Maternal Obesity in Early Pregnancy and Risk of Spontaneous and Elective Preterm Deliveries: A Retrospective Cohort Study

Gordon C.S. Smith, MD, PhD, Imran Shah, MSc, Jill P. Pell, MD, Jennifer A. Crossley, PhD, and Richard Dobbie, BSc

Objectives. We sought to determine the association between maternal body mass index and risk of preterm delivery.

Methods. We assessed 187 290 women in Scotland and estimated adjusted odds ratios for spontaneous and elective preterm deliveries among overweight, obese, and morbidly obese women relative to normal-weight women.

Results. Among nulliparous women, the risk of requiring an elective preterm delivery increased with increasing BMI, whereas the risk of spontaneous preterm labor decreased. Morbidly obese nulliparous women were at increased risk of all-cause preterm deliveries, neonatal death, and delivery of an infant weighing less than 1000 g who survived to 1 year of age (a proxy for severe long-term disability). By contrast, obesity and elective preterm delivery were only weakly associated among multiparous women.

Conclusions. Obese nulliparous women are at increased risk of elective preterm deliveries. This in turn leads to an increased risk of perinatal mortality and is likely to lead to increased risks of long-term disability among surviving offspring.
(*Am J Public Health.* 2007;97:157–162. doi:10.2105/AJPH.2005.074294)

The association between maternal obesity and pregnancy outcomes is complex. Maternal obesity is known to be associated with increased rates of complications in late pregnancy such as stillbirth, cesarean delivery, gestational diabetes, and shoulder dystocia.[1–3] However, a low body mass index (BMI) is associated with an increased risk of preterm delivery, and some studies have shown that BMIs above the "normal" range are protective against spontaneous preterm births.[4–6] A large-scale retrospective cohort study demonstrated an interaction between BMI and parity: obese nulliparous women were at increased risk of extreme preterm deliveries and neonatal death, whereas obese multiparous women were not at increased risk of these outcomes.[7] The reasons for these complex patterns of association are unclear.

Preterm deliveries can occur as a result of preterm labor or can be elective procedures. Preeclampsia is the reason for elective preterm deliveries in more than 40% of cases.[4] It is well recognized that obese women are at increased risk of preeclampsia[8] and that nulliparous women are at higher risk of preeclampsia than multiparous women. We hypothesized that the higher background risk of preeclampsia among nulliparous women might lead to a stronger association between obesity and elective preterm deliveries and might therefore explain the association between obesity and extreme preterm deliveries among these women.

Our aim was to determine the association between maternal obesity in early pregnancy and risk of preterm delivery, with attention given to type of delivery (spontaneous vs elective), parity (nulliparous vs multiparous), and the most important negative consequences of prematurity. In assessing consequences of prematurity, we examined both neonatal death and long-term survival of extremely low-birthweight (ELBW) infants. Because ELBW infants have a 40% to 45% risk of severe neurodevelopmental delays in childhood,[9] we used ELBW as a proxy measure of severe long-term morbidity.

METHODS

Data Sources and Patient Selection

The Scottish Morbidity Record (SMR2) collects information on clinical and demographic characteristics and outcomes for all women discharged from Scottish maternity hospitals. The registry is subjected to regular quality assurance checks, and its data have been more than 99% complete since the late 1970s.[10] In addition, the Scottish Stillbirth and Infant Death Enquiry (SSBIDE), a national register, routinely classifies all perinatal deaths in Scotland.[11]

All women presenting for prenatal care in the west of Scotland are offered biochemical screening, using maternal serum α-fetoprotein and human chorionic gonadotrophin, to assess their risk of having a fetus affected by Down syndrome or a structural fetal abnormality.[12] Maternal weight is recorded at the time of sampling for biochemical screening to allow for weight correction of analytes. This process corrects levels of these proteins for the effect of maternal size and improves prediction of Down syndrome risk. The laboratory information management system of the West of Scotland Regional Genetics Service (Institute of Medical Genetics) contains a database including this maternal information along with biochemical screening results. The General Registrar's Office maintains computerized birth and death registration records.

