Diabetes in Pregnancy and Cesarean Delivery

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OBJECTIVE — To evaluate the effect of diabetes during pregnancy on cesarean delivery and to determine whether the association between diabetes during pregnancy and cesarean delivery is mediated by birth weight.

RESEARCH DESIGN AND METHODS — South Carolina 1993 birth certificates were matched through a unique identifier with infant and maternal hospital discharge records for the same year, yielding a total study population of 42,071 singleton births. Adjusted odds ratios (ORs) and 95% CIs were determined for the association between diabetes in pregnancy and cesarean delivery through multiple logistic regression, controlling for maternal age, race, education, number of prenatal care visits, length of gestation, birth weight, and a number of medical indications.

RESULTS — Of the study population, 0.7% were pregnancies complicated by preexisting diabetes, 2.9% were pregnancies complicated by gestational diabetes, and 23.4% were cesarean deliveries. After controlling for confounders, including birth weight, cesarean delivery was strongly associated with both preexisting diabetes (OR [95% CI] 6.20 [4.47–8.61]) and gestational diabetes (1.71 [1.41–2.07]). The estimates remained essentially unchanged without birth weight in the model, and were substantially higher in analyses restricted to deliveries without common medical indications for cesarean delivery.

CONCLUSIONS — Both preexisting and gestational diabetes increase the risk for cesarean delivery, independent of the effect of birth weight. The association is markedly greater among women without other medical indications for cesarean delivery. The increased risk of cesarean delivery for women with diabetes is mediated through other factors, which may include practice patterns and physician referrals to high-risk care.

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Diabetes in pregnancy is associated worldwide with adverse maternal and neonatal outcomes. Among these complications are preeclampsia, large-for-gestational-age infants, and an increased rate of cesarean delivery (1–8). In 1994, diabetes occurred in 3% of pregnancies in South Carolina (9). This statistic is consistent with data reported by Ventura and associates (10), who found diabetes listed on the birth certificate as a complication in 2.6% of all live births, and with the National Maternal and Infant Health Survey in 1988, which showed that diabetes complicates 4% of U.S. pregnancies (11). The most frequent complications during labor and delivery in diabetic women in South Carolina are meconium, breech/malpresentation, cephalopelvic disproportion, fetal distress, and cesarean delivery (9).

Cesarean delivery was the most common major operation performed in the U.S. for each year between 1984 and 1993 (12). Though rates of cesarean delivery have been declining in recent years (10), it remains the most frequent major surgical procedure among women. In 1996, 20.7% of deliveries in the United States were by cesarean, a decrease from 22.8% in 1989. The rate of vaginal birth after previous cesarean has increased over the same period from 18.9 to 28.3%.

Cesarean delivery rates increase with age. Older women are about twice as likely to deliver by cesarean and ~50% more likely to have a primary cesarean, while the youngest mothers are ~50% more likely to experience a vaginal birth after cesarean delivery. There is considerable regional variation in rates of both cesarean delivery and vaginal birth after cesarean (10,13).

While there is still debate about the indications for cesarean delivery, especially for macrosomic infants, there has been increased caution about routine cesarean delivery and greater acceptance of a trial of labor and vaginal delivery (14–19). This approach gains support from studies indicating that diabetic women have fewer complications and shorter recuperation after vaginal delivery (12,20–22), although the evidence is not unanimous (23). However, among women with diabetes in pregnancy, rates of cesarean delivery remain higher and vaginal births after cesarean section lower than in women who do not have diabetes (10). Given that birth weight is considered in the election of cesarean delivery (24,25), this cross-sectional study uses 1993 South Carolina birth certificates linked to maternal and infant hospital discharge records to examine how diabetes during pregnancy and birth weight affect the rate of cesarean delivery.

RESEARCH DESIGN AND METHODS

Data for this study were extracted from 1993 maternal and infant hospital discharge summaries and birth certificates. By means of maternal and infant identification numbers, hospital discharge records provided by the Office of Health Statistics were linked with birth records from the Office of Vital Records and Public Health

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Abbreviations: HBW, high birth weight; ICD-9, *International Classification of Diseases, Ninth Revision*; LBW, moderately low birth weight; NBW, normal birth weight; OR, odds ratio; VHBW, very high birth weight; VLBW, very low birth weight.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Statistics, South Carolina Department of Health and Environmental Control. Within the 1993 birth cohort, infants or their mothers who did not have hospital discharge records for the initial birth period, multiple-birth infants, and infants weighing <500 g were excluded. While birth records, either alone or with hospital discharge diagnoses, are not considered highly reliable sources for studies of birth defects (26,27), they have been shown to be valid sources of data for other perinatal studies (28–30).

