthy Days questions. Although these missing data will affect national-level estimates for 2002, the impact on the overall trend of obesity-related QALYs lost from 1993 to 2008 and on state-level estimations will be minimal.

Conclusion

Collaborative efforts among groups at the national, state, and community (local) levels are needed in order to establish and sustain effective programs to reduce the prevalence of obesity. Although the impact of current and future interventions on curtailing the burden of disease might not be available for a number of years, this method can provide an additional tool for the Healthy People 2020 toolbox by providing a means to measure objectives and goals. The availability of timely data would enable the impact of evidence-based interventions to be assessed on targeted populations and subgroups, promote continuous quality improvement through monitoring trends, and facilitate head-to-head comparisons with other modifiable health behaviors/risk factors and diseases.

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