Revisiting the Obesity Paradox in Health Care Expenditures Among Adults With Diabetes

Virender Kumar[1] *and William Encinosa*[2,3]

Recent studies of diabetes suggest an obesity paradox: mortality risk increases with weight in people without diabetes but decreases with weight in people with diabetes. A recent study also reports the paradox more generally with health care utilization. Whether this paradox in health care utilization and spending is causal or instead the result of empirical biases and confounding factors has yet to be examined in detail. This study set out to examine changes in the relationship between BMI and health care expenditures in populations with versus without diabetes, controlling for confounding risk factors. It found that the obesity paradox does not exist and is the result of statistical biases such as confounding and reverse causation. Obesity is not cost-saving for people with diabetes. Thus, insurers and physicians should renew efforts to prevent obesity in people with diabetes.

BMI is positively associated with mortality in the general population (1–5) and with the risk of developing type 2 diabetes and other diseases (e.g., cardiovascular disease [CVD], hypertension, coronary artery disease, stroke, and heart failure) (6–12). Obesity accounts for 80–85% of the overall risk of type 2 diabetes (13). However, among people with type 2 diabetes, numerous studies (12,14–20) have shown a reduction in mortality risk among those with overweight and obesity compared with those of normal weight, a phenomenon often called the "obesity paradox." The coronavirus disease 2019 (COVID-19) pandemic has renewed interest in the obesity paradox because both obesity and diabetes are significant predictors of mortality from COVID-19, and any accurate prediction model requires one to take into account the interaction between obesity and diabetes (i.e., the obesity paradox).

One explanation for the obesity paradox is the failure to address confounding variables and reverse causation biases in studies of the relationship between obesity and the risk of mortality (21). For example, because smoking is negatively associated with BMI and positively associated with the risk of mortality, appropriate analytical adjustment for the confounding effect of smoking status is important (22). Some chronic diseases such as cancer can lead to both weight loss and elevated risk of death (23–26), thus, leading to an underestimation of the effect of weight on mortality risk (i.e., reverse causation). Another explanation is that diabetes among people without obesity may be the result of a different and possibly more severe disease process (e.g., CVD) (14). If these factors are not accounted for, one can expect to see what appears to be an obesity paradox in mortality data.

A recent article extended the obesity paradox from mortality to morbidity (27). It found an obesity paradox in terms of health care expenditures; compared with people of normal weight, people with obesity were found to have average total health care expenditures that were significantly lower if they had diabetes and nonsignificantly higher if they did not have diabetes. This expenditure paradox may again be the result of a failure to control adequately for confounding biases.

In this article, we revisit the obesity paradox for expenditures using the same Medical Expenditure Panel Survey (MEPS) data (27), but updated for the years 2008–2016. Our study built on the previous study in the following way to control for possible confounding: *1*) we restricted our study to people with type 2 diabetes; *2*) we designated people as having diabetes who reported not having it in the main survey but reported having it in the MEPS diabetes care survey (DCS), a

[1]Westat, Rockville, MD; [2]Agency for Healthcare Research and Quality, Rockville, MD; [3]Georgetown University, Washington, DC

Corresponding author: William Encinosa, william.encinosa@ahrq.hhs.gov

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self-administered supplement survey; and *3*) we excluded from our expenditure analyses women with gestational diabetes mellitus (GDM), smokers, and people with cancer or CVD diagnoses. In this cleaner sample of diabetes cases, we found no obesity paradox in expenditures.

Research Design and Methods

Data Sample

The MEPS is a nationally representative, annual survey sponsored by the Agency for Healthcare Research and Quality. A new panel is introduced every year, and people in each panel are followed for 2 years. Every year, the survey interviews about 15,000 households to get a nationally representative sample of the civilian, noninstitutionalized U.S. population. It collects information on health status, health insurance coverage, and health care utilization and expenditures for each household over the course of 2 years.

Our study used MEPS data for the years 2008–2016, which yielded data on 210,797 people with a positive survey weight and a valid BMI value (>0). Our analytic sample included people who either were never diagnosed with diabetes or were diagnosed with type 2 diabetes; we excluded *1*) those who were taking only insulin and were <30 years of age at the time of diabetes diagnosis (n = 469) and *2*) those who reported being pregnant and who were diagnosed with diabetes during the survey year (n = 11). A total of 210,317 individuals remained in our analytical sample. For additional analyses, we excluded those who had ever been smokers and those who had ever been diagnosed with cancer or cardiovascular diseases (i.e., myocardial infarction [MI], angina, coronary heart disease [CHD], stroke, or other heart disease) (32% of the sample). The sample for additional analyses thus included 142,551 individuals. From this point onward, we will refer to the analytical sample as the ANS sample and the sample for additional analyses as the ADS sample.

Measures

Health Care Utilization

We used the seven health care utilization measures listed below, adjusted for inflation.

