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The Burden of Obesity on Diabetes in the United States: Medical Expenditure Panel Survey, 2008 to 2012

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ABSTRACT

Background: Diabetes is one of the most prevalent and costly chronic diseases in the United States. **Objectives:** To analyze the risk of developing diabetes and the annual cost of diabetes for a US general population. **Methods:** Data from the Medical Expenditure Panel Survey, 2008 to 2012, were used to analyze 1) probabilities of developing diabetes and 2) annual total health care expenditures for diabetics. The age-, sex-, race-, and body mass index (BMI)-specific risks of developing diabetes were estimated by fitting an exponential survival function to age at first diabetes diagnosis. Annual health care expenditures were estimated using a generalized linear model with log-link and gamma variance function. Complex sampling designs in the Medical Expenditure Panel Survey were adjusted for. All dollar values are presented in 2012 US dollars. **Results:** We observed a more than 6 times increase in diabetes risks for class III obese (BMI $\geq$ 40 kg/m^2) individuals compared with normal-weight individuals. Using age 50 years as an example, we found a more than 3 times increase in annual health care expenditures for those with diabetes ($13,581) compared with those without diabetes ($3,954). Compared with normal-weight (18.5 $\leq$ BMI $<$ 25 kg/m^2) individuals, class II obese (35 $\leq$ BMI $<$ 40 kg/m^2) and class III obese (BMI $\geq$ 40 kg/m^2) individuals incurred an annual marginal cost of $628 and $756, respectively. The annual health care expenditure differentials between those with and without diabetes of age 50 years were the highest for individuals with class II ($12,907) and class III ($9,703) obesity. **Conclusions:** This article highlights the importance of obesity on diabetes burden. Our results suggested that obesity, in particular, class II and class III (i.e., BMI $\geq$ 35 kg/m^2) obesity, is associated with a substantial increase in the risk of developing diabetes and imposes a large economic burden.

Keywords: diabetes, economic burden, health care expenditures, obesity.

Introduction

Diabetes is one of the most prevalent and costly chronic diseases in the United States. In 2011, it was estimated that 20.8 million US adults (9%) lived with diabetes [1], and about 1.5 million new cases of diabetes were diagnosed [2]. Diabetes is not only detrimental to the health and productivity of those who suffer from it but also incurs substantial economic burden to them and to society. The total estimated cost of diagnosed diabetes in 2012 was $245 billion, including $69 billion in reduced productivity and $176 billion in direct medical costs [3].

Obesity is a significant risk factor of diabetes. It has been shown that 87% of US adults with diabetes are overweight or obese (body mass index [BMI] $\geq$ 25 kg/m^2) [4]. Moreover, previous studies have shown a strong association of overweight and obesity with the incidence of type 2 diabetes [5] and diabetes-related comorbidities [6], which lead to higher medical expenses for the obese population compared with the normal-weight population [7]. Therefore, it is important to better understand the association of obesity with the risk of developing diabetes and the medical expenditures associated with diabetes and diabetes-related comorbidities.

Previous studies have investigated the association of obesity with diabetes and suggested a positive relationship between obesity and the incidence of diabetes. Geiss et al. [8] analyzed the association between the time trend of obesity and the incidence of diabetes from 1980 to 2012. Narayan et al. [9] estimated the incidence of diabetes to predict the remaining lifetime risk of developing diabetes by BMI category, rather than the annual risks of developing diabetes. Using nationally representative data from 1997 to 2000, Leung et al. [10] computed the life-years lost and the lifetime health care expenditures associated with diabetes by age, sex, race, and BMI category. In this study, we report the annual risks of developing diabetes by age, sex, race, and BMI category, the results of which can be used to inform future cost-effectiveness analyses of obesity prevention programs or diabetes prevention and control interventions.

There is a substantial amount of literature addressing the costs associated with diabetes. Trogdon and Hylands [11] analyzed annual medical expenditures as a function of duration of

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diabetes. Zhuo et al. [12] computed the excess medical spending attributable to diabetes, differentiating by types of medical services. Other studies have shown that BMI is associated with increased medical expenditures for patients with and without diabetes. A study in Spain showed that an increase in BMI among patients with type 2 diabetes was associated with an increase in direct health care costs [13]. Cawley et al. [14] used an instrumental variable approach to examine the causal relationship between BMI and savings in medical expenditures by diabetes status. Our study will be the first to compare the differences in total health care expenditures by diabetic status across BMI category.

The purpose of this study was to examine the age-, sex-, and race-specific risks of diabetes and the annual total health care expenditures by BMI category for both those with and without diabetes in the US population. Because obesity is one of the most important modifiable risk factors of diabetes, our study findings will help inform future decision analyses in diabetes prevention studies when the BMI category is considered an important determinant of outcomes.

