VALUE IN HEALTH ▮ (2016) ▮▮▮–▮▮▮

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Estimating the Medical Care Costs of Obesity in the United States: Systematic Review, Meta-Analysis, and Empirical Analysis

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ABSTRACT

Background: The prevalence of adult obesity exceeds 30% in the United States, posing a significant public health concern as well as a substantial financial burden. Although the impact of obesity on medical spending is undeniably significant, the estimated magnitude of the cost of obesity has varied considerably, perhaps driven by different study methodologies. **Objectives:** To document variations in study design and methodology in existing literature and to understand the impact of those variations on the estimated costs of obesity. **Methods:** We conducted a systematic review of the twelve recently published articles that reported costs of obesity and performed a meta-analysis to generate a pooled estimate across those studies. Also, we performed an original analysis to understand the impact of different age groups, statistical models, and confounder adjustment on the magnitude of estimated costs using the nationally representative Medical Expenditure Panel Surveys from 2008-2010. **Results:** We found significant variations among cost estimates in the existing literature. The meta-analysis found that the annual medical spending attributable to an obese individual was $1901 ($1239-$2582) in 2014 USD, accounting for $149.4 billion at the national level. The two most significant drivers of variability in the cost estimates were age groups and adjustment for obesity-related comorbid conditions. **Conclusions:** It would be important to acknowledge variations in the magnitude of the medical cost of obesity driven by different study design and methodology. Researchers and policy-makers need to be cautious on determining appropriate cost estimates according to their scientific and political questions.

Keywords: economic burden, medical care costs, obesity, United States.

Introduction

The prevalence of obesity, which is defined as a body mass index (BMI) of greater than 30, has increased dramatically in the United States since the late 1990s [1]. So much so that recently obesity has been officially recognized as a disease by the American Medical Association, an action that could put more emphasis on the health condition by doctors and insurance companies so as to minimize its adverse effects. Currently, rates of obesity exceed 30% in most sex and adult age groups, whereas its prevalence among children and adolescents, defined as a BMI of more than 95th percentile, has reached 17% [2].

The alarming rates of the high prevalence of obesity have posed a significant public health concern as well as a substantial financial burden on our society because obesity is known to be a risk factor for many chronic diseases, such as type 2 diabetes, cancer, hypertension, asthma, myocardial infarction, stroke, and other conditions–[3,4]. To understand the economic burden of obesity, several studies have attempted to estimate the attributable costs of obesity, following the burden-of-illness literature on other disease areas [5–9]. A previous cost-of-illness study estimated that health care spending attributable to the rising prevalence of obesity has increased by 27% between 1987 and 2001 [10]. In gross terms, the annual medical costs of obesity were estimated to be $40 billion in 2006 [11]. The latest study using an instrumental variable (IV) approach even showed that the estimated medical costs related to obesity could reach $209.7 billion, which is twice higher than the previous estimate, $86 billion [12].

As evidenced by the aforementioned estimates, although the impact of obesity on the medical care spending is undeniably significant, the estimated magnitude of the medical care costs attributable to obesity has varied considerably, perhaps driven by different study methodologies, including data, statistical models, confounder adjustment, and target populations. In this article, we approach these issues systematically with two goals: 1) to conduct a systematic review and meta-analysis of recently published articles that estimated the medical costs associated

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1098-3015$36.00 – see front matter

http://dx.doi.org/10.1016/j.jval.2016.02.008

with obesity between 2008 and 2012 and to document the variations in study methodologies and 2) to demonstrate the importance of study methodologies by performing an original analysis to examine the impact of age group, confounder adjustment, and statistical methods on the cost estimates of obesity through the empirical analysis of a nationally representative US population. Especially, we also examined the impact of obesity-related diseases (ORDs) on the medical costs of obesity to show that most, if not all, of those costs are attributable to ORDs.

We believe that it would be important to recognize significant variations among estimates of obesity-attributable costs in the existing literature and to understand the impact of study methodology on the magnitude of these estimates so that researchers and policymakers are able to determine the appropriate estimate and methods according to their scientific and political questions.

Methods

A Systematic Review and Meta-Analysis

Literature search

We searched the MEDLINE and Cochran database to identify articles related to medical costs of obesity using keywords "obesity AND (cost OR expenditure) AND healthcare)) AND "united states." To account for the unique health care system and the impact of costs attributable to obesity in the United States, we limited the search to studies conducted in the US settings. We initially identified 567 articles from the search, then narrowed down to 16 articles for in-depth reviews. Following the extensive reviews, we excluded three studies that did not provide explicit methods and/or aggregate annual costs per person, in addition to a previously conducted systematic review [13–16]. Finally, we included 12 studies in this study for the systematic review [17–26]. Appendix Figure A in Supplemental Materials found at http://dx.dor.org/10.1016/j.jval.2016.02.008 provides details on search strategies for identifying studies included in this review.

