Research Square

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Maternal and neonatal outcomes with increasing number of planned repeat cesarean deliveries: a retrospective cohort study

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Research Article

Keywords: Placenta accreta spectrum, Uterine dehiscence, Peripartum hysterectomy, Transient tachypnea of the newborn, Grand multiparity

Posted Date: November 16th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11547454/v1

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Additional Declarations: No competing interests reported.

Abstract

Purpose

To evaluate the dose–response association between the number of planned repeat cesarean deliveries and maternal and neonatal outcomes, with emphasis on high-order (fourth, fifth and subsequent) cesareans.

Methods

Retrospective cohort of singleton planned cesarean deliveries at a single medical center, 2013–2024. Second (reference), third, fourth and fifth-or-more cesareans were compared. Because many women contributed several deliveries, regression models with robust standard errors clustered by woman were used, with cesarean order as a continuous term, adjusted for maternal age and year; Firth regression was used for outcomes with fewer than 20 events. Neonatal models were further adjusted for gestational age.

Results

We included 3,893 repeat cesareans in 3,068 women. From the second to the fifth or later cesarean, uterine scar dehiscence or rupture rose from 2.5% to 5.4% (aOR per cesarean 1.29, 95% CI 1.16–1.43), placenta accreta from 0.1% to 1.3% (17 cases; aOR 1.71, 1.33–2.22), hysterectomy from 0.1% to 1.3% (11 cases; aOR 1.85, 1.42–2.57), transfusion from 1.5% to 3.1% (aOR 1.26, 1.06–1.49) and composite severe maternal morbidity from 2.2% to 3.8% (aOR 1.19, 1.03–1.37). Gestational age fell from 39.0 to 37.9 weeks. Composite neonatal morbidity rose from 3.8% to 11.2% (aOR 1.37, 1.25–1.51); the association was attenuated but persisted after adjustment for gestational age (aOR 1.18, 1.06–1.32) and in term births (aOR 1.24, 1.10–1.40). Sensitivity analyses gave similar results.

Conclusion

Maternal surgical morbidity and neonatal respiratory morbidity rise progressively with each repeat cesarean. The neonatal association is attenuated, but not explained, by earlier delivery.

Introduction

About one in five births worldwide is by cesarean, and this proportion is projected to reach 28.5% by 2030 [1]. After a first cesarean, women can choose between a trial of labor and a planned repeat cesarean. A trial of labor carries a small absolute risk of uterine rupture [2], and after two or more cesareans it is often declined or not offered. Women who desire large families therefore accumulate repeat cesareans, especially in populations with high fertility.

The maternal cost of repeat cesareans is cumulative. In the prospective NICHD Maternal-Fetal Medicine Units cohort of 30,132 women delivered by cesarean without labor, placenta accreta rose from 0.24% at the first cesarean to 2.13% at the fourth and 6.74% at the sixth or more, and hysterectomy from 0.65% to 2.41% and

8.99%, respectively [3]. A systematic review confirmed a progressive rise in hysterectomy, transfusion, adhesions and surgical injury with the number of previous cesareans [4]. The FIGO consensus on placenta accreta spectrum identifies prior cesarean, and particularly multiple prior cesareans combined with placenta previa, as the dominant risk factor [5]. Adhesions are found in about a quarter of women at the second cesarean and in almost half at the fourth or later, and they lengthen the time to delivery of the neonate [6].

Most of these data come from cohorts in which fourth and later cesareans are rare. Studies from populations where large families are common report more adhesions, scar dehiscence, abnormal placentation, bladder injury and hysterectomy from the fourth cesarean onward [7, 8]. In Israel, a cohort of planned cesareans found that major complications rose from 4.3% at the second cesarean to 7.5% at the third and 12.5% at the fourth or later [9], and a prospective study found longer surgery and more transfusions in women with four or more previous cesareans [10]. In the United Kingdom, a fifth or later cesarean occurs in about 1.2 per 10,000 maternities and carries a markedly higher risk of major hemorrhage, visceral injury and critical care admission [11]. Other series found that a fourth or fifth cesarean was relatively safe in low-risk women [12, 13]. These studies were small, mostly compared broad groups, rarely adjusted for confounders and treated repeated deliveries of the same woman as independent observations.