We used a probability-based matching approach[13] with maternal identifiers to link information from the SMR2, the SSBIDE, the Institute of Medical Genetics prenatal screening database, and the General Registrar's Office database of birth certificates. We used offspring identifiers contained in the birth certificates used to link biochemical, pregnancy, and perinatal mortality data to the death certificate registry, allowing us to identify deaths among offspring. We excluded multiple births, stillbirths, and births occurring outside 22 to 43 weeks of gestation.

Births in the cohort assessed here occurred between November 1991 and December

2001. The cohort was defined as women who (1) had a record in the prenatal screening database (in which maternal weight was recorded), (2) could be linked to an SMR2 record, (3) had given birth to a singleton infant weighing more than 400 g, and (4) had given birth between 22 and 43 weeks of gestation. In addition to excluding stillbirths and perinatal deaths because of fetal abnormalities, we excluded women with missing data.

Definitions

Several outcomes were examined: preterm delivery, spontaneous preterm delivery, elective preterm delivery, neonatal death, delivery of an ELBW infant, delivery of an ELBW infant surviving to 1 year of age, and preeclampsia. A preterm delivery was defined as a birth occurring before 37 weeks of gestation, and a term delivery was defined as a birth occurring at or after 37 weeks of gestation. A spontaneous delivery was defined as a vaginal birth or a birth in which the woman was documented as having been in labor at the time of delivery but the labor was not documented as having been induced and was therefore presumed to be spontaneous. An elective delivery was defined as a birth in which the woman did not experience spontaneous labor (i.e., an induced vaginal birth or cesarean birth without a documented duration of labor).

Infants weighing between 400 g and 1000 g were classified as ELBW infants. Infants recorded as having been live born but not as having died (according to either the SSBIDE database or the General Registrar's Office death certificate database) in the first year of life were defined as surviving to 1 year of age. Preeclampsia was defined according to *International Classification of Diseases, Ninth Revision,* diagnostic codes in relation to post-delivery hospital discharge.[14]

Maternal age, parity, postcode of residence, and all outcome data were obtained solely from the SMR2. Data on maternal weight were obtained solely from the biochemical database. When possible, maternal height and smoking data were obtained from the SMR2; in instances in which this information was missing, the biochemical database was used. Smoking status (defined as the smoking status of the woman at the time of her first prenatal care visit) was determined as recorded in the patient's case record. Maternal age was classified as the age of the mother at the time of delivery. Maternal weight was defined as that recorded at the time of Down syndrome screening. BMI (defined as weight in kilograms divided by height in meters squared) was categorized as lean (less than 20 kg/m^2), normal (20–24.9 kg/m^2), overweight (25–29.9 kg/m^2), obese (30–34.9 kg/m^2), and morbidly obese (35 kg/m^2 or above).

Postcode of residence was used to calculate Carstairs socioeconomic deprivation values (higher values indicated greater deprivation). Deprivation classifications were based on 1991 census data on car ownership, unemployment, overcrowding, and social class within postcode sectors containing, on average, approximately 1600 residents.[15] Since the early 1990s, gestational age has been confirmed (in the first half of pregnancy) using ultrasound in more than 95% of pregnancies in the United Kingdom.[16] Gestational age at birth was defined as completed weeks of gestation on the basis of the estimated date of delivery from each woman's clinical record, and standard national criteria exist for using menstrual and ultrasound data to estimate date of delivery. However, the specific means employed in a given record are not specified. Birthweight was categorized into gender-specific and gestational age–specific percentiles derived from the study cohort.

Statistical Analysis

We summarized continuous variables (age, height, and BMI) using medians and interquartile ranges, and we compared groups using the Kruskal–Wallis test. We made univariate comparisons of dichotomous data categories using the χ^2 test or the Fisher exact test. All continuous variables were categorized. The level of statistical significance was set at $P<.05$ (2-sided). Logistic regression analyses were used to calculate adjusted odds ratios (ORs).[17] Independent variables were BMI, age, height, deprivation category, smoking and marital status, and numbers of previous spontaneous early pregnancy losses and therapeutic abortions.