Using hospital discharge diagnoses, diabetes in pregnancy was classified by *International Classification of Diseases*, *Ninth Revision* (ICD-9) (31) codes for diabetes antedating pregnancy, termed preexisting diabetes (codes 648.0 and 250), and gestational diabetes (code 648.8). The referent group were subjects in the cohort who had no listed diagnosis of diabetes. Delivery method was obtained from the ICD-9 procedure coding for cesarean birth (codes 74.0–74.2, 74.4, 74.99).

The following risk factors were assessed as potential confounders for the association between diabetes in pregnancy and cesarean delivery: prenatal care, length of gestation, maternal age, race, and education. Based on convention and literature review, maternal age was categorized as <20, 20–34, and ≥35, and maternal education dichotomized as <12 years versus ≥12 years. Following the convention of the South Carolina health department, race was categorized as white or black and other. Prenatal care was assessed both in terms of the trimester in which care began and whether <6 or ≥6 prenatal visits were recorded on the birth certificate, with six visits representing a minimal level of care.

Medical risk factors (and associated ICD-9 codes) included previous cesarean delivery (654.2), preeclampsia, eclampsia, and other hypertension complicating pregnancy (642.4–642.7, 642.9), maternal hemorrhage, including placenta previa and abruptio placentae (640, 641), failed induction (659.0–659.1), obstructed labor (660), inertia or other abnormal labor (661), prolonged labor (662.0–662.2), fetal distress (656.3), excessive fetal growth or large fetus (653.5, 656.6), disproportion (653, excluding 653.5 for analysis), abnormal uterus excluding scar for previous cesarean delivery (654.0, 654.1, 654.3–654.8), and malpresentation (652).

Because the association between diabetes and cesarean delivery may be mediated in part through macrosomia or early delivery for medical indications, both birth weight and gestational age were evaluated in the logistic regression models. Birth weight was categorized as very low birth weight (VLBW: 500–1,499 g), moderately low birth weight (LBW: 1,500–2,499 g), normal birth weight (NBW: 2,500–3,999 g, the referent group), high birth weight (HBW: 4,000–4,499 g), and very high birth weight (VHBW: ≥4,500 g). Infants with ICD-9 codes for excessive fetal growth (656.6) or large fetus (653.5) in both the NBW range and the two high birth weight groups were placed in separate categories to assess the association of cesarean delivery with macrosomia apart from the variables for birth weight and disproportion. Gestational age, based on the clinical estimate of gestation on the birth certificate, was categorized <32 completed weeks, 32 to <37 completed weeks, 38–42 completed weeks (the referent group), and >42 completed weeks. If the clinical estimate was missing, the date of last normal menses was used to calculate gestational age.

Frequencies and distributions of potential risk factors were calculated for preexisting diabetes, gestational diabetes, and nondiabetic status. Differences across categories were tested by χ^2 statistic. The association between cesarean delivery and diabetes in pregnancy was assessed while controlling for confounders using multiple logistic regression. Variables that remained as significant (α = 0.05) correlates of cesarean delivery or that were determined to confound the association between diabetes and cesarean delivery were retained in the final model. Maternal race was forced in the model a priori because of the association with many pregnancy outcomes and because of the elevated rates of diabetes in black women in South Carolina. Interaction terms for diabetes type with each medical indication were tested for significance in the logistic regression models to determine if the association of diabetes with cesarean delivery varied according to the presence or absence of any medical condition. Odds ratios (ORs) and 95% CIs were calculated for each relevant association. To determine if birth weight accounted for the observed association, models were run with and without the birth weight categories, and the ORs for the diabetes–cesarean delivery association were compared. Finally, models were run on a restricted sample, excluding births with any of the common medical indications for cesarean delivery, namely disproportion, malpresentation, fetal distress, failed induction, previous cesarean section, obstructed labor, abnormal uterus, abnormal labor, hemorrhage, and preeclampsia. Women with prolonged labor only were retained and the model was adjusted for prolonged labor. All analyses were performed using SAS software (SAS Institute, Cary, NC).