Neonatal outcomes have received even less attention. Pre-labor cesarean at term increases neonatal respiratory morbidity, and the risk falls with each additional week of gestation up to 39 weeks [14, 15]. In the MFMU network, the composite neonatal outcome after elective repeat cesarean was more frequent at 37 and 38 than at 39 weeks [16], and current guidance recommends avoiding non-indicated delivery before 39 weeks [17]. Women with several previous cesareans, however, are often scheduled earlier to avoid labor and uterine rupture [18, 19], so any neonatal excess in high-order cesareans may simply reflect timing. Whether the number of cesareans carries a neonatal risk beyond gestational age is unknown.

We therefore examined maternal and neonatal outcomes across the full range of planned repeat cesareans, from the second to the fifth and beyond, in a population with many high-order cesareans. We aimed to quantify the risk per additional cesarean, to account for women who contributed several deliveries, and to separate the neonatal association of cesarean order from that of earlier delivery.

Materials and methods

Study design and population

This retrospective cohort study included cesarean deliveries performed between January 2013 and December 2024 at a single university-affiliated medical center in Israel. The center serves a population with high parity, in which repeat and high-order cesareans are common, and manages placenta accreta spectrum on site. Cesareans recorded as planned (elective) were extracted from the computerized obstetric database and linked to coded discharge diagnoses. Every case with a coded or suspected placenta previa, placenta accreta or hysterectomy was reviewed manually in the medical record. Antenatal corticosteroids are not given before planned cesarean at term in our unit. The study was approved by the institutional Helsinki committee (approval no. LND-0004-24), which waived informed consent.

We included singleton pregnancies. Deliveries whose structured indication field recorded an intrapartum or urgent indication were considered misclassified as planned and were excluded: non-reassuring fetal heart rate, arrest of labor, cephalopelvic disproportion, preeclampsia, placental abruption, failed induction, failed vacuum, cord prolapse and uterine atony. We also excluded any delivery with induction or augmentation of labor, and deliveries with a missing or unclassifiable indication. Planned indications such as suspected macrosomia and maternal request were retained.

Exposure

The exposure was the order of the current cesarean, derived from the number of previous cesareans recorded at admission: second, third, fourth, and fifth or more. In trend models, the actual cesarean number was used (range 2–11); a sensitivity analysis capped it at five. The second cesarean was the reference, so that all women had a uterine scar.

Outcomes

Uterine scar dehiscence and uterine rupture were identified from the surgeon's operative report and the delivery summary. Because the two could not be reliably distinguished in the coded data, they were combined into a single outcome, uterine scar dehiscence or rupture. Placenta accreta was a clinical diagnosis made at the operation. Other maternal outcomes were placental abruption, hysterectomy, blood transfusion, laparotomy after the cesarean, bladder laceration, ureteral injury, pelvic organ injury, venous thromboembolism and postpartum length of stay. Postpartum hemorrhage was not analyzed because it was severely under-coded; blood transfusion was used as the measure of hemorrhage. Composite severe maternal morbidity was defined as any of hysterectomy, transfusion, bladder, ureteral or pelvic organ injury, laparotomy, coded uterine rupture or venous thromboembolism.

Neonatal outcomes were gestational age at delivery, early-term delivery (37 + 0 to 38 + 6 weeks), preterm delivery (< 37 weeks), birth weight, transient tachypnea of the newborn (TTN), respiratory distress syndrome (RDS), any ventilation, NICU admission, hypoglycemia, jaundice, 5-minute Apgar < 7, umbilical artery pH < 7.10 and newborn length of stay. Composite neonatal morbidity was defined as any of TTN, RDS, ventilation, NICU admission, hypoglycemia or 5-minute Apgar < 7.

Statistical analysis

Crude differences across groups were tested with a Monte-Carlo exact chi-square test (5,000 permutations), ANOVA or the Kruskal–Wallis test.

