Risk of complications in a second pregnancy following caesarean section in the first pregnancy: a population-based study

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ABSTRACT

Objective: To estimate the risks of maternal and perinatal morbidity and mortality in a second pregnancy, attributable to caesarean section in a first pregnancy.

Design and setting: Cross-sectional analytic study of hospital births in New South Wales, based on linked population databases.

Participants: 136 101 women with one previous birth who gave birth to a singleton infant in NSW in 1998–2002.

Main outcome measures: Crude and adjusted odds ratios (aOR) and 95% confidence intervals (95% CI) for maternal and perinatal morbidity and mortality.

Results: 19% of mothers had a caesarean section in their first pregnancy. Compared with mothers who had had primary vaginal births, mothers who had had primary caesarean section and undewent labour in the second birth were at increased risk of uterine rupture (aOR, 12.3; 95% CI, 5.0–30.1; $P < 0.0001$), hysterectomy (3.5; 1.5–8.4; $P < 0.01$), postpartum haemorrhage (PPH) following vaginal delivery (1.6; 1.4–1.7; $P < 0.0001$), manual removal of placenta (1.3; 1.1–1.6; $P < 0.01$), infection (6.2; 4.7–8.2; $P < 0.0001$) and intensive care unit (ICU) admission (3.1; 2.1–4.7; $P < 0.0001$); among mothers who did not undergo labour (ie, had an elective caesarean section), there was a lower risk of PPH (0.6; 0.5–0.7; $P < 0.0001$) and ICU admission (0.4; 0.3–0.5; $P < 0.0001$). For infants there was increased risk of preterm delivery (1.2; 1.1–1.3; $P < 0.0001$) and neonatal intensive care unit admission following labour (1.6; 1.4–1.9; $P < 0.0001$) in the birth after primary caesarean section. The occurrence of stillbirth was not modified by labour.

Conclusions: Caesarean section in a first pregnancy confers additional risks on the second pregnancy, primarily associated with labour. These should be considered at the time caesarean section in the first pregnancy is being considered, particularly for elective caesarean section for non-medical reasons.

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Evidence on the risks and benefits of caesarean section fuels vigorous debate, most recently about the risk of stillbirth after previous caesarean section.[1] Caesarean section rates are now above 20% in many countries,[1-7] and in all Australian states and territories,[8] raising concerns about morbidity in subsequent pregnancies that could be substantial at a population level.

The evidence that women who have a caesarean section may be at increased risk of complications in a subsequent pregnancy comes largely from hospital-based studies. These studies are limited because the frequency and severity of morbidities suffered by mothers and babies is related to the risk-profile of mothers attending the hospital.

Previous population-based studies have examined a small number of morbidities using a variety of study designs. At a population level, compared with vaginal delivery in the first pregnancy, caesarean section has been found to be associated with significantly increased rates of: uterine rupture in labour;[9] placenta praevia and placental abruption;[10] placenta praevia leading to peripartum hysterectomy;[11] stillbirth;[1] and perinatal death.[12]

In this study, we estimate the risk of perinatal mortality and maternal and neonatal morbidities attributable to caesarean section in a first pregnancy.

METHODS

The study population included all women with a first birth and second singleton birth in a New South Wales hospital in 1994–2002. Data were obtained from:

- NSW Health Department databases of births (Midwives Data Collection [MDC]) and hospital separations (Inpatient Statistics Collection [ISC]); and
- NSW Registry of Births, Deaths and Marriages (RBDM).

The MDC covers all live births and stillbirths of at least 20 weeks' gestation or 400 g birthweight, and includes information on maternal demographic factors, pregnancy, labour, delivery and perinatal outcomes. The ISC includes demographic and data related to episode-of-care for every inpatient discharged from hospital, and contains fields for principal diagnosis, comorbidities and procedures.

The NSW Health Department Centre for Epidemiology and Research performed the data linkage using probabilistic record linkage software (Automatch Version 4.01, MatchWare Technologies, Burtonsville, Mass). A birth history dataset was created by linking MDC records to each other for the years 1994 to 2002. The birth history dataset was linked with ISC records of pregnancy and birth for mothers and ISC records of birth for live-born infants to produce two linked MDC-ISC datasets — one for mothers and one for infants. RBDM death registration data were then linked in an infant MDC-ISC-RBDM dataset.

The study was approved by the NSW Health Department Ethics Committee.

Statistical analyses

Analysis was restricted to singleton births in the 5 years 1998–2002 among the 142 135 mothers with one previous birth. Infant analyses were restricted to the 141 281 live births of 24–44 weeks' gestation. Data for one or more variables were missing for 6034 mothers (4.2%) and 6162 babies (4.6%).

