Birth outcomes following cesarean delivery on maternal request: a population-based cohort study

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Cite as: *CMAJ* 2021 May 3;193:E633-44. doi: 10.1503/cmaj.202262

ABSTRACT

BACKGROUND: Data on the effect of cesarean delivery on maternal request (CDMR) on maternal and neonatal outcomes are inconsistent and often limited by inadequate case definitions and other methodological issues. Our objective was to evaluate the trends, determinants and outcomes of CDMR using an intent-to-treat approach.

METHODS: We designed a population-based retrospective cohort study using data on low-risk pregnancies in Ontario, Canada (April 2012–March 2018). We assessed temporal trends and determinants of CDMR. We estimated the relative risks for component and composite outcomes used in the Adverse Outcome Index (AOI) related to planned CDMR compared with planned vaginal delivery using generalized estimating equation models. We compared the Weighted Adverse Outcome Score (WAOS) and the Severity Index (SI) across planned modes of delivery using analysis of variance.

RESULTS: Of 422 210 women, 0.4% (*n* = 1827) had a planned CDMR and 99.6% (*n* = 420 383) had a planned vaginal delivery. The prevalence of CDMR remained stable over time at 3.9% of all cesarean deliveries. Factors associated with CDMR included late maternal age, higher education, conception via in vitro fertilization, anxiety, nulliparity, being White, delivery at a hospital providing higher levels of maternal care and obstetrician-based antenatal care. Women who planned CDMR had a lower risk of adverse outcomes than women who planned vaginal delivery (adjusted relative risk 0.42, 95% confidence interval [CI] 0.33 to 0.53). The WAOS was lower for planned CDMR than planned vaginal delivery (mean difference −1.28, 95% CI −2.02 to −0.55). The SI was not statistically different between groups (mean difference 3.6, 95% CI −7.4 to 14.5).

Interpretation: Rates of CDMR have not increased in Ontario. Planned CDMR is associated with a decreased risk of short-term adverse outcomes compared with planned vaginal delivery. Investigation into the long-term implications of CDMR is warranted.

Cesarean delivery is the most common inpatient surgical procedure in North America,[1,2] where rates often exceed World Health Organization recommendations (10%–15% of deliveries).[3] Given the financial and resource implications of cesarean deliveries on health care systems, the contribution of cesarean deliveries on maternal request (CDMR) to rising cesarean section rates is of ongoing interest. Women may prefer CDMR for many reasons, including scheduling convenience, anxiety regarding labour pain, perceptions that the quality of obstetrical care is better for women who have cesarean deliveries, and concerns about possible urinary incontinence and sexual dysfunction after vaginal delivery.[4–7] Challenges in characterizing the epidemiology of CDMR include the lack of internationally accepted case definitions and inconsistencies in documentation that hinder meaningful comparisons across jurisdictions.[8–11] In Canada, the prevalence of CDMR has been estimated at 2% of cesarean deliveries,[12] but robust contemporary data are lacking.

The benefits of vaginal delivery are well known and include a lower risk of transient tachypnea of the newborn, newborn exposure to the vaginal microbiome, shorter maternal hospital stays and lower risk of complications associated

with abdominal surgeries. The findings of 1 Canadian study suggest that midpelvic operative vaginal delivery is associated with a greater risk of severe birth and obstetric trauma than cesarean delivery.[13] Evidence on the risks and benefits of CDMR is sparse, and existing data are inconsistent.[14–19] Analyses are frequently limited by inadequate case definitions and unaddressed confounding from baseline maternal and neonatal factors.[4,11] Professional organizations in the United States, Canada and Europe do not recommend CDMR over vaginal delivery.[11,20–22] Patient counselling is suggested to inform patients of pain management options, and of potential benefits and harms related to cesarean deliveries. However, obstetrical care providers often accede to patient preferences, given the ethical imperative of patient autonomy.[23–27] Contemporary, high-quality observational studies leveraging robust population-based data are required. Our objective was to evaluate the trends, determinants and outcomes of CDMR compared with planned vaginal delivery using an intent-to-treat approach.