In analyses of birth outcomes for which the same women may have been included 2 or more times as a result of successive pregnancies, we estimated odds ratios using logistic regressions involving robust standard errors and clustering with maternal identifiers. We assessed interaction terms using the Wald test, as is appropriate for clustered data.[17] We used Stata Version 8.2 (Stata Corp, College Station, Tex) to conduct all statistical analyses.

RESULTS

The linked database contained 227 490 records of singleton births. Data for height were missing in 6270 cases (2.8%) and data for weight in 24 835 cases (10.9%); in 26 171 (11.5%) records, either or both of these values were missing. Among the remaining 201 319 records, we excluded 206 (0.1%) deaths because of fetal abnormalities and 893 (0.4%) stillbirths because of other causes, leaving 200 220 records. Of this total, birthweight data were missing or birthweights were less than 400 g in 57 cases (0.03%), and data on gestational age were missing or gestational age was outside 22 to 43 weeks in 62 cases (0.03%). Among the remaining 200 104 records, maternal age was missing in 3 cases (less than 0.01%), parity was missing in 23 cases (0.01%), deprivation category was missing in 347 cases (0.2%), and smoking status was missing in 12 487 cases (6.2%). Overall, 1 or more of these values were missing in 12 814 records (6.4%), leaving a study sample of 187 290 singleton births.

Table 1 presents maternal characteristics and basic outcome data broken down by term delivery, spontaneous preterm delivery, and elective preterm delivery. All of the factors assessed varied among these 3 categories, although the highly statistically significant differences in maternal height actually reflected very small differences in mean height and the 3 groups had identical median values. Among women with preterm deliveries, elective delivery was associated with a reduced risk of neonatal death (relative risk [RR]=0.72; 95% confidence interval [CI]=0.55, 0.94; $P=.02$) and no overall increased risk of delivering an ELBW infant (RR=1.06; 95% CI=0.88, 1.28; $P=.51$). However, it was associated with an increased risk of delivering an ELBW infant who survived to 1 year of age (RR=1.92; 95% CI=1.49, 2.47; $P<.001$).

In the case of all adverse outcomes, nulliparous women were at greater risk than

TABLE 1—Maternal Characteristics and Pregnancy Outcome Data, by Type of Delivery: Cohort of Scottish Women, 1991–2001

	Term Delivery (n = 177 098)	Preterm Spontaneous Delivery (n = 5835)	Preterm Elective Delivery (n = 4357)
Median age, y (IQR)	28 (24-32)	28 (23-31)	29 (25-32)
Median height, cm (IQR)	162 (158-167)	162 (157-166)	162 (157-166)
Median body mass index, kg/m^2 (IQR)	23.9 (21.7-27.0)	23.1 (20.8-26.2)	24.2 (21.7-27.7)
Deprivation category, no. (%)			
1 (least deprivation)	26 055 (14.7)	673 (11.5)	558 (12.8)
2	30 841 (17.4)	924 (15.8)	691 (15.9)
3	33 577 (19.0)	1023 (17.5)	787 (18.1)
4	36 703 (20.7)	1219 (20.9)	939 (21.6)
5 (most deprivation)	49 922 (28.2)	1996 (34.2)	1382 (31.7)
Smoking status, no. (%)			
Never	110 657 (62.4)	3044 (52.2)	2497 (57.3)
Former	13 428 (7.6)	374 (6.4)	302 (6.9)
Current	53 113 (30.0)	2417 (41.4)	1558 (35.8)
Marital status, no. (%)			
Married	106 841 (60.3)	3002 (51.5)	2423 (55.6)
Not married	70 257 (39.7)	2833 (48.6)	1934 (44.4)
Previous spontaneous losses, no. (%)			
0	142 618 (80.5)	4531 (77.7)	3293 (75.6)
≥1	34 480 (19.5)	1304 (22.4)	1064 (24.4)
Previous therapeutic abortions, no. (%)			
0	159 033 (89.8)	5081 (87.1)	3882 (89.1)
≥1	18 065 (10.2)	754 (12.9)	475 (10.9)
Parity status, no. (%)			
Nulliparous	79 421 (44.9)	3101 (53.1)	2179 (50.0)
Multiparous	97 677 (55.2)	2734 (46.9)	2178 (50.0)
Outcome of pregnancy, no. (%)			
Neonatal death	91 (0.1)	160 (2.8)	87 (2.0)
ELBW infant	0 (0.0)	265 (4.5)	210 (4.8)
ELBW infant surviving to 1 year	0 (0.0)	105 (1.8)	148 (3.4)
Preeclampsia	3 910 (2.2)	73 (1.3)	934 (21.4)

