International Journal of Women's Health

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Associated Factors for Cesarean Section in Pregnant Women with Gestational Diabetes Mellitus

Haiwei Liu*, Boxia Fu*, Lan Gao, Fei Wang, Qun Ji, Chunlan Chen, Caiqiong Lin, Cunxia Fan, Kaining Chen

Department of Endocrinology, Hainan General Hospital (Hainan Affiliated Hospital of Hainan Medical University), Haikou City, Hainan Province, 570311, People's Republic of China

*These authors contributed equally to this work

Correspondence: Haiwei Liu, Email hndxlhw@126.com

Introduction: Women with gestational diabetes mellitus (GDM) have an increased risk of undergoing cesarean section (CS). This study aimed to identify factors associated with CS in women with GDM.

Methods: A retrospective observational study was conducted on patients with GDM who delivered at Hainan General Hospital between January 2021 and June 2023. The patients were grouped by delivery type: CS vs. vaginal. A multivariable logistic regression model was used to identify the factors associated with CS.

Results: Of the 1689 women with GDM, 731 had CS. Logistic regression revealed that CS was independently associated with maternal age (OR: 1.07, 95% CI: 1.04–1.10, $p < 0.001$), pre-pregnancy body mass index (BMI) (OR: 1.05, 95% CI: 1.02–1.08, $p = 0.003$), and education level (high school education: OR: 1.53, 95% CI: 1.08–2.17, $p = 0.018$; bachelor's degree or higher: OR: 1.58, 95% CI: 1.13–2.23, $p = 0.008$). The most significant associated perinatal factor was cephalopelvic disproportion (including breech presentation or other abnormal fetal positions) (OR: 12.31, 95% CI: 1.46–104.11, $p = 0.021$). The absence of a past medical history of heart disease (OR: 0.26, 95% CI: 0.07–0.859, $p = 0.031$) was inversely independently associated with CS.

Conclusion: Higher maternal age, elevated BMI, higher education, specific perinatal diagnoses, and the presence of a history of heart disease were independently associated with CS in women with GDM.

Keywords: cesarean section, associated factors, gestational diabetes mellitus, retrospective observational study, retrospective study

Introduction

Gestational diabetes mellitus (GDM) is a common chronic condition during pregnancy and affects approximately 14% of pregnancies globally.[1] With the global prevalence of obesity reaching epidemic levels, the number of pregnant women diagnosed with GDM is increasing, and these women face a higher risk of various maternal and fetal complications,[2] like large for gestational age (LGA) infants, postpartum hemorrhage, infections, delivery asphyxia, stillbirth, shoulder dystocia, and hypertension.[3]

The rising incidence of LGA or macrosomic infants among women with GDM contributes to an increased likelihood of cesarean sections (CS) due to fetal distress and cephalopelvic disproportion.[4] The elective CS birth rate among women with GDM is 16–70% higher than in women without GDM,[5–7] including nulliparous and multiparous women.[8] Women requiring insulin for GDM management face significantly higher CD rates due to associations with poor glycemic control and fetal macrosomia.[9,10] Despite these findings indicating higher rates of elective CS among women with GDM, limited data are available on emergency CS among those women. Nulliparous GDM patients experience a 40% higher incidence of emergency CDs than non-GDM counterparts,[7,11] but the exact associated/risk factors remain poorly defined. The risk of CS is further increased when GDM is accompanied by other factors such as hypertension, preeclampsia, prior CS, or

https://doi.org/10.2147/IJWH.S586026
Received: 2 December 2025
Accepted: 10 April 2026
Published: 28 May 2026

fetal distress.[12] In some studies, women with GDM and a previous uterine scar (Robson group 5) had particularly high rates of CS delivery.[12] The need for CS in women with GDM is primarily driven by higher rates of fetal macrosomia (large for gestational age infants), maternal comorbidities, and sometimes physician preference for intervention.[12,13] Efforts to promote spontaneous labor and appropriate monitoring may help reduce unnecessary CSs among women with GDM.[12] However, most previous studies in women with GDM, presented above, have focused predominantly on antepartum determinants of CS, such as maternal age, pre-pregnancy BMI, comorbidities, and fetal overgrowth, while relatively few have comprehensively evaluated perinatal and intrapartum conditions (including labor progression, fetal presentation, and specific obstetric complications) within the same cohort. This limits understanding of how risk factors present before labor interact with events arising during the perinatal period to influence the ultimate mode of delivery. From a clinical standpoint, it is important to distinguish antepartum factors (for example, maternal age, pre-pregnancy BMI, metabolic status, and socioeconomic characteristics) from intrapartum and perinatal conditions, such as fetal presentation, cephalopelvic disproportion, or oligohydramnios, which often function as immediate indications for cesarean delivery rather than antecedent predictors. Clarifying how these antepartum profiles relate to subsequent intrapartum indications may help clinicians identify women with GDM who are more likely to require cesarean section and to optimize the timing and planning of elective versus emergency procedures. Accordingly, the present study concurrently examines antepartum characteristics and perinatal diagnoses associated with cesarean section in women with GDM, with the aim of informing risk stratification and delivery decision-making in routine practice.

Although CS is a common surgical intervention that can effectively reduce maternal and fetal morbidity and mortality when performed according to the appropriate indications, the procedure is associated with significant risks, particularly in emergency settings. Complications of emergency CS include obstetric hemorrhage (including severe hemorrhage requiring hysterectomy), wound hematoma, postpartum infections, anesthetic complications, and long-term issues related to CS scarring.[10] Women who undergo planned vaginal deliveries generally have lower rates of severe morbidity and mortality compared to those undergoing emergency CS.[14] Therefore, it could be practical to identify patients with GDM at higher risk of CS, allowing elective CS to be planned rather than performing an emergency CS.

Therefore, this study aimed to analyze the factors associated with CS in women with GDM. The results could help minimize adverse outcomes and provide evidence-based recommendations to improve delivery management in women with GDM. The hypothesis was that specific factors were associated with CS in pregnant women with GDM.

Materials and Methods

Study Design and Population

This retrospective observational study analyzed the data from patients with GDM who delivered at Hainan General Hospital between January 2021 and June 2023. This study was approved by the Medical Ethics Committee of Hainan General Hospital (Approval number: [2021]226). The Medical Ethics Committee of Hainan General Hospital waived the requirement for individual patient consent to review medical records for this retrospective study. All patient data were anonymized before analysis, and no information that could directly or indirectly identify individual participants is published, in accordance with institutional policies and the journal's guidelines on patient privacy and confidentiality.

The inclusion criteria were 1) diagnosis of GDM according to the Chinese guidelines for the prevention and treatment of type 2 diabetes (2017 version)[15] and 2) age > 18 years old. The exclusion criteria were 1) history of diabetes before pregnancy, 2) diabetes caused by glucocorticoid use, 3) complicated with serious systemic diseases and malignant tumors, 4) in a state of stress such as infection or trauma, or 5) combined with severe mental illness and cognitive impairment. According to the diagnosis guidelines, GDM was diagnosed using a 75-g oral glucose tolerance test performed at 24–28 weeks of gestation; GDM was defined when at least one of the following plasma glucose thresholds was met: fasting ≥5.1 mmol/L, 1-hour ≥10.0 mmol/L, or 2-hour ≥8.5 mmol/L.[15]

The patients were divided into two groups according to whether they underwent CS or vaginal delivery.