Methods

Study design and population

We conducted a population-based retrospective cohort study of low-risk pregnancies resulting in a live birth or intrapartum stillbirth (≥ 500 g) whose deliveries occurred in an Ontario, Canada, hospital from Apr. 1, 2012, to Mar. 31, 2018. We identified low-risk pregnancies using the definition provided by Health Quality Ontario, which is based on pregnancies graded as Robson class criteria 1 to 4.[28,29] Briefly, this included singleton pregnancies with cephalic presentation that were delivered at term (between ≥ 37 weeks' and ≤ 42 weeks' gestation). We excluded pregnancies with medical or prelabour indications for cesarean delivery, as well as records with missing data or data quality issues. The specific variables used to define medical or prelabour indications for cesarean delivery are detailed in Appendix 1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.202262/tab-related-content. We further excluded mothers with a cesarean delivery in a previous pregnancy.

Data sources

We obtained data from the Better Outcomes Registry & Network (BORN) Ontario, which captures maternal and neonatal information and outcome data for all Ontario births.[30] Data quality assessments show good agreement of BORN variables with patient records, including for the variable "indications for cesarean section" (κ 0.92, 95% confidence interval [CI] 0.89 to 0.95).[31] To improve outcome ascertainment, we linked records with maternal obstetrical discharge abstracts, and with stillbirth and newborn abstracts from the Canadian Institute for Health Information Discharge Abstract Database.

Exposures

We used an intent-to-treat methodology to distinguish planned CDMR and planned vaginal delivery subgroups (Figure 1).[11] The intent-to-treat design addresses a frequently cited challenge in distinguishing the potential risks and benefits of CDMR.[11,22] Limitations of alternative approaches (i.e., using insufficient proxies for CDMR) include misguided estimates of harm or benefit when unplanned cesarean deliveries are unaccounted for or the impact of labour on maternal and neonatal outcomes cannot be addressed. We defined CDMR in keeping with guidance provided by the American College of Obstetricians and Gynecologists[22] and the Society for Obstetricians and Gynaecologists of Canada.[32] The BORN database routinely captures information on the type (i.e., "planned — as scheduled," "planned — not as scheduled," "unplanned") and indications for cesarean deliveries, including whether or not it was by maternal request. Therefore, we further limited CDMR cases to those that were planned, and where records showed that cesarean delivery was by maternal request. We included unplanned cesarean deliveries in the planned vaginal delivery group because women originally intended to deliver vaginally.

Outcomes

The primary outcome was the Adverse Outcome Index (AOI), a composite of 10 adverse events related to labour and delivery.[33,34] The AOI is reported as the percentage of individual patients with at least 1 adverse event relative to the total number of deliveries. As the AOI may be influenced by dominant outcomes, it cannot be used as an exclusive measure of quality and safety. For this reason, we also measured the Weighted Adverse Outcomes Score (WAOS) and the Severity Index (SI). The WAOS reflects a combination of the frequency and severity of events, and the SI evaluates the severity of adverse events among the pregnancies with an adverse event. For the WAOS, each AOI component is assigned a weighted score, and the WAOS represents the sum of all scored events, divided by the total number of deliveries. The SI is calculated by dividing the WAOS by the number of deliveries with an adverse event. These perinatal health indicators have been previously used in research using population-based perinatal databases.[35] The elements and calculations for the AOI, WAOS and SI are provided in Appendix 2, and the specific variables and codes we used to define each component outcome of the AOI are detailed in Appendix 3, both available at www.cmaj.ca/lookup/doi/10.1503/cmaj.202262/tab-related-content.

Covariates

We identified potential covariates and confounders based on a literature review, review of a directed acyclic graph (DAG), as well as data availability. Covariates included maternal age, neighbourhood-level income and education, race, parity, prepregnancy body mass index (BMI), gestational weight gain, method of conception, drug use, alcohol use, smoking during pregnancy, prenatal class attendance, self-reported anxiety and depression, antenatal health care provider, maternity hospital level-of-care,[36] gestational age, infant sex and birth weight.