Women could contribute more than one delivery. We therefore fitted logistic (binary outcomes) and linear (continuous outcomes) regression models with robust (sandwich) standard errors clustered by woman, equivalent to generalized estimating equations with an independence working correlation [20]. Cesarean order was entered as a continuous term, giving an adjusted odds ratio (aOR) per additional cesarean and a test for trend. All models were adjusted for maternal age and year of delivery. For outcomes with fewer than 20 events, we used Firth penalized logistic regression [21], with 95% confidence intervals from 1,000 bootstrap samples

of women and an exact permutation test for trend (20,000 permutations). To examine whether a constant per-cesarean effect fitted the data, we also estimated aORs for the third, fourth and fifth-or-more cesarean versus the second and tested departure from linearity with a Wald test (Supplementary Table S2).

Neonatal models were additionally adjusted for gestational age in completed weeks (< 37, 37, 38, ≥ 39), because respiratory morbidity changes non-linearly across these weeks. Because gestational age lies on the pathway between cesarean order and neonatal outcome, this estimate represents the association not mediated by earlier delivery. We repeated the neonatal analysis in term births (≥ 37 + 0 weeks) and present neonatal outcomes stratified by completed week (Supplementary Table S3). Among fourth and later cesareans, we described maternal and neonatal outcomes by week of delivery (Supplementary Table S4).

Sensitivity analyses (Supplementary Table S1) entered year of delivery as three periods, added the number of previous vaginal births, capped cesarean order at five, used a composite maternal outcome that excluded transfusion and included accreta, and repeated the analysis 1,000 times with one randomly selected delivery per woman, reporting the median aOR and the 2.5th–97.5th percentiles. Data were complete except for cord pH (1,759 deliveries). Two-sided $p < 0.05$ was considered significant. Analyses were performed in Python 3.13 with NumPy 2.5 and SciPy 1.18; the regression, bootstrap and permutation procedures were implemented directly in NumPy. A large language model (Claude, Anthropic) was used to assist with writing the statistical analysis code and with drafting the manuscript. All analyses, results and text were reviewed, verified and edited by the authors, who take full responsibility for the content of this article.

Results

Study population

The source dataset included 6,256 cesareans recorded as planned, of which 5,692 were singleton deliveries. After exclusion of one delivery with a missing number of previous cesareans, 96 deliveries with an intrapartum or urgent indication, 93 deliveries with induction or augmentation and 17 with a missing indication, 5,485 planned cesareans remained. Excluding 1,592 first cesareans left 3,893 repeat cesareans in 3,068 women for the analysis: 1,487 second, 1,367 third, 593 fourth and 446 fifth-or-more cesareans. The fifth-or-more group included 253 fifth, 122 sixth, 44 seventh and 27 eighth to eleventh cesareans. In total, 672 women contributed more than one delivery (1,497 deliveries).

Maternal age and parity rose with cesarean order, whereas the number of previous vaginal births was similar across groups (mean 1.8). Mean gestational age at delivery fell from 39.0 weeks at the second cesarean to 37.9 weeks at the fifth or more (− 0.30 weeks per additional cesarean, $p < 0.001$). Early-term delivery rose from 51.9% to 86.5% and preterm delivery from 1.7% to 7.2% (aOR 1.44 per cesarean, 1.28–1.61). Diabetes and hypertensive disorders did not differ (Table 1).

Table 1
Baseline characteristics by order of the planned repeat cesarean (n = 3,893)

Variable	CS 2 (n = 1,487)	CS 3 (n = 1,367)	CS 4 (n = 593)	CS ≥ 5 (n = 446)	p
Maternal age (y)	33.71 ± 5.57	34.46 ± 4.52	35.19 ± 4.55	36.38 ± 3.89	< 0.001
Parity	2.8 ± 1.7	3.8 ± 1.7	4.8 ± 1.7	6.5 ± 1.9	< 0.001
Previous vaginal births	1.8 ± 1.7	1.8 ± 1.7	1.8 ± 1.7	1.8 ± 1.6	0.035
Placenta previa as indication for cesarean	14 (0.9%)	2 (0.1%)	2 (0.3%)	3 (0.7%)	0.027
Gestational age at delivery (wk)	39.04 ± 1.14	38.53 ± 0.80	38.17 ± 0.87	37.91 ± 0.74	< 0.001
Delivery 37 + 0–38 + 6 wk	772 (51.9%)	998 (73.0%)	485 (81.8%)	386 (86.5%)	< 0.001
Preterm < 37 wk	26 (1.7%)	33 (2.4%)	21 (3.5%)	32 (7.2%)	< 0.001
Birth weight (kg)	3.34 ± 0.48	3.22 ± 0.43	3.17 ± 0.42	3.11 ± 0.40	< 0.001
Diabetes (any)	181 (12.2%)	131 (9.6%)	60 (10.1%)	45 (10.1%)	0.132
Hypertensive disorders (any)	50 (3.4%)	37 (2.7%)	10 (1.7%)	13 (2.9%)	0.213

