Perinatal Services BC
An agency of the Provincial Health Services Authority

# Pregnancy outcomes of women with a previous cesarean delivery in British Columbia, Canada, 2001-2010

**A Perinatal Services BC Surveillance Special Report**

Volume 1, Issue 2, July 2011

**Publication Information**



Suggested citation: Perinatal Services BC (July 2011). *Pregnancy outcomes of women with a previous cesarean delivery in British Columbia, 2001-2010.* Vancouver, BC.

Perinatal Services BC
West Tower, 3rd Floor
555 West 12th Avenue
Vancouver, BC V5Z 3X7
T: 604-877-2121
F: 604-872-1987
www.perinatalservicesbc.ca

ISBN: 978-0-9811237-5-2

Published: July 2011

**Surveillance Special Report**

**Pregnancy outcomes of women with a previous cesarean section, 2001-2010** is Volume 1 Issue No. 2, 2011 of the Perinatal Services BC's Surveillance Special Reporting Series. The goal of this publication is to provide information to maternity health care providers, researchers and health information specialists about the pregnancy outcomes associated with mode of delivery choice for women with a previous cesarean birth, critical for evidence-based clinical decision-making and monitoring of maternal and perinatal population health in BC. This Special Report examines the obstetrical and neonatal outcomes of women delivering in British Columbia between 2001 and 2010 following a single previous cesarean delivery.

**Acknowledgement**
We are grateful to the individuals who have assisted in the development of this manuscript:

Jennifer Hutcheon, Epidemiologist, PSBC
Cathe Johnson, Health Data Analyst, PSBC
Brooke Kinniburgh, Epidemiologist, PSBC
Lily Lee, Leader, Surveillance, PSBC

**About Perinatal Services British Columbia**
The Ministry of Health and the British Columbia Medical Association (BCMA) initiated the British Columbia Reproductive Care Program (BCRCP) in June 1988. One of the mandates of the BCRCP was "the collection and analysis of data to evaluate perinatal outcomes, care processes and resources via a province-wide computerized database". This mandate was fundamental to the development of the British Columbia Perinatal Data Registry (BCPDR), which was initiated in 1993. Individuals instrumental in the creation of the BCPDR included Dr. Sidney Effer, Dr. William J. Ehman, Dr. Margaret Pendray, Mr. Peter Hayles and Dr. Alan Thomson with the support of the BC Ministry of Health.

The BCRCP became part of the Provincial Health Services Authority (PHSA) in 2001 when the government of British Columbia introduced five geographically based health authorities and one provincial health service authority.

In 2007, with the addition of the Provincial Specialized Perinatal Services (PSPS), the BCRCP was renamed the BC Perinatal Health Program (BCPHP). The BCPHP continued to work towards optimizing neonatal, maternal and fetal health in the province through educational support to care providers, outcome analysis and multidisciplinary perinatal guidelines. The BCPHP was overseen by a Provincial Perinatal Advisory Committee with representation from the Ministry of Health Services (MOHS), the Provincial Health Services Authority (PHSA), Children's and Women's Health Centre of BC, Health Authorities, health care providers and academic organizations.

In 2010, Perinatal Services BC (PSBC) was created to replace its predecessors, the BC Reproductive Care Program and the BC Perinatal Health Program. PSBC is overseen by a Provincial Perinatal Services Oversight Council and provides strategic leadership on the full continuum of perinatal care throughout the province focusing on perinatal care planning, service delivery and quality improvement. PSBC works collaboratively with local health authorities and stakeholders to improve perinatal health outcomes and enhance the quality of perinatal services in BC.

## Abstract

This report examined the obstetrical and neonatal outcomes of women delivering in British Columbia between 2001 and 2010 with a single previous cesarean delivery. In BC, the vast majority (over 80%) of women with previous cesarean had a repeat cesarean delivery. The rate of attempted vaginal birth after cesarean (VBAC) decreased from 39% in 2001 to 23% in 2006, and then rose to 29% in 2010. The rate of cesarean delivery following attempted VBAC decreased steadily from 39% in 2001 to 35% in 2010, suggesting either improved selection of VBAC candidates or changes in clinical practice for cesarean during attempted vaginal delivery. Maternal characteristics such as age and pre-pregnancy body mass index were important determinants of attempted VBAC rates and VBAC success rates, while site of delivery factors such as Health Authority or hospital obstetrical volume had minimal influence.

The risks of severe maternal or neonatal morbidity were significantly increased among women attempting a vaginal delivery compared with women undergoing a planned repeat cesarean delivery. Risks of severe maternal morbidity were 2-fold higher (relative risk=1.9, 95% CI 1.3, 2.7) and risks of neonatal mortality were 5.6-fold higher (95% CI 2.8-11.2) among women attempting a vaginal delivery. Nevertheless, the increase in risk associated with a vaginal delivery was small on the absolute scale (3/1000 and 2/1000, respectively; 95% CIs [0.9/1000, 4/1000] and [0.8/1000, 4/1000] respectively), and risks for both groups of women were low.