- Total health care expenditures ≥$0. This includes all health care expenditures, including expenditures for prescription medicines
- Combined expenditures, category 1 ≥$0 (Expense1). All expenditures for inpatient discharges, prescription medicines, emergency department visits, and visits to physicians in offices and outpatient departments
- Combined expenditures, category 2 ≥$0 (Expense2). All expenditures for inpatient discharges, prescription medicine, emergency department visits, and visits to all office-based providers in offices (OBD) and outpatient departments (OP)
- Emergency room (ER) visit expenditures ≥$0. Facility and physician expenditures for visits to emergency departments
- Expenditure for inpatient stays ≥$0. Facility and physician expenditures for all hospital inpatient discharges
- All OBD visit expenditures ≥$0. Expenditures for visits to office-based health care providers, including physicians and nonphysicians
- All outpatient visit expenditures ≥$0. Facility and provider expenditures for OP visits

Health Status and Sociodemographics

We used BMI to categorize individuals' weight using five dummy variables—underweight: BMI <20 kg/m^2, normal weight: BMI 20 to <25 kg/m^2, overweight: BMI 25 to <30 kg/m^2, obese: BMI 30 to <35 kg/m^2, and severely obese: BMI ≥35 kg/m^2. Diabetes was self-reported either in the MEPS household survey or the MEPS DCS. We used individuals' age in years and reported smoking status as a dummy variable.

Individuals' health insurance status was indicated via dummy variables: any private insurance (without non-Medicare public insurance), Medicare insurance only, any public insurance (with or without Medicare or private insurance), and uninsured. Private coverage meant covered by private third parties or Tricare (uniformed services insurance program). A five-category variable controlled for individuals' education in terms of years of education. Education categories were postgraduate (>16 years), college graduate (16 years), some college (13–15 years), high school graduate (12 years), and less than high school (<12 years). Other indicator variables included seven self-reported chronic conditions, including hypertension, asthma, stroke, emphysema, CHD, cancer, and MI; sex; race/ethnicity, including Asian, Hispanic, African American, and Non-Hispanic other races; household income level as percentage of the federal poverty level, including ≥200, 125 to <200, 100 to <125, or <100%; and census region, including West, Midwest, South, and Northeast. We accounted for year-specific fixed effects by using an indicator variable for each data year.

Statistical Analysis

This study used Stata SE, v. 15.1, statistical software (Stata Corporation, College Station, TX) to predict health care expenditures accounting for the MEPS complex survey design. Our analyses examined how the association between BMI and each of the seven health care expenditure measures varied with diabetes status.

Analyses used a two-part model because of highly skewed expenditures. Logistic regression predicted the likelihood of individuals to have positive expenditures. Generalized linear regression using a γ distribution and log link predicted the expenditures among those with positive expenditures. Using combined estimates from the two parts for each type of health care utilization, we used the Stata margin command to predict expenditures and marginal effects by BMI and diabetes status at sampled values of all other predictors. We compared differences in health care expenditures between individuals with and without diabetes within the same BMI category. We also compared differences in health care expenditures between individuals with normal weight and those in other weight categories separately for people with and without diabetes. In addition, we compared the difference observed between any two BMI categories among people with diabetes with the difference observed between the same two BMI categories among individuals without diabetes. We refer to this comparison as the "difference-in-differences estimate."

In all of the models, we also included interactions of diabetes status with the BMI categorical variable, as well as age. We predicted expenditures separately for individuals in both samples: ANS (excluding those with type 1 diabetes or GDM) and ADS (all in the ANS sample excluding current smokers and individuals with cancer or cardiovascular disease).

Results

Table 1 presents demographic characteristics of the ANS and ADS samples. In the ANS sample, there were 210,317 adults ≥18 years of age with a positive survey weight in the MEPS consolidated public use files for years 2008–2016. A total of 21,532 were diagnosed with type 2 diabetes, and the rest had no diabetes diagnosis history (Table 1). Compared with people with type 2 diabetes, people with no diabetes diagnosis were younger and more likely to be male and non-Hispanic other or Asian, have higher household income and education, have any private insurance (private or private with Medicare) or no insurance, reside in the West or Northeast region, and have a BMI in the overweight category or lower. They were less likely to be a smoker or to be diagnosed with any of the seven chronic diseases. In each of the seven expenditure measures, individuals with type 2 diabetes had average health care expenditures higher than those who were never diagnosed for diabetes. Those reporting that they had no cancer and that they were not a current smoker had relatively lower utilization levels for each of the six health care provider types. Average utilization of five of the six provider services was higher among older versus younger adults.

Compared with people in the ANS sample, people in the ADS sample were younger, more educated, more likely to have any private coverage, and healthier, with higher income and relatively lower average expenditures of each type.

Across all seven expenditure measures in each sample, those with type 2 diabetes had average expenditures higher than those without diabetes for any given BMI level. Compared with the ANS sample, people in the ADS sample had lower average expenditures for a given BMI category, by diabetes status and expenditure measure (Supplementary Table S1). Among individuals without diabetes in the ANS sample, normal-weight people had the lowest unadjusted average expenditures, but did not significantly differ from underweight people in all expenditure measures or from overweight in four measures (total, ER, inpatient stays, and OBD) (Supplementary Table S2). On the contrary, among people with diabetes, the overweight category had the lowest average expenditures for three expenditure measures (total, expense1, and expense2), and the obese category had the lowest average expenditures for the remaining four measures (ER, inpatient stays, OBD, and OP). However, in each measure, average expenditures for the normal-weight group did not differ significantly from the lowest average figures.

