ORIGINAL ARTICLE

Association between Obesity during Pregnancy and Increased Use of Health Care

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ABSTRACT

BACKGROUND

In the United States, obesity during pregnancy is common and increases obstetrical risks. An estimate of the increase in use of health care services associated with obesity during pregnancy is needed.

METHODS

We used electronic data systems of a large U.S. group-practice health maintenance organization to identify 13,442 pregnancies among women 18 years of age or older at the time of conception that resulted in live births or stillbirths. The study period was between January 1, 2000, and December 31, 2004. We assessed associations between measures of use of health care services and body-mass index (BMI, defined as the weight in kilograms divided by the square of the height in meters) before pregnancy or in early pregnancy. The women were categorized as underweight (BMI <18.5), normal (BMI 18.5 to 24.9), overweight (BMI 25.0 to 29.9), obese (BMI 30.0 to 34.9), very obese (BMI 35.0 to 39.9), or extremely obese (BMI ≥40.0). The primary outcome was the mean length of hospital stay for delivery.

RESULTS

After adjustment for age, race or ethnic group, level of education, and parity, the mean (±SE) length of hospital stay for delivery was significantly ($P<0.05$) greater among women who were overweight (3.7±0.1 days), obese (4.0±0.1 days), very obese (4.1±0.1 days), and extremely obese (4.4±0.1 days) than among women with normal BMI (3.6±0.1 days). A higher-than-normal BMI was associated with significantly more prenatal fetal tests, obstetrical ultrasonographic examinations, medications dispensed from the outpatient pharmacy, telephone calls to the department of obstetrics and gynecology, and prenatal visits with physicians. A higher-than-normal BMI was also associated with significantly fewer prenatal visits with nurse practitioners and physician assistants. Most of the increase in length of stay associated with higher BMI was related to increased rates of cesarean delivery and obesity-related high-risk conditions.

CONCLUSIONS

Obesity during pregnancy is associated with increased use of health care services.

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Obese women are at increased risk for complications of pregnancy, particularly hypertensive disorders, preexisting and gestational diabetes mellitus, and cesarean delivery.[1-5] Given the rapid increase in the prevalence of obesity in the United States,[6] obesity during pregnancy is now a common high-risk obstetrical condition affecting about one in five women who give birth.[7] Although it is recognized that the use of health care services is increased for obese women who are pregnant, published estimates of the magnitude of the increase are limited in number and scope.[8-10] The objective of this study was to estimate the increase in use of maternal health care services associated with obesity during pregnancy.

METHODS

SOURCES OF DATA

We analyzed electronic data from Kaiser Permanente Northwest, a large, nonprofit, prepaid, group-practice health maintenance organization (HMO) with approximately 486,000 members in western Oregon and western Washington State. The members include persons covered by commercial and individual health plans, the Washington State Basic Health Program (state-sponsored coverage for the uninsured), Medicare, and Medicaid. Individual-level information was obtained from several data systems, including records of ambulatory encounters (office visits with a health care provider), enrollment records, emergency department visits, records of hospital discharges, outside claims and referrals, radiologic and other diagnostic imaging procedures, laboratory results, and pharmacy records. Oregon and Washington State birth certificates and Kaiser Permanente Northwest data were matched with the use of a probabilistic algorithm based on the mother's name, birth date, and address and the delivery date. From the birth certificates, we obtained data on race or ethnic group, parity, marital status, and years of education. The study was approved by institutional review boards at the Centers for Disease Control and Prevention and Kaiser Permanente Northwest. Because the data in this study were collected by reviewing existing electronic medical records and no direct contact with study participants was involved, the institutional review boards did not require written informed consent from the participants.