## Introduction

As in other industrialized countries, the rate of cesarean delivery in Canada has increased steadily in recent decades.[1-5] Between 1995 and 2005, the cesarean delivery rate rose by 45%, from 17.6 to 25.6 per 100 deliveries.[3] Rising rates of obesity, older age at first pregnancy, and changing social factors (such as malpractice litigation) are believed to be contributing to the phenomenon.[2, 3, 6, 7] In British Columbia (BC), where cesarean rates are the highest in the country, 1 in 3 women now delivers her first child by cesarean.[2]

Mode of delivery planning for women with a previous cesarean delivery is a controversial issue. Attempting a vaginal birth or opting for an elective repeat cesarean delivery are each associated with different risks for mother and newborn, and deciding on a delivery plan involves a difficult weighing of those risks.[8] An elective repeat cesarean delivery increases the risk of mortality and surgical complications for the mother, and is associated with complications such as placenta accreta in future pregnancies.[9, 10] A major concern with attempting a vaginal birth after cesarean (VBAC), however, is that the uterus will rupture at the site of the cesarean scar during labour. While relatively uncommon (0.3 percent among women with a previous cesarean delivery), a recent systematic review by the US National Institutes of Health (NIH) found that uterine rupture is 21-fold more likely to occur among women attempting a VBAC than those undergoing an elective repeat cesarean (95% confidence interval (CI) [9.77,44.02]).[9, 11] This corresponds to a risk of uterine rupture of 1 in 200 among women attempting a VBAC. Further, a trial of labour carries a 1 in 4 chance that the trial will be unsuccessful and an emergency cesarean delivery will need to be performed.[9, 11] In the event of an emergency cesarean delivery, the risks of adverse maternal and neonatal outcomes are significantly higher than those following an elective repeat cesarean.[12]

At present, there is no universally recommended mode of delivery for women with a previous cesarean birth, and birth plans should be made on an individualized basis after discussing the risks and benefits of each option.[8, 13] Despite recent efforts in BC and elsewhere in Canada to promote VBAC,[13, 14] Canadian data from 2009/2010 show that the vast majority of women with a previous cesarean have a repeat cesarean delivery (82.5%).[15]

An accurate understanding of the pregnancy outcomes associated with each mode of delivery choice for women with a previous cesarean birth in the BC health care setting is critical for evidence-based clinical decision-making and monitoring maternal and perinatal population health. In this *Special* report, we examine the pregnancy outcomes of women with a previous cesarean birth in BC. Temporal trends in rates of cesarean delivery, attempted vaginal delivery, and cesarean delivery following attempted vaginal birth are presented. We establish the extent to which these outcomes differ according to maternal characteristics and site of delivery. Finally, the risks of serious maternal and neonatal complications according to planned mode of delivery are quantified.

## Methods

We studied the pregnancy outcomes of women with a previous cesarean birth who delivered in British Columbia between April 2001 and September 2010. The data used for this analysis were obtained from the British Columbia Perinatal Data Registry (BCPDR). The BCPDR is a quality-controlled database maintained by Perinatal Services BC, an agency of the Provincial Health Services Authority, and contains data abstracted from obstetrical and neonatal medical records on 99% of births in the province (either in obstetrical facilities or occurring at home attended by BC Registered Midwives). The BCPDR has had province-wide coverage since April 1, 2000, and currently contains records for more than 500,000 births.

Our study population was restricted to women of parity 1 with a single previous cesarean, as multiple previous cesareans or previous successful vaginal delivery are known to influence mode of delivery planning and maternal

and perinatal outcomes.[10, 16] We further restricted our study to singleton births in cephalic presentation with no congenital anomalies.

We examined temporal trends in the rate of cesarean delivery (number of cesarean deliveries per 100 deliveries), the rate of attempted vaginal deliveries (number of attempted vaginal deliveries per 100 deliveries), and the rate of cesarean delivery following attempted vaginal deliveries ("unsuccessful VBAC attempt", the number of cesarean deliveries per 100 attempted vaginal deliveries). Attempted vaginal deliveries were defined as either 1) vaginal deliveries following the onset of spontaneous or induced labour or 2) cesarean deliveries performed following spontaneous or induced labour for an indication that was *not* suggestive of a planned cesarean delivery (indications suggestive of planned cesarean included "elective repeat cesarean", "VBAC declined/Maternal request", "Placenta Previa", "Placenta Abruptio").

Rates of cesarean delivery, attempted vaginal delivery, and cesarean delivery following attempted vaginal delivery were examined according to maternal age (years), pre-pregnancy body mass index (BMI, $kg/m^2$), BC Health Authority of delivery institution (Fraser, Interior, Northern, Vancouver Coastal, Vancouver Island, and Provincial Health Services Authority (PHSA, i.e. the BC Women's Hospital)), and hospital obstetrical volume (total number of deliveries per year). Differences in rates were evaluated by calculating risk differences using generalized linear models with log links and binomial distributions.

The risks of serious maternal or neonatal outcomes were compared among women undergoing a planned cesarean delivery and women attempting a vaginal delivery. Uterine rupture was defined as a frank rupture and excluded uterine dehiscence. Severe maternal morbidity/mortality was examined as a composite outcome defined as the occurrence of any of: death, cardiac arrest, haemorrhage requiring transfusion or hysterectomy, obstetric shock, mechanical ventilation, and other serious medical morbidity (pulmonary edema, adult respiratory distress syndrome, acute renal failure, disseminated intravascular coagulation). Severe neonatal morbidity/mortality was defined as the occurrence of any of: in-hospital newborn death, need for positive pressure ventilation, or neonatal seizures. International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada (ICD-10-CA) codes and the Canadian Classification of Health Interventions (CCI) codes used in outcome definition are provided in the Appendix. Risk differences and relative risks were calculated using generalized linear models with binomial distributions and log and logit links, respectively.

Comparisons between delivery sites and risks of adverse maternal and perinatal outcomes according to planned mode of delivery were additionally adjusted for maternal age, pre-pregnancy BMI, diabetes in pregnancy (type 1, type 2, gestational), and hypertensive disorders of pregnancy (pre-existing hypertension, gestational hypertension, pre-eclampsia, eclampsia). We used multiple imputation to account for missing pre-pregnancy BMI information in adjusted models.[17]

# Results

### Cesarean deliveries

The cesarean delivery rate among primiparous women with a previous cesarean in British Columbia between 2001-2010 (delivering a singleton infant with no congenital anomalies in cephalic presentation) was 82% (22,295/27,213). As shown in Figure 1, the cesarean delivery rate increased from 76% in 2001 to a high of 85% in 2006 and 2007, before decreasing to 81% in 2010.