Data Collection

Demographic and obstetric characteristics, as well as laboratory data, were extracted from the mothers' and neonates' electronic medical records. The demographic and obstetric data included age, pre-pregnancy body mass index (BMI), gravidity, gestational age at the index delivery, mode of conception, ethnicity, education level, past medical history, and family history of diabetes. The laboratory data included fasting glucose levels, glucose tolerance test (2-hour postprandial), peak glucose (1-hour postprandial), glycated hemoglobin (HbA1c), Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), and Homeostatic Model Assessment of beta-cell function (HOMA-β). Perinatal data included premature delivery, cephalopelvic disproportion, breech position, abnormal fetal position, prolonged labor, premature rupture of fetal membranes, polyhydramnios, fetal macrosomia, small for gestational age, postpartum hemorrhage, gestational hypertension, intrahepatic cholestasis of pregnancy, placenta previa, placenta accreta, oligohydramnios, nuchal cord, epilepsy, thalassemia in pregnancy, and thyroid disorders in pregnancy. The fetal characteristics included death, hospitalization, cephalhematoma, aspiration pneumonia, hyaline membrane disease, hypoxic-ischemic encephalopathy, intracranial hemorrhage, hyperbilirubinemia, neonatal hypoglycemia, and neonatal jaundice were also recorded. Perinatal and intrapartum diagnoses such as cephalopelvic disproportion, breech or abnormal fetal position, oligohydramnios, placenta previa, and placenta accreta were extracted as binary variables from the medical records and included as covariates in the analyses.

Preterm birth was defined as the delivery of a newborn before 37 weeks of gestation.[16] Macrosomia was defined as a fetal birth weight $\geq$ 4000 g.[17] Small for gestational age (SGA) was defined as an infant whose birth length and/or weight was at least 2 standard deviations (SD) below the mean for gestational age and gender.[18] Polyhydramnios was defined as either an amniotic fluid index (AFI), calculated as the sum of the four quadrants, exceeding 24 cm, or a single pocket of amniotic fluid measuring more than 8 cm.[19,20]

The primary outcome was mode of delivery (cesarean section vs vaginal delivery). Data on the specific indication for cesarean section and the classification as elective versus emergency were not consistently available in the medical records, particularly for women referred from local hospitals; therefore, cesarean deliveries were analyzed as a single combined outcome.

Statistical Analysis

All statistical analyses were conducted using R version 4.2.3 (The R Project for Statistical Computing, www.r-project.org). A p-value <0.05 was considered statistically significant. The handling of missing data followed a specific protocol. Variables with >20% missing values were excluded, while multiple imputation was performed using the R package "mice" for variables with <20% missing values. The continuous variables were assessed for normality using the Shapiro–Wilk test. Continuous variables with a normal distribution were presented as mean ± SD and analyzed using Student's *t*-test. Continuous variables not following a normal distribution were presented as median (interquartile range (IQR)) and analyzed using the Mann–Whitney test. Categorical variables were described using n (%) and analyzed using Fisher's exact test or the χ^2-test. Univariable logistic regression analyses were performed with CS delivery as the dependent variable to identify potential associated factors. Variables with p-values <0.05 in the univariable logistic regression analyses were included in a multivariable analysis to identify factors independently associated with CS. A sensitivity analysis was performed by using only the antepartum variables. For perinatal variables with relatively low event counts, odds ratios and 95% confidence intervals are presented and interpreted with caution, reflecting the potential for model instability.

Results

Characteristics of the Patients

A total of 1689 patients with GDM were included in this study. Among them, 731 underwent CS, and 958 did not (controls). Their characteristics are presented in Table 1. The women in the CS group were older than those in the control group (34.00 (IQR: 30.00, 37.00) vs. 32.00 (IQR: 29.00, 36.00) years, $p < 0.001$). Women who underwent CS showed higher frequencies of a family history of diabetes, a family history of miscarriage, and a prior history of renal and heart diseases. Women in the CS group had higher rates of premature delivery, cephalopelvic disproportion (breech or

Table 1 Clinical Characteristics of the Patients

Characteristics	No Cesarean Section (n = 958)	Cesarean Section (n = 731)	Total (n = 1689)	Statistic	*P*
Age, M (Q_1, Q_3)	32.00 (29.00, 36.00)	34.00 (30.00, 37.00)	33.00 (30.00, 36.00)	Z=−5.99	**<0.001**
Pre-pregnancy BMI, M (Q_1, Q_3)	22.06 (19.92, 24.73)	22.86 (20.74, 24.97)	22.46 (20.20, 24.84)	Z=−3.92	**<0.001**
Gravidity, M (Q_1, Q_3)	2.00 (1.00, 3.00)	2.00 (2.00, 3.00)	2.00 (1.00, 3.00)	Z=−2.91	**0.004**
Gestational age of the index delivery, M (Q_1, Q_3)	38.00 (37.00, 39.00)	38.00 (37.00, 38.00)	38.00 (37.00, 39.00)	Z=−6.01	**<0.001**
Conception, n (%)				χ^2=11.67	**<0.001**
Natural	866 (90.40)	621 (84.95)	1487 (88.04)		
Assisted	92 (9.60)	110 (15.05)	202 (11.96)		
Ethnicity, n (%)				χ^2=4.73	0.193
Unknown	69 (7.20)	50 (6.84)	119 (7.05)		
Han	845 (88.20)	649 (88.78)	1494 (88.45)		
Li	39 (4.07)	22 (3.01)	61 (3.61)		
Others	5 (0.52)	10 (1.37)	15 (0.89)		
Education, n (%)				χ^2=5.69	0.058
Junior high school or below	168 (17.59)	99 (13.54)	267 (15.84)		
High school	321 (33.61)	245 (33.52)	566 (33.57)		
Bachelor's degree or above	466 (48.80)	387 (52.94)	853 (50.59)		
Past medical history					
Heart disease, n (%)	4 (0.42)	10 (1.37)	14 (0.83)	χ^2=4.56	**0.033**
Kidney disease, n (%)	42 (4.38)	51 (6.98)	93 (5.51)	χ^2=5.36	**0.021**
Thyroid disease, n (%)	89 (9.29)	70 (9.58)	159 (9.41)	χ^2=0.04	0.842
Connective tissue diseases, n (%)	15 (1.57)	9 (1.23)	24 (1.42)	χ^2=0.33	0.565
Polycystic ovarian syndrome, n (%)	66 (6.89)	40 (5.47)	106 (6.28)	χ^2=1.42	0.234
Thalassemia, n (%)	62 (6.47)	55 (7.52)	117 (6.93)	χ^2=0.71	0.399
Family history of diabetes, n (%)	272 (28.39)	252 (34.47)	524 (31.02)	χ^2=7.16	**0.007**
Gravidity, n (%)				χ^2=9.92	**0.019**
1	291 (30.38)	173 (23.67)	464 (27.47)		
2	321 (33.51)	257 (35.16)	578 (34.22)		
3	179 (18.68)	154 (21.07)	333 (19.72)		
4	167 (17.43)	147 (20.11)	314 (18.59)		
Laboratory					
Fasting glucose				χ^2=1.27	0.259
Normal (3.9–6.1 mmol/L)	583 (60.86)	425 (58.14)	1008 (59.68)		
Above normal	375 (39.14)	306 (41.86)	681 (40.32)		
Glucose tolerance test (2-hour postprandial)				χ^2=2.74	0.098
Normal (≤7.8 mmol/L)	284 (29.65)	190 (25.99)	474 (28.06)		
Above normal	674 (70.35)	541 (74.01)	1215 (71.94)		
Peak blood glucose (1-hour postprandial)				χ^2=3.24	0.072
Normal (≤10.0 mmol/L)	250 (26.10)	163 (22.30)	413 (24.45)		
Above normal	708 (73.90)	568 (77.70)	1276 (75.55)		
HBA1c				-	0.901
Below normal	2 (0.21)	2 (0.27)	4 (0.24)		
Normal (4–6%)	817 (85.28)	628 (85.91)	1445 (85.55)		
Above normal	139 (14.51)	101 (13.82)	240 (14.21)		
HOMA-IR				χ^2=0.11	0.744
Normal (<2.69)	689 (71.92)	531 (72.64)	1220 (72.23)		
Above normal	269 (28.08)	200 (27.36)	469 (27.77)		
HOMA-β (no established normal range)	92.50 (0.00, 203.04)	112.95 (0.00, 207.40)	122.34 (0.00, 209.73)	Z=−2.48	**0.013**
Other diagnoses during the perinatal period					
Premature delivery, n (%)	36 (3.76)	103 (14.09)	139 (8.23)	χ^2=58.61	**<0.001**
Cephalopelvic disproportion, n (%)	1 (0.10)	16 (2.19)	17 (1.01)	χ^2=18.08	**<0.001**