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These records were excluded, leaving 136 101 records for mothers and 135 119 infant records for analysis. The characteristics of excluded records were similar to those for the study cohort, except for birth defects, which had a slightly higher overall prevalence in excluded records compared with the study cohort (1.2% v 0.9%).

Outcome measures for mothers and infants following primary caesarean section were compared with those following primary vaginal birth.

The outcome measures for mothers were: uterine rupture (with suture of ruptured uterus, abdominal hysterectomy); hysterectomy; postpartum haemorrhage (PPH); complicated PPH (with renal failure, arterial embolisation, transfusion of blood/packed cells/blood expander); postpartum infection; admission to intensive care unit (ICU); manual removal of placenta; and stillbirth.

The outcome measures for infants were: neonatal death; infant death; admission to neonatal intensive care unit (NICU); small for gestational age (SGA; <10th percentile); respiratory distress syndrome (RDS); bacterial sepsis; and preterm delivery. The source data sets and variable definition codes are available from the authors.

The relationships between each pregnancy outcome and the following covariates were examined: maternal age; prior uterine curettage; smoking in pregnancy; health insurance status (public/private); ethnicity (Australian born non-Indigenous, Australian Indigenous, non-Australian born); socio-economic group; pre-existing diabetes; gestational diabetes; pre-existing hypertension; pregnancy-induced hypertension and labour. For mothers, other covariates examined were: non-vertex presentation for all maternal outcomes except major puerperal infection and stillbirth; gestational age and prelabour premature rupture of membranes for major puerperal infection; and prior stillbirth for stillbirth. For infants, other covariates examined were: sex; gestational age (except where preterm birth was the outcome); and SGA (except where SGA was the outcome). If an interaction with labour was found, the analysis was stratified by labour/no labour; for the labour analysis covariates also included induction/augmentation of labour and caesarean section in labour. All infant analyses were repeated excluding records of babies with a congenital malformation detected at birth.

All analyses were carried out using SAS for Windows, version 8.02 (SAS Institute, Cary, NC, USA). Logistic regression with backward elimination was used to adjust the effect of primary caesarean section for covariates. Covariates were included in the initial models if the crude χ^2 test gave $P<0.25$ where the number of outcome events was less than 50, or $P<0.1$ where there were 50 or more outcome events. Covariates were retained if they were significant at $P<0.05$ for less than 50 or $P<0.01$ for 50 or more outcome events, or if they were confounders (change in adjusted odds ratios [aOR] of 10% or more). Interactions were considered significant at $P<0.01$.

1 Maternal and infant characteristics by primary caesarean section, New South Wales 1988–2002

Characteristics	Primary caesarean	No primary caesarean
Mothers	**(*n* = 25 596)**	**(*n* = 110 505)**
Age (years)		
< 25	2552 (10.0%)	20 239 (18.3%)
25–34	16 499 (64.5%)	72 591 (65.7%)
35 +	6545 (25.6%)	17 675 (16.0%)
Ethnicity		
Australian non-Indigenous	18 128 (70.8%)	77 547 (70.2%)
Australian Indigenous	465 (1.8%)	2242 (2.0%)
Non-Australian born	7003 (27.4%)	30 716 (27.8%)
Private health insurance	10 821 (42.3%)	33 934 (30.7%)
Social disadvantage quintile		
1 (Least disadvantaged)	5774 (22.6%)	19 936 (18.0%)
2	5103 (19.9%)	21 853 (19.8%)
3	4932 (19.3%)	21 785 (19.7%)
4	4706 (18.4%)	20 039 (18.1%)
5 (Most disadvantaged)	5081 (19.9%)	26 892 (24.3%)
Smoking in pregnancy	3405 (13.3%)	17 963 (16.3%)
Prior uterine curettage	2792 (10.9%)	10 819 (9.8%)
Pre-existing diabetes	283 (1.1%)	415 (0.4%)
Gestational diabetes	1613 (6.3%)	4698 (4.3%)
Pre-existing hypertension	431 (1.7%)	1126 (1.0%)
Pregnancy-induced hypertension	2037 (8.0%)	6709 (6.1%)
Non-vertex presentation	1794 (7.0%)	3772 (3.4%)
Pre-labour premature rupture of membranes	1041 (4.1%)	5892 (5.3%)
Labour		
Spontaneous	6536 (25.5%)	61 028 (55.2%)
Augmented	2403 (9.4%)	17 591 (15.9%)
Induced	1804 (7.0%)	26 729 (24.2%)
No labour (ie, elective caesarean section)	14 853 (58.0%)	5157 (4.7%)
Caesarean section in labour	4675 (18.3%)	3928 (3.6%)
Infants	**(*n* = 25 414)**	**(*n* = 109 705)**
Gestational age (weeks)		
< 32	172 (0.7%)	575 (0.5%)
32–36	1045 (4.1%)	3921 (3.6%)
37 +	24 197 (95.2%)	105 209 (95.9%)
Birthweight percentile		
0.0–9.9	1935 (7.6%)	8569 (7.8%)
10.0–90.0	19 851 (78.1%)	88 356 (80.5%)
90.1–100.0	3628 (14.3%)	12 780 (11.6%)
Congenital abnormality	234 (0.9%)	1046 (1.0%)