Similar to the ANS, people with diabetes, in the ADS, had average expenditures higher than those without diabetes for a given BMI category and expenditure measure. Among individuals without diabetes in the ADS sample, the normal-weight group had average expenditures lower than the average expenditures of those in each higher-weight category across all seven measures (Supplementary Table S3). Average expenditures of the normal-weight group were significantly less than those of the obese and severely obese groups in each of the seven measures, and those of the overweight group only in the case of ER expenditures. However, among

TABLE 1 Characteristics of the Study Sample

Characteristics	Respondents (Excluding People With Type 1 Diabetes or GDM)					
				Excluding Smokers and People With Cancer or CVD		
	All (*N* = 210,317)	With Diabetes (*N* = 21,532 [10.2%])	Without Diabetes (*N* = 188,785 [89.8%])	All (*N* = 142,551)	With Diabetes (*N* = 10,437 [7.3%])	Without Diabetes (*N* = 132,114 [92.7%])
Age, years, mean (SE)	46.8 (0.2)	61.6 (0.2)	45.3 (0.18)	42.8 (0.1)	57.8 (0.2)	41.7 (0.1)
Female, % (SE)	51.4 (0.2)	50.1 (0.6)	51.6 (0.2)	52.3 (0.2)	51.4 (0.9)	52.4 (0.2)
Family income as a percentage of FPL, % (SE)						
≥200%	70.5 (0.5)	63.1 (0.8)	71.2 (0.5)	73.7 (0.5)	66.9 (0.9)	74.1 (0.5)
125 to <200%	13.3 (0.2)	16.4 (0.4)	12.9 (0.2)	12.3 (0.2)	15.1 (0.5)	12.1 (0.2)
100 to <125%	4.2 (0.1)	6.0 (0.2)	4.1 (0.1)	3.7 (0.1)	5.3 (0.3)	3.5 (0.1)
<100%	12.0 (0.3)	14.5 (0.5)	11.8 (0.3)	10.4 (0.3)	12.7 (0.6)	10.2 (0.3)
Education level, % (SE)						
5+ years of college	9.6 (0.3)	6.5 (0.4)	9.9 (0.3)	10.5 (0.3)	7.0 (0.6)	10.8 (0.3)
4 years of college	15.8 (0.3)	10.0 (0.4)	16.4 (0.3)	17.8 (0.3)	11.3 (0.6)	18.3 (0.3)
Some college	24.0 (0.2)	22.2 (0.6)	24.1 (0.2)	24.0 (0.3)	22.8 (0.8)	24.0 (0.3)
High school	25.3 (0.3)	29.8 (0.6)	24.8 (0.2)	22.6 (0.3)	28.2 (0.8)	22.2 (0.3)
Less than high school	25.4 (0.3)	31.6 (0.6)	24.8 (0.3)	25.1 (0.3)	30.7 (0.7)	24.7 (0.3)
Race/ethnicity, % (SE)						
Other	72.3 (0.8)	68.7 (1.0)	72.7 (0.8)	67.8 (0.9)	61.7 (1.2)	68.2 (0.9)
Hispanic	12.9 (0.7)	13.3 (0.9)	12.9 (0.7)	15.8 (0.8)	17.1 (1.1)	15.7 (0.8)
Asian	4.6 (0.4)	4.3 (0.4)	4.6 (0.4)	5.9 (0.4)	6.1 (0.6)	5.9 (0.4)
Black	10.2 (0.5)	13.7 (0.8)	9.9 (0.5)	10.5 (0.5)	15.1 (0.9)	10.2 (0.5)
Health insurance,* % (SE)						
Any private	66.1 (0.5)	55.4 (0.7)	67.2 (0.6)	70.3 (0.6)	61.0 (0.9)	71.0 (0.6)
Medicare only	7.4 (0.2)	17.5 (0.4)	6.4 (0.2)	4.5 (0.1)	12.5 (0.5)	3.9 (0.1)
Any public	13.2 (0.4)	19.9 (0.6)	12.6 (0.4)	11.4 (0.3)	17.0 (0.7)	11.0 (0.3)
Uninsured	13.2 (0.3)	7.2 (0.3)	13.8 (0.4)	13.8 (0.4)	9.4 (0.5)	14.1 (0.4)
Chronic conditions, % (SE)						
Hypertension	32.9 (0.3)	77.9 (0.5)	28.3 (0.3)	24.4 (0.3)	71.1 (0.8)	21.2 (0.3)
Asthma	9.4 (0.1)	13.4 (0.4)	9.0 (0.2)	8.2 (0.2)	10.1 (0.5)	8.1 (0.2)
Stroke	3.7 (0.1)	12.1 (0.4)	2.8 (0.1)	–	–	–
Emphysema	2.2 (0.1)	5.2 (0.3)	1.9 (0.1)	0.7 (0.0)	1.7 (0.2)	0.6 (0.0)
CHD	13.8 (0.2)	32.7 (0.6)	11.8 (0.2)	–	–	–
MI	3.7 (0.1)	13.6 (0.4)	2.7 (0.1)	–	–	–
Cancer	10.5 (0.2)	18.9 (0.5)	9.7 (0.2)	–	–	–
Smoker, % (SE)	15.6 (0.3)	13.8 (0.4)	15.8 (0.3)	–	–	–
Region						
Northeast	18.1 (0.6)	17.2 (0.7)	18.2 (0.6)	18.4 (0.6)	16.9 (0.7)	18.5 (0.6)
Midwest	21.5 (0.6)	21.4 (0.8)	21.5 (0.6)	20.3 (0.6)	19.8 (0.9)	20.3 (0.6)
South	37.1 (0.7)	41.4 (1.0)	36.6 (0.7)	36.2 (0.8)	41.4 (1.1)	35.9 (0.8)
West	23.3 (0.6)	20.0 (0.8)	21.5 (0.7)	25.1 (0.7)	22.0 (1.0)	25.3 (0.7)
BMI, kg/m^2,† % (SE)						
<20	5.5 (0.1)	1.5 (0.1)	5.9 (0.3)	5.6 (0.1)	1.0 (0.1)	5.9 (0.1)
20 to <25	30.2 (0.3)	12.6 (0.4)	32.1 (0.3)	31.3 (0.3)	11.8 (0.5)	32.7 (0.3)
25 to <30	34.2 (0.2)	30.3 (0.5)	34.6 (0.2)	34.1 (0.2)	29.8 (0.7)	34.4 (0.3)
30 to <35	17.9 (0.2)	27.2 (0.5)	16.9 (0.2)	17.4 (0.2)	28.4 (0.7)	16.7 (0.2)
≥35	12.1 (0.2)	28.5 (0.6)	10.5 (0.2)	11.5 (0.2)	29.0 (0.7)	10.3 (0.2)