Note. IQR = interquartile range; ELBW = extremely low birthweight. All between-group differences were significant at $P \le .001$ level (P values derived from the Kruskal–Wallis test, the χ^2 test, or the Fisher exact test as appropriate).

TABLE 2—Associations Between Parity and Pregnancy Outcomes: Cohort of Scottish Women, 1991–2001

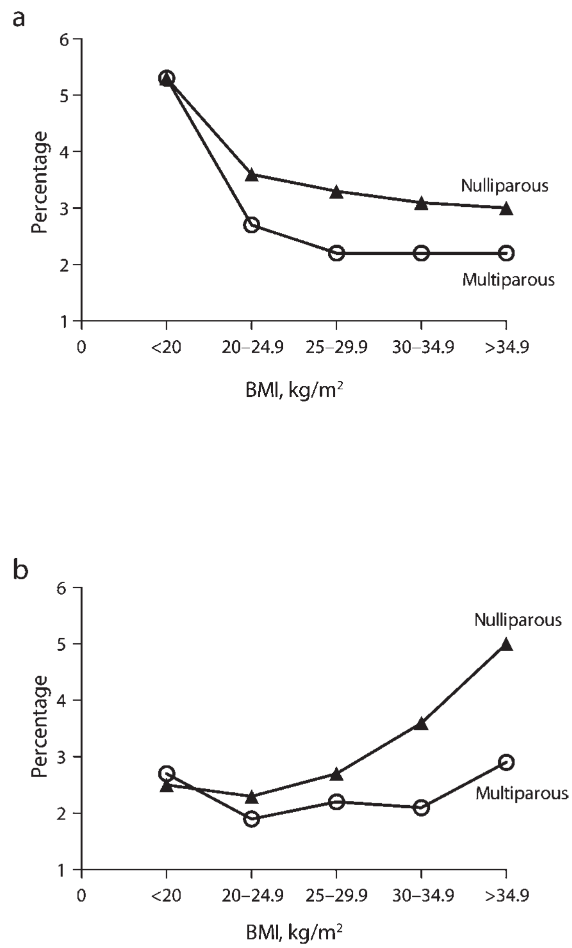
Outcome	Nulliparous (n = 84 701), No. (%)	Multiparous (n = 102 589), No. (%)	Odds Ratio[a] (95% Confidence Interval)
Overall preterm delivery	5280 (6.2)	4912 (4.8)	1.32 (1.27, 1.38)
Spontaneous preterm delivery	3101 (3.7)	2734 (2.7)	1.39 (1.32, 1.46)
Elective preterm delivery	2179 (2.6)	2178 (2.1)	1.22 (1.15, 1.29)
Neonatal death	203 (0.24)	135 (0.13)	1.82 (1.47, 2.27)
ELBW infant	298 (0.35)	177 (0.17)	2.04 (1.69, 2.46)
ELBW infant surviving to 1 year	162 (0.19)	91 (0.09)	2.16 (1.67, 2.80)
Preeclampsia	3272 (3.9)	1645 (1.6)	2.47 (2.32, 2.62)

Note. ELBW = extremely low birthweight. All outcomes were significant at $P < .001$.
[a]Estimated via logistic regressions clustered on maternal identifiers.

multiparous women (Table 2). There were statistically significant interactions between nulliparity and BMI for overall preterm deliveries, spontaneous preterm deliveries, and elective preterm deliveries (all Ps<.001). There was a nonsignificant trend toward interactions between BMI and nulliparity for preeclampsia (P=.12), delivery of an ELBW infant (P=.06), and neonatal death (P=.23). All further analyses of outcomes related to BMI involved stratification according to parity.