(*Continued*)

Table 1 (Continued).

Characteristics	No Cesarean Section (n = 958)	Cesarean Section (n = 731)	Total (n = 1689)	Statistic	*P*
Prolonged labor, n (%)	1 (0.10)	1 (0.14)	2 (0.12)	-	>0.999
Premature rupture of fetal membranes, n (%)	101 (10.54)	93 (12.72)	194 (11.49)	χ^2=1.94	0.164
Polyhydramnios, n (%)	4 (0.42)	21 (2.87)	25 (1.48)	χ^2=17.14	**<0.001**
Fetal macrosomia, n (%)	6 (0.63)	19 (2.60)	25 (1.48)	χ^2=11.07	**<0.001**
Small for gestational age, n (%)	3 (0.31)	18 (2.46)	21 (1.24)	χ^2=15.60	**<0.001**
Postpartum hemorrhage, n (%)	1 (0.10)	0 (0.00)	1 (0.06)	-	>0.999
Gestational hypertension, n (%)	18 (1.88)	64 (8.76)	82 (4.85)	χ^2=42.44	**<0.001**
Intrahepatic cholestasis of pregnancy, n (%)	2 (0.21)	20 (2.74)	22 (1.30)	χ^2=20.60	**<0.001**
Placenta previa, n (%)	0 (0.00)	21 (2.87)	21 (1.24)	χ^2=27.87	**<0.001**
Placenta accreta, n (%)	1 (0.10)	12 (1.64)	13 (0.77)	χ^2=12.83	**<0.001**
Oligohydramnios, n (%)	8 (0.84)	57 (7.80)	65 (3.85)	χ^2=54.32	**<0.001**
Nuchal cord, n (%)	103 (10.75)	235 (32.15)	338 (20.01)	χ^2=118.58	**<0.001**
Epilepsy, n (%)	1 (0.10)	5 (0.68)	6 (0.36)	χ^2=2.47	0.116
Thalassemia in pregnancy, n (%)	29 (3.03)	60 (8.21)	89 (5.27)	χ^2=22.29	**<0.001**
Thyroid disorders in pregnancy, n (%)	7 (0.73)	22 (3.01)	29 (1.72)	χ^2=12.76	**<0.001**
Others, n (%)	73 (7.62)	123 (16.83)	196 (11.60)	χ^2=34.26	**<0.001**
Condition of the fetus					
Death, n (%)	7 (0.73)	2 (0.27)	9 (0.53)	χ^2=0.89	0.347
Hospitalization, n (%)	6 (0.63)	26 (3.56)	32 (1.89)	χ^2=19.16	**<0.001**
Cephalhematoma, n (%)	1 (0.10)	1 (0.14)	2 (0.12)	-	>0.999
Aspiration pneumonia, n (%)	6 (0.63)	7 (0.96)	13 (0.77)	χ^2=0.60	0.44
Hyaline membrane disease, n (%)	1 (0.10)	3 (0.41)	4 (0.24)	χ^2=0.60	0.437
Hypoxic ischemic encephalopathy, n (%)	0 (0.00)	1 (0.14)	1 (0.06)	-	0.433
Intracranial hemorrhage, n (%)	2 (0.21)	3 (0.41)	5 (0.30)	χ^2=0.09	0.761
Hyperbilirubinemia, n (%)	1 (0.10)	3 (0.41)	4 (0.24)	χ^2=0.60	0.437
Neonatal hypoglycemia, n (%)	5 (0.52)	14 (1.92)	19 (1.12)	χ^2=7.24	**0.007**
Neonatal jaundice, n (%)	9 (0.94)	26 (3.56)	35 (2.07)	χ^2=14.00	**<0.001**

Notes: Bolded P-values are statistically significant (i.e, <0.05). Cephalopelvic disproportion includes breech position and abnormal fetal position.
Abbreviations: M, median; Q, quartile; BMI, body mass index; HbA1c, glycated hemoglobin; HOMA-IR, Homeostatic Model Assessment of Insulin Resistance; HOMA-β, Homeostatic Model Assessment of beta-cell function.

abnormal fetal position), and polyhydramnios compared with those in the control group. In addition, CS was associated with adverse neonatal outcomes, including more frequent hospitalizations and higher rates of neonatal hypoglycemia and neonatal jaundice.

Factors Associated with Cesarean Section

The univariable analyses showed that CS in pregnant women with GDM was associated with age, pre-pregnancy BMI, assisted conception, gravidity, and education level (bachelor's degree or above) (all $p < 0.05$). No history of heart disease, no history of kidney disease, and no family history of diabetes were inversely associated with CS. Among perinatal diagnoses, premature delivery, cephalopelvic disproportion (breech or abnormal fetal position), polyhydramnios, fetal macrosomia, SGA, gestational hypertension, intrahepatic cholestasis of pregnancy, placenta accreta, oligohydramnios, nuchal cord, thalassemia, and thyroid disorders were associated with CS (Table 2).