Values are mean ± SD or n (%). p: ANOVA (Kruskal–Wallis for previous vaginal births) for continuous variables and Monte-Carlo exact χ^2 for categorical variables; these crude tests do not account for repeat deliveries by the same woman.

Maternal outcomes

Uterine scar dehiscence or rupture rose from 2.5% at the second cesarean to 6.1% at the fourth and 5.4% at the fifth or more (aOR 1.29 per cesarean, 1.16–1.43; Table 2). Placenta accreta rose from 0.1% to 1.3% (17 cases; aOR 1.71, 1.33–2.22), and hysterectomy from 0.1% to 1.3% (11 cases; aOR 1.85, 1.42–2.57); 9 of the 11 hysterectomies occurred at the fourth cesarean or later. Blood transfusion increased from 1.5% to 3.1% (aOR 1.26, 1.06–1.49). Bladder laceration occurred in five women, all at the third cesarean or later (aOR 2.15, 1.38–4.01; exact p for trend 0.010).

Table 2
Maternal outcomes by order of the planned repeat cesarean

Outcome	CS 2 (n = 1,487)	CS 3 (n = 1,367)	CS 4 (n = 593)	CS ≥ 5 (n = 446)	p (groups)	aOR or β per CS (95% CI)	p-trend
Uterine scar dehiscence or rupture	37 (2.5%)	60 (4.4%)	36 (6.1%)	24 (5.4%)	< 0.001	1.29 (1.16–1.43)	< 0.001
Placenta accreta (a)	1 (0.1%)	5 (0.4%)	5 (0.8%)	6 (1.3%)	0.003	1.71 (1.33–2.22)	< 0.001
Placental abruption (a)	1 (0.1%)	2 (0.1%)	3 (0.5%)	1 (0.2%)	0.166	1.36 (1.01–1.88)	0.126
Hysterectomy (a)	1 (0.1%)	1 (0.1%)	3 (0.5%)	6 (1.3%)	< 0.001	1.85 (1.42–2.57)	< 0.001
Blood transfusion	23 (1.5%)	27 (2.0%)	12 (2.0%)	14 (3.1%)	0.198	1.26 (1.06–1.49)	0.008
Laparotomy (a)	5 (0.3%)	3 (0.2%)	0 (0.0%)	1 (0.2%)	0.566	0.72 (0.25–1.25)	0.408
Bladder laceration (a)	0 (0.0%)	1 (0.1%)	2 (0.3%)	2 (0.4%)	0.056	2.15 (1.38–4.01)	0.010
Ureteral injury (a)	0 (0.0%)	2 (0.1%)	1 (0.2%)	0 (0.0%)	0.385	1.24 (1.01–1.71)	0.578
Pelvic organ injury (a)	2 (0.1%)	6 (0.4%)	2 (0.3%)	1 (0.2%)	0.491	1.11 (0.78–1.44)	0.548
Venous thromboembolism (a)	1 (0.1%)	2 (0.1%)	1 (0.2%)	1 (0.2%)	0.868	1.35 (0.67–2.59)	0.375
Composite severe maternal morbidity (b)	32 (2.2%)	44 (3.2%)	20 (3.4%)	17 (3.8%)	0.154	1.19 (1.03–1.37)	0.015
Postpartum stay (days)	4.33 ± 3.73	4.25 ± 2.10	4.57 ± 2.94	5.21 ± 2.89	< 0.001	β + 0.21 (+ 0.12 to + 0.31)	< 0.001

aOR = adjusted odds ratio per additional cesarean, adjusted for maternal age and year of delivery, with robust standard errors clustered by woman. (a) Fewer than 20 events: Firth penalized logistic regression with 95% CI from 1,000 bootstrap samples of women, and exact permutation test for trend. (b) Hysterectomy, blood transfusion, bladder, ureteral or pelvic organ injury, laparotomy, coded uterine rupture or venous thromboembolism.