The cesarean delivery rate varied significantly according to maternal characteristics (Table 1). Cesarean delivery rates increased with increasing maternal age (11 percentage points higher among women ≥40 years compared with women 25-29.9 years) and maternal pre-pregnancy BMI (12 percentage points higher among obese women compared with normal weight women). Health Authority and hospital delivery volume were not major determinants of cesarean delivery rate (Table 2). Even after adjusting for differences in maternal characteristics between Health Authorities, the cesarean delivery rates for each Health Authority were all within several percentage points. Cesarean rates were slightly lower among hospitals with lower obstetrical volume (<500, 500-999 births per year), but these differences were no longer significant after accounting for differences in maternal characteristics. Hospitals with a delivery volume of 1500-2499 were estimated to have an 11% lower rate of cesarean, however, since no clear trend by hospital volume is otherwise apparent, we suspect this may be a chance finding.

### Attempted vaginal deliveries

The attempted VBAC rate was 28% between 2001 and 2010. The temporal trends in VBAC during this period mirrored the cesarean delivery rate, decreasing from 39% in 2001 to a low of 23% in 2006, before rising again to 29% in 2010 (Figure 2).

Rates of attempted vaginal delivery were significantly lower among older women and women with higher pre-pregnancy BMI (Table 3). Only 18% of women aged 40 years or older attempted a vaginal delivery, compared with 30% among women aged 25-29.9. The attempted vaginal delivery rate was 21% among obese women compared with 34% among normal weight women. After accounting for differences in maternal characteristics, the attempted vaginal delivery rate was within 3 percentage points across Health Authorities (Table 4). The exception was Vancouver Island Health Authority, which, with a 31% attempted VBAC rate, had a rate 6 percentage points higher than that of PHSA. No clear trend was apparent according to hospital delivery volume, with attempted vaginal delivery rates slightly higher in hospitals with <500 and 1500-2499 births per year, but slightly lower in sites with 1000-1499 births, compared with sites delivering ≥ 2500 births per year.

### Cesareans following attempted vaginal deliveries

Among women attempting a vaginal delivery in British Columbia between 2001 and 2010, 35% of women had a cesarean delivery (unsuccessful VBAC attempts). Modest but statistically significant decreases were observed during this period, from 39% in 2001 to 35% in 2010 (Figure 3).

Risk of cesarean following attempted vaginal delivery increased with advancing maternal age and obesity (Table 5). Women aged 25-29.9 had a 33% risk of a cesarean following attempted vaginal delivery, while the risk among women ≥40 was 13 percentage points higher. Likewise, obese women had a risk of cesarean following attempted vaginal delivery 15 percentage points higher than normal weight women (47% vs 32%, respectively). Risk of cesarean following attempted vaginal delivery was not significantly different across Health Authorities, and no consistent trends emerged according to hospital delivery volume (Table 6).

**Maternal and neonatal outcomes according to planned mode of delivery**

Table 7 shows the occurrence of adverse maternal and neonatal outcome according to planned mode of delivery. There were no maternal deaths. The adjusted relative risks of all adverse outcomes were significantly higher among women with a planned vaginal delivery compared with women with a planned repeat cesarean, most notably for uterine rupture (8-fold increased risk) and neonatal mortality (5-fold increased risk). Although relative risks were increased among women planning a vaginal delivery, the extent of increased risk was very small on the absolute scale. Adjusted risk differences for uterine rupture, serious maternal morbidity, and neonatal mortality were increased by 2-3 per 1000, while risk of serious neonatal morbidity or mortality was increased by 7 per 1000.

## Discussion

Cesarean delivery remains by far the most common mode of delivery for women with a single previous cesarean birth in British Columbia (approximately 80% of deliveries). Temporal trends in repeat cesarean delivery closely mirrored trends in attempted VBAC, which decreased steadily between 2001 to 2006 before beginning to increase again in 2007. Despite this recent increase, the attempted VBAC rate remains low (29%), and has not yet regained 2001 rates. The increase in repeat cesarean delivery and decrease in attempted VBAC observed in BC between 2001 and 2006 is similar to trends reported elsewhere in Canada and in the United States. In Canada, the rate of repeat cesarean delivery increased from 70% in 2000-2001 to 80% in 2004-2005,[3] while in the United States, the repeat cesarean delivery rate rose from approximately 85% in 2001 to approximately 90% in 2007.[11]

The optimal rate of vaginal delivery among women with a previous cesarean is unclear. Nevertheless, a study examining the cesarean delivery rate among multiparous women with a previous cesarean and a singleton, term, cephalic infant from a tertiary care centre in each of 9 industrialized countries (Ireland, UK, Australia, New Zealand, Canada, Belgium, Sweden, Norway, Iceland) reported an average rate of 67%, with a range of 51-80%.[18] BC's cesarean delivery rate in this population of women is therefore considerably above those of institutions in peer nations, and on the upper limit of observed rates. While maternal and neonatal outcomes were not examined, it seems likely that the elective repeat cesarean delivery rate in BC could be safely decreased.

The risk of cesarean following an attempted VBAC decreased modestly over the past decade (5 percentage points), suggesting either improved selection of VBAC candidates or changes in clinical practice for cesarean delivery during a trial of labour. However, at 35%, the risk of cesarean following attempted VABC in BC remains higher than the average risk of 26% reported by a recent systematic evidence review commissioned by the U.S. National Institutes of Health (NIH).[9, 11] Room for improvement in identifying which women are most likely to have successful VBACs still exists in BC.