Crude and adjusted odds ratios and 95% confidence intervals (95% CI) were produced for each outcome. For outcomes where the aOR for primary caesarean section was significantly raised at the 5% level, population attributable risk (PAR) was calculated according to the following formula:

$$PAR = \frac{\text{Proportion of the population exposed to the factor} \times (OR - 1)}{1 + (\text{Proportion of the population exposed to the factor} \times [OR - 1])}$$

RESULTS

Of the 136 101 women with data on both first and second births, 25 596 (18.8%) had a caesarean section in their first pregnancy. Compared with mothers with primary vagi-

2 Crude and adjusted odds ratios for selected maternal and infant outcomes for primary caesarean section versus no primary caesarean section, New South Wales 1988–2002

	Primary caesarean section		No primary caesarean section		Crude odds ratio	Adjusted odds ratio (95% CI)
Morbidity	No.	Rate/1000	No.	Rate/1000		
Mothers	25 596		110 505			
Uterine rupture	14	0.54	9	0.08		
Hysterectomy	14	0.55	27	0.24		
Postpartum haemorrhage	947	37.00	6323	57.22		
Postpartum haemorrhage with complications	139	5.43	498	4.51		
Postpartum infection	292	11.41	194	1.76		
Intensive care unit admission	78	3.05	138	1.25		
Stillbirth	119	4.65	463	4.19	1.11	1.10 (0.90–1.35)
Labour	10 743		105 348			
Uterine rupture	11	1.02	9	0.08	12.00	12.26 (5.00–30.07)*
Hysterectomy	7	0.65	21	0.20	3.27	3.54 (1.49–8.41)†
Postpartum haemorrhage	662	61.62	6142	58.30		
Postpartum haemorrhage — caesarean section in labour§	133	28.45	214	54.48	0.51	0.55 (0.44–0.69)*
Postpartum haemorrhage — vaginal delivery¶	529	87.18	5928	58.45	1.54	1.56 (1.42–1.71)*
Postpartum haemorrhage with complications	84	7.82	466	4.42		
Postpartum haemorrhage with complications — caesarean	24	5.13	38	9.67	0.53	0.53 (0.32–0.88)‡
Postpartum haemorrhage with complications — vaginal	60	9.89	428	4.22	2.36	2.36 (1.79–3.10)*
Manual removal of placenta¶	139	22.91	1711	16.87	1.37	1.34 (1.13–1.60)†
Postpartum infection	83	7.73	127	1.21	6.45	6.18 (4.68–8.18)*
Intensive care unit admission	31	2.89	91	0.86	3.35	3.11 (2.06–4.69)*
No labour (ie, elective caesarean section)	14 853		5157			
Uterine rupture	3	0.20	0	0.00	—	—
Hysterectomy	7	0.47	6	1.16	0.41	0.74 (0.23–2.42)
Postpartum haemorrhage	285	19.20	181	35.10	0.54	0.55 (0.46–0.67)*
Postpartum haemorrhage with complications	55	3.70	32	6.21	0.54	0.61 (0.40–0.95)‡
Postpartum infection	209	14.07	67	12.99	1.08	1.11 (0.84–1.46)
Intensive care unit admission	47	3.16	47	9.11	0.35	0.36 (0.24–0.54)*
Infants	25 414		109 705			
Neonatal death	41	1.61	133	1.21	1.33	1.07 (0.73–1.57)
Infant death	66	2.60	255	2.32	1.12	0.99 (0.74–1.33)
Neonatal intensive care unit admission	600	23.61	1677	15.29		
Neonatal intensive care unit admission — labour**	263	24.75	1309	12.52	2.00	1.60 (1.36–1.88)*
Neonatal intensive care unit admission — no labour††	337	22.79	368	71.82	0.30	0.65 (0.54–0.78)*
Small for gestational age	1935	76.14	8569	78.11	0.97	1.04 (0.99–1.09)
Respiratory distress syndrome of newborn	379	14.91	916	8.35	1.80	1.17 (0.997–1.37)
Bacterial sepsis	73	2.87	241	2.20	1.34	1.21 (0.92–1.58)
Preterm delivery	1217	47.89	4496	40.98	1.18	1.20 (1.12–1.29)*