Risk of spontaneous preterm deliveries decreased with increasing BMI, and this protective effect of increasing BMI was stronger among multiparous women (Figure 1a; Tables 3 and 4). By contrast, risk of elective preterm deliveries increased with increasing BMI, and the association was stronger among nulliparous women (Figure 1b; Tables 3 and 4). Therefore, the net effect of BMI on key outcomes associated with prematurity differed according to parity status. Among nulliparous women, a BMI of 35 or above was associated with increased risks of overall preterm birth, neonatal death, and delivery of an ELBW infant still alive at 1 year of age (Table 3). By contrast, multiparous women with a BMI of 35 or above were not at increased risk of any of these outcomes (Table 4).

Among nulliparous women with a BMI of 35 or above who had had an elective preterm delivery, 40.2% (49 of 122) had been diagnosed with preeclampsia; the corresponding percentage for multiparous women was 18.0% (25 of 139; P<.001). Preeclampsia had been diagnosed in 4917 (2.6%) women in the cohort overall. Among nulliparous women, neither neonatal death (adjusted OR=1.23; 95% CI=0.57, 2.66; P=.59) nor delivery of an ELBW infant who survived until 1 year of age (adjusted OR=1.75; 95% CI=0.81, 3.77; P=.15) was associated with obesity (BMI of 35 or above) after adjustment for gestational age at delivery. In the same group, adjustment for preeclampsia resulted in attenuation of the associations between obesity and elective preterm delivery (adjusted OR=1.43; 95% CI=1.16, 1.75; P=.001), neonatal death (adjusted OR=2.43; 95% CI=1.35, 4.41; P=.003), and delivery of an ELBW infant who survived until 1 year of age (adjusted OR=2.52; 95% CI=1.40, 4.52; P=.002).



Note. The χ^2 test for trend was significant at $P < .001$ for all associations except elective preterm birth among multiparous women ($P = .12$).

FIGURE 1—Relationship between maternal body mass index (BMI) in early pregnancy in nulliparous and multiparous women and the proportion of spontaneous preterm births (a) and elective preterm births (b).

Of the original 227 490 records, 38 795 (17.1%) were excluded as a result of missing data for BMI, maternal age, parity, deprivation category, or smoking status. The rates of prematurity (5.84%) and low birthweight (5.65%) in this group were slightly higher than (but similar to) those of the study population. Among the group with missing data, 12 814 (33.0%) had a BMI recorded. We compared the relation between BMI (expressed as a continuous variable) and risk of prematurity in the group with missing data and the study population. The odds ratio for spontaneous preterm delivery associated with a 1-unit increase in BMI was 0.96 in both the group with missing data (95% CI=0.94, 0.98; $P<.001$) and the study population (95% CI=0.95, 0.96; $P<.001$). Odds ratios for elective preterm delivery were 1.03 (95% CI=1.01, 1.05; $P=.008$) in the group with missing data and 1.02 (95% CI=1.01, 1.04; $P<.001$) in the study population.

DISCUSSION

The main finding of this study is that obesity in early pregnancy is associated with an increased risk of elective preterm delivery. By contrast, obesity was associated with a decreased risk of spontaneous preterm delivery. The net effect of obesity depends, therefore, on the balance between these 2 outcomes. We found that morbidly obese nulliparous women had a more than 2-times greater risk of elective preterm delivery but only a 20% lower risk of spontaneous preterm delivery. The net effect was that these women were at increased risk of all-cause prematurity, neonatal death, and delivery of an ELBW infant who survived to 1 year of age. These data indicate that morbidly obese women who are planning to conceive should be encouraged to lose weight before their first birth and that rising rates of morbid obesity in the prepregnant population are likely to lead to increased rates of severe morbidity and neonatal death related to prematurity.