To identify pregnancies, we used a complex validated algorithm that accessed multiple Kaiser Permanente Northwest automated data systems and searched for indicators of pregnancy; this method has been used and described previously.[11] The algorithm identified pregnancy episodes, which were defined as beginning at 2 weeks before conception (the last menstrual period before conception) and ending 8 weeks after delivery. Each pregnancy episode was considered a separate unit of analysis. We selected pregnancy episodes that began on or after January 1, 2000, and ended on or before December 31, 2004, and that resulted in a live birth or a stillbirth (fetal death at 20 weeks of gestation or later). The mother had to be 18 years of age or older at the time of conception. We excluded a pregnancy if the mother was not enrolled in Kaiser Permanente Northwest at the time of delivery, the delivery did not occur in a hospital, the electronic database had no record of the mother's weight during the period from 6 months before to 3 months after the beginning of pregnancy (i.e., before substantial pregnancy-associated weight gain would be expected), or the electronic database had no record of the mother's height after the age of 16 years. The height measurement used for analysis was the median of all heights recorded after the age of 16 years for an individual woman. We used the National Heart, Lung, and Blood Institute definitions to categorize women according to body-mass index (BMI, defined as the weight in kilograms divided by the square of the height in meters) as underweight (BMI <18.5), normal (BMI 18.5 to 24.9), overweight (BMI 25.0 to 29.9), obese (BMI 30.0 to 34.9), very obese (BMI 35.0 to 39.9), or extremely obese (BMI ≥40.0).

We examined information on the use of health care services during the pregnancy episode. We used only the diagnosis and procedure codes of the *International Classification of Diseases, Ninth Revision, Clinical Modification* and of *Current Procedural Terminology* that were specific to the mother; records and codes specific to the fetus and infant were not included. We considered a woman to have a high-risk condition during pregnancy if a diagnosis of preexisting diabetes mellitus, gestational diabetes mellitus, or hypertensive disorder was recorded on the electronic medical record or birth certificate. Hypertensive disorders included chronic hypertension, gestational hypertension, and preeclampsia or eclampsia.

Length of hospital stay for delivery was our

Table 1. Characteristics of Pregnancy Episodes According to Maternal Body-Mass Index.*

Characteristic	Underweight, BMI <18.5 (N=259)	Normal, BMI 18.5–24.9 (N=6091)	Overweight, BMI 25.0–29.9 (N=3634)	Obese, BMI 30.0–34.9 (N=1848)	Very Obese, BMI 35.0–39.9 (N=918)	Extremely Obese, BMI ≥40.0 (N=692)	P Value†
Maternal age — no. (%)							
18–24 yr	111 (42.9)	1717 (28.2)	994 (27.4)	539 (29.2)	278 (30.3)	172 (24.9)	<0.001
25–29 yr	73 (28.2)	1922 (31.6)	1138 (31.3)	589 (31.9)	308 (33.6)	212 (30.6)	
30–34 yr	51 (19.7)	1692 (27.8)	1013 (27.9)	503 (27.2)	221 (24.1)	204 (29.5)	
35–39 yr	18 (6.9)	641 (10.5)	409 (11.3)	176 (9.5)	98 (10.7)	87 (12.6)	
≥40 yr	6 (2.3)	119 (2.0)	80 (2.2)	41 (2.2)	13 (1.4)	17 (2.5)	
Maternal race or ethnic group — no./total no. (%)‡							
White	155/258 (60.1)	4526/6053 (74.8)	2738/3615 (75.7)	1420/1837 (77.3)	723/912 (79.3)	546/688 (79.4)	<0.001
Black	6/258 (2.3)	155/6053 (2.6)	147/3615 (4.1)	90/1837 (4.9)	48/912 (5.3)	60/688 (8.7)	
Hispanic	14/258 (5.4)	433/6053 (7.2)	429/3615 (11.9)	222/1837 (12.1)	101/912 (11.1)	56/688 (8.1)	
Asian	79/258 (30.6)	879/6053 (14.5)	255/3615 (7.1)	70/1837 (3.8)	20/912 (2.2)	14/688 (2.0)	
Other	4/258 (1.6)	60/6053 (1.0)	46/3615 (1.3)	35/1837 (1.9)	20/912 (2.2)	12/688 (1.7)	
Maternal education — no./total no. (%)							
<12 yr	25/241 (10.4)	353/5775 (6.1)	256/3448 (7.4)	170/1746 (9.7)	54/863 (6.3)	44/652 (6.7)	<0.001
12 yr	85/241 (35.3)	1578/5775 (27.3)	1045/3448 (30.3)	551/1746 (31.6)	302/863 (35.0)	229/652 (35.1)	
>12 yr	131/241 (54.4)	3844/5775 (66.6)	2147/3448 (62.3)	1025/1746 (58.7)	507/863 (58.7)	379/652 (58.1)	
Medicaid or Washington State Basic Health Program — no. (%)	19 (7.3)	352 (5.8)	213 (5.9)	174 (9.4)	102 (11.1)	91 (13.2)	<0.001
Parity — no./total no. (%)							
0	150/257 (58.4)	2719/6058 (44.9)	1462/3622 (40.4)	670/1836 (36.5)	327/913 (35.8)	218/689 (31.6)	<0.001
1	80/257 (31.1)	2091/6058 (34.5)	1238/3622 (34.2)	640/1836 (34.9)	340/913 (37.2)	239/689 (34.7)	
2	21/257 (8.2)	823/6058 (13.6)	574/3622 (15.8)	317/1836 (17.3)	148/913 (16.2)	153/689 (22.2)	
≥3	6/257 (2.3)	425/6058 (7.0)	348/3622 (9.6)	209/1836 (11.4)	98/913 (10.7)	79/689 (11.5)	
Cesarean delivery — no. (%)	53 (20.5)	1295 (21.3)	983 (27.1)	603 (32.6)	339 (36.9)	313 (45.2)	<0.001
Pregnancy outcome — no. (%)							
Live infant	257 (99.2)	6057 (99.4)	3612 (99.4)	1832 (99.1)	909 (99.0)	688 (99.4)	0.56
Stillbirth	2 (0.8)	34 (0.6)	22 (0.6)	16 (0.9)	9 (1.0)	4 (0.6)	
Gestational age <37 wk — no. (%)	30 (11.6)	495 (8.1)	305 (8.4)	195 (10.6)	82 (8.9)	86 (12.4)	<0.001
Birth weight — g	3232±510	3393±546	3475±580	3469±611	3555±623	3554±687	<0.00