The multivariable logistic regression analysis was conducted to identify the factors independently associated with CS in women with GDM. Maternal age (OR: 1.07, 95% CI: 1.04–1.10, $p < 0.001$), pre-pregnancy BMI (OR: 1.05, 95% CI: 1.02–1.08, $p = 0.003$), and education level (high school: OR: 1.53, 95% CI: 1.08–2.17, $p = 0.018$; bachelor's degree or above: OR: 1.58, 95% CI: 1.13–2.23, $p = 0.008$) were independently associated with CS. Diagnoses during the perinatal period, including premature delivery, cephalopelvic disproportion (breech or abnormal fetal position), polyhydramnios,

Table 2 Univariable Logistic Regression Analysis for Factors Associated with Cesarean Section in Pregnant Women with Gestational Diabetes

Variables	β	S.E	Z	*P*	OR (95% CI)
Age	0.06	0.01	5.93	**<0.001**	1.06 (1.04 ~ 1.09)
Pre-pregnancy BMI	0.05	0.01	3.44	**<0.001**	1.05 (1.02 ~ 1.07)
Gestational age	−0.02	0.02	−0.84	0.399	0.98 (0.95 ~ 1.02)
Mode of conception					
Natural					1.00 (Reference)
Assisted	0.51	0.15	3.39	**<0.001**	1.67 (1.24 ~ 2.24)
Ethnicity					
Unknown					1.00 (Reference)
Han	0.06	0.19	0.3	0.763	1.06 (0.73 ~ 1.55)
Li	−0.25	0.32	−0.77	0.441	0.78 (0.41 ~ 1.47)
Others	1.02	0.58	1.76	0.079	2.76 (0.89 ~ 8.57)
Education					
Junior high school or below					1.00 (Reference)
High school	0.26	0.15	1.7	0.09	1.30 (0.96 ~ 1.75)
Bachelor's degree or above	0.34	0.14	2.38	**0.017**	1.41 (1.06 ~ 1.87)
Absence of a past medical history of					
Heart disease	−1.2	0.59	−2.02	**0.044**	0.30 (0.09 ~ 0.97)
Kidney disease	−0.49	0.21	−2.29	**0.022**	0.61 (0.40 ~ 0.93)
Thyroid disease	−0.03	0.17	−0.2	0.842	0.97 (0.70 ~ 1.34)
Connective tissue diseases	0.24	0.42	0.57	0.566	1.28 (0.56 ~ 2.93)
Polycystic ovarian syndrome	0.25	0.21	1.19	0.235	1.28 (0.85 ~ 1.92)
Thalassemia	−0.16	0.19	−0.84	0.399	0.85 (0.58 ~ 1.24)
Gravidity, n (%)					
1					1.00 (Reference)
2	0.3	0.13	2.34	**0.019**	1.35 (1.05 ~ 1.73)
3	0.37	0.15	2.53	**0.011**	1.45 (1.09 ~ 1.93)
4	0.39	0.15	2.65	**0.008**	1.48 (1.11 ~ 1.98)
Family history of diabetes, n (%)	−0.28	0.11	−2.67	**0.008**	0.75 (0.61 ~ 0.93)
2					
Laboratory					
Fasting glucose					
Normal					1.00 (Reference)
Above normal	0.11	0.1	1.13	0.26	1.12 (0.92 ~ 1.36)
Glucose tolerance test (1-hour postprandial)					
Normal					1.00 (Reference)
Above normal	0.18	0.11	1.65	0.098	1.20 (0.97 ~ 1.49)
Glucose tolerance test (2-hour postprandial)					
Normal					1.00 (Reference)
Above normal	0.21	0.12	1.8	0.072	1.23 (0.98 ~ 1.54)
HBA1c					
Below normal					1.00 (Reference)
Normal	−0.26	1	−0.26	0.793	0.77 (0.11 ~ 5.47)
Above normal	−0.32	1.01	−0.32	0.752	0.73 (0.10 ~ 5.25)
HOMA-IR					
Normal					1.00 (Reference)
Above normal	−0.04	0.11	−0.33	0.744	0.96 (0.78 ~ 1.20)
HOMA-β	−0.01	0	−2.16	**0.03**	0.99 (0.99 ~ 0.99)
Other diagnoses during the perinatal period					
Premature delivery, n (%)	1.44	0.2	7.16	**<0.001**	4.20 (2.84 ~ 6.22)
Cephalopelvic disproportion, n (%)	3.06	1.03	2.97	**0.003**	21.42 (2.83 ~ 161.85)

(*Continued*)

Table 2 (Continued).

Variables	β	S.E	Z	*P*	OR (95% CI)
Prolonged labor, n (%)	0.27	1.42	0.19	0.848	1.31 (0.08 ~ 20.99)
Premature rupture of fetal membranes, n (%)	0.21	0.15	1.39	0.165	1.24 (0.92 ~ 1.67)
Polyhydramnios, n (%)	1.95	0.55	3.57	**<0.001**	7.05 (2.41 ~ 20.64)
Fetal macrosomia, n (%)	1.44	0.47	3.06	**0.002**	4.23 (1.68 ~ 10.66)
Small for gestational age, n (%)	2.08	0.63	3.33	**<0.001**	8.04 (2.36 ~ 27.39)
Postpartum hemorrhage, n (%)	−12.3	324.74	−0.04	0.97	0.00 (0.00 ~ Inf)
Gestational hypertension, n (%)	1.61	0.27	5.93	**<0.001**	5.01 (2.94 ~ 8.53)
Intrahepatic cholestasis of pregnancy, n (%)	2.6	0.74	3.5	**<0.001**	13.45 (3.13 ~ 57.69)
Placenta previa, n (%)	15.87	317.59	0.05	0.96	7,768,992.56 (0.00 ~ Inf)
Placenta accreta, n (%)	2.77	1.04	2.66	**0.008**	15.97 (2.08 ~ 122.93)
Oligohydramnios, n (%)	2.31	0.38	6.06	**<0.001**	10.04 (4.76 ~ 21.19)
Nuchal cord, n (%)	1.37	0.13	10.46	**<0.001**	3.93 (3.04 ~ 5.08)
Epilepsy, n (%)	1.89	1.1	1.72	0.085	6.59 (0.77 ~ 56.54)
Thalassemia in pregnancy, n (%)	1.05	0.23	4.54	**<0.001**	2.86 (1.82 ~ 4.51)
Thyroid disorders in pregnancy, n (%)	1.44	0.44	3.29	**<0.001**	4.22 (1.79 ~ 9.92)
Others, n (%)	0.9	0.16	5.72	**<0.001**	2.45 (1.80 ~ 3.34)

Notes: Bolded P-values are statistically significant (i.e, <0.05). Cephalopelvic disproportion includes breech position and abnormal fetal position.

Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index; HbA1c, glycated hemoglobin; HOMA-IR, Homeostatic Model Assessment of Insulin Resistance; HOMA-β, Homeostatic Model Assessment of beta-cell function.

fetal macrosomia, gestational hypertension, intrahepatic cholestasis of pregnancy, placenta accreta, oligohydramnios, nuchal cord, thalassemia, and thyroid disorders, were also independently associated with CS (all $p < 0.05$) (Table 3). Among these, cephalopelvic disproportion (breech or abnormal fetal position) was the most statistically significant factor

Table 3 Multivariable Logistic Regression Analysis for Factors Independently Associated with Cesarean Section in Pregnant Women with Gestational Diabetes