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TABLE 1 Characteristics of the Study Sample *(Continued)*

Characteristics	Respondents (Excluding People With Type 1 Diabetes or GDM)					
				Excluding Smokers and People With Cancer or CVD		
	All (*N* = 210,317)	With Diabetes (*N* = 21,532 [10.2%])	Without Diabetes (*N* = 188,785 [89.8%])	All (*N* = 142,551)	With Diabetes (*N* = 10,437 [7.3%])	Without Diabetes (*N* = 132,114 [92.7%])
Health care expenditures, $, mean (SE)						
Total‡	4,847 (54)	11,291 (218)	4,189 (51)	3,197 (42)	7,300 (228)	2,915 (42)
Expense1§	3,767 (45)	9,318 (188)	3,201 (41)	2,407 (35)	6,076 (212)	2,156 (34)
Expense2‖	4,284 (49)	10,242 (202)	3,676 (46)	2,782 (39)	6,699 (224)	2,514 (38)
ER visits	194 (4)	311 (10)	183 (4)	141 (4)	217 (14)	135 (4)
Inpatient stay	1,301 (28)	3,110 (111)	1,116 (27)	726 (19)	1,454 (97)	676 (19)
OBD visits	1,194 (15)	2,256 (52)	1,086 (15)	852 (12)	1,547 (62)	804 (12)
OP visits	450 (13)	820 (41)	412 (13)	315 (13)	608 (64)	295 (13)

*Any private includes any coverage through a private insurer or Tricare but not combined with a non-Medicare public plan any time during the year; any public includes any coverage through non-Medicare public plans (e.g., Medicaid or State Children's Health Insurance Program); Medicare includes coverage through Medicare only; and uninsured includes no coverage throughout the year. †BMI <20 kg/m^2 = underweight, 20 to <25 kg/m^2 = normal weight, 25 to <30 kg/m^2 = overweight, 30 to <35 kg/m^2 = obese, and ≥35 kg/m^2 = severely obese. ‡Includes expenditures for all health services, including dental, other medical, home health, and so forth. §Includes expenditures for inpatient stays, ER visits, office-based physician visits, outpatient department physician visits, and prescription medicine. ‖Includes expenditures for inpatient stays, ER visits, prescription medicine, and all office-based and outpatient department visits. FPL, federal poverty level; OBD, all office-based providers; OP, all outpatient department providers.

people with diabetes in the ADS sample, the BMI category with the lowest average weight varied across expenditure measures as follows: the overweight group had the lowest average total and expense2 expenditures; the normal-weight group had the lowest average expense1, inpatient, and OP expenditures; the obese group had the lowest average ER expenditures; and the underweight group had the lowest average OBD expenditures. In all measures, the category with the lowest expenditures did not have expenditures that were significantly different from those of the normal-weight group.

Table 2 presents adjusted average expenditures by diabetes status and BMI category for each expenditure measure within the ANS and ADS samples. Tables 3 and 4 present differences in the adjusted average expenditures of the ANS and ADS samples, respectively. Similar to the unadjusted expenditures, for any given BMI category, average adjusted expenditures among people with diabetes was higher than those of people without diabetes in each model of the two samples (Tables 3 and 4). In the ANS sample (Table 3), among people in normal- and higher-weight groups, the overweight group had the lowest average expenditures in three measures (total, expense1, and expense2), and the obese group had the lowest average expenditures in the remaining four measures (ER visits, inpatient stays, OBD visits, and OP visits). However, among people without diabetes, the normal-weight group had the lowest expenditures across all measures. Compared with average expenditures of normal-weight people, the average expenditures of overweight people were lower in each of three measures (total, by $306, $P < 0.389$; expense1, by $136, $P < 0.658$; and expense2, by $158, $P < 0.645$) and were higher among people without diabetes (total, by $17, $P < 0.890$; expense1, by $74, $P < 0.465$; and expense2, by $111, $P < 0.0.310$) (Table 3). However, these differences were not statistically significant. The difference between people with and without diabetes in the difference in average expenditures for the overweight group versus the normal-weight group was not significant for any of the three measures (total, by $322, $P < 0.322$; expense1, by $209, $P < 0.505$; and expense2, by $269, $P < 0.433$).