Table 1—*Comparison of characteristics of the merged birth certificate–hospital discharge sample used in the study with all 1993 singleton births in South Carolina*

Characteristic	Study sample	All singleton births in South Carolina
Low birth weight (<2,500 g)	7.6	7.9
Black or other maternal race	39.3	39.2
Maternal education <12 years	22.0	22.5
Maternal age >35 years	7.8	5.6
Cesarean delivery	22.9	25.8
Diabetes in pregnancy	3.6	3.1

Data are %. All data are from the birth certificate except for classification of delivery method and diabetes in the study sample.

RESULTS

Population

There were 54,448 live births recorded in South Carolina in 1993, of which 53,058 were singleton births. Birth certificates and hospital discharge records for mother and infant were matched according to unique identifiers, producing records with information from all three sources. There were 11,734 birth records that could not be matched to discharge records; these were excluded, as were an additional 643 records for multiple births. The final analysis sample therefore consisted of 42,071 singleton births. Because the loss of about one-fifth of the births due to nonmatching records raises the possibility of selection bias, Table 1 is provided to illustrate the general comparability of the complete 1993 South Carolina singleton birth cohort and the merged file used in these analyses. The analysis sample has a slightly lower rate of cesarean delivery and a slightly higher overall rate of diabetes based on discharge diagnoses than the total cohort, based only on birth certificate information, which does not distinguish between preexisting and gestational diabetes. However, the crude ORs for diabetes in pregnancy and cesarean delivery are virtually identical (2.1) in the two samples.

Description of data

Over one-fifth (22.9%) of births in this sample were by cesarean delivery. Diabetes was listed as a complication of pregnancy in 3.6% of all births. That figure divides into roughly four-fifths gestational diabetes (2.9% of the total births) and one-fifth preexisting diabetes (0.7% of the total births). Women with preexisting diabetes had the highest percentage of cesarean deliveries (51.3%), followed by those with gestational diabetes (34.4%), compared with 22.4% for the women without diabetes. Women in both diabetic categories were also significantly more likely to have had a previous cesarean delivery, though this may be confounded by age, which is related to both diabetic status and prior cesarean delivery, with older women at higher risk for both.

Table 2 displays the distribution of other variables by diabetic category. Maternal age differed significantly across categories of diabetes, with women ≥35 years of age about twice as likely to have pregnancies complicated by both gestational and preexisting diabetes, and women <20 years of age about one-fourth as likely. Women with diabetes had more prenatal care visits and earlier initiation of prenatal care.

Gestational age was marginally different across categories of diabetes: women with preexisting diabetes were more likely to have preterm deliveries than either women with gestational diabetes or nondiabetic women. There were no pregnancies complicated by diabetes >42 weeks' gestation. Birth weight appears normally distributed among the nondiabetic women, with higher percentages of larger infants in mothers with either preexisting diabetes or gestational diabetes. Infants with discharge diagnostic codes for excessive fetal growth or large fetus were more frequently born to diabetic women.

A number of the common medical indications for cesarean delivery differed significantly by diabetes status. Preeclampsia, disproportion, failed induction, obstructed labor, and abnormalities of the uterus were

Table 2—*Comparison of selected characteristics by type of diabetes, singleton births in South Carolina, 1993*