Variables	β	S.E	Z	*P*	OR (95% CI)
Intercept	−2.8	0.88	−3.16	**0.002**	0.06 (0.01 ~ 0.35)
Age	0.07	0.01	5.08	**<0.001**	1.07 (1.04 ~ 1.10)
Pre-pregnancy BMI	0.05	0.02	2.98	**0.003**	1.05 (1.02 ~ 1.08)
Mode of conception					
Natural					1.00 (Reference)
Assisted	0.27	0.18	1.52	0.128	1.31 (0.93 ~ 1.84)
Education					
Junior high school or below					1.00 (Reference)
High school	0.42	0.18	2.37	**0.018**	1.53 (1.08 ~ 2.17)
Bachelor's degree or above	0.46	0.17	2.65	**0.008**	1.58 (1.13 ~ 2.23)
Absence of a past medical history of					
Heart disease	−1.36	0.63	−2.15	**0.031**	0.26 (0.07 ~ 0.89)
Kidney disease	−0.38	0.25	−1.54	0.124	0.68 (0.42 ~ 1.11)
No family history of diabetes, n (%)	−0.22	0.12	−1.81	0.073	0.80 (0.63 ~ 1.02)
Other diagnoses during the perinatal period					
Premature delivery, n (%)	1.18	0.23	5.14	**<0.001**	3.25 (2.07 ~ 5.08)
Cephalopelvic disproportion, n (%)	2.51	1.09	2.3	**0.021**	12.31 (1.46 ~ 104.11)
Polyhydramnios, n (%)	2.05	0.58	3.54	**<0.001**	7.76 (2.50 ~ 24.13)
Fetal macrosomia, n (%)	1.32	0.52	2.53	**0.011**	3.74 (1.35 ~ 10.40)
Gestational hypertension, n (%)	1.21	0.3	4.03	**<0.001**	3.35 (1.86 ~ 6.03)

(*Continued*)

https://doi.org/10.2147/IJWH.S586026

Table 3 (Continued).

Variables	β	S.E	Z	*P*	OR (95% CI)
Weight lower than the gestational age standard for the infant	0.89	0.69	1.29	0.197	2.43 (0.63 ~ 9.33)
Intrahepatic cholestasis of pregnancy, n (%)	2.04	0.77	2.63	**0.009**	7.66 (1.68 ~ 34.89)
Placenta accreta, n (%)	2.47	1.08	2.29	**0.022**	11.83 (1.43 ~ 97.84)
Oligohydramnios, n (%)	2.36	0.4	5.89	**<0.001**	10.62 (4.84 ~ 23.29)
Nuchal cord, n (%)	1.34	0.14	9.37	**<0.001**	3.81 (2.88 ~ 5.04)
Thalassemia in pregnancy, n (%)	0.83	0.26	3.14	**0.002**	2.29 (1.37 ~ 3.83)
Thyroid disorders in pregnancy, n (%)	1.17	0.49	2.39	**0.017**	3.22 (1.23 ~ 8.42)
Others, n (%)	0.47	0.18	2.52	**0.012**	1.59 (1.11 ~ 2.29)
HOMA-β	0	0	−1.81	0.07	1.00 (1.00 ~ 1.00)
Gravidity, n (%)					
1					1.00 (Reference)
2	0.16	0.15	1.05	0.294	1.17 (0.87 ~ 1.57)
3	0.17	0.17	0.96	0.337	1.18 (0.84 ~ 1.67)
4	−0.03	0.19	−0.15	0.878	0.97 (0.67 ~ 1.41)

Notes: Bolded P-values are statistically significant (i.e, <0.05). Cephalopelvic disproportion includes breech position and abnormal fetal position.
Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index; HOMA-β, Homeostatic Model Assessment of beta-cell function.

(OR: 12.31, 95% CI: 1.46–104.11, p = 0.021). The absence of a past medical history of heart disease was inversely associated with CS (OR: 0.26, 95% CI: 0.07–0.89, p = 0.031) (Table 3).

Sensitivity Analysis

In an additional multivariable analysis restricted to antepartum variables (maternal age, pre-pregnancy BMI, mode of conception, education level, past medical history, family history of diabetes, HOMA-β, and gravidity) and excluding the other diagnoses during the perinatal period (which can be risk factors for CS), older age and higher pre-pregnancy BMI remained independently associated with a higher likelihood of CS. Assisted conception and higher education levels were also positively associated with CS delivery, whereas the absence of kidney disease showed an inverse association (Table 4). These sensitivity analysis findings support the robustness of the observed associations for key antepartum characteristics, independent of perinatal and intrapartum factors.

Table 4 Sensitivity Multivariable Logistic Regression Analysis for Antepartum Factors Independently Associated with Cesarean Section in Pregnant Women with Gestational Diabetes

Variables	β	S.E	Z	*P*	OR (95% CI)
Intercept	−1.92	0.82	−2.34	**0.019**	0.15 (0.03 ~ 0.73)
Age	0.06	0.01	4.72	**<0.001**	1.06 (1.03 ~ 1.08)
Pre-pregnancy BMI	0.05	0.01	3.29	**0.001**	1.05 (1.02 ~ 1.08)
Mode of conception					
Natural					1.00 (Reference)
Assisted	0.4	0.16	2.56	**0.01**	1.49 (1.10 ~ 2.03)
Education					
Junior high school or below					1.00 (Reference)
High school	0.38	0.16	2.39	**0.017**	1.46 (1.07 ~ 1.99)
Bachelor's degree or above	0.46	0.15	2.95	**0.003**	1.58 (1.17 ~ 2.14)
Absence of a past medical history of					
Heart disease	−1.11	0.6	−1.85	0.064	0.33 (0.10 ~ 1.07)

(*Continued*)

Table 4 (Continued).

Variables	β	S.E	Z	*P*	OR (95% CI)
Kidney disease	−0.47	0.22	−2.12	**0.034**	0.63 (0.41 ~ 0.96)
No family history of diabetes, n (%)	−0.21	0.11	−1.92	0.055	0.81 (0.65 ~ 1.00)
HOMA-β	0	0	−1.87	0.062	1.00 (1.00 ~ 1.00)
Gravidity, n (%)					
1					1.00 (Reference)
2	0.14	0.13	1.07	0.285	1.15 (0.89 ~ 1.50)
3	0.2	0.16	1.25	0.21	1.22 (0.90 ~ 1.65)
4	0.13	0.17	0.78	0.437	1.14 (0.82 ~ 1.58)

Note: Bolded P-values are statistically significant (i.e, <0.05).
Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index; HOMA-β, Homeostatic Model Assessment of beta-cell function.

Discussion

This study suggested that older age, higher BMI, higher education levels, specific diagnoses during the perinatal period, and a past medical history of heart disease were independently associated with CS among women with GDM. The novelty of this research lies in its identification and quantification of independently associated factors for CS among women with GDM using multivariable logistic regression analysis in a well-characterized, recent Chinese hospital cohort. This study not only reaffirms established associations (such as elevated maternal age and pre-pregnancy BMI) but also provides new insight into the association of education level and specific perinatal factors (eg, cephalopelvic disproportion, abnormal fetal position), as well as protective associations for the absence of certain medical and family histories. This study suggests that older maternal age, higher pre-pregnancy BMI, higher education levels, and specific perinatal diagnoses are independently associated with a higher likelihood of CS among women with GDM, rather than demonstrating causal effects. The present study adds to the existing literature by concurrently examining maternal, metabolic, socioeconomic (including education), and perinatal factors associated with CS in a large, contemporary cohort of women with GDM. By extending the focus beyond traditional clinical predictors to include educational level and specific perinatal conditions observed in routine practice, these findings provide clinically credible, internally consistent information that complements prior reports while remaining subject to the inherent limitations of an observational design.