This is the first study, to our knowledge, to demonstrate an increased risk of elective preterm delivery among obese women. It has previously been shown that obese women are at lower risk of spontaneous preterm birth.[4–6] Two recent studies analyzing the relation between BMI and elective preterm delivery did not demonstrate an overall association.[4,18] The probable explanation for this apparent discrepancy is that data on nulliparous and multiparous women were pooled. In addition, both cohorts included fewer than 3000 women. The cohort used in our study was more than 50-times larger than the cohorts from these previous studies, and the highly statistically significant results indicate that the associations described are very unlikely to be chance findings.

Moreover, it is biologically plausible that such associations would be observed. Forty percent of morbidly obese nulliparous women who had had an elective preterm delivery had been diagnosed with preeclampsia, compared with only 2.6% of the remainder of the study population. Many previous studies have shown that preeclampsia risk increases with increasing BMI, and this effect is thought to be mediated by the cardiovascular influences of insulin resistance and dyslipidemia.[19] We found that increasing BMI was associated with comparably increased relative risks of preeclampsia in nulliparous and multiparous women (Tables 3 and 4). However, overall rates of preeclampsia were 3.9% and 1.6%, respectively, in these 2 groups (Table 2). The stronger association

TABLE 3—Body Mass Index (BMI) in Early Pregnancy and Outcome of First Pregnancy: Cohort of Scottish Women (n = 84 701), 1991–2001

	BMI < 20		BMI 20–24.9[b]	BMI 25–29.9		BMI 30–34.9		BMI ≥ 35	
	No. (%)	OR[a] (95% CI)	No. (%)	No. (%)	OR[a] (95% CI)	No. (%)	OR[a] (95% CI)	No. (%)	OR[a] (95% CI)
Overall preterm delivery	750 (7.8)	1.36 (1.25, 1.48)	2697 (5.9)	1234 (5.9)	0.99 (0.93, 1.07)	404 (6.7)	1.12 (1.00, 1.25)	195 (8.0)	1.34 (1.15, 1.56)
Spontaneous preterm delivery	507 (5.3)	1.46 (1.32, 1.62)	1654 (3.6)	678 (3.3)	0.89 (0.82, 0.98)	189 (3.1)	0.85 (0.73, 0.99)	73 (3.0)	0.81 (0.64, 1.03)
Elective preterm delivery	243 (2.5)	1.16 (1.00, 1.34)	1043 (2.3)	556 (2.7)	1.15 (1.03, 1.27)	215 (3.6)	1.52 (1.31, 1.77)	122 (5.0)	2.13 (1.75, 2.58)
Neonatal death	31 (0.3)	1.67 (1.10, 2.54)	88 (0.2)	54 (0.3)	1.35 (0.96, 1.90)	17 (0.3)	1.46 (0.86, 2.46)	13 (0.5)	2.77 (1.54, 4.99)
ELBW infant	40 (0.4)	1.35 (0.94, 1.93)	135 (0.3)	73 (0.4)	1.20 (0.90, 1.60)	26 (0.4)	1.47 (0.96, 2.24)	24 (1.0)	3.31 (2.13, 5.14)
ELBW infant surviving to 1 year	18 (0.2)	1.02 (0.61, 1.72)	79 (0.2)	36 (0.2)	1.02 (0.69, 1.52)	15 (0.3)	1.47 (0.84, 2.56)	14 (0.6)	3.36 (1.89, 5.98)
Preeclampsia	208 (2.2)	0.79 (0.68, 0.91)	1350 (3.0)	1025 (4.9)	1.68 (1.54, 1.82)	446 (7.4)	2.57 (2.30, 2.88)	243 (10.0)	3.60 (3.12, 4.17)

Note. OR = odds ratio; CI = confidence interval; ELBW = extremely low birthweight. The total numbers of births across the 5 BMI categories were 9573 (11.3%), 45 812 (54.1%), 20 819 (24.6%), 6060 (7.2%), and 2437 (2.9%), respectively.
[a]Adjusted for maternal age, height, deprivation category, smoking and marital status, and number of previous spontaneous early pregnancy losses and therapeutic abortions and referent to women with a BMI of 20–24.9.
[b]Reference group.