Improve comparability across studies

To improve comparability across heterogeneous studies, we performed appropriate adjustments to convert estimates from each study into annual per-person costs among all obese population (BMI $\geq$ 30).

First, we converted cost estimates to 2014 USD to adjust for the inflation over time using annual average consumer price index for medical care [27]. One study reported the quarter-per-person medical costs, and we annualized the cost estimate [17]. All the 12 studies reported direct medical costs, including the out-of-pocket costs for inpatient, noninpatient (outpatient, emergency room, and other), and prescription drug spending.

Then, we aggregated all BMI-specific estimates into a single composite estimate of costs attributable to all obese individuals. Among the 12 studies, 8 studies defined obesity as a BMI of greater than 30 whereas 4 studies implemented more comprehensive obesity categories, defined as class I obesity (30 $<$ BMI $\leq$ 35), class II obesity (35 $<$ BMI $\leq$ 40), and class III obesity (40 $<$ BMI) [21,22,24,26]. Two of the four studies combined class II and class III obesity into a single category because of the sample size issue [22,26]. To generate comparable cost estimates, we calculated a weighted average among subgroup-specific estimates on the basis of the number of each subgroup reported in each of the four studies.

In addition, three studies estimated sex-specific costs of obesity [18,20,23], and one study provided race (non-Hispanic whites vs. blacks) stratified results [26]. Another study reported both sex and race (non-Hispanic whites vs. blacks) stratified estimates [19]. Based on the sample size of each stratum presented in each study, only the weighted average estimates for aggregating sex and race categories are presented in Table 2.

Evaluating quality of studies

We evaluated the quality of studies on the basis of four criteria: the use of nationally representative samples, longitudinal data sets, analysis of adults of all ages, and appropriate confounding factor adjustments. A previous systematic review also used a similar set of criteria for evaluating cost-of-illness studies of obesity [13].

Meta-analysis

To generate a pooled estimate of medical costs of obesity across different studies, we conducted a meta-analysis using the `metaan` command in STATA 12 (StataCorp., College Station, TX) [28]. The `metaan` command is used to conduct random-effect meta-analysis for one-variable relationship. Because the meta-analysis for one-variable relationship requires both the effect size estimate and the standard error, we were able to include only eight estimates of annual incremental costs of obesity from seven studies (Table 2). Because of the presence of extremely high heterogeneity between studies ($I^2 = 96.61\%$; $\tau^2 = 5.6 \times 10^5$), the random-effect model is used in the final analysis.

Empirical Analysis: The Role of Alternative Statistical Models in Estimating Costs of Obesity

Study data

The medical costs of obesity were estimated using regression analysis and the 2008-2010 Medical Expenditure Panel Surveys (MEPS). The MEPS is a nationally representative survey of the civilian noninstitutionalized population, collecting detailed information on health care expenditures and utilization, health insurance, health status, and sociodemographic factors. Nationally representative estimates were obtained by using MEPS sampling weights.

Variables

As a dependent variable, *medical care costs* (which include costs for office-based visits, hospital outpatient visits, emergency room visits, inpatient hospital stays, prescription drugs, dental visits, and home care) are defined as the sum of direct payments from all parties (out-of-pocket, private insurers, government, and other payers) for care provided during the year. For a primary independent variable, we identified obesity status on the basis of the constructed BMI through self-reported height and measure [29]. (Please note that because of confidentiality concerns and restrictions, the self-reported weight and height variables were not available from the public-access MEPS data sets.) Also, we categorized potential confounding factors into four categories to examine the impact of confounder adjustments on the magnitude of the cost estimates: 1) Demographic factors or cov1 (age, sex, and race/ethnicity), 2) Socioeconomic factors or cov2 (education, household income based on the federal poverty line, smoking status, and marital status), 3) Additional factors or cov3 (census region and insurance status), and 4) comorbidity conditions or cov4. *Comorbidity conditions* are defined as a continuous variable ranging from 0 to 10 by summing up 10 potential health consequences that can be caused be obesity. These conditions, called ORDs, which are defined by the Centers for Disease Control and Prevention, include hypertension, heart diseases (coronary heart disease, angina, myocardial infarction, others), stroke, cancer, diabetes, arthritis, and high cholesterol [30]. In this data set, children or adolescents (age $<$ 18 years) do not have any information on comorbidity conditions and