These findings are valuable for the early identification of GDM women at elevated risk for CS. As supported by this study, women with GDM should receive counseling regarding their risk of emergency CS, particularly those with advanced maternal age and elevated BMI.[21] These results are supported by previous studies across diverse settings and populations. For example, contributing factors to the CS rate in Korea included higher socioeconomic status, older maternal age, multiple pregnancies, and maternal obesity; in addition, women with the highest educational levels had the highest CS rates, followed by those with intermediate education levels.[22] Similarly, Yisma et al[23] reported that CS rates in Ethiopia were highest among women with higher education and those from the wealthiest households. However, contrasting findings were reported in Norway, showing that the lowest-educated group had the highest risk of CS, followed by the intermediate-educated group, with differences increasing over time.[24] Recently, a large-scale analysis in China revealed that both high socioeconomic status and older age were robust predictors of elective CS, reflecting cultural preferences and perceived safety concerns among more educated women.[25,26] This trend may result from the vulnerability of the lowest-educated groups due to social migration and the rising CS rates requested by women with lower education in recent years.

GDM is a challenging pregnancy complication characterized by glucose intolerance. It is associated with several obstetric complications such as polyhydramnios, preterm delivery, and hypertensive disorders of pregnancy. Fetal complications include congenital malformations, macrosomia, neonatal respiratory distress syndrome, and intrauterine death.[27] In the present study, preterm birth was independently associated with CS in women with GDM. Recent prospective studies have confirmed that preterm birth is more frequent among GDM mothers, often mediated by

metabolic dysregulation, subclinical inflammation, and altered placental function.[28,29] Studies have highlighted that high preterm birth and CS rates remain significant and interlinked clinical concerns in GDM pregnancies.[8] Importantly, cephalopelvic disproportion (breech or abnormal fetal position) emerged as the most significant factor associated with CS in women with GDM. Consistent with these findings, cephalopelvic disproportion remains a leading indication for operative delivery globally.[30–32] In cases of obstructed labor or labor arrest due to disproportion, timely access to obstetric surgical resources markedly reduces adverse maternal and neonatal outcomes.

In addition, previous studies have suggested associations between oligohydramnios and GDM.[33,34] The rate of CS is significantly higher in pregnancies complicated by oligohydramnios compared with those without.[35] Recent evidence further indicates that oligohydramnios in women with GDM may reflect placental functional abnormalities or poor glycemic control, both of which can increase the risk of fetal distress and subsequent surgical delivery.[36–38] Therefore, diagnoses during the perinatal period, such as cephalopelvic disproportion, preterm birth, and oligohydramnios, appear to be significant predictors of CS in pregnant women with GDM.

Consistent with the finding that the absence of heart disease was inversely associated with CS, previous studies have shown that pregnancy and delivery substantially alter hemodynamics, and that complex congenital heart disease is associated with adverse maternal outcomes and an increased rate of CS.[39] Conversely, CS delivery does not necessarily mitigate adverse cardiovascular outcomes, and planned vaginal birth is generally recommended for most women with stable cardiovascular disease, including those with high-risk conditions.[40]

The findings of this study have critical clinical implications for the management of GDM. Specifically, they highlight that higher maternal age, increased pre-pregnancy BMI, and higher education level independently raise the likelihood of CS. These factors suggest the need for early risk stratification and individualized counseling to better inform delivery planning and optimize shared decision-making in this high-risk group. The influence of intrapartum complications, particularly cephalopelvic disproportion and abnormal fetal presentation, underscores the importance of vigilant perinatal assessment and real-time intervention protocols to reduce emergent surgical deliveries. Furthermore, the observed protective effects of the absence of heart disease reinforce the necessity of a holistic maternal assessment, encompassing cardiovascular, metabolic, and obstetric parameters, to tailor risk-based perinatal care strategies that improve outcomes for women with GDM.

The global and socioeconomic burden of CS is substantial, with rates nearly tripling worldwide over the past decades and millions of procedures now considered unnecessary. Social, economic, and health system factors, including higher maternal education, increased private-sector care, and systemic health financing policies, are closely linked to rising CS rates, especially in upper- and middle-income countries.[41–43] Excessive CS imposes a heavy economic load on health systems due to increased direct (surgical costs, longer hospital stays, resource use) and indirect costs (complications, subsequent CS in future pregnancies, impacts on maternal and child health).[44,45] Globally, estimates indicate that 8.8 to 17 million unnecessary CS occur annually, with the majority occurring in upper-middle- and high-income settings, driven by provider, patient, and system-level incentives.[42] Socioeconomic status, maternal education, insurance type, and urban residence all play critical roles, with higher resource and private care environments often correlating with more frequent non-indicated CS.[41,42] Overuse of CS, particularly when not medically indicated, is not only costly but also increases risks of maternal and neonatal morbidity and mortality, especially in women with risk factors like GDM.[12,45] Clinicians should prioritize evidence-based protocols to distinguish true medical indications for CS from potentially modifiable factors such as patient or provider preference, fear of litigation, or convenience.[46,47] Promoting spontaneous labor and supporting vaginal birth after CS (VBAC), when clinically safe, should be key strategies, particularly among women with GDM, unless clear contraindications exist.[12,46] Enhancing antenatal education for women by explaining the risks and benefits of both delivery modes improves patient-provider alignment and may reduce demand-driven non-indicated CS.[46] Training and incentivizing providers in evidence-based, assisted vaginal delivery techniques (eg, vacuum, forceps) can offer safe alternatives to CS in cases with prolonged labor or abnormal fetal positioning, provided careful risk assessment is undertaken.[46,47] System-level interventions, such as removing unnecessary financial incentives for CS, standardizing care pathways, and routine performance feedback on CS rates, have proven successful in safely curbing unnecessary procedures.[42,46,47] For women with GDM, strict glycemic control, careful monitoring, and tailored labor management protocols (avoiding early induction without indication) help optimize outcomes and can lower CS rates.[46,47] Policy

initiatives must target both patient- and provider-level drivers of unnecessary CS, balancing safety, resource allocation, and informed choice.[46,47] Investing in continuing education, robust clinical guidelines, and multidisciplinary care models (including midwives and obstetricians) will support a sustainable reduction in unnecessary CS rates and enhance maternal and family health.[46–48] In summary, addressing the socioeconomic and medical burden of CS, especially in the context of rising GDM prevalence, requires multi-level interventions, cross-sector collaboration, and continuous quality improvement in clinical practice, with a focus on safe, evidence-driven care.

Because of the retrospective observational design, all reported relationships should be interpreted as associations, not as causal effects. The multivariable models that include perinatal and intrapartum diagnoses (such as cephalopelvic disproportion, oligohydramnios, and placenta accreta) are intended to describe clinical profiles associated with CS in women with GDM, rather than to disentangle causal pathways. Some of these intrapartum factors may lie on the pathway between antepartum risk profiles and mode of delivery, so estimates from such models should be interpreted with caution in light of potential mediation or over-adjustment. To address this concern, a sensitivity analysis restricted to antepartum variables only was performed; in that analysis, maternal age, pre-pregnancy BMI, and higher education remained independently associated with CS, supporting the robustness of the main associations.