Compared with average of expenditures for inpatient stays and OBD visits for normal-weight people, the respective average for the obese group was lower among people with diabetes (inpatient stays, by $145, $P < 0.429$, and OBD, by $8, $P < 0.942$) but was higher among people without diabetes (inpatient stays, by $73, $P < 0.274$, and OBD, by $108, $P < 0.001$). The difference was significant only for OBD among people

TABLE 2 Adjusted Expenditures per Person by Health Care Setting and BMI Category in People With and Without Diabetes

BMI Category*		Average Expenditures per Person, $													
		Total†		Expense1‡		Expense2§		ER Visits		Inpatient Stays		OBD Visits		OP Visits	
		Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*
All respondents including smokers and those with cancer or CVD (ANS sample)															
With diabetes	Underweight	11,694 (1,891)	0.000	9,634 (1,758)	0.000	10,358 (1,764)	0.000	295 (58)	0.000	4,279 (820)	0.000	1,601 (306)	0.000	993 (466)	0.034
	Normal	7,599 (360)	0.000	6,182 (310)	0.000	6,960 (345)	0.000	307 (37)	0.000	1,849 (184)	0.000	1,684 (104)	0.000	923 (144)	0.000
	Overweight	7,293 (256)	0.000	6,046 (230)	0.000	6,802 (254)	0.000	266 (22)	0.000	1,747 (133)	0.000	1,737 (85)	0.000	791 (100)	0.000
	Obese	7,809 (332)	0.000	6,517 (341)	0.000	7,241 (335)	0.000	238 (20)	0.000	1,705 (123)	0.000	1,676 (74)	0.000	698 (66)	0.000
	Severely obese	8,599 (285)	0.000	7,221 (255)	0.000	8,042 (277)	0.000	250 (16)	0.000	1,712 (118)	0.000	1,937 (93)	0.000	947 (125)	0.000
Without diabetes	Underweight	4,652 (182)	0.000	3,407 (151)	0.000	3,885 (158)	0.000	203 (15)	0.000	1,303 (92)	0.000	1,109 (52)	0.000	390 (32)	0.000
	Normal	4,453 (95)	0.000	3,354 (80)	0.000	3,830 (85)	0.000	179 (6)	0.000	1,155 (49)	0.000	1,101 (22)	0.000	370 (20)	0.000
	Overweight	4,470 (88)	0.000	3,427 (74)	0.000	3,941 (82)	0.000	184 (6)	0.000	1,217 (50)	0.000	1,133 (22)	0.000	416 (17)	0.000
	Obese	4,642 (96)	0.000	3,589 (82)	0.000	4,140 (91)	0.000	200 (7)	0.000	1,228 (47)	0.000	1,209 (28)	0.000	458 (30)	0.000
	Severely obese	5,264 (139)	0.000	4,087 (113)	0.000	4,707 (126)	0.000	224 (9)	0.000	1,418 (68)	0.000	1,274 (35)	0.000	610 (45)	0.000
Excluding smokers and those with cancer or CVD (ADS sample)															
With diabetes	Underweight	6,548 (1,882)	0.001	5,728 (1,948)	0.004	5,876 (1,904)	0.002	323 (106)	0.003	2,181 (1,154)	0.060	688 (118)	0.000	773 (484)	0.112
	Normal	5,120 (383)	0.000	4,171 (312)	0.000	4,663 (358)	0.000	295 (66)	0.000	848 (153)	0.000	1,163 (120)	0.000	514 (104)	0.000
	Overweight	5,235 (280)	0.000	4,350 (248)	0.000	4,846 (272)	0.000	239 (33)	0.000	1,040 (144)	0.000	1,190 (77)	0.000	588 (124)	0.000
	Obese	5,902 (387)	0.000	4,977 (399)	0.000	5,471 (385)	0.000	207 (32)	0.000	1,056 (136)	0.000	1,246 (91)	0.000	492 (70)	0.000
	Severely obese	6,688 (339)	0.000	5,614 (315)	0.000	6,202 (335)	0.000	228 (22)	0.000	1,158 (131)	0.000	1,467 (99)	0.000	833 (194)	0.000
Without diabetes	Underweight	2,991 (151)	0.000	2,120 (135)	0.000	2,441 (140)	0.000	137 (15)	0.000	690 (88)	0.000	755 (41)	0.000	255 (29)	0.000
	Normal	2,944 (80)	0.000	2,148 (70)	0.000	2,493 (76)	0.000	119 (5)	0.000	634 (33)	0.000	791 (16)	0.000	263 (18)	0.000
	Overweight	2,926 (62)	0.000	2,170 (51)	0.000	2,537 (58)	0.000	135 (6)	0.000	689 (33)	0.000	814 (19)	0.000	304 (18)	0.000
	Obese	2,976 (67)	0.000	2,224 (57)	0.000	2,613 (64)	0.000	150 (8)	0.000	710 (39)	0.000	858 (23)	0.000	303 (18)	0.000
	Severely obese	3,456 (104)	0.000	2,653 (91)	0.000	3,066 (99)	0.000	170 (9)	0.000	852 (57)	0.000	911 (30)	0.000	415 (36)	0.000

*BMI <20 kg/m^2 = underweight, 20 to <25 kg/m^2 = normal weight, 25 to <30 kg/m^2 = overweight, 30 to <35 kg/m^2 = obese, and ≥35 kg/m^2 = severely obese. †Includes expenditures for all health services including dental, other medical, home health, and so forth. ‡Includes expenditures for inpatient stays, ER visits, office-based physician visits, outpatient department physician visits, and prescription medicine. §Includes expenditures for inpatient stays, ER visits, prescription medicine, and all office-based and outpatient department visits.