Maternal characteristics including older age and higher pre-pregnancy body mass index were significant determinants of cesarean delivery, attempted VBAC, and need for a cesarean following attempted VBAC. These findings are consistent with research from other populations.[9, 16] Ideally, information on maternal characteristics could be combined to predict an individual woman's chance of having a successful vaginal delivery, and guide mode of delivery planning accordingly. Although intuitively appealing, available research suggests that this strategy is likely ineffective. The NIH systematic evidence review assessed 11 multivariable screening tools designed to predict VBAC success (or need for a cesarean following attempted VBAC) using factors such as maternal age, BMI, race, gestational age, indication for the index cesarean, and presence of comorbidities.[9] The report concluded that "none provides consistent ability to identify women at risk for failed trial of labor" (p.967).[16] Until improved screening tools have been developed and externally validated, population-level estimates of risk of cesarean following vaginal delivery remain appropriate for counselling in clinical practice.

We found that serious maternal and neonatal complications were higher among women attempting a vaginal delivery compared with women undergoing a planned repeat cesarean delivery. In their systematic review, the NIH conducted meta-analyses of studies examining maternal and child outcomes according to planned mode of delivery.[9, 11] Similar to our results, they found a significantly increased risk of uterine rupture among women attempting a vaginal delivery. Based on eight studies with at total of 63,499 women, a 21-fold increased risk of uterine rupture among women attempting a trial of labour compared with elective repeat cesarean was found (RR=20.7, 95%CI [9.8, 44.0]).

The relationship between mode of delivery and other maternal complications was less clear in the NIH review. No significant differences were found for hysterectomy, transfusion, or infection; although the report noted that the effects of factors such as gestational age were often not considered. The NIH review deemed that there were insufficient data to assess outcomes such as hemorrhage and surgical injury. Although our study population was not large enough to examine maternal mortality, the NIH review found that maternal death was significantly lower among women attempting a vaginal delivery (RR=0.33 95%CI [0.13, 0.88]) compared with women undergoing an elective repeat cesarean.[9, 11]

As in our analyses, the NIH review found significantly increased risks of neonatal death among women attempting a VBAC (RR=2.1 95% CI [1.35-3.13]), while they found insufficient data to assess serious neonatal morbidity such as hypoxic ischemic encephalopathy, sepsis, trauma, neurological outcomes, or NICU admission.[9, 11]

Understanding both the relative and absolute risks associated with each planned mode of delivery is important for clinical decision making and informed consent in this population. Despite the increased relative risks associated with attempted vaginal delivery, the increases are still relatively small on the absolute scale. Serious maternal morbidity was 3/1000 higher for women attempting a trial of labour; newborn death was 2/1000 higher, and serious neonatal morbidity was 7/1000 higher. These small absolute differences support both attempted vaginal delivery and planned cesarean as reasonable mode of delivery choices for women with a previous cesarean.

Several limitations of the analyses should be noted. First, information on planned mode of delivery is unavailable in the BCPDR. We therefore created a variable for planned mode of delivery using information on labour status, onset of labour (spontaneous vs induced), and indication for a cesarean. While sensitivity analyses examining the time from admission to delivery according to indication for cesarean support the validity of our definition (mean times for indications defined as ‘planned cesareans’ were significantly lower than the mean time for women delivering following spontaneous vaginal delivery, while the mean times for indications defined as ‘planned vaginal births’ were all significantly longer than the mean time for women delivering following spontaneous vaginal delivery), misclassification may have occurred in our dataset, and it is difficult to speculate what impact this may have had on observed rates. For example, misclassification of women with a planned cesarean as ‘planned vaginal delivery’ (e.g. if the primary indication for a planned cesarean was listed as dystocia or failure to progress) could have increased the apparent risk of cesarean following attempted vaginal delivery, while misclassification of women with a planned vaginal delivery as ‘planned cesarean’ (e.g. the indication for a cesarean following an unsuccessful trial of labour was listed as ‘elective repeat’) could have decreased the apparent risk of cesarean following attempted vaginal delivery. Confirmation of our results in data with detailed information on planned mode of delivery, ideally including any changes in planning throughout gestation, is therefore needed.

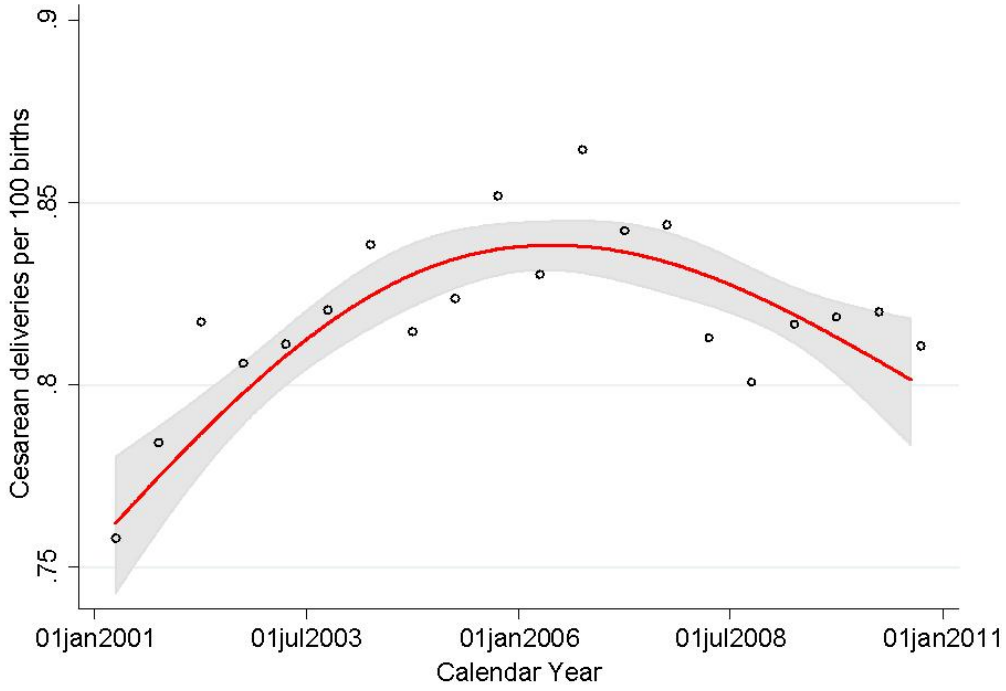
Second, although we were interested in examining temporal trends in risks of serious adverse maternal or neonatal outcomes according to planned mode of delivery (i.e. have the risks associated with a planned vaginal birth increased or decreased over time?), we were unable to do so due to the (fortunately) small number of adverse events in our population. Analyses using national-level data may be needed to examine this important issue.