* $P < 0.0001$. † $P < 0.01$. ‡ $P < 0.05$. § Caesarean section (CS) in labour: previous CS, 4675; no previous CS, 3928. ¶ Vaginal delivery: previous CS, 6068; no previous CS, 101 420. ** Neonatal intensive care unit (NICU) admission — labour: previous CS, 10 625; no previous CS, 104 581. †† NICU admission — no labour: previous CS, 14 789; no previous CS, 5124. ◆

nal birth, mothers who had primary caesarean section tended to be older, more socially advantaged and more likely to have medical and obstetric complications (Box 1). Infants of mothers who had a primary caesarean section were more likely to be preterm and large for gestational age.

At their second birth, 1470 mothers who had had a primary caesarean section (5.7%) experienced one or more of the eight outcomes examined, compared with 7701 mothers with primary vaginal birth (7.0%). Several significant interactions were found in the regression models, indicating that the size of the effect of primary caesarean was dependent on (modified by) another factor, usually whether or not the woman underwent labour in the second birth. For mothers, the effect of primary caesarean section on all outcomes except stillbirth was significantly modified by labour (Box 2). For PPH, there was an additional interaction with caesarean section in labour. For infants, only the effect of primary caesarean section on NICU admission was modified by labour.

For mothers who underwent labour, adjusted rates of uterine rupture, hysterectomy, manual removal of the placenta, postpartum infection and admission to ICU were significantly higher among those who had had a primary caesarean section (Box 2). The greatest difference was for uterine rupture (aOR, 12.3). However, only 20 cases of uterine rupture were found among mothers who underwent labour over the 5-year period. Rates of PPH and complicated PPH were higher for mothers who had had a primary caesarean section if labour proceeded to vaginal delivery. If caesarean section was performed during labour, primary caesarean section exerted a protective effect. Among mothers who had had a primary caesarean section, PPH following vaginal delivery (aOR, 1.56) and manual removal of placenta (aOR, 1.34) had the lowest levels of increased risk, but were the most common of the morbidities examined.

For mothers who did not undergo labour (ie, had elective caesarean section in the second pregnancy), adjusted rates of PPH, complicated PPH and ICU admission were significantly lower among those who had had a primary caesarean section (Box 2). The hysterectomy rate was also lower among these mothers, but the numbers were small. There were only three cases of uterine rupture among mothers who did not undergo labour, all occurring in those who had had a primary caesarean section.

For births following primary caesarean section, 3379 liveborn infants (13.3%) experienced one or more of the seven outcomes examined, compared with 13 622 (12.4%) born following primary vaginal birth. For infants, NICU admission following labour and risk of preterm delivery were significantly higher among mothers who had had a primary caesarean section (Box 2). When infants with a congenital malformation were excluded, the pattern of results was the same.

Crude and adjusted population attributable risks for outcomes with significantly raised aORs are shown in Box 3. For mothers in labour, 51% of uterine ruptures, 19% of hysterectomies and 32% of postpartum infections were attributable to primary caesarean section. For infants, 5% of admissions to NICU following labour, and 4% of premature births were attributable to primary caesarean section.

3 Crude and adjusted population attributable risks (PAR) for selected maternal and infant outcomes following primary caesarean section, New South Wales 1988–2002

Outcome	Crude PAR	Adjusted PAR
Mothers who undergo labour		
Uterine rupture	50.4%	51.0%
Hysterectomy	17.3%	19.0%
Postpartum haemorrhage — vaginal delivery	2.9%	3.0%
Postpartum haemorrhage with complications — vaginal delivery	7.1%	7.1%
Manual removal of placenta	2.0%	1.9%
Postpartum infection	33.5%	32.4%
Intensive care unit admission	17.8%	16.3%
Infants		
Neonatal intensive care unit admission — labour	8.4%	5.2%
Preterm delivery	3.2%	3.7%

DISCUSSION

We found primary caesarean section (compared with primary vaginal birth) conferred additional risk of complications in the second pregnancy for both mother (primarily if she underwent labour) and baby, and that a substantial proportion of serious complications were attributable to primary caesarean section. However, the complications we examined were uncommon, regardless of whether the mother had a primary caesarean section.