Factor	Preexisting diabetes	Gestational diabetes	Nondiabetic	*P* value
Mode of delivery				<0.001*
Cesarean	154 (51.3)	418 (34.4)	9,083 (22.4)	
Vaginal	146 (48.7)	798 (65.6)	31,472 (77.6)	
Maternal age (years)				
<20	12 (4.0)	50 (4.1)	6,653 (16.4)	<0.001*
20–34	242 (80.7)	965 (79.4)	30,857 (76.1)	
≥35	46 (15.3)	201 (16.5)	3,045 (7.5)	
Maternal race				0.556
Black and other	124 (41.3)	464 (38.2)	15,930 (39.3)	
White	176 (58.7)	752 (61.8)	24,614 (60.7)	
Missing	—	—	11	
Education (years)				<0.001*
<12	52 (17.3)	162 (13.4)	9,056 (23.1)	
≥12	248 (82.7)	1,051 (86.6)	30,165 (76.9)	
Missing	—	3	146	
Trimester prenatal care began				<0.001*
First	251 (84.2)	951 (78.9)	29,741 (74.1)	
Second	37 (12.4)	208 (17.3)	8,000 (19.9)	
Third	8 (2.7)	43 (3.6)	1,875 (4.7)	
None	2 (0.7)	3 (0.3)	528 (1.3)	
Missing	2	11	411	
Total number of prenatal visits				<0.001*
<6	9 (3.0)	58 (4.8)	4,455 (11.0)	
≥6	291 (97.0)	1,158 (95.2)	36,100 (89.0)	
Length of gestation (weeks)				0.025*
<32	7 (2.3)	9 (0.7)	586 (1.4)	
32 to <37	32 (10.7)	73 (6.0)	2,709 (6.7)	
37 to 42	261 (87.0)	1,134 (93.3)	37,089 (91.6)	
>42	0 (0.0)	0 (0.0)	110 (0.3)	
Missing	—	—	61	
Birth weight				<0.001*
VLBW (500–1,499 g)	3 (1.0)	6 (0.5)	454 (1.1)	
LBW (1,500–2,499 g)	18 (6.0)	53 (4.4)	2,681 (6.6)	
NBW (2,500–3,999 g)	221 (73.9)	974 (80.1)	33,891 (83.7)	
HBW (4,000–4,499 g)	43 (14.4)	143 (11.8)	2,994 (7.4)	
VHBW (≥4,500 g)	14 (4.7)	40 (3.3)	492 (1.2)	
Missing	1	0	43	
Excessive fetal growth or large fetus coded				<0.001*
Yes	11 (3.7)	47 (3.9)	580 (1.4)	
No	289 (96.3)	1,169 (96.1)	39,975 (98.6)	
Previous cesarean delivery				<0.001*
Yes	50 (16.7)	199 (16.4)	4,245 (10.5)	
No	250 (83.3)	1,017 (83.6)	36,310 (89.5)	
Maternal hemorrhage				0.049
Yes	2 (0.7)	9 (0.7)	607 (1.5)	
No	298 (99.3)	1,207 (99.3)	39,948 (98.5)	
Preeclampsia				<0.001
Yes	30 (10.0)	74 (6.1)	1,617 (4.0)	
No	270 (90.0)	1,142 (93.9)	38,938 (96.0)	
Disproportion (including large fetus)				0.004*
Yes	21 (7.0)	82 (6.7)	1,996 (4.9)	
No	279 (93.0)	1,134 (93.3)	38,559 (95.1)	

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Table 2 ***(continued)***

Factor	Preexisting diabetes	Gestational diabetes	Nondiabetic	*P* value
Failed induction				0.001*
Yes	3 (1.0)	29 (2.4)	266 (0.7)	
No	297 (99.0)	1,187 (97.6)	40,289 (99.3)	
Fetal distress				0.443
Yes	14 (4.7)	65 (5.4)	2,413 (6.0)	
No	286 (95.3)	1,151 (94.6)	38,142 (94.0)	
Malpresentation				0.113
Yes	22 (7.3)	66 (5.4)	1,991 (4.9)	
No	278 (92.7)	1,150 (94.6)	38,564 (95.1)	
Obstructed labor				0.008*
Yes	22 (7.3)	93 (7.6)	2,305 (5.7)	
No	278 (92.7)	1,123 (92.4)	38,246 (94.3)	
Abnormality of uterus				<0.001*
Yes	14 (4.7)	45 (3.7)	709 (1.8)	
No	286 (95.3)	1,171 (96.3)	39,846 (98.2)	
Other abnormality of labor or inertia				0.559
Yes	25 (8.3)	82 (6.7)	2,777 (6.8)	
No	275 (91.7)	1,134 (93.3)	37,778 (93.2)	

Data are *n* (%). *n* = 42,071. All percentages and statistical tests are calculated based on nonmissing values. *Statistically significant difference at $\alpha = 0.05$.

all more frequent in women with diabetes. Fetal distress, malpresentation, and inertia or other abnormalities of labor did not differ by diabetic classification. Bleeding problems were marginally less likely among diabetic women, though the numbers were quite small.