## Conclusion

The proportion of women with a single previous cesarean who undergo a repeat cesarean delivery in British Columbia remains high, although the repeat cesarean rate has shown modest decreases in recent years. This trend appears to be the result of both increases in the rates of attempted VBAC as well as decreased risks of cesarean following attempted VBACs. Relative risks of serious adverse maternal and perinatal outcomes were higher among women attempting a trial of labour compared with women planning a repeat cesarean, but the increased risks were small in absolute terms.

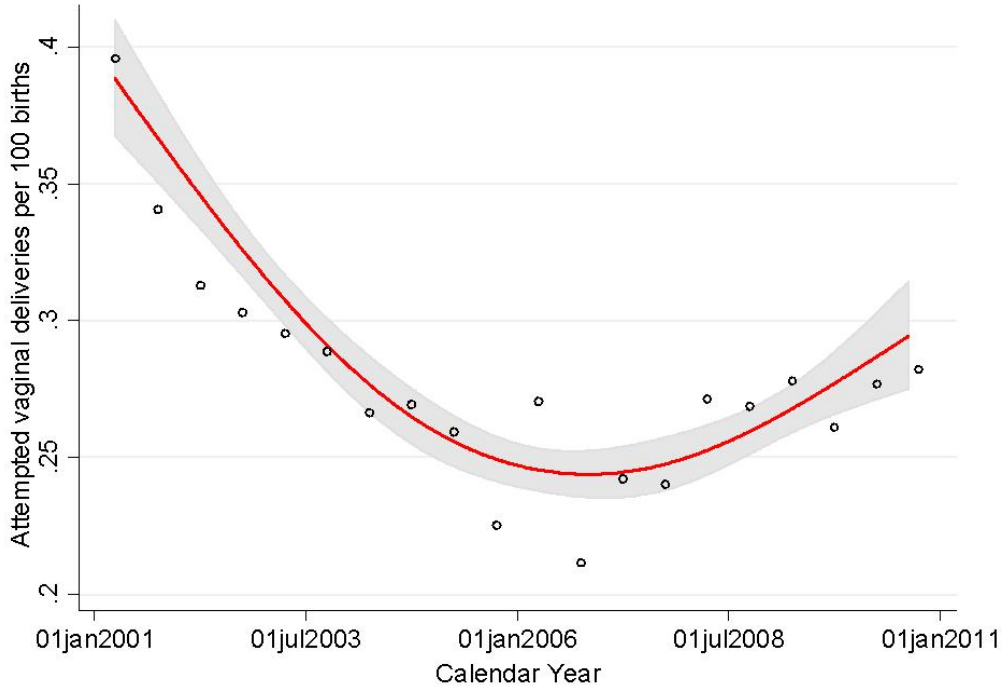
# Figures

**Figure 1.** Temporal trends in cesarean delivery among women with a previous cesarean birth in British Columbia, 2001-2010. Smoothed rate with 95% confidence intervals is overlaid on observed semi-annual rates.



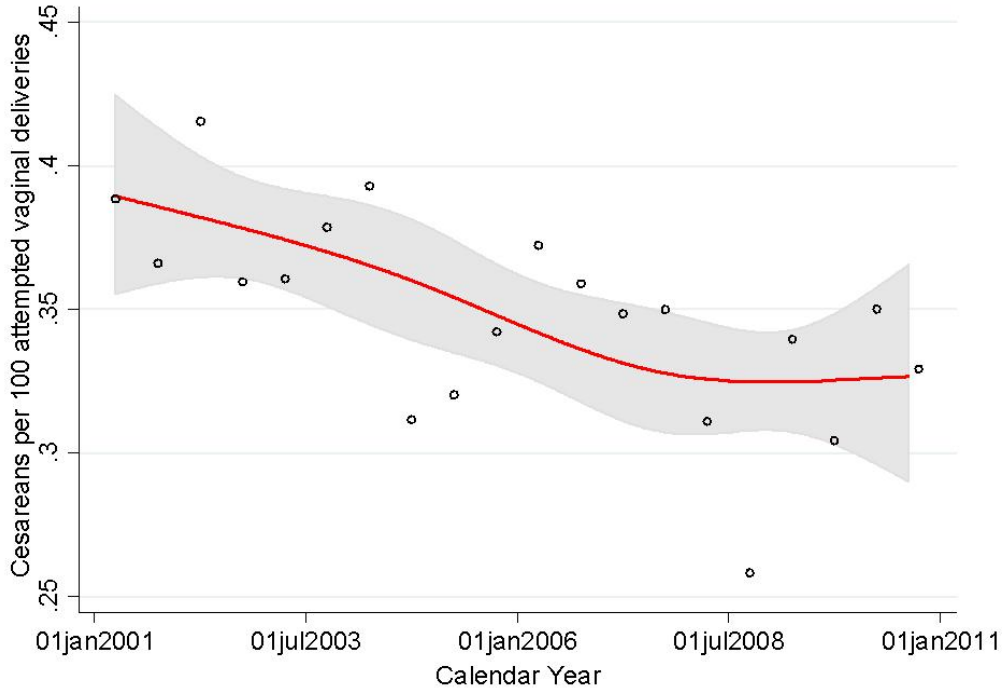

**Source:** BC Perinatal Data Registry

**Figure 2**. Temporal trends in attempted vaginal delivery among women with a previous cesarean birth in British Columbia, 2001-2010. Smoothed rate with 95% confidence intervals is overlaid on observed semi-annual rates.