Diabetes mellitus — no. (%)							
Gestational§	9 (3.5)	229 (3.8)	171 (4.7)	130 (7.0)	88 (9.6)	76 (11.0)	<0.001
Preexisting¶	0	48 (0.8)	61 (1.7)	45 (2.4)	63 (6.9)	67 (9.7)	<0.001
Hypertensive disorder — no. (%)‖	15 (5.8)	555 (9.1)	485 (13.3)	383 (20.7)	214 (23.3)	219 (31.7)	<0.001
High-risk condition — no. (%)**	23 (8.9)	800 (13.1)	662 (18.2)	518 (28.0)	317 (34.5)	315 (45.5)	<0.001
Tobacco use — no. (%)††	50 (19.3)	843 (14.0)	536 (14.9)	324 (17.7)	222 (24.3)	154 (22.3)	<0.001
Alcohol or drug dependence — no. (%)‡‡	5 (1.9)	128 (2.1)	61 (1.7)	36 (1.9)	19 (2.1)	16 (2.3)	0.76
Depression — no. (%)§§	22 (8.5)	431 (7.1)	307 (8.4)	195 (10.6)	112 (12.2)	79 (11.4)	<0.001

* A pregnancy episode was defined as beginning 2 weeks before conception (the last menstrual period before conception) and ending 8 weeks after delivery. Plus–minus values are means ±SE. Because of rounding, percentages may not total 100.
† P values were calculated with the use of the uncorrected chi-square test, except for the P value for birth weight, which was calculated with the use of the F test.
‡ Race or ethnic group was obtained from the birth certificate.
§ Gestational diabetes mellitus was recorded for women with a diagnosis of codes 250.0 to 250.9 or 648.0 according to the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM), or as indicated on the birth certificate.
¶ Preexisting diabetes mellitus was recorded for women with a diagnosis of ICD-9-CM code 648.8, or as indicated on the birth certificate.
‖ Hypertensive disorder (chronic hypertension, gestational hypertension, preeclampsia, or eclampsia) was recorded for women with a diagnosis of ICD-9-CM codes 401 to 405, 642, or 760.0, or as indicated on the birth certificate (for Oregon only).
** High-risk conditions during pregnancy were preexisting diabetes mellitus, gestational diabetes mellitus, and hypertensive disorders, as reported on the electronic medical record or the birth certificate.
†† Tobacco use at any time during pregnancy was reported in the Kaiser Permanente Northwest database or on the birth certificate.
‡‡ Alcohol or drug use during pregnancy was reported on the Kaiser Permanente Northwest database or on the birth certificate.
§§ Depression was recorded for women with a diagnosis of ICD-9-CM code 296.2, 296.20 to 296.25, 296.3, 296.30 to 296.82, 300.4 to 309.1, 309.28, 311, or 648.4 (with an antidepressant medication dispensed within 30 days after the diagnosis).

primary measure of use of health care services; the total length of stay was defined as the number of days from admission to discharge, and the postpartum length of stay as the number of days from delivery to discharge. Other measures of use of health care services included prenatal visits (with a physician, nurse practitioner, or physician assistant), telephone calls to the department of obstetrics and gynecology that addressed clinical concerns (calls to arrange clinic appointments, for example, were not included), fetal tests (e.g., nonstress tests, contraction stress tests, and diagnostic amniocentesis), and obstetrical ultrasonographic examinations. Use of medication was measured by the number of medications dispensed from outpatient pharmacies.