Methods

Data

We used data from the Medical Expenditure Panel Survey (MEPS) Household Component (HC) Full-Year Consolidated Data files collected by the Agency for Healthcare Research and Quality and the National Center for Health Statistics [15]. The MEPS is a complex multistage probability sample design data set that provides nationally representative data containing detailed information such as health care use, expenditures, sources of payment, and health insurance coverage for the US civilian noninstitutionalized population [16]. In addition, information regarding respondents' health status, demographic characteristics, and insurance coverage is provided in the HC data files. The MEPS HC data files were merged with the Medical Conditions files to supplement the data set with diabetes-related comorbidities.

Analytic Cohort

We targeted US adults aged 20 years or older in our study cohort. The analytic cohort was assembled by excluding the following people: 1) individuals with missing values on the target variables; 2) underweight (BMI < 18.5 kg/m^2) individuals, because they may include heavy smokers or persons with severe chronic diseases and malignancies [17]; 3) women pregnant at the time of survey, because their BMI levels are unstable during pregnancy [17,18]; 4) individuals diagnosed with cancer because their BMI levels are less stable due to cancer treatment and appetite loss [18,19]; and 5) those with diabetes who reported inconsistent diabetes status across MEPS 2008 to 2012.

Models and Analyses

The MEPS collected information about diabetes by asking participants whether they had ever been diagnosed with diabetes and when their first diagnosis was. The probabilities of developing diabetes were estimated by fitting an exponential survival function to age at first diabetes diagnosis separately for males and females [10]). Covariates included age at survey (20–29, 30–39, 40–49, 50–59, 60–69, and ≥70 years), race (white, black, and other), and BMI category (normal weight [$18.5 \leq$ BMI < 25 kg/m^2], overweight [$25 \leq$ BMI < 30 kg/m^2], class I obese [$30 \leq$ BMI $<$ 35 kg/m^2], class II obese [$35 \leq$ BMI < 40 kg/m^2], and class III obese [BMI ≥ 40 kg/m^2]) [20] on the basis of self-reported BMI at survey. We then predicted the probabilities of developing diabetes for each individual.

We ran a regression of BMI at survey on duration of diabetes, age category, and race category separately for males and females (see details in part A of the Appendix in Supplemental Materials found at 10.1016/j.jval.2016.08.735). We then predicted BMI at diabetes diagnosis for each individual with diabetes. On the basis of these predicted BMIs at diagnosis for individuals with diabetes and BMI at survey for individuals without diagnosis, we grouped the population into the five BMI categories using the aforementioned criteria [20]. The predicted probabilities of developing diabetes (computed according to the model described in the previous paragraph) were then averaged across individuals in each BMI category to obtain the mean probabilities of developing diabetes for each BMI category.

Annual total health care expenditures were estimated using a generalized linear model with log-link and gamma variance function [21]. We controlled for diabetes status, duration of diabetes, duration of diabetes-squared, age (at survey), age-squared, interactions between diabetes status with age and with age-squared, sex, race (white, black, Hispanic, Asian, and other), education level (less than high school, high school diploma, college degree, graduate degree, and other degree), household income level as a percentage of the federal poverty level (<100%, 100%–199%, 200%–399%, and ≥400%), census region (northeast, midwest, south, and west), primary source of health insurance (Medicaid, Medicare, private insurance, other public insurance, and uninsured), diabetes-related comorbidities (heart disease, stroke, congestive heart failure, hypertension, high cholesterol, and renal failure), BMI category (normal weight, overweight, and class I, II, and III obesity) on the basis of self-reported BMI at survey, current smoker or not, survey year dummies (2009, 2010, 2011, and 2012), and interactions between BMI categories and diabetes status. We added the last covariate in addition to the covariates included in the study by Trogdon and Hylands [11] to test for differences in the effect of BMI categories on health care expenditures between individuals with and without diabetes.

An alternative model using a two-part model with a logit model in the first part and a separate generalized linear model with log-link and gamma variance function in the second part was also constructed. Sensitivity analyses using the inverse of BMI as a continuous variable in the cost estimation were also performed to examine whether our main conclusion was sensitive to the specification of BMI as a categorical versus a continuous variable. We computed health care cost differentials associated with diabetes by taking the differences between the predicted health care expenditures of those with and without diabetes for each age, sex, race, and BMI category.

The MEPS data do not allow us to differentiate between type 1 and 2 diabetes. Because 78% of diabetes incidence before the age of 20 years is type 1 diabetes [22], we conducted sensitivity analyses for the risks of developing diabetes and costs associated with diabetes by excluding diabetic patients who reported to be younger than 20 years at diabetes diagnosis.

Statistical Analyses

We merged multiple years (2008–2012) of the MEPS data to increase the sample size for analysis, following the analytic guidelines published on the MEPS Web site. A common variance structure is specified across years that accurately reflects the complex sample design of the MEPS [23]. The complex sampling designs in the MEPS were adjusted for in all the analyses. All dollar values were deflated using the Personal Health Care Expenditure Price Index and are presented at 2012 price levels [24]. STATA version 12 (StataCorp, College Station, TX) was used in all the analyses.