**Source:** BC Perinatal Data Registry

**Figure 3**. Temporal trends in cesarean deliveries following attempted vaginal deliveries for women with a previous cesarean birth in British Columbia, 2001-2010. Smoothed rate with 95% confidence intervals is overlaid on observed semi-annual rates.




**Source:** BC Perinatal Data Registry

# Tables

**Table 1.** Variation in cesarean delivery rates by maternal characteristics among women with a previous cesarean birth in British Columbia, 2001-2010.

| Maternal Characteristic | n | Cesarean n (%) | Risk difference % [95% CI] |
|---|---|---|---|
| Maternal age (years) | | | |
| <25 | 2,326 | 1,833 (78.8%) | -0.8 [-2.7, 1.2] |
| 25-29.9 | 6,330 | 5,038 (79.6%) | reference |
| 30-34.9 | 10,183 | 8,224 (80.8%) | 1.2 [-0.1, 2.4] |
| 35-39.9 | 6,931 | 5,895 (85.0%) | **5.5 [4.2, 6.8]** |
| ≥40 | 1,443 | 1346 (90.44%) | **10.8 [9.0, 12.7]** |
| Pre-pregnancy BMI (kg/m$^2$) | | | |
| Under weight (<18.5) | 754 | 589 (78.1%) | 1.2 [-1.9, 4.3] |
| Normal weight (18.5-24.9) | 10,025 | 7,712 (76.9%) | reference |
| Over weight (25-29.9) | 4,366 | 3,582 (82.0%) | **5.1 [3.7, 6.5]** |
| Obese (≥30) | 2,848 | 2,529 (88.8%) | **11.9 [10.4, 13.3]** |
| missing | 9,220 | 7,883 (85.5%) | - |

**Source:** BC Perinatal Data Registry

**Table 2**. Variation in cesarean delivery rates by delivery site among women with a previous cesarean birth in British Columbia, 2001-2010.*

| Maternal Characteristic | n | Cesarean n (%) | Risk difference % [95% CI] | Adjusted Risk Difference† % [95% CI] |
|---|---|---|---|---|
| Health Authority | | | | |
| Fraser | 9,150 | 7,466 (81.6%) | **-2.0 [-3.2, -0.7]** | **-2.1 [-3.8, -0.4]** |
| Interior | 2,881 | 2,361 (82.0%) | -1.6 [-3.3, 0.1] | 2.3 [-5.1, 9.7] |
| Northern | 2,412 | 1,943 (81.0%) | **-3.0 [-4.9, -1.1]** | **-2.6 [-5.0, -0.1]** |
| PHSA | 5,338 | 4,461 (83.6%) | reference | reference |
| Vancouver Coastal | 3,434 | 2,883 (84.0%) | 0.4 [-1.2, 2.0] | 0.5 [-1.6, 2.6] |
| Vancouver Island | 3,926 | 3,181 (81.0%) | **-2.5 [-4.1, -1.0]** | **-3.5 [-5.6, -1.4]** |
| Hospital obstetrical volume | | | | |
| <500 | | | | |
| 500-999 | 3,066 | 2,438 (79.5%) | **-2.9 [-4.4, -1.3]** | -1.9 [-4.0, 0.2] |
| 1000-1499 | 3,403 | 2,749 (80.8%) | **-1.6 [-3.1, -0.1]** | -0.8 [-2.7, 1.2] |
| 1500-2499 | 4,135 | 3,383 (81.8%) | -0.6 [-1.9, 0.8] | 0.4 [-1.3, 2.2] |
| ≥2500 | 4,528 | 3,833 (84.7%) | **2.3 [1.0, 3.5]** | **-11.0 [-15.5, -6.5]** |
| | 12,009 | 9,892 (82.4%) | reference | reference |

**Source:** BC Perinatal Data Registry

*72 home births, all delivered vaginally, were excluded from analyses

†Adjusted for maternal age, pre-pregnancy BMI, diabetes in pregnancy, hypertensive disorders of pregnancy

**Table 3.** Variation in attempted vaginal delivery by population subgroups among women with a previous cesarean birth in British Columbia, 2001-2010.

| Maternal Characteristic | Attempted Vaginal Delivery n (%) | Risk difference % [95% CI] |
|---|---|---|
| Maternal age (years) | | |
| <25 | 709 (30.5%) | 0.2 [-2.0, 2.4] |
| 25-29.9 | 1,917 (30.3%) | reference |
| 30-34.9 | 3,011 (29.6%) | -0.7 [-2.2, 0.7] |
| 35-39.9 | 1,670 (24.1%) | **-6.2 [-7.7, -4.7]** |
| ≥40 | 255 (17.7%) | **-12.6 [-14.9, -10.3]** |
| Pre-pregnancy BMI (kg/m$^2$) | | |
| <18.5 | 236 (31.3%) | -2.5 [-6.0, 0.1] |
| 18.5-24.9 | 3,387 (33.8%) | reference |
| 25-29.9 | 1,287 (29.5%) | **-4.3 [-5.9, -2.7]** |
| ≥30 | 602 (21.1%) | **-12.6 [-14.4, -10.9]** |
| missing | 2,050 (22.2%) | - |