STATISTICAL ANALYSIS

An uncorrected chi-square test was used to compare distributions of categorical variables. Means were calculated for continuous variables, with adjustment for age (years as a continuous variable), race or ethnic group (white, black, Hispanic, Asian, or other); educational level (<12 years, 12 years, or >12 years), and parity (0, 1 or 2, or ≥3). The statistical significance of differences between women with a normal BMI and those with a higher BMI was assessed with the use of a generalized linear models procedure (SAS software, version 8.2) and with the Tukey–Kramer adjustment for multiple comparisons. Two-sided P values less than 0.05 were considered to indicate statistical significance.

To better understand the associations and potential causal pathways between maternal BMI and length of hospital stay for delivery (our primary measure of use of health care services), we further adjusted for high-risk conditions and mode of delivery (vaginal or cesarean). Because women with high-risk conditions have a greater requirement for prenatal surveillance, we analyzed the other measures of use of health care services after stratification according to the presence of a high-risk condition. Linear trends were tested with BMI used as a continuous variable; slopes were estimated by the least-squares method and were considered significant if the P value was less than 0.05. To assess whether the association between length of hospital stay and BMI varied according to mode of delivery or the presence of a high-risk condition, we ran two separate models using the interaction terms BMI × mode of delivery and

BMI × high-risk condition, with BMI as a continuous variable. Similarly, for each procedure and encounter (e.g., prenatal fetal tests), we tested for interaction between BMI and the presence of a high-risk condition.

RESULTS

We identified 19,538 pregnancy episodes that began on or after January 1, 2000, and ended on or before December 31, 2004, among mothers 18 years of age and older at the time of conception and that resulted in a live birth or a stillbirth. We excluded 6096 of these pregnancies because data were lacking to calculate the BMI (5486 pregnancies, all with missing height data), the woman was not enrolled at Kaiser Permanente Northwest at delivery (427 pregnancies), or the delivery did not occur in a hospital (183 pregnancies); the analysis was conducted on the remaining 13,442 pregnancies. Women whose pregnancies were included in the analysis were significantly older, more likely to be white, more likely to be married, more likely to be highly educated, and less likely to use tobacco during pregnancy than those whose pregnancies were not included in the analysis (see Table 1 of the Supplementary Appendix, available with the full text of this article at www.nejm.org).

Of the pregnancy episodes included in the analysis, 1.9% occurred in underweight women, 45.3% in women of normal weight, 27.0% in overweight women, 13.8% in obese women, 6.8% in very obese women, and 5.2% in extremely obese women. The distributions of various maternal and infant characteristics according to these six BMI categories are shown in Table 1. Increasing maternal BMI was associated with increasing maternal age, parity, and mean birth weight and with lower maternal education levels. The rate of cesarean deliveries increased as BMI increased, as did the rates of gestational diabetes mellitus, preexisting diabetes mellitus, and hypertensive disorders.

The total length of hospital stay increased significantly with increasing BMI category. The length of stay was at least 4 days in 40.3% of pregnancies of women of normal weight and 60.4% of pregnancies of extremely obese women (Table 2). The mean total length of stay and the mean postpartum length of stay were significantly higher for pregnancies of overweight and obese women than for pregnancies of women of normal weight, and the results of tests for trend were significant for both of these measures ($P<0.001$). In analyses of total length of stay, there were significant interactions between BMI and mode of delivery ($P<0.001$) and between BMI and the presence or absence of a high-risk condition ($P<0.001$). For pregnancies resulting in vaginal delivery, the total length of stay was greater when the maternal BMI was 30.0 or more (i.e., the obese, very obese, and extremely obese categories) than when the woman was of normal weight, whereas no significant association was found between BMI and total length of stay for pregnancies resulting in cesarean delivery. Similarly, for pregnancies without a high-risk condition, the total length of stay was significantly higher among obese, very obese, and extremely obese women than among women of normal weight, whereas for pregnancies with a high-risk condition, the total length of stay did not increase significantly with increasing BMI. For postpartum length of stay, the association with BMI was not significantly modified by the mode of delivery or the presence of a high-risk condition.