Composite severe maternal morbidity rose from 2.2% to 3.8% (aOR 1.19 per cesarean, 1.03–1.37). Placental abruption (7 cases), laparotomy, ureteral injury, pelvic organ injury and venous thromboembolism did not show a significant trend. Postpartum stay increased by 0.21 days per additional cesarean (0.12–0.31), from 4.3 to 5.2 days.

Categorical estimates rose from the third cesarean onward, with no evidence of departure from a constant per-cesarean trend (p for non-linearity 0.13–0.94; Supplementary Table S2). For uterine scar dehiscence or rupture, the aOR was 1.87 (1.23–2.84) at the third, 2.73 (1.69–4.42) at the fourth and 2.56 (1.51–4.34) at the fifth or later cesarean.

Neonatal outcomes

TTN rose from 2.0% to 7.2% (aOR 1.43 per cesarean, 1.27–1.61), RDS from 0.1% to 1.8% (aOR 1.58, 1.31–1.98), ventilation from 0.9% to 3.8% and NICU admission from 2.8% to 6.1%. Composite neonatal morbidity increased from 3.8% to 11.2% (aOR 1.37, 1.25–1.51; Table 3).

Table 3
Neonatal outcomes by order of the planned repeat cesarean

Outcome	CS 2 (n = 1,487)	CS 3 (n = 1,367)	CS 4 (n = 593)	CS ≥ 5 (n = 446)	p (groups)	aOR or β per CS (95% CI)	p-trend	aOR per CS, adjusted also for GA (95% CI)	p-trend
TTN	30 (2.0%)	38 (2.8%)	25 (4.2%)	32 (7.2%)	< 0.001	1.43 (1.27–1.61)	< 0.001	1.24 (1.08–1.43)	0.002
RDS (a)	1 (0.1%)	6 (0.4%)	4 (0.7%)	8 (1.8%)	< 0.001	1.58 (1.31–1.98)	< 0.001	1.46 (1.16–1.84)	0.001
Ventilation (any)	14 (0.9%)	19 (1.4%)	11 (1.9%)	17 (3.8%)	< 0.001	1.38 (1.18–1.61)	< 0.001	1.17 (0.98–1.41)	0.082
NICU admission	42 (2.8%)	48 (3.5%)	26 (4.4%)	27 (6.1%)	0.010	1.24 (1.10–1.38)	< 0.001	1.05 (0.91–1.21)	0.499
Hypoglycemia	12 (0.8%)	7 (0.5%)	2 (0.3%)	6 (1.3%)	0.181	1.24 (0.90–1.72)	0.194	1.03 (0.69–1.56)	0.870
Jaundice	57 (3.8%)	72 (5.3%)	34 (5.7%)	32 (7.2%)	0.026	1.21 (1.08–1.36)	0.001	1.14 (1.00–1.30)	0.057
5-min Apgar < 7 (a)	6 (0.4%)	2 (0.1%)	4 (0.7%)	3 (0.7%)	0.221	1.35 (0.81–1.93)	0.304	1.18 (0.84–1.66)	0.332
Cord pH < 7.10 (c)	24 (3.5%)	21 (3.4%)	5 (1.9%)	7 (3.4%)	0.638	0.92 (0.73–1.17)	0.490	0.98 (0.77–1.24)	0.857
Composite neonatal morbidity (b)	56 (3.8%)	70 (5.1%)	46 (7.8%)	50 (11.2%)	< 0.001	1.37 (1.25–1.51)	< 0.001	1.18 (1.06–1.32)	0.003
Newborn hospital stay (days)	5.11 ± 2.26	5.20 ± 1.81	5.54 ± 4.92	5.94 ± 2.03	< 0.001	β + 0.21 (+ 0.16 to + 0.27)	< 0.001		

aOR per additional cesarean adjusted for maternal age and year of delivery; the last two columns are additionally adjusted for gestational age (GA) in completed weeks (< 37, 37, 38, ≥ 39). (a) Fewer than 20 events: Firth penalized logistic regression; per-CS CI from 1,000 bootstrap samples of women and exact permutation test for trend. (b) TTN, RDS, ventilation, NICU admission, hypoglycemia or 5-minute Apgar < 7. (c) Cord pH available for 1,759 deliveries. In term births only (≥ 37 + 0 weeks, n = 3,781), aORs adjusted also for GA were 1.28 (1.10–1.48) for TTN, 1.55 (1.21–1.97) for RDS and 1.24 (1.10–1.40) for composite neonatal morbidity.