TABLE 3 Differences in Adjusted Expenditures per Person in the Analytical Sample (ANS)

BMI Category*		Differences in Average Expenditures per Person, $													
		Total†		Expense1‡		Expense2§		ER Visits		Inpatient Stays		OBD Visits		OP Visits	
		Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*
Between respective BMI category and normal-weight group															
With diabetes	Underweight	4,095 (1,826)	0.026	3,452 (1,681)	0.041	3,398 (1,690)	0.046	−11 (62)	0.856	2,430 (813)	0.003	−83 (307)	0.787	70 (463)	0.879
	Overweight	−306 (354)	0.389	−136 (307)	0.658	−158 (341)	0.645	−41 (37)	0.273	−103 (201)	0.611	53 (109)	0.632	−132 (128)	0.305
	Obese	210 (433)	0.629	335 (398)	0.402	281 (421)	0.505	−69 (39)	0.081	−145 (183)	0.429	−8 (104)	0.942	−225 (119)	0.061
	Severely obese	1,000 (448)	0.027	1,039 (377)	0.006	1,082 (415)	0.010	−56 (37)	0.132	−137 (217)	0.527	253 (130)	0.053	24 (144)	0.870
Without diabetes	Underweight	199 (198)	0.316	53 (168)	0.752	55 (177)	0.757	24 (15)	0.112	148 (95)	0.120	8 (51)	0.872	20 (38)	0.593
	Overweight	17 (120)	0.890	74 (101)	0.465	111 (107)	0.301	5 (8)	0.557	62 (63)	0.330	32 (24)	0.188	46 (23)	0.051
	Obese	189 (129)	0.144	236 (111)	0.035	309 (121)	0.011	21 (9)	0.029	73 (67)	0.274	108 (30)	0.000	88 (34)	0.010
	Severely obese	811 (151)	0.000	733 (139)	0.000	876 (147)	0.000	45 (10)	0.000	262 (87)	0.003	173 (38)	0.000	240 (45)	0.000
Between people with and without diabetes															
	Underweight	7,043 (1,903)	0.000	6,227 (1,768)	0.001	6,473 (1,778)	0.000	92 (60)	0.124	2,976 (829)	0.000	492 (318)	0.123	603 (467)	0.198
	Normal	3,146 (371)	0.000	2,828 (327)	0.000	3,130 (360)	0.000	127 (39)	0.001	694 (200)	0.001	583 (105)	0.000	553 (143)	0.000
	Overweight	2,824 (256)	0.000	2,619 (232)	0.000	2,861 (255)	0.000	82 (22)	0.000	530 (132)	0.000	604 (86)	0.000	375 (100)	0.000
	Obese	3,167 (337)	0.000	2,927 (350)	0.000	3,101 (341)	0.000	38 (21)	0.072	476 (129)	0.000	467 (78)	0.000	241 (70)	0.001
	Severely obese	3,335 (329)	0.000	3,135 (292)	0.000	3,336 (318)	0.000	27 (18)	0.135	294 (135)	0.030	663 (99)	0.000	336 (133)	0.012
Between people with and without diabetes, less normal‖															
	Underweight	3,897 (1,842)	0.036	3,398 (1,693)	0.046	3,343 (1,705)	0.051	−35 (64)	0.578	2,282 (823)	0.006	−91 (315)	0.773	50 (461)	0.914
	Overweight	−322 (352)	0.362	−209 (314)	0.505	−269 (342)	0.433	−45 (39)	0.242	−165 (209)	0.433	21 (109)	0.848	−178 (128)	0.165
	Obese	21 (443)	0.963	99 (415)	0.812	−28 (435)	0.948	−89 (39)	0.024	−218 (199)	0.275	−116 (107)	0.281	−312 (123)	0.012
	Severely obese	189 (490)	0.700	306 (427)	0.474	206 (463)	0.657	−101 (38)	0.009	−400 (248)	0.108	80 (138)	0.562	−217 (152)	0.156

*BMI <20 kg/m^2 = underweight, 20 to <25 kg/m^2 = normal weight, 25 to <30 kg/m^2 = overweight, 30 to <35 kg/m^2 = obese, and ≥35 kg/m^2 = severely obese. †Includes expenditures for all health services, including dental, other medical, home health, and so forth. ‡Includes expenditures for inpatient stays, ER visits, office-based physician visits, outpatient department physician visits, and prescription medicine. §Includes expenditures for inpatient stays, ER visits, prescription medicine, and all office-based and outpatient department visits. ‖Estimate of people in respective BMI category minus estimate for people in normal-weight group.