Logistic regression analysis

ORs and 95% CIs from the logistic regression analyses are shown in Table 3. Although interaction terms for individual medical risk factors with diabetes were not significant, there was a significant interaction of preexisting diabetes with an overall term for any medical indication for cesarean section. Therefore, results are presented for two models: one includes all women with complete information and adjusts for medical indications for cesarean delivery, and the other is restricted to those women without medical indications for cesarean section. The risk of cesarean delivery was modestly increased for women with gestational diabetes (OR [95% CI] 1.71 [1.41– 2.07]) and significantly higher for those with preexisting diabetes (6.20 [4.47–8.61]). Even after controlling for the large number of confounders and medical risk factors, the ORs remain statistically significant, suggesting that both gestational and preexisting diabetes are independent risk factors for cesarean delivery. The marked change in the magnitude of the OR from the crude association for preexisting diabetes suggests there may be substantial confounding from the medical risk factors controlled for in the model. All of the medical risk factors exhibit very strong associations, although some estimates may be unstable because of small numbers.

The ORs change very little in a multivariable model without birth weight—6.39 (4.63–8.81) for preexisting diabetes and 1.77 (1.47–2.15) for gestational diabetes—suggesting that the association between diabetes and cesarean section is not mediated through infant size alone. Inclusion of a term for macrosomia, without other birth weight categories, results in <10% attenuation of the ORs. Preterm delivery was also significantly associated with cesarean delivery in a model without birth weight (OR = 3.32 for <32 weeks' gestation and 2.08 for 32–37 weeks), but only moderately preterm delivery (32 to <37 weeks) was significantly associated when controlling for birth weight. Both LBW and VLBW were significantly associated with cesarean delivery, indicating that other risk factors not accounted for could have been associated with early delivery. The strongest associations were observed for the medical risk factors, especially disproportion, previous cesarean delivery, failed induction, and malpresentation.

When the data were analyzed excluding women with any of the strong medical risk factors but including birth weight and macrosomia (Model 2 in Table 3), the OR for preexisting diabetes was substantially elevated (11.25 [7.32–17.28]) while the OR for gestational diabetes remained essentially unchanged. An additional model, including only those without any of the strong medical indications and further restricted to NBW infants who were not coded as large for gestational age, yielded similar ORs: 11.87 (7.22–19.51) for preexisting diabetes and 2.13 (1.32–3.43) for gestational diabetes (model not shown).

CONCLUSIONS — In these analyses, diabetes was an independent and significant risk factor for cesarean delivery, after controlling for medical risk factors and other potential confounders as well as for infant size. As expected, preexisting diabetes exhibited a stronger association than gestational diabetes. The category of maternal bleeding includes women with placenta previa, virtually all of whom would have cesarean delivery. Several of the other medical indications also show very strong associations. The analysis of the restricted sample, excluding women with these strong medical risk factors, yielded even larger ORs, confirming the association between diabetes and cesarean delivery to be independent of the identified medical conditions or events.

Maternal race was not a statistically significant predictor of cesarean delivery in the adjusted models except in the restricted sample, where there was a modestly elevated OR. Race is often associated with infant outcomes and pregnancy complications (32), but it does not appear to be a substantial factor in recent population-based statistics (10) and was not in this study. This implies that the supposed relevance of race to cesarean delivery is explained by other variables. The absence of an association for race is unlikely to be due to a lack of statistical power, given the size of the study population. Therefore race may be an indirect measure of several risk factors for pregnancy outcome, such as socioeconomic status and access to comprehensive health care.

Education was used instead of socioeconomic status. Lower educational levels were associated with a lower cesarean delivery rate. Fewer prenatal visits also were associated with a lower cesarean section rate. Later entry into prenatal care and fewer visits could be indicative of an uncomplicated pregnancy that would be less likely to end in cesarean delivery. Although late entry into care and few or no prenatal visits are associated with pregnancies at higher risk for preterm delivery, there may be a distinction between the spontaneous preterm delivery and the iatrogenic preterm delivery by cesarean section. Conversely, high-risk pregnancies are more likely to result in increased numbers of prenatal care visits, although the dividing point of 6 for number of visits in our dichotomous variable is not indicative of a high-risk pregnancy and represents a minimal level of care.