**Source:** BC Perinatal Data Registry

**Table 4.** Variation in attempted vaginal delivery by delivery site among women with a previous cesarean birth in British Columbia, 2001-2010.*

| Maternal Characteristic | Attempted Vaginal Delivery n (%) | Risk difference % [95% CI] | Adjusted risk difference† % [95%CI] |
|---|---|---|---|
| Health Authority | | | |
| Fraser | 2,617 (28.6%) | **3.3 [1.9, 4.8]** | **3.4 [1.7, 5.2]** |
| Interior | 816 (28.3%) | **3.1 [1.1, 5.1]** | -1.1 [-2.1, 0.03] |
| Northern | 696 (28.9%) | **3.6 [1.5, 5.8]** | **2.8 [0.3, 5.4]** |
| PHSA | 1,348 (25.3%) | reference | reference |
| Vancouver Coastal | 816 (23.8%) | -1.5 [-3.3, 0.3] | -1.8 [-4.0, 0.4] |
| Vancouver Island | 1,197 (30.5%) | **5.2 [3.4, 7.1]** | **6.1 [4.0, 8.2]** |
| Hospital obstetrical volume | | | |
| <500 | 972 (31.7%) | **3.7 [1.9, 5.5]** | **2.4 [0.3, 4.5]** |
| 500-999 | 1,014 (29.8%) | **1.8 [0.1, 3.5]** | 0.8 [-1.2,2.8] |
| 1000-1499 | 1,099 (26.6%) | -1.4 [-3.0, 0.2] | **-2.7 [-4.6, -0.9]** |
| 1500-2499 | 1,043 (23.0%) | **-5.0 [-6.4, -3.5]** | **3.8 [2.7, 5.0]** |
| ≥2500 | 3,362 (28.0%) | reference | reference |

**Source:** BC Perinatal Data Registry
*72 home births, all delivered vaginally, were excluded from analyses
†Adjusted for maternal age, pre-pregnancy BMI, diabetes in pregnancy, hypertensive disorders of pregnancy

**Table 5** Variation in risk of cesarean following attempted vaginal delivery by population subgroups among women with a previous cesarean birth in British Columbia, 2001-2010.

| Maternal Characteristic | n | Cesarean n (%) | Risk difference % [95% CI] |
|---|---|---|---|
| Maternal age (years) | | | |
| <25 | 709 | 216 (30.5%) | -2.1 [-6.1, 1.8] |
| 25-29.9 | 1,917 | 625 (32.6%) | reference |
| 30-34.9 | 3,011 | 1,052 (34.9%) | 2.3 [-0.4, 5.0] |
| 35-39.9 | 1,670 | 634 (38.0%) | **5.4 [2.2, 8.5]** |
| ≥40 | 255 | 117 (45.9%) | **13.3 [6.8, 19.7]** |
| Pre-pregnancy BMI (kg/m$^2$) | | | |
| <18.5 | 236 | 71 (30.1%) | -1.6 [-7.7, 4.4] |
| 18.5-24.9 | 3,387 | 1,074 (31.7%) | reference |
| 25-29.9 | 1,287 | 503 (39.1%) | **7.4 [4.3, 10.5]** |
| ≥30 | 602 | 283 (47.0%) | **15.3 [11.0, 19.6]** |
| missing | 2,050 | 713 (34.8%) | - |

**Source:** BC Perinatal Data Registry

**Table 6** Variation in risk of cesarean following attempted vaginal delivery by delivery site among women with a previous cesarean birth in British Columbia, 2001-2010.

| Maternal Characteristic | n | Cesarean n (%) | Risk difference % [95% CI] | Adjusted risk difference† % [95% CI] |
|---|---|---|---|---|
| Health Authority | | | | |
| Fraser | 2,617 | 933 (35.7%) | 1.3 [-2.8, 5.5] | 1.0 [-1.9, 3.8] |
| Interior | 816 | 296 (36.3%) | 0.7 [-2.4, 3.8] | -0.8 [-2.2, 0.5] |
| Northern | 696 | 227 (32.6%) | -2.3 [-6.6, 2.0] | -1.3 [-5.2, 2.6] |
| PHSA | 1,348 | 471 (34.9%) | reference | reference |
| Vancouver Coastal | 816 | 265(32.5%) | -2.5 [-6.7, 1.6] | -1.9 [-5.5, 1.7] |
| Vancouver Island | 1,197 | 452 (37.8%) | 2.8 [-0.9, 6.6] | 2.5 [-0.9, 5.8] |
| Hospital obstetrical volume | | | | |
| <500 | 972 | 344 (35.4%) | -1.6 [-5.1, 1.8] | -0.5 [-3.6, 2.7] |
| 500-999 | 1,014 | 360 (35.5%) | -1.5 [-4.9, 1.8] | -0.8 [-3.9, 2.2] |
| 1000-1499 | 1,099 | 347 (31.6%) | **-5.5 [-8.7, -2.3]** | **-3.7 [-6.6, -0.9]** |
| 1500-2499 | 1,043 | 348 (33.4%) | **-3.7 [-7.0, -0.4]** | 1.0 [-0.2, 2.2] |
| ≥2500 | 3,362 | 1,245 (37.0%) | reference | reference |

**Source:** BC Perinatal Data Registry
*72 home births, all delivered vaginally, were excluded from analyses
†Adjusted for maternal age, pre-pregnancy BMI, diabetes in pregnancy, hypertensive disorders of pregnancy

**Table 7**. Adverse maternal and neonatal outcomes according to planned mode of delivery among women with a previous cesarean birth in British Columbia, 2001-2010.

| Outcome | Planned vaginal n | Planned cesarean n | Adjusted relative risk for planned vaginal* [95% CI] | Adjusted risk difference for planned vaginal* % [95% CI] |
|---|---|---|---|---|
| *n* | 7,562 | 19,651 | | |
| Uterine rupture | 20 | 6 | **8.0 [3.2, 20.0]** | **0.3 [.05, 0.5]** |
| Composite maternal morbidity | 50 | 68 | **1.9 [1.3, 2.8]** | **0.3 [0.08 0.5]** |
| Composite neonatal morbidity | 67 | 72 | **2.5 [1.8, 3.5]** | **0.7 [0.3, 0.1]** |
| Newborn death | 24 | 12 | **5.4 [2.7, 10.9]** | **0.2 [0.04, 0.4]** |