However, this study has certain limitations. First, the clinical data were collected retrospectively, which may introduce bias. In addition, although data on whether they underwent CS for the index delivery were available for all included women, only data from the majority (>80%, as per the statistical analysis protocol) of the patients could be included in the analyses. A history of previous CS could not be used to perform subgroup analyses because that data had too many missing values. This observational study is hypothesis-generating and does not provide incidence rates or establish causal associations; therefore, the findings should be interpreted as associations only. Because the multivariable models included perinatal and intrapartum diagnoses, some of which may lie on the causal pathway between antepartum factors and CS delivery, the corresponding estimates should be interpreted cautiously. These models are intended to describe clinical profiles associated with CS, rather than to infer causal relationships between specific intrapartum events and mode of delivery. Second, the generalizability of the findings is limited by the specific population studied. Third, the CS group included all women who underwent CS because the exact indication for CS was not always clearly documented in the charts, especially for patients transferred from local hospitals. Furthermore, the associations between perinatal variables and CS should be interpreted with caution, given the relatively low number of events. Future large-scale studies are needed to investigate these associations and other potential risk factors in greater detail.

In conclusion, this study suggests that older maternal age, elevated pre-pregnancy BMI, higher education levels, specific diagnoses during the perinatal period, and a past medical history of heart disease are independently associated with CS among women with GDM. These associative findings may help inform delivery counseling and risk stratification in women with GDM, while recognizing that they do not establish causal relationships. Nevertheless, rigorous prospective studies across diverse populations are needed to confirm these associations, explore underlying mechanisms, and refine how such information is incorporated into clinical decision-making. This retrospective observational study is hypothesis-generating, does not provide longitudinal incidence estimates, and cannot determine causal associations; several perinatal and intrapartum factors likely reflect clinical indications for CS delivery (eg, cephalopelvic disproportion, oligohydramnios) rather than antecedent risk predictors.

Data Sharing Statement

All data generated or analyzed during this study are included in this article.

Ethics Approval and Consent to Participate

This work has been carried out in accordance with the Declaration of Helsinki (2000) of the World Medical Association. This study was approved by the Medical Ethics Committee of Hainan General Hospital (Approval number: [2021]226). The Medical Ethics Committee of Hainan General Hospital waived informed consent due to the study's retrospective design.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study was supported by the Joint Program on Health Science & Technology Innovation of Hainan Province (WSJK2024MS173 and WSJK2024MS172) and Hainan Province Clinical Medical Center.

Disclosure

The authors declare that they have no competing interests in this work.

References

1. Sweeting A, Hannah W, Backman H, et al. Epidemiology and management of gestational diabetes. *Lancet*. 2024;404(10448):175–192. doi:10.1016/s0140-6736(24)00825-0
2. McIntyre HD, Catalano P, Zhang C, Desoye G, Mathiesen ER, Damm P. Gestational diabetes mellitus. *Nat Rev Dis Primers*. 2019;5(1):47. doi:10.1038/s41572-019-0098-8
3. Greco E, Calanducci M, Nicolaides KH, Barry EVH, Huda MSB, Iliodromiti S. Gestational diabetes mellitus and adverse maternal and perinatal outcomes in twin and singleton pregnancies: a systematic review and meta-analysis. *Am J Clin Exp Obstet Gynecol*. 2024;230(2):213–225. doi:10.1016/j.ajog.2023.08.011
4. Feleke BE, Feleke TE, Adane WG, et al. Maternal and newborn effects of gestational diabetes mellitus: a prospective cohort study. *Primary Care Diab*. 2022;16(1):89–95. doi:10.1016/j.pcd.2021.09.007
5. Maya J, Selen DJ, Thaweethai T, et al. Gestational glucose intolerance and birth weight-related complications. *Obstetrics Gynecol*. 2023;142(3):594–602. doi:10.1097/aog.0000000000005278
6. Ye W, Luo C, Huang J, Li C, Liu Z, Liu F. Gestational diabetes mellitus and adverse pregnancy outcomes: systematic review and meta-analysis. *BMJ*. 2022;377:e067946. doi:10.1136/bmj-2021-067946
7. Iman AE, Huniadi A, Sandor M, Zaha IA, Rotar I, Iuhas C. Prevalence and risk factors of gestational diabetes mellitus in romania: maternal and fetal outcomes. *Medicina*. 2025;61(2). doi:10.3390/medicina61020194
8. Zeki R, Oats JJN, Wang AY, Li Z, Homer CSE, Sullivan EA. Cesarean section and diabetes during pregnancy: an NSW population study using the Robson classification. *J Obstetrics Gynaecol Res*. 2018;44(5):890–898. doi:10.1111/jog.13605
9. Will JS, Crellin H. Gestational diabetes mellitus: update on screening, diagnosis, and management. *Am Family Phys*. 2023;108(3):249–258.
10. Phaloprakarn C, Tangjitgamol S. Risk score for predicting primary cesarean delivery in women with gestational diabetes mellitus. *BMC Pregnancy Childbirth*. 2020;20(1):607. doi:10.1186/s12884-020-03306-y
11. Boriboonhirunsarn D, Waiyanikorn R. Emergency cesarean section rate between women with gestational diabetes and normal pregnant women. *Taiwan J Obstetrics Gynecol*. 2016;55(1):64–67. doi:10.1016/j.tjog.2015.08.024
12. Oliveira APV, Zaccara TA, Bernardi MDC, et al. Risk factors and primary indications for cesarean section in women with gestational diabetes mellitus according to Robson classification. *Clinics*. 2025;80:100705. doi:10.1016/j.clinsp.2025.100705
13. Hu Y, Wang F. The association of gestational diabetes in wound complications following cesarean section: a meta-analysis. *Current Probl Surg*. 2025;71:101867. doi:10.1016/j.cpsurg.2025.101867
14. Fernández-Carrasco FJ, Cristóbal-Cañadas D, Gómez-Salgado J, Vázquez-Lara JM, Rodríguez-Díaz L, Parrón-Carreño T. Maternal and fetal risks of planned vaginal breech delivery vs planned caesarean section for term breech birth: a systematic review and meta-analysis. *J Global Health*. 2022;12:04055. doi:10.7189/jogh.12.04055
15. Diabetes Branch of the Chinese Medical Association. Guidelines for prevention and treatment of type 2 diabetes in China (2017 edition). *Chin J Diabetes Mellitus*. 2018;10(1):1.
16. Zierden HC, Shapiro RL, DeLong K, Carter DM, Ensign LM. Next generation strategies for preventing preterm birth. *Adv Drug Delivery Rev*. 2021;174:190–209. doi:10.1016/j.addr.2021.04.021
17. American College of Obstetricians and Gynecologists. Macrosomia: ACOG practice bulletin, number 216. *Obstetrics Gynecol*. 2020;135(1):e18–e35. doi:10.1097/aog.0000000000003606
18. Lee PA, Chernausek SD, Hokken-Koelega AC, Czernichow P. International Small for Gestational Age Advisory Board consensus development conference statement: management of short children born small for gestational age, April 24-October 1, 2001. *Pediatrics*. 2003;111(6 Pt 1):1253–1261. doi:10.1542/peds.111.6.1253
19. Fields H, Greene JW Jr, Franklin RR. Prolonged labor. *Am J Clin Exp Obstet Gynecol*. 1959;77(1):34–40. doi:10.1016/0002-9378(59)90265-0
20. Moore TR, Cayle JE. The amniotic fluid index in normal human pregnancy. *Am J Clin Exp Obstet Gynecol*. 1990;162(5):1168–1173. doi:10.1016/0002-9378(90)90009-v
21. Zhang Y, Lu M, Yi Y, et al. Influence of maternal body mass index on pregnancy complications and outcomes: a systematic review and meta-analysis. *Front Endocrinol*. 2024;15:1280692. doi:10.3389/fendo.2024.1280692
22. Chung SH, Seol HJ, Choi YS, Oh SY, Kim A, Bae CW. Changes in the cesarean section rate in Korea (1982-2012) and a review of the associated factors. *J Korean Med Sci*. 2014;29(10):1341–1352. doi:10.3346/jkms.2014.29.10.1341