To determine the relative contributions of the mode of delivery, the presence or absence of a high-risk condition, and BMI to length of hospital stay, we calculated the adjusted means for length of stay according to BMI group with the use of four different multivariate models (Table 3). When we controlled for either the mode of delivery or the presence or absence of a high-risk condition, the length of stay remained significantly higher for pregnancies of obese, very obese, and extremely obese women than for pregnancies of women of normal weight. However, after adjustment for both mode of delivery and presence or absence of a high-risk condition, the length of stay did not increase significantly with increasing BMI. Because 10.3% of pregnancies occurred in women who had more than one pregnancy during the 5-year study period, we recalculated the adjusted mean length of stay for only the first pregnancy recorded for each woman in our study. The results were essentially unchanged.

We also examined the use of various prenatal procedures and encounters according to BMI group (Table 4). The frequencies of fetal tests, obstetrical ultrasonographic examinations, prenatal visits with physicians, outpatient medications dispensed, and telephone calls to the department of obstetrics and gynecology were significantly greater for pregnancies of obese, very obese, and extremely

Table 2. Adjusted Length of Hospital Stay in Relation to Maternal Body-Mass Index.*

Length of Hospital Stay	Underweight, BMI <18.5 (N=259)	Normal, BMI 18.5–24.9 (N=6091)	Overweight, BMI 25.0–29.9 (N=3634)	Obese, BMI 30.0–34.9 (N=1848)	Very Obese, BMI 35.0–39.9 (N=918)	Extremely Obese, BMI ≥40.0 (N=692)
Total						
1 day — no. of patients (%)	1 (0.4)	14 (0.2)	10 (0.3)	6 (0.3)	1 (0.1)	0
2 days — no. of patients (%)	40 (15.4)	922 (15.1)	475 (13.1)	193 (10.4)	82 (8.9)	61 (8.8)
3 days — no. of patients (%)	117 (45.2)	2700 (44.3)	1507 (41.5)	690 (37.3)	344 (37.5)	213 (30.8)
≥4 days — no. of patients (%)	101 (39.0)	2455 (40.3)	1642 (45.2)	959 (51.9)	491 (53.5)	418 (60.4)
Mean no. of days	3.5±0.2	3.6±0.1	3.7±0.1†	4.0±0.1†	4.1±0.1†	4.4±0.1†
From delivery to discharge						
0 days — no. of patients (%)	3 (1.2)	58 (1.0)	34 (0.9)	17 (0.9)	7 (0.8)	2 (0.3)
1 day — no. of patients (%)	57 (22.0)	1392 (22.9)	736 (20.3)	321 (17.4)	163 (17.8)	98 (14.2)
2 days — no. of patients (%)	129 (49.8)	2949 (48.4)	1683 (46.3)	813 (44.0)	376 (41.0)	269 (38.9)
3 days — no. of patients (%)	41 (15.8)	1071 (17.6)	747 (20.6)	439 (23.8)	232 (25.3)	171 (24.7)
≥4 days — no. of patients (%)	29 (11.2)	621 (10.2)	434 (11.9)	258 (14.0)	140 (15.3)	152 (22.0)
Mean no. of days	2.2±0.1	2.2±0.1	2.3±0.1†	2.4±0.1†	2.6±0.1†	2.7±0.1†
Total no. of days						
Vaginal delivery	3.1±0.1	3.2±0.1	3.3±0.1	3.4±0.1†	3.6±0.1†	3.7±0.1†
Cesarean delivery	4.9±0.5	5.2±0.2	5.1±0.2	5.3±0.2	5.2±0.2	5.3±0.2
No. of days from delivery to discharge						
Vaginal delivery	1.8±0.1	1.9±0.1	1.9±0.1	1.9±0.1†	2.0±0.1†	2.0±0.1†
Cesarean delivery	3.5±0.2	3.5±0.1	3.5±0.1	3.6±0.1	3.6±0.1	3.7±0.1
Total no. of days						
With high-risk condition‡	4.4±0.8	4.4±0.2	4.4±0.2	4.5±0.2	4.5±0.3	4.6±0.3
Without high-risk condition	3.4±0.1	3.5±0.1	3.6±0.1	3.8±0.1†	4.0±0.1†	4.2±0.1†
No. of days from delivery to discharge						
With high-risk condition‡	2.6±0.4	2.5±0.1	2.6±0.1	2.7±0.1	2.8±0.1	2.9±0.1†
Without high-risk condition	2.1±0.1	2.1±0.1	2.2±0.1†	2.3±0.1†	2.5±0.1†	2.6±0.1†