TABLE 4—Body Mass Index (BMI) in Early Pregnancy and Outcomes of Multiparous Women: Cohort of Scottish Women (n = 102 589), 1991–2001

	BMI < 20		BMI 20–24.9[b]	BMI 25–29.9		BMI 30–34.9		BMI ≥ 35	
	No. (%)	OR[a] (95% CI)	No. (%)	No. (%)	OR[a] (95% CI)	No. (%)	OR[a] (95% CI)	No. (%)	OR[a] (95% CI)
Overall preterm delivery	675 (8.0)	1.70 (1.55, 1.86)	2280 (4.6)	1273 (4.3)	0.93 (0.87, 1.00)	438 (4.3)	0.91 (0.81, 1.01)	246 (5.1)	1.09 (0.95, 1.26)
Spontaneous preterm delivery	447 (5.3)	1.87 (1.67, 2.10)	1320 (2.7)	639 (2.2)	0.82 (0.74, 0.90)	221 (2.2)	0.80 (0.69, 0.92)	107 (2.2)	0.83 (0.67, 1.01)
Elective preterm delivery	228 (2.7)	1.37 (1.18, 1.60)	960 (1.9)	634 (2.2)	1.10 (0.99, 1.22)	217 (2.1)	1.06 (0.91, 1.24)	139 (2.9)	1.45 (1.21, 1.75)
Neonatal death	17 (0.2)	1.49 (0.86, 2.58)	58 (0.1)	39 (0.1)	1.18 (0.78, 1.77)	17 (0.2)	1.44 (0.84, 2.47)	4 (0.1)	0.73 (0.27, 2.01)
ELBW infant	22 (0.3)	1.61 (0.99, 2.62)	70 (0.1)	54 (0.2)	1.33 (0.93, 1.90)	24 (0.2)	1.65 (1.03, 2.64)	7 (0.1)	1.04 (0.48, 2.26)
ELBW infant surviving to 1 year	7 (0.1)	0.96 (0.43, 2.14)	41 (0.1)	24 (0.1)	0.96 (0.58, 1.59)	13 (0.1)	1.46 (0.78, 2.76)	6 (0.1)	1.45 (0.61, 3.44)
Preeclampsia	62 (0.7)	0.77 (0.59, 1.01)	515 (1.0)	531 (1.8)	1.72 (1.52, 1.94)	307 (3.0)	2.89 (2.50, 3.34)	230 (4.7)	4.57 (3.88, 5.38)

Note. OR = odds ratio; CI = confidence interval; ELBW = extremely low birthweight. The total numbers of births in the 5 BMI categories were 8395 (8.2%), 49 704 (48.5%), 29 395 (28.7%), 10 245 (10.0%), and 4850 (4.7%), respectively.
[a]Adjusted for maternal age, height, deprivation category, smoking and marital status, and number of previous spontaneous early pregnancy losses and therapeutic abortions and referent to women with a BMI of 20–24.9; estimated via logistic regressions clustered on maternal identifiers.
[b]Reference group.

between obesity and elective preterm delivery among nulliparous women was probably because of these women's higher background risk of preeclampsia.

Areas of Future Study

Among nulliparous women, obesity was not associated with risk of either neonatal death or delivery of an ELBW infant who survived to 1 year of age after adjustment for gestational age at delivery. This finding suggests that the association between obesity and these clinically important outcomes is mediated by obesity's association with prematurity. Adjustment for preeclampsia resulted in marked, but not complete, attenuation of the associations observed between morbid obesity and elective preterm delivery, neonatal death, and delivery of an ELBW infant who survived to 1 year of age. The persistence of positive associations between morbid obesity and these outcomes after adjustment for preeclampsia may reflect errors in preeclampsia diagnoses, or, alternatively, other complications of pregnancy may be associated with obesity and may lead to an increased risk of these outcomes. This issue requires further study.