23. Yisma E, Smithers LG, Lynch JW, Mol BW. Cesarean section in Ethiopia: prevalence and sociodemographic characteristics. *J Maternal-Fetal Neonatal Med*. 2019;32(7):1130–1135. doi:10.1080/14767058.2017.1401606
24. Tollånes MC, Thompson JM, Daltveit AK, Irgens LM. Cesarean section and maternal education; secular trends in Norway, 1967-2004. *Acta Obstetricia et Gynecologica Scand*. 2007;86(7):840–848. doi:10.1080/00016340701417422
25. Long Q, Zhang Y, Zhang J, Tang X, Kingdon C. Changes in caesarean section rates in China during the period of transition from the one-child to two-child policy era: Cross-sectional national household health services surveys. *BMJ Open*. 2022;12(4):e059208. doi:10.1136/bmjopen-2021-059208
26. Shen M, Wu Y, Xiang X. Hukou-based rural–urban disparities in maternal health service utilization and delivery modes in two Chinese cities in Guangdong Province. *Int J Equity Health*. 2021;20(1):145. doi:10.1186/s12939-021-01485-4
27. Schiattarella A, Lombardo M, Morlando M, Rizzo G. The impact of a plant-based diet on gestational diabetes: a review. *Antioxidants*. 2021;10(4). doi:10.3390/antiox10040557
28. Li G, Xing Y, Wang G, et al. Does recurrent gestational diabetes mellitus increase the risk of preterm birth? A population-based cohort study. *Diabet Res Clin Pract*. 2023;199:110628. doi:10.1016/j.diabres.2023.110628
29. Muraca GM, Peled T, Kirubarajan A, et al. The association between unintended hysterotomy extensions with cesarean delivery and subsequent preterm birth. *Ame J Obstetrics Gynecol MFM*. 2024;6(4):101326. doi:10.1016/j.ajogmf.2024.101326
30. Mendez-Dominguez N, Vazquez-Vazquez GG, Laviada-Molina HA, de Jesus Inurreta-Diaz M, Fajardo-Ruiz LS, Azcorra H. Cephalopelvic disproportion as primary diagnosis for cesarean section: role of neonatal birthweight in relation to maternal height at a Hospital in Merida, Mexico. *Am J Human Biol*. 2021;33(2):e23463. doi:10.1002/ajhb.23463
31. Light L, Virdee SK, Dickens C, Diogo R. Obstructed labor, evolution, and health disparities. *Biology*. 2024;13(12). doi:10.3390/biology13121001
32. Yeshitila YG, Daniel B, Desta M, Kassa GM. Obstructed labor and its effect on adverse maternal and fetal outcomes in Ethiopia: a systematic review and meta-analysis. *PLoS One*. 2022;17(9):e0275400. doi:10.1371/journal.pone.0275400
33. Bakhsh H, Alenizy H, Alenazi S, et al. Amniotic fluid disorders and the effects on prenatal outcome: a retrospective cohort study. *BMC Pregnancy Childbirth*. 2021;21(1):75. doi:10.1186/s12884-021-03549-3
34. Kang SH, Park M, Moon JY, Kim SY. Association between types of diabetes and amniotic fluid disorders during pregnancy: a cohort study in South Korea. *HIRA*. 2024;4(2):214–224. doi:10.52937/hira.24.4.2.e6
35. Hou L, Wang X, Hellerstein S, Zou L, Ruan Y, Zhang W. Delivery mode and perinatal outcomes after diagnosis of oligohydramnios at term in China. *J Maternal-Fetal Neonatal Med*. 2020;33(14):2408–2414. doi:10.1080/14767058.2018.1553944
36. Sawant AA, Wankhede S, Thakare S, et al. Maternal and perinatal outcomes in oligohydramnios: a cross-sectional analysis of pregnancies between 28 to 42 weeks of gestation. *Cureus*. 2025;17(2):e79232. doi:10.7759/cureus.79232
37. Molla M, Mengistu Z, Tsehaye W, Sisay G. Magnitude and associated factors of adverse perinatal outcomes among women with oligohydramnios at 3rd trimester at University of Gondar comprehensive specialized hospital, North West Ethiopia. Original Research. *Front Global Women's Health*. 2023. doi:10.3389/fgwh.2022.958617
38. Khanduri S, Chawla H, Khan A, et al. Association and correlation between amniotic fluid index and glucose concentration. *Cureus*. 2022;14(6):e25973. doi:10.7759/cureus.25973
39. Wedlund F, von Wowern E, Hlebowicz J. Increased cesarean section rate and premature birth according to modified WHO maternal cardiovascular risk in pregnant women with congenital heart disease. *PLoS One*. 2023;18(11):e0294323. doi:10.1371/journal.pone.0294323
40. Easter SR, Rouse CE, Duarte V, et al. Planned vaginal delivery and cardiovascular morbidity in pregnant women with heart disease. *Am J Clin Exp Obstet Gynecol*. 2020;222(1):77.e1–77.e11. doi:10.1016/j.ajog.2019.07.019
41. Sayed G, Salama H, Abumhara S, Al Obaidly S, Al-Qubaisi M, Al-Rifai H. Review of socioeconomic risk factors for cesarean births: a population-based study. *Acta Biomed*. 2023;94(3):e2023082. doi:10.23750/abm.v94i3.13907
42. Hoxha I, Fink G. Caesarean sections and health financing: a global analysis. *BMJ Open*. 2021;11(5):e044383. doi:10.1136/bmjopen-2020-044383
43. Zaffarini E, Mitteroecker P. Secular changes in body height predict global rates of caesarean section. *Proc R Soc B*. 2019;286(1896):20182425. doi:10.1098/rspb.2018.2425
44. Angolile CM, Max BL, Mushemba J, Mashauri HL. Global increased cesarean section rates and public health implications: a call to action. *Health Sci Rep*. 2023;6(5):e1274. doi:10.1002/hsr2.1274
45. Haider MR, Rahman MM, Moinuddin M, Rahman AE, Ahmed S, Khan MM. Ever-increasing Caesarean section and its economic burden in Bangladesh. *PLoS One*. 2018;13(12):e0208623. doi:10.1371/journal.pone.0208623
46. Metwali NY, Ahmed RA, Hussain Timraz J, et al. Evidence-based strategies to minimize unnecessary primary cesarean sections: a comprehensive review. *Cureus*. 2024;16(11):e74729. doi:10.7759/cureus.74729
47. Betrán AP, Temmerman M, Kingdon C, et al. Interventions to reduce unnecessary caesarean sections in healthy women and babies. *Lancet*. 2018;392(10155):1358–1368. doi:10.1016/S0140-6736(18)31927-5
48. Sakala C. Midwifery care and out-of-hospital birth settings: how do they reduce unnecessary cesarean section births? *Soc Sci Med*. 1993;37(10):1233–1250. doi:10.1016/0277-9536(93)90335-2