**Source:** BC Perinatal Data Registry
*Adjusted for maternal age, pre-pregnancy body mass index, diabetes in pregnancy (gestational, type 1 or type 2), hypertensive disorders of pregnancy (pre-existing, gestational, pre-eclampsia, eclampsia)

**APPENDIX.** International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada (ICD-10-CA) diagnostic coding and Canadian Classification of Health Interventions (CCI) codes used to identify adverse maternal and neonatal outcomes

**Composite Maternal Morbidity Outcome**

Maternal mortality
- BCPDR variable for death (death_code=1 through 10)

Cardiac arrest
- 1.HZ.30.^^ - Resuscitation, heart NEC
- O89.1 – Cardiac complications of anesthesia during the puerperium
- O74.2 – Cardiac complications of anesthesia during labour & delivery
- O75.4 – Other complications of obstetric surgery and procedures (includes cardiac arrest following cesarean or other obstetric surgery/procedures including delivery NOS)
- I46 – Cardiac arrest

Severe medical morbidity
- I21 – Acute myocardial infarction
- I50 – Heart failure
- J81 – Pulmonary edema
- J80 – Adult respiratory distress syndrome
- N17 – Acute renal failure
- D65 - DIC

Surrogates for ICU
- I.GZ.31.CA-ND – Mechanical ventilation through endotracheal tube

Obstetric Shock
- O75.1 – Shock during or following labour & delivery
- R57 – Shock, not elsewhere classified

Post-partum hemorrhage
- O72 – Post-partum hemorrhage or coagulation defects

Blood transfusion
- BCPDR variable (blood_transfusion_flg="Y")

Hysterectomy
- 5.MD.60.RC-CB – Cesarean hysterectomy
- 1.RM.89.LA – Total hysterectomy, open approach (exclude if 1PL74 <fixation bladder neck>, 1RS74 <fixation vagina>, IRS80 <repair vagina>)
- 1.RM.87.LA-GX – Subtotal hysterectomy, open approach

**Composite Neonatal Morbidity Outcome**

Neonatal death
- BCPDR variable for in-hospital death (newborn admission or transfer) (discharge_to=D)

Neonatal seizures
- P90 – convulsions of newborn

Serious neonatal respiratory morbidity
- BCPDR variable for ventilation days (ventilation_days>=1)
- 1GZ31CBND- positive pressure (e.g. CPAP, BIPAP), non-invasive approach
- 1GZ31CAND- positive pressure (e.g. CPAP, BIPAP), invasive per orifice approach by endotracheal intubation
- 1GZ31CRND- positive pressure (e.g. CPAP, BIPAP) invasive per orifice approach through tracheostomy

**REFERENCES**


1. Dobson R. Caesarean section rate in England and Wales hits 21. BMJ 2001;323:951.
2. Liu S, Rusen ID, Joseph KS, et al. Recent trends in caesarean delivery rates and indications for caesarean delivery in Canada. J Obstet Gynaecol Can 2004;26:735-42.
3. Public Health Agency of Canada. Canadian Perinatal Health Report, 2008 Edition. Ottawa; 2008.
4. Martin JA, Hamilton BE, Sutton PD, et al. Births: final data for 2007. Natl Vital Stat Rep;58:1-85.
5. Menacker F, Hamilton BE. Recent trends in cesarean delivery in the United States. NCHS Data Brief 2010:1-8.
6. Cnattingius R, Cnattingius S, Notzon FC. Obstacles to reducing cesarean rates in a low-cesarean setting: the effect of maternal age, height, and weight. Obstet Gynecol 1998;92:501-6.
7. Parrish KM, Holt VL, Easterling TR, Connell FA, LoGerfo JP. Effect of changes in maternal age, parity, and birth weight distribution on primary cesarean delivery rates. JAMA 1994;271:443-7.
8. Cunningham FG, Bangdiwala SI, Brown SS, et al. NIH Consensus Development Conference Statement on Vaginal Birth After Cesarean: New Insights. Obstet Gynecol 2010;115:1279-95.
9. Guise JM, Eden K, Emeis C, et al. Vaginal birth after cesarean: new insights. Evid Rep Technol Assess (Full Rep) 2010:1-397.
10. Silver RM, Landon MB, Rouse DJ, et al. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstet Gynecol 2006;107:1226-32.
11. Guise JM, Denman MA, Emeis C, et al. Vaginal birth after cesarean: new insights on maternal and neonatal outcomes. Obstet Gynecol 2010;115:1267-78.
12. Allen VM, O'Connell CM, Baskett TF. Maternal morbidity associated with cesarean delivery without labor compared with induction of labor at term. Obstet Gynecol 2006;108:286-94.
13. Martel MJ, MacKinnon CJ. Guidelines for vaginal birth after previous Caesarean birth. J Obstet Gynaecol Can 2005;27:164-88.
14. Power to push campaign. 2010. (Accessed May 31, 2011, at http://www.powertopush.ca/.)
15. Canadian Institute for Health Information. Highlights of the 2009-2010 Selected Indicators Describing the Birthing Process in Canada. Ottawa, ON; 2011.
16. Eden KB, McDonagh M, Denman MA, et al. New insights on vaginal birth after cesarean: can it be predicted? Obstet Gynecol 2010;116:967-81.
17. Sterne JA, White IR, Carlin JB, et al. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. BMJ 2009;338:b2393.
18. Brennan DJ, Robson MS, Murphy M, O'Herlihy C. Comparative analysis of international cesarean delivery rates using 10-group classification identifies significant variation in spontaneous labour. Am J Obstet Gynecol 2009;201:308.e1-8.