Many studies addressing factors associated with preterm labor lack either the data or the statistical power necessary to address the important consequences of prematurity. In addition to neonatal deaths, the record linkages used in the present study allowed us to identify long-term survivors whose birthweights were below 1000 g. Follow-up studies of these survivors in childhood demonstrated that 40% to 45% had severe neurodevelopmental impairments,[9] as mentioned earlier, and this finding led to our designation of ELBW as a proxy for severe long-term morbidity. We demonstrated that morbidly obese nulliparous women were at increased risk of both perinatal mortality and perinatal outcomes likely to lead to severe morbidity. This underlines the clinical significance of the association with preterm delivery described here. Ideally, future studies will analyze risks of long-term severe morbidity directly rather than use a proxy measure.

The overall rate of prematurity in our study was relatively low, at 5.4%. This result is consistent with the findings of other European studies.[7] By contrast, previous US studies have reported overall prematurity rates of 10% to 15%.[4,18] However, these cohorts included 40% to 60% African American women and involved similarly high percentages of women who were unmarried or living in households with incomes below the poverty level. The present data are applicable to a relatively low-risk population. However, as observed in our comparisons of nulliparous and multiparous women, associations of birth outcomes with BMI depend on the relative balance of background risks of spontaneous and elective preterm deliveries. Among nulliparous women at high risk of spontaneous preterm delivery, an increased BMI may be associated with a reduced overall risk of prematurity. Again, this is an issue for further study.

Limitations

As is the case with any large-scale study in which routinely collected data are used, our study involved a number of weaknesses. The SMR2 database does not routinely collect data on maternal weight, and we were able to obtain this information only by linking records to a prenatal screening database. As a result, the population studied was selected on the basis of women having accepted screening for congenital abnormalities. However, 81% of women in the west of Scotland undergo serum screening,[12] and thus, the study included most women seeking prenatal care.

Because maternal weight was used to adjust prenatal screening results, the value recorded was that from early pregnancy. As a result, we lacked data on prepregnancy weight and weight gain during pregnancy. However, our primary aim was to determine the probable effects of rising obesity rates in the general population on negative consequences of prematurity. BMI in early pregnancy is a good proxy for prepregnancy BMI, given that relatively little weight gain will have occurred between these intervals. Finally, approximately 17% of eligible women were excluded because of missing data, raising the possibility that our study population was biased. However, associations between BMI and spontaneous and elective preterm deliveries were similar when women with missing data on other maternal variables were compared with the study population.

Our results show that maternal obesity is associated with an increased risk of elective preterm delivery. The association is stronger among nulliparous women, probably as a result of their increased risk of preeclampsia, and here it led to an overall association between obesity and preterm birth in this group. Obese nulliparous women are at increased risk of the serious negative consequences associated with preterm births. ■

About the Authors

At the time of the study, Gordon C.S. Smith and Imran Shah were with the Department of Obstetrics and Gynaecology, Cambridge University, Cambridge, England. At the time of the study, Imran Shah was with the Department of Obstetrics and Gynaecology, Cambridge University, and Jill P. Pell was with the Department of Public Health, Greater Glasgow, Glasgow, Scotland. Jennifer A. Crossley was with the Institute of Medical Genetics, Glasgow. Richard Dobbie was with the Information and Statistics Division, National Health Service for Scotland, Glasgow.

Requests for reprints should be sent to Gordon C.S. Smith, MD, PhD, Department of Obstetrics and Gynaecology, Cambridge University, Rosie Maternity Hospital, Cambridge CB2 2SW, United Kingdom (e-mail: gcss2@cam.ac.uk).

This article was accepted January 23, 2006.

Contributors

G.C.S. Smith originated the study and drafted the article. G.C.S. Smith and I. Shah analyzed and interpreted the data. All of the authors contributed to critical revisions of the article.

Acknowledgments

This research was funded by project grants from the Foundation for the Study of Infant Deaths (grants 245 and 249).

Human Participant Protection

The record linkage for this study was approved by the Privacy Advisory Committee, National Health Service for Scotland.

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