* The results were adjusted for maternal age, race or ethnic group, education, and parity. Plus–minus values are means ±SE.
† P<0.05 for the comparison with women of normal weight.
‡ High-risk conditions during pregnancy were preexisting diabetes mellitus, gestational diabetes mellitus, and hypertensive disorders, as reported on the electronic medical record or the birth certificate.

obese women (BMI ≥30.0) than for pregnancies of women of normal weight. The results of tests for trend for all procedures and encounters were significant (P<0.001). The numbers of outpatient medications dispensed and of telephone calls were also significantly higher for pregnancies of overweight women than for pregnancies of women of normal weight. However, the relation between BMI and frequency of prenatal visits varied according to the type of health care provider seen. The frequency of visits with physicians increased significantly with increasing BMI, but the frequency of visits with nurse practitioners and physician assistants decreased significantly with increasing BMI.

The presence of a high-risk condition during pregnancy increased overall use of health care services, but it also modified the association between BMI and use of health care for all procedures and encounters (tests for interaction, P<0.001) (Table 4). For example, among very obese and extremely obese women who had high-risk conditions during pregnancy, the frequency of prenatal fetal tests was significantly higher than among women of normal weight who had high-risk conditions, but among women without high-

Table 3. Four Multivariate Models for Adjusted Length of Hospital Stay, According to Maternal BMI.*

Model	Underweight, BMI <18.5 (N=259)	Normal, BMI 18.5–24.9 (N=6091)	Overweight, BMI 25.0–29.9 (N=3634)	Obese, BMI 30.0–34.9 (N=1848)	Very Obese, BMI 35.0–39.9 (N=918)	Extremely Obese, BMI ≥40.0 (N=692)
				days		
Basic model	3.5±0.2	3.6±0.1	3.7±0.1†	4.0±0.1†	4.1±0.1†	4.4±0.1†
Basic model plus high-risk condition‡	3.8±0.2	3.9±0.1	4.0±0.1	4.2±0.1†	4.3±0.1†	4.4±0.1†
Basic model plus mode of delivery§	4.0±0.2	4.1±0.1	4.2±0.1	4.3±0.1†	4.4±0.1†	4.5±0.1†
Basic model plus high-risk condition plus mode of delivery	4.3±0.2	4.4±0.1	4.4±0.1	4.5±0.1	4.5±0.1	4.5±0.1

* Plus–minus values are means ±SE. Adjustment factors for the basic model were age in years (18 to 24, 25 to 29, 30 to 34, 35 to 39, or ≥40), race or ethnic group (white, black, Hispanic, Asian, or other), educational level in years (<12, 12, or >12), and parity (0, 1 or 2, or ≥3 births).
† $P<0.05$ for the comparison with women of normal weight.
‡ High-risk conditions during pregnancy were preexisting diabetes mellitus, gestational diabetes mellitus, and hypertensive disorders, as reported on the electronic medical record or the birth certificate.
§ The mode of delivery was vaginal or cesarean.

risk conditions during pregnancy, no significant increases were found for these groups. A similar pattern was seen for prenatal obstetrical ultrasonographic examinations.

DISCUSSION

Numerous studies have documented the increased risks of adverse outcomes associated with obesity during pregnancy,[1-5] but few studies have provided quantitative estimates of the associated increase in the use of health care services. Two reports from Montpellier, France, estimated the complications from and costs of obesity during pregnancy in the same clinic population during two time periods (from 1980 to 1993 in one study and from October 1993 to December 1994 in another study).[8,9] The average costs were significantly higher for overweight and obese women than for women of normal weight, but these cost estimates were based only on costs incurred during hospitalization. In a more recent qualitative study from the United Kingdom, 33 maternity and health care professionals were interviewed about their views of the effect of maternal obesity on the use of maternity services and health care resources.[10] There was general consensus that maternal obesity has a major effect on the level of care required for both the mother and the infant, but this study could not provide quantitative estimates of the effect.