At the time that a woman is facing her first birth, it is relevant to consider the risk that caesarean section (compared with vaginal delivery) will confer on subsequent pregnancies. We therefore used primary vaginal delivery as the point of comparison. On the other hand, once a mother has had a primary caesarean section, the question then changes to the risks of trial of labour in the next pregnancy. Much of the published literature on morbidity arising from previous caesarean section has used elective repeat caesarean section as the point of comparison.[13-15]

Our study's strengths are that it is population-based rather than hospital-based, and used linked datasets that enabled us to adjust for a large number of possible clinical confounders in addition to demographic factors. A limitation of the study is that it was carried out retrospectively on population health datasets that contain no specific information on the clinical indication for caesarean section. We took the clinical indication for the caesarean into account by adjusting for the presence of a range of medical conditions in the coded dataset, but this could not cover all possible indications. We found a higher uterine rupture rate among mothers who had had primary caesarean section. This confirms the findings of a previous study,[9] though our rates of uterine rupture are lower because we used a more stringent definition that specified reporting of suture of ruptured uterus or abdominal hysterectomy in addition to the rupture. We found uterine rupture was not confined to mothers who underwent labour — there were three cases among mothers who did not undergo labour, all of whom had had a primary caesarean section.

Among mothers who underwent labour, we found higher rates of PPH, hysterectomy, and manual removal of placenta in those who had had a primary caesarean section

than in those who had not. This is most likely to be related to abnormal placentation, which is associated with uterine scarring from primary caesarean section.[10,11] Primary caesarean section conferred a higher risk of postpartum infection, which is not surprising given the substantially higher caesarean section rate in the second pregnancy in these mothers (18% v 4%). Primary caesarean section also conferred a higher risk of admission to ICU for women who undergo labour, consistent with higher rates of complications overall.

Among mothers who did not undergo labour (ie, had elective caesarean section) the rate of adverse outcomes was lower in those who had had a primary caesarean section than in those who had not. This apparent protective effect may be the result of mothers who elect repeat caesarean section in their second pregnancy being otherwise well. Mothers who have an elective caesarean section for the first time in their second pregnancy are more likely to have a condition affecting them or their fetuses that was not adjusted for in our analysis.

For infants, we found no increased risk of neonatal death. The elevated risk of admission to NICU following labour is consistent with the elevated risk of complications experienced by the mother during labour. The elevated risk of preterm delivery for infants of mothers who had had a primary caesarean section may be related to the higher elective caesarean section rate for those mothers compared with mothers who had not had primary caesarean section (58% v 5%). Babies of mothers who had had a primary caesarean section had almost double the crude risk of RDS; the adjusted risk was only slightly elevated, reflecting the impact of low gestational age and elective caesarean section.[16]

In contrast to an earlier study,[1] we did not find an elevated risk of stillbirth following primary caesarean section; population differences may be the reason for this. Our population included Indigenous mothers, had a higher initial caesarean section rate, and higher stillbirth rate as we included births at less than 24 weeks' gestation. Also, the higher preterm delivery rate for infants of mothers who had had a primary caesarean section in NSW may have prevented some stillbirths.

Of clinical interest is the number of mothers who need to give birth to produce one additional bad outcome — the "number needed to harm". The additional risk conferred by primary caesarean section ranged from 0.04 per 1000 deliveries for uterine rupture in labour to 28.7 per 1000 for PPH following vaginal delivery, giving numbers needed to harm varying from 25 000 for uterine rupture in labour to 35 for PPH following vaginal delivery. The number needed to harm was 2222 for hysterectomy, 492 for ICU admission and 294 for PPH with complications. For infants, the number needed to harm was 145 for preterm birth. While some outcomes such as uterine rupture are extremely rare, clinicians involved with maternity care are very likely to encounter PPH and preterm birth as complications in the second pregnancy.

Our results lead us to conclude that, if a mother has had a primary caesarean section, she will only reduce her risks of complications in her second pregnancy to the level commensurate with a mother who had a primary vaginal delivery if she also has a caesarean section in her second pregnancy. However, the risks faced by women may well vary according to indication for primary caesarean section. Further studies are needed to clarify this.

Caesarean section in a first pregnancy confers additional risks for the second pregnancy when compared with vaginal delivery in the first pregnancy. For mothers, the increased risks are primarily associated with labour in the second pregnancy. These risks should be considered as part of the overall clinical assessment at the time caesarean section in the first pregnancy is being considered. In particular, mothers considering an elective caesarean section for non-medical reasons in their first pregnancy should be advised of the possible consequences for their next pregnancy.

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