After additional adjustment for gestational age, the associations were attenuated but remained significant for TTN (aOR 1.24, 1.08–1.43), RDS (aOR 1.46, 1.16–1.84) and composite neonatal morbidity (aOR 1.18, 1.06–1.32). The associations with NICU admission (aOR 1.05, 0.91–1.21), ventilation and jaundice were no longer significant. Apgar scores, cord pH and hypoglycemia did not differ. Results were similar in term births (composite aOR 1.24, 1.10–1.40; TTN 1.28, 1.10–1.48; RDS 1.55, 1.21–1.97). Within each completed week, composite neonatal morbidity was higher at the fifth or later cesarean than at the second, for example 6.7% versus 3.4% at 38 weeks (Supplementary Table S3).

Among fourth and later cesareans, composite neonatal morbidity was 12.3% at 37 weeks, 5.9% at 38 weeks and 6.1% at 39 weeks or later, whereas uterine scar dehiscence or rupture did not differ by week (4.7%, 5.3% and 3.5%, respectively). Accreta and hysterectomy were concentrated in deliveries before 38 weeks (Supplementary Table S4).

Sensitivity analyses

Results were consistent across sensitivity analyses (Supplementary Table S1). Capping cesarean order at five gave slightly larger per-cesarean estimates, for example 1.40 (1.21–1.62) for uterine scar dehiscence or rupture. A composite maternal outcome without transfusion also rose with cesarean order (aOR 1.24, 1.02–1.47). Across 1,000 analyses with one delivery per woman, the median aOR was 1.86 for accreta, 1.98 for hysterectomy and 1.39 for composite neonatal morbidity.

Discussion

Principal findings

In this cohort of almost 3,900 planned repeat cesareans, more than a quarter of which were fourth or later operations, maternal surgical morbidity rose with each additional cesarean, with most hysterectomies from the fourth cesarean onward. Composite neonatal morbidity tripled; after accounting for earlier delivery, this association was attenuated but persisted, mainly for TTN and RDS.

Comparison with previous studies

Our maternal findings agree with the MFMU cohort [3], the systematic review of Marshall et al. [4] and the UK national cohort [11]. They also agree with Nisenblat et al., who used the same design of planned cesareans with the second cesarean as reference and found a stepwise rise in major complications, excessive blood loss and dense adhesions with each additional cesarean [9]. Our cohort is about five times larger, includes more than 1,000 fourth and later cesareans, and adds neonatal outcomes. Absolute rates of accreta and hysterectomy in our cohort were lower than in the MFMU data. This may reflect the exclusion of urgent cesareans, including women presenting with bleeding from placenta previa–accreta; the choice of some women with an antenatal diagnosis of accreta spectrum to deliver at a tertiary center, although our unit manages these cases and has no referral policy; and differences in coding and in surgical practice over time.

Studies from high-parity populations reported similar findings from the fourth cesarean [7, 8], and an Israeli prospective study found more transfusions with four or more previous cesareans [10]. Other studies found no difference in serious morbidity between women with fewer and more previous cesareans [12, 13]. Our

approach adds three elements to this literature. First, the per-cesarean models use the full ordinal information rather than broad groups, and penalized regression avoids overstating the precision of estimates for rare outcomes. Second, they account for women who contributed several deliveries, which earlier series treated as independent. Third, the comparison is restricted to planned cesareans without labor, so intrapartum events do not drive the associations.

Uterine scar dehiscence or rupture rose until the fourth cesarean and then reached a plateau. This may reflect earlier delivery in women with several scars, or the selection of women with a well-healed scar who go on to a fifth cesarean.