Our study quantifies the increased use of health care services associated with obesity during pregnancy. We found that obesity was associated with greater use of inpatient and outpatient health care services, including increased length of stay during hospitalization for delivery, greater use of physician services, and less use of services by nurse practitioners and physician assistants during prenatal visits. The difference in prenatal-care visits to a physician was evident even among women without a high-risk condition, a result suggesting that regardless of risk status, physicians (rather than mid-level providers) are more likely to provide prenatal care for pregnancies associated with higher BMI, with attendant cost implications.

As was found in other studies, we found strong associations between higher maternal BMI and older age, higher parity, and lower socioeconomic status.[12,13] The increased risks and higher medical costs of cesarean delivery, preexisting and gestational diabetes mellitus, and hypertensive disorders associated with higher maternal BMI are also well known.[14] Our analysis found that the associations of maternal BMI with the mode of delivery and the presence of a high-risk condition explained most, but not all, of the increased use of health care services that was associated with maternal obesity. Further exploration of other factors driving the use of health care services and examination of the associations between length of hospital stay and health outcomes could help clarify whether the increased use of health care services for obese women without high-risk conditions represents valuable (e.g., additional tests and treatment for obesity-related coexisting conditions) or unnecessary variations in care.

The presence of a high-risk condition modified

Table 4. Number of Prenatal Tests, Medications, and Visits with Health Care Providers According to Maternal Body-Mass Index and Presence or Absence of a High-Risk Condition.*

Variable	Underweight, BMI <18.5 (N=259)	Normal, BMI 18.5–24.9 (N=6091)	Overweight, BMI 25.0–29.9 (N=3634)	Obese, BMI 30.0–34.9 (N=1848)	Very Obese, BMI 35.0–39.9 (N=918)	Extremely Obese, BMI ≥40.0 (N=692)
			number			
Fetal tests						
All pregnancies	1.3±0.3	1.6±0.1	1.8±0.1	2.1±0.1†	2.8±0.2†	3.8±0.2†
With high-risk condition	2.6±1.2	3.5±0.3	3.9±0.3	3.9±0.4	5.4±0.4†	6.4±0.4†
Without high-risk condition	1.3±0.2	1.3±0.1	1.3±0.1	1.4±0.1	1.4±0.1	1.7±0.2
Obstetrical ultrasonographic examinations						
All pregnancies	3.5±0.4	3.7±0.1	3.9±0.2	4.4±0.2†	5.4±0.2†	7.5±0.2†
With high-risk condition	6.2±1.7	6.6±0.5	7.0±0.5	7.1±0.5	9.2±0.6†	11.0±0.6†
Without high-risk condition	3.3±0.3	3.3±0.1	3.3±0.1	3.3±0.2	3.4±0.2	4.7±0.3†
Physician visits						
All pregnancies	4.3±0.3	4.4±0.1	4.6±0.1	4.8±0.1†	5.4±0.2†	6.0±0.2†
With high-risk condition	5.1±1.1	5.6±0.3	5.9±0.3	5.9±0.3	6.6±0.4†	7.6±0.4†
Without high-risk condition	4.3±0.3	4.2±0.1	4.4±0.1	4.4±0.2	4.8±0.2†	4.9±0.2†
Visits with nurse practitioner or physician assistant						
All pregnancies	5.0±0.3	4.9±0.1	4.8±0.1	4.6±0.1	4.5±0.2†	3.9±0.2†
With high-risk condition	3.9±0.9	4.1±0.2	4.1±0.2	3.6±0.2	3.6±0.3	3.2±0.3†
Without high-risk condition	5.1±0.3	5.0±0.1	4.9±0.1	4.9±0.2	4.9±0.2	4.3±0.2†
Medications dispensed from outpatient pharmacy‡						
All pregnancies	3.6±0.4	3.6±0.1	4.1±0.2†	4.9±0.2†	6.3±0.2†	7.7±0.3†
With high-risk condition	4.7±2.0	5.6±0.5	6.4±0.5	7.0±0.6†	9.9±0.6†	10.8±0.6†
Without high-risk condition	3.5±0.3	3.4±0.1	3.6±0.2	4.1±0.2†	4.5±0.2†	5.1±0.3†
Telephone calls to obstetrician-gynecologist						
All pregnancies	5.0±0.3	4.8±0.1	5.2±0.1†	5.4±0.1†	6.5±0.2†	7.0±0.2†
With high-risk condition	8.5±1.3	7.0±0.4	7.6±0.4	7.4±0.4	9.5±0.4†	9.5±0.4†
Without high-risk condition	4.7±0.3	4.5±0.1	4.6±0.1	4.7±0.1	5.1±0.2†	5.3±0.2†