TABLE 4 Differences in Adjusted Expenditures per Person in the Sample Excluding Smokers and Those With Cancer or CVD (ADS)

BMI Category*		Differences in Average Expenditures per Person, $													
		Total†		Expense1‡		Expense2§		ER Visits		Inpatient Stays		OBD Visits		OP Visits	
		Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*	Mean (SE)	*P*
Between respective BMI category and normal-weight group															
With diabetes	Underweight	1,428 (1,835)	0.437	1,557 (1,908)	0.415	1,213 (1,854)	0.514	28 (119)	0.814	1,333 (1,119)	0.235	−475 (144)	0.001	259 (488)	0.596
	Overweight	115 (365)	0.754	179 (306)	0.561	183 (340)	0.591	−56 (68)	0.413	193 (185)	0.298	27 (116)	0.817	73 (130)	0.574
	Obese	782 (511)	0.127	806 (487)	0.100	808 (497)	0.106	−88 (66)	0.188	208 (193)	0.282	82 (121)	0.496	−22 (97)	0.821
	Severely obese	1,568 (468)	0.001	1,443 (398)	0.000	1,539 (449)	0.001	−67 (68)	0.330	310 (200)	0.123	303 (149)	0.043	319 (185)	0.086
Without diabetes	Underweight	47 (170)	0.783	−28 (155)	0.855	−52 (163)	0.751	19 (16)	0.236	55 (91)	0.545	−36 (42)	0.394	−8 (34)	0.819
	Overweight	−19 (98)	0.849	22 (85)	0.798	44 (92)	0.635	16 (7)	0.032	55 (43)	0.199	24 (21)	0.274	41 (23)	0.084
	Obese	32 (98)	0.743	75 (87)	0.386	119 (93)	0.202	31 (9)	0.001	76 (49)	0.124	68 (25)	0.007	41 (19)	0.037
	Severely obese	512 (123)	0.000	505 (112)	0.000	573 (119)	0.000	51 (10)	0.000	218 (68)	0.001	120 (32)	0.000	152 (37)	0.000
Between people with and without diabetes															
	Underweight	3,557 (1,881)	0.060	3,608 (1,948)	0.065	3,435 (1,905)	0.073	186 (107)	0.084	1,491 (1,157)	0.199	−66 (127)	0.602	519 (487)	0.288
	Normal	2,176 (400)	0.000	2,023 (327)	0.000	2,170 (374)	0.000	176 (66)	0.008	213 (154)	0.167	373 (121)	0.002	251 (105)	0.018
	Overweight	2,309 (287)	0.000	2,180 (259)	0.000	2,309 (279)	0.000	104 (34)	0.002	351 (149)	0.019	376 (79)	0.000	284 (122)	0.021
	Obese	2,926 (384)	0.000	2,753 (401)	0.000	2,858 (385)	0.000	57 (34)	0.091	345 (144)	0.017	387 (94)	0.000	189 (69)	0.007
	Severely obese	3,232 (363)	0.000	2,961 (335)	0.000	3,136 (358)	0.000	59 (22)	0.009	306 (136)	0.025	556 (102)	0.000	418 (196)	0.034
Between people with and without diabetes, less normal‖															
	Underweight	1,381 (1,834)	0.452	1,585 (1,910)	0.408	1,265 (1,855)	0.496	9 (120)	0.937	1,278 (1,121)	0.256	−439 (153)	0.004	267 (489)	0.585
	Overweight	133 (371)	0.720	157 (311)	0.614	139 (344)	0.686	−72 (69)	0.297	138 (186)	0.461	3 (115)	0.977	33 (131)	0.802
	Obese	750 (521)	0.152	730 (497)	0.143	689 (507)	0.176	−119 (67)	0.076	132 (200)	0.509	15 (120)	0.904	−63 (98)	0.523
	Severely obese	1,056 (503)	0.037	938 (425)	0.028	966 (482)	0.046	−118 (69)	0.090	92 (206)	0.655	183 (154)	0.238	167 (186)	0.370

*BMI <20 kg/m^2 = underweight, 20 to <25 kg/m^2 = normal weight, 25 to <30 kg/m^2 = overweight, 30 to <35 kg/m^2 = obese, and ≥35 kg/m^2 = severely obese. †Includes expenditures for all health services, including dental, other medical, home health, and so forth. ‡Includes expenditures for inpatient stays, ER visits, office-based physician visits, outpatient department physician visits, and prescription medicine. §Includes expenditures for inpatient stays, ER visits, prescription medicine, and all office-based and outpatient department visits. ‖Estimate of people in respective BMI category minus estimate for people in normal-weight group.

without diabetes. The difference between people with and without diabetes in the difference in average expenditures for inpatient stays and OBD between the obese and normal-weight groups was lower, but not statistically significant (inpatient stays, by $218, $P < 0.275$, and OBD, by $116, $P < 0.281$).

In the case of the ER visits, compared with people without diabetes, those with diabetes who were in either the obese or severely obese category had average expenditures significantly lower than those of the normal-weight group (obese vs. normal group by $89, $P < 0.024$, and severely obese vs. normal group by $101, $P < 0.009$). However, among people with diabetes, average expenditures for ER visits in each of the two categories—obese and severely obese—were lower than, but not statistically different from, those in the normal-weight category (obese vs. normal by $69, $P < 0.081$, and severely obese vs. normal by $56, $P < 0.132$). Among people without diabetes, average expenditures in each of the groups—obese and severely obese—were significantly higher than those in the normal-weight group (obese vs. normal by $21, $P < 0.029$, and severely obese vs. normal by $45, $P < 0.001$). The joint test of two-way interaction terms between BMI category and diabetes status was significant ($P < 0.044$) (Supplementary Table S4).