Neonatal outcomes and timing of delivery

Most fifth-or-more cesareans were performed in the early-term period, and pre-labor cesarean before 39 weeks increases neonatal respiratory and other morbidity [14–16], so part of the neonatal excess in high-order cesareans is expected. Adjustment for gestational age in completed weeks removed the association with NICU admission, which is consistent with a timing effect. However, TTN, RDS and the composite outcome remained associated with cesarean order, also in term births and within each completed week. Because antenatal corticosteroids are not given before planned term cesareans in our unit, they do not explain these differences. Dense adhesions lengthen the time to delivery of the neonate [6] and have been associated with neonatal morbidity in repeat cesareans [22], which offers one possible explanation; we could not test it, because the time from skin incision to delivery was not available. Other possible explanations include residual confounding by gestational age within the same week, more frequent general anesthesia, and maternal characteristics that we could not measure, including body mass index.

The optimal timing of high-order cesareans balances the risk of unscheduled delivery and uterine rupture against neonatal morbidity. In women with three or more previous cesareans, planned delivery at 37 weeks reduced unscheduled deliveries without a clear difference in perinatal outcomes [18]. Current guidance discourages non-indicated delivery before 39 weeks [17] but supports individualized early-term timing for some indications [19]. In our fourth and later cesareans, neonatal morbidity was about twice as high at 37 as at 38 weeks, whereas uterine scar dehiscence or rupture was not more frequent at 38 weeks or later. These numbers are small, and we could not assess unscheduled deliveries, so they do not support a firm recommendation. They suggest that, even when delivery is planned, a fifth or later cesarean carries a measurable neonatal respiratory risk that should be included in counseling.

Strengths and limitations

Strengths include a large number of fourth and later cesareans, manual review of every case of placenta previa, accreta and hysterectomy, exclusion of intrapartum operations, and methods that account for repeat deliveries and rare events.

The study has limitations. It is retrospective and relies partly on coded diagnoses; postpartum hemorrhage was under-recorded, and dehiscence and rupture could not be distinguished. Planned status was based on the source dataset and the indication field, so a planned cesarean performed after the spontaneous onset of labor before the scheduled date may not have been identified. Body mass index, operative time, time from skin incision to delivery, adhesion severity, estimated blood loss, anesthesia type and maternal ICU admission were

not available in a structured form. Rare events limit precision and the number of covariates. Placenta previa, the main mediator between repeat cesarean and accreta, was not analyzed as a separate exposure. Because urgent cesareans were excluded, women with the most severe presentations, such as antepartum bleeding with previa–accreta, are under-represented, and some women with an antenatal diagnosis of accreta spectrum may have chosen to deliver elsewhere; both would bias the maternal estimates toward the null. Women who had a severe complication, such as hysterectomy, cannot contribute later cesareans, and women advised against further pregnancies after a difficult operation may be under-represented in the high-order groups, so women reaching a fifth cesarean are probably a selected, lower-risk group. Finally, this single-center population with high parity may limit generalizability to settings in which high-order cesareans are uncommon.

Conclusion

Maternal surgical morbidity, including scar dehiscence or rupture, accreta, hysterectomy and transfusion, increases progressively with each planned repeat cesarean, with most severe events at the fourth cesarean and beyond. Neonatal respiratory morbidity also rises, and this association is attenuated but not eliminated by adjustment for the earlier gestational age at delivery. These absolute and per-cesarean risks can inform counseling about family planning, trial of labor after a first cesarean and the timing of subsequent planned cesareans.

Declarations

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics approval

This retrospective study was performed in line with the principles of the Declaration of Helsinki and was approved by the institutional Helsinki committee (approval no. LND-0004-24).

Consent to participate

The requirement for informed consent was waived by the Helsinki committee because of the retrospective design and the use of de-identified data.

Consent to publish

Not applicable.

Funding

The authors declare that no funds, grants or other support were received during the preparation of this manuscript.

Author Contribution

Y.B. and Y.P. conceived and designed the study. Y.B. and R.R. collected and managed the data. Y.P. performed the data analysis. Y.B. and Y.P. wrote the main manuscript text. H.H., Y.Y., A.W. and N.R.D. supervised the work and reviewed and edited the manuscript. All authors read and approved the final manuscript.

Acknowledgments:

None.

Data Availability

The data that support the findings of this study are available from the corresponding author on reasonable request, subject to institutional approval.

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