Length of gestation and birth weight exhibit the expected U-shaped risk curves. In bivariate analysis, at the lower and upper ends of each spectrum, the risk of cesarean delivery is greater than that found within the midrange of gestation or birth weight. The associations with cesarean delivery for both shorter and longer gestations were statistically significant only for moderately preterm delivery after controlling for infant size and medical risk factors. When separate categories are included for infants with discharge diagnoses of excessive fetal growth or "large fetus," the categories for higher birth weight infants, even those weighing >4,500 g, are no longer statistically significant. Physicians may be more likely to code for a "large fetus" after a cesarean delivery than after a vaginal delivery for an infant of the same size. From an epidemiologic perspective, birth weight is not technically a confounder because it is thought to be an intermediate step in the causal pathway between diabetes in pregnancy and cesarean delivery (33). However, the independent effects of both birth weight and diabetes suggest that there are alternate pathways between diabetes and cesarean delivery.

This finding is consistent with the study reported by Naylor and associates (34). They found that there was an increased rate of cesarean delivery in treated diabetic women whether the infant was macrosomic or not. While macrosomia increased the risk of cesarean delivery, there was no difference in the rates of cesarean delivery between large and normal weight infants among treated diabetic women. As in our own analysis, the addition of birth weight to the analysis had very little effect on the association with cesarean delivery when comparing diabetic with nondiabetic women.

Table 3—*Adjusted odds ratios for cesarean delivery and diabetes in pregnancy in South Carolina singleton births, 1993*

Factor	OR (95% CI)
Model 1: Total sample with complete information (*n* = 41,814)	
Diabetes in pregnancy	
Preexisting	6.20 (4.47–8.61)
Gestational	1.71 (1.41–2.07)
None	1.00
Demographic factors	
Maternal age (years)	
<20	0.86 (0.76–0.97)
20–34	1.00
≥35	1.45 (1.28–1.64)
Maternal race (black and other vs. white)	1.02 (0.95–1.10)
Education (<12 vs. ≥12 years)	0.88 (0.80–0.97)
Prenatal care (<6 vs. ≥6 visits)	0.80 (0.70–0.91)
Length of gestation (weeks)	
<32	0.92 (0.60–1.43)
32 to <37	1.54 (1.32–1.80)
37 to 42	1.00
>42	1.24 (0.65–2.36)
Birth weight	
VLBW (500–1,499 g)	6.30 (4.03–9.84)
LBW (1,500–2,499 g)	1.83 (1.57–2.13)
NBW (2,500–3,999 g)	1.00
NBW (but large for gestational age)	11.46 (7.15–18.35)
HBW (4,000–4,499 g)	1.08 (0.93–1.24)
VHBW (≥4,500 g)	1.32 (0.92–1.88)
HBW and large for gestational age or large fetus	8.95 (7.01–11.44)
Medical factors	
Previous cesarean delivery	73.16 (66.35–80.68)
Preeclampsia	5.23 (4.52–6.05)
Maternal bleeding	12.77 (10.34–15.77)
Failed induction	51.96 (34.58–78.06)
Obstructed labor	4.05 (3.49–4.69)
Inertia or other abnormality of labor	12.17 (10.88–13.62)
Prolonged labor	1.68 (1.24–2.28)
Fetal distress	14.99 (13.39–16.78)
Disproportion (excluding large fetus)	700.49 (483.64–999.00)
Abnormality of uterus	3.41 (2.70–4.31)
Malpresentation	57.13 (50.16–65.06)
Model 2: Sample restricted to those without medical indications for cesarean delivery (*n* = 26,900)	
Diabetes in pregnancy	
Preexisting	11.25 (7.32–17.28)
Gestational	1.85 (1.24–7.75)
None	1.00
Maternal age (years)	
<20	0.76 (0.57–1.01)
20–34	1.00
≥35	1.97 (1.53–2.54)
Maternal race (black and other vs. white)	1.25 (1.05–1.49)
Maternal education (<12 vs. ≥ 12 years)	0.85 (0.67–1.07)
Prenatal care (<6 vs. ≥6 visits)	0.67 (0.51–0.89)
Prolonged labor	5.56 (3.56–8.68)
Length of gestation (weeks)	
<32	1.77 (0.87–3.60)
32 to <37	2.39 (1.80–3.17)
37 to 42	1.00
>42	2.17 (0.52–9.06)

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Table 3 ***(continued)***

Factor	OR (95% CI)
Model 2 (continued)	
Birth weight	
VLBW (500–1,499 g)	15.02 (7.13–31.63)
LBW (1,500–2,499 g)	2.60 (1.93–3.48)
NBW (2,500–3,999 g)	1.00
NBW (but large for gestational age)	24.89 (12.72–48.72)
HBW (4,000–4,499 g)	0.95 (0.63–1.43)
VHBW (≥4,500 g)	2.17 (0.99–4.74)
HBW and large for gestational age or large fetus	22.08 (15.18–32.12)

Sample in Model 2 is restricted to those without any of the following: previous cesarean delivery, preeclampsia, maternal bleeding, failed induction, obstructed labor, inertia or other abnormality of labor, fetal distress, disproportion, abnormality of uterus, or malpresentation.