Statistical analysis

We used summary statistics and standardized mean differences to compare maternal, obstetrical and delivery characteristics between planned CDMR and planned vaginal delivery groups. We evaluated the contribution of CDMR to the cesarean delivery rate in Ontario over the study period with a Cochran-Armitage trend test. We employed a multivariable logistic regression model to generate adjusted odds ratios (ORs) and 95% CIs to estimate the strength of association between covariates and planned CDMR. To evaluate the association of planned mode of delivery with adverse outcomes, we estimated crude and adjusted relative risks (RRs) with 95% CI using generalized estimating equation models with a log-link function and a Poisson distribution with a robust error variance.[37] We used multiple imputation methods to account for the missing data of covariates and confounders in the regression models. Five complete data sets were imputed by using the fully conditional specification method (detailed in Appendix 4, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.202262/tab-related-content).

We identified group differences in WAOS and SI by ANOVA, and used Dunnett's correction, where appropriate, to control the family-wise error rate. We used the tableone package of R to produce the study characteristics table by exposure group. We used SAS version 9.4 (SAS Institute) to perform all other analyses. We used 2-tailed tests of statistical significance with a threshold of $p < 0.05$.

Sensitivity analysis

We conducted sensitivity analyses to assess the impact of our analytical strategies on the findings. Specifically, we used generalized estimating equation models to estimate crude and adjusted RRs with 95% CIs for the AOI with revisions to our study cohort and comparison groups. First, we limited our cohort to nulliparous women to determine whether or not parity had a modifying effect on adverse outcomes. We did another analysis in which we separated unplanned cesarean deliveries from the planned vaginal delivery group to assess the extent to which unplanned cesarean deliveries contributed to the risk of adverse outcomes in the vaginal delivery group. Next, we assessed study outcomes among women with planned cesarean deliveries for medical indications who otherwise met the study inclusion criteria. These women were excluded from the main analysis. For our final sensitivity analysis, we limited the study cohort to include only records with complete data before