* Plus–minus values are means ±SE. Means were adjusted for maternal age, race or ethnic group, education, and parity. Prenatal refers to the interval between the start of pregnancy and admission to the hospital for delivery. High-risk conditions during pregnancy were preexisting diabetes mellitus, gestational diabetes mellitus, and hypertensive disorders, as reported on the electronic medical record or the birth certificate.

† P<0.05 for the comparison with women of normal weight.

‡ For women in all categories of body-mass index, the most commonly dispensed medications were antibiotics, narcotics, antiemetics, antidepressants, antiasthmatics, and cough-and-cold preparations. The single exception was insulin, which was the second most frequently used medication among very obese and extremely obese women but was not commonly used by women in other categories.

the associations between maternal BMI and certain measures of use. For example, among women with a high-risk condition during pregnancy, the numbers of prenatal fetal tests and obstetrical ultrasonographic examinations were significantly higher for women in the two highest BMI categories, but among women without a high-risk condition during pregnancy, the increases were small, and most differences between women with higher BMI and those with normal BMI were not significant. This finding may reflect the fact that clinicians will monitor fetal growth and development more closely in women with high-risk conditions, but because measuring growth clinically

in very obese or extremely obese women is more difficult, more frequent tests may be needed.[15]

In contrast, whereas pregnancies complicated by preexisting diabetes mellitus, gestational diabetes mellitus, or a hypertensive disorder were associated with greater use of medications than were pregnancies without apparent complications, the use of medications (as well as the number of telephone calls to the department of obstetrics and gynecology) increased with increasing maternal BMI, even for women without a high-risk condition. We were not able to determine whether these increases represent increases in the frequency of health-seeking behavior or greater needs related to other, unknown complications associated with high BMI.

Several limitations should be considered in interpreting our results. First, our findings are not necessarily generalizable to the U.S. population of pregnant women, since our study population consisted of members of a managed-care health plan located in the northwest United States that had relatively high percentages of white and highly educated women. In addition, because we excluded pregnancies for which data on maternal height were missing, pregnancies of women with complete medical records and frequent care were more likely to be included. Second, our findings are based on existing data taken primarily from electronic records and secondarily from birth certificates, and any misclassification of variables due to coding errors would probably bias the findings toward the null hypothesis.

Third, because we did not validate reported diagnoses, misclassification of clinical conditions is possible. However, because administrative data systems of managed-care plans are designed to monitor the use of resources, and because we had information on all prenatal visits and hospitalizations during pregnancy and post partum, we consider substantial errors in coding or underreporting to be unlikely.[11] Medication use, however, might be underreported, since the records included only prescriptions dispensed at Kaiser Permanente Northwest pharmacies. For reasons of cost and convenience, most Kaiser Permanente Northwest enrollees do not use pharmacies outside the group-practice HMO; however, we cannot assess the extent to which outside pharmacies were used. Such underreporting would affect estimates of the absolute number of medications used but is unlikely to substantially affect the relative differences in medication use associated with BMI. Finally, although we controlled for maternal age, race or ethnic group, educational level, and parity, we cannot exclude the possibility of uncontrolled confounding by unmeasured factors associated with both BMI and use of health care.

In conclusion, we found that a maternal BMI higher than normal is associated with greater use of health care services, especially for pregnancies associated with a BMI of 35.0 or greater. Almost all of the increase in use of services was related to the increased rates of cesarean delivery, gestational diabetes mellitus, preexisting diabetes mellitus, and hypertensive disorders among obese pregnant women. According to a recent estimate, about 22% of pregnant women in nine states are obese.[7] This could be extrapolated to indicate that of the 4 million births each year in the United States, approximately 1 million involve obese women. Thus, even a small increase in the cost of health care associated with obesity will have substantial economic implications.

No potential conflict of interest relevant to this article was reported.

The findings and conclusions expressed in this article are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention or Kaiser Permanente.

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