Naylor et al. (34) suggest that, while medical factors and infant size may account for some of the increased risk of cesarean delivery among diabetic women, practice patterns and physician referrals to high-risk care may be a larger factor. Other studies have also suggested that practice patterns play a large role in the rate of cesarean delivery for women with diabetes (35,36).

Women who have had a cesarean delivery before their current delivery are at much higher risk of a cesarean delivery in the current pregnancy. It is not surprising that previous cesarean delivery is highly associated with subsequent cesarean delivery, inasmuch as the number of repeat cesareans was ~2.5 times greater than the number of vaginal births after cesarean deliveries in 1996 (10). Although incomplete ascertainment of prior cesarean could bias this odds ratio, it is unlikely to account for an association of this magnitude.

The current population-based analysis makes use of information collected on virtually all births in the state. The information on diagnoses and procedures was gathered for hospital billing, insurance, and resource utilization studies, but the coding was based on physicians' notes. Because the hospital discharge records were intended to track costs through material and personnel utilization, the collection mechanism itself should minimize underreporting. Ascertaining pregnancy complications from the birth certificate has been considered unreliable (37), and some studies have found deficiencies in computerized discharge databases for studies of birth defects (26,27). However, linked birth certificate and hospital discharge records have been a valid source for epidemiologic investigations of other perinatal outcomes (28–30). Validating the computerized information by comparison with hospital charts would be a desirable quality control measure.

Despite the consideration of these data as robust and appropriate for the proposed study, there are some limitations. There is a potential for misclassification of conditions labeled with ICD-9 codes because of medical chart omissions or data entry errors. South Carolina residents who went elsewhere for maternity care were not included. Nor were we able to compare cesarean delivery rates across hospital types (e.g., academic versus community hospitals).

Neither fetal health nor the potential effect of diabetes management on cesarean delivery were examined. Information was not available from the birth certificate and hospital discharge data on glucose levels, maternal weight, or antepartum surveillance. Because these data do not include early termination of pregnancy or fetal deaths, there may be a small bias due to selective survival. Because of the risk for fetal death and early pregnancy termination when diabetes is a factor, analyzing birth certificates and hospital discharge records combined with fetal death records is an appropriate and necessary step, and would provide a relatively complete characterization of the birth experience.

How much diabetes influences the occurrence of cesarean delivery in women with diabetes can be measured through attributable risk. Attributable risk is the excess in the rate of an event in some exposed group beyond the baseline rate observed in a similar nonexposed group. The excess is assumed to be related to the exposure and can be expressed as the percentage of observed events in the exposed group attributable to the exposure. After adjustment of the ORs to account for a common outcome in the total sample, it is estimated nearly two-thirds of cesarean deliveries in women with preexisting diabetes, and nearly one-third of such deliveries in women with gestational diabetes, are attributable to the diabetic condition. More striking, however, are the estimates among women with no other major medical indications. In that subgroup, among women with preexisting diabetes, 89% of cesarean deliveries are attributed to the diabetes, as are 45% of cesarean deliveries among women with gestational diabetes and no other major medical conditions.

A fuller picture of diabetes in pregnancy on a population basis could be gained by including more detailed information on birth certificates concerning type of diabetes, pregnancy complications, and infant status. Further investigations, using more complete information from medical records, should explore both prenatal and postnatal maternal and infant conditions to expand our understanding of factors contributing to cesarean delivery, and the sequelae in diabetic women and their infants. The increased risk of cesarean delivery for women with diabetes appears to be mediated through factors other than infant size and common medical indications, which may include practice patterns and physician referrals to high-risk care. The present findings underscore the need for continuing attention to the indications for cesarean delivery, especially in diabetic women.

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