For OP visits, the difference in average expenditures between the obese and normal-weight groups among people with diabetes was significantly lower than the difference among those without diabetes (by $312, $P < 0.012$). Among people with diabetes, the obese group had average expenditures lower than in the normal-weight group, but the difference was not significant (by $225, $P < 0.061$). In contrast, among people without diabetes, those in the obese category had average expenditures significantly higher than in the normal-weight group (by $88, $P < 0.01$). The two-way interaction term between BMI category and diabetes status was not significant ($P < 0.116$).

In the ADS sample, the difference in average expenditures between people with and without diabetes in the normal-weight category was higher than in the obese category in the OP model (by $63, $P < 0.5230$) and was higher than in the overweight (by $72, $P < 0.297$), obese (by $119, $P < 0.076$), and severely obese (by $118, $P < 0.09$) categories in the ER model (Table 4). However, these differences were not statistically significant. Even average expenditures among people with diabetes did not significantly differ between the normal-weight and obese categories in the OP model or between normal-weight people and those in each of the three higher-weight categories in the ER model. In all other models (total, expense1, expense2, inpatient stays, and OBD), normal-weight people had average expenditures lower than those of people in the higher-weight categories among people with diabetes. However, the difference in average expenditures among people with diabetes was statistically significant only between the normal-weight and severely obese groups and only in four measures—total, expense1, expense2, and OBD. The same trend was found in the difference in differences in expenditures. That is, the difference in average expenditures between people with and without diabetes in the normal-weight group were lower than those of each higher-weight group, and this difference in differences was statistically significant only between the normal-weight and severely obese groups and only in three measures (total, expense1, and expense2). In all models, wherever normal-weight people had higher average expenditures than those of any of the three higher-weight groups—overweight, obese, and severely obese—the differences were not statistically significant. The two-way interaction term between BMI category and diabetes status was statistically significant only in the OBD visits model ($P < 0.006$).

Discussion

Using nationally representative survey-based data, we analyzed total health care expenditures in addition to expenditures for four provider settings (OP, ERs, OBD, and inpatient stays), and two different summations of the four groups by individuals with and without type 2 diabetes. In the main ANS (excluding people with type 1 diabetes or GDM), people with diabetes had higher health care expenditures than those without diabetes across all BMI categories in each health care expenditure type we analyzed. Among people with diabetes, individuals with one or more BMI categories higher than normal weight had lower expenditures across seven measures (Supplementary Figure S1 *A–G* for the ANS and *A1–G1* for the ADS), but the difference in expenditures between the normal-weight group and the BMI group with the lowest expenditures was not statistically significant for any of the expenditure types. We did find evidence of a BMI/health care expenditure paradox in diabetes only in the case of expenditures for visits to OP and ERs. In contrast, we did not find any evidence of an obesity paradox in any of the seven expenditure types analyzed in the ADS sample (excluding current smokers and individuals with cancer or CVD from the main ANS). Our results suggest that common biases such residual confounding and reverse

causation (e.g., when some diseases among people with diabetes cause low weight and high expenditures) are potential reasons for the presence of an obesity paradox in type 2 diabetes.

To our knowledge, only one prior study examined health care expenditures by BMI category among individuals with and without diabetes (27), and it found that normal-weight people with diabetes had total health care costs higher than those in the obese group. In addition, the normal-weight group had higher utilization of hospitals and ERs than the overweight group. However, the study included individuals with type 1 diabetes or GDM. In our study, we excluded individuals with type 1 diabetes or GDM from the ANS. In addition, we also designated as people with diabetes respondents who reported a diabetes diagnosis in the MEPS DCS, a self-administered paper-and-pencil questionnaire fielded at the end of the year to individuals who reported a diabetes diagnosis in the main MEPS household survey. The DCS correctly identifies who in the household has diabetes (sometimes a wrong household member has been previously reported as having or not having diabetes in the main survey). Those identified as not having diabetes in the DCS were already redesignated as not having diabetes in the public use data files, but the new household members now correctly identified with a diabetes diagnosis in the DCS are not flagged with diabetes in the public use data files. The earlier study did not incorporate this correction in diagnosis from the DCS. Furthermore, we included an interaction of age and diabetes status to account for differences in association between expenditures and diabetes status as people age and to account for the changes in expenditures with the duration of diabetes (i.e., with longer duration of diabetes, diabetes-related complications are expected to increase, thus resulting in higher health care expenditures, and older people, in general, are expected to have had a longer duration of diabetes). Although the previous study restricted analysis of expenditures to total health care expenditures, we not only analyzed total expenditures, but also expenditures specifically for hospital stays, OP visits, ER visits, and OBD visits, and two-variant summations of four settings. In our ADS sample, we also excluded smokers and people with cancer or CVD. The previous study did conduct sensitivity analyses on the sample (excluding smokers and people with cancer), but it did not exclude people with CVD, type 1 diabetes, or GDM.

Our study has some limitations. First, it used self-reported information, which may have been subject to reporting bias. For example, some respondents reported a diabetes diagnosis in the DCS but not in the main MEPS. However, the accuracy of self-reported diabetes status has been shown to be reasonably high (28). This study is cross-sectional; therefore, its findings cannot be interpreted as causal.

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DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

V.K. researched data and wrote the introduction, RESEARCH DESIGN AND METHODS, and RESULTS sections. W.E. wrote the DISCUSSION section and reviewed and editing the manuscript. Both authors are guarantors of this work and, as such, had full access to all the data and take responsibility for the integrity of the data and the accuracy of the data analyses.

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