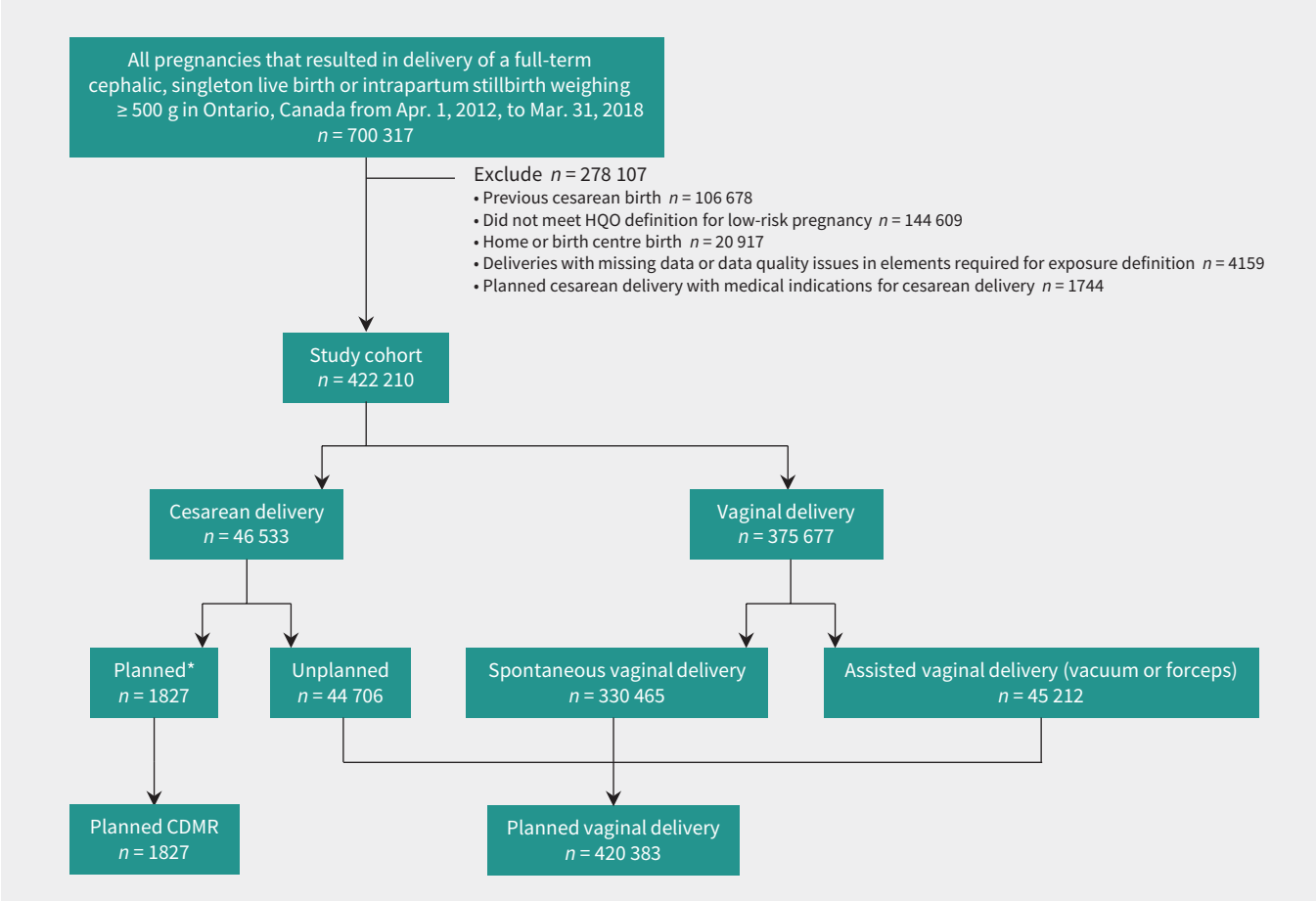

Figure 1: Flow chart of cohort development. All deliveries were identified through Better Outcomes Registry & Network Ontario. Note: CDMR = cesarean delivery on maternal request, HQO = Health Quality Ontario. *Planned cesarean deliveries included 83.8% ($n = 1531$) that were planned (as scheduled), 13.5% ($n = 247$) that were planned (not as scheduled) and 2.6% ($n = 49$) that were planned with no specification regarding scheduling.

multiple imputation (i.e., complete case analysis). This sensitivity analysis was designed to test the performance of our multiple imputation approach. We excluded records that had missing data on any covariates included in the adjusted RR models.

Ethics approval

This study was reviewed and approved by the Ottawa Health Science Network Research Ethics Board (20180440-01H;20180558-01H).

Table 1 (part 1 of 2): Characteristics of women with low-risk singleton pregnancies resulting in a live or intrapartum stillbirth delivery in Ontario, Canada, between 2012 and 2018, by planned mode of delivery

Characteristics	No. (%) of pregnancies* *n* = 422 210	No. (%) of planned CDMR* *n* = 1827	No. (%) of planned vaginal delivery* *n* = 420 383	SMD
Maternal age, yr, mean ± SD	29.7 ± 5.2	32.5 ± 5.7	29.7 ± 5.2	0.5
Neighbourhood family income quintile				
Quintile 1 (lowest)	92 362 (21.9)	365 (20.0)	91 997 (21.9)	0.2
Quintile 2	76 406 (18.1)	288 (15.8)	76 118 (18.1)	
Quintile 3	80 216 (19.0)	307 (16.8)	79 909 (19.0)	
Quintile 4	91 771 (21.7)	414 (22.7)	91 357 (21.7)	
Quintile 5 (highest)	57 372 (13.6)	332 (18.2)	57 040 (13.6)	
Missing	24 083 (5.7)	121 (6.6)	23 962 (5.7)	
Neighbourhood education level quintile†				
Quintile 1 (lowest)	82 632 (19.6)	246 (13.5)	82 386 (19.6)	0.3
Quintile 2	88 891 (21.1)	306 (16.7)	88 585 (21.1)	
Quintile 3	84 780 (20.1)	294 (16.1)	84 486 (20.1)	
Quintile 4	86 618 (20.5)	423 (23.2)	86 195 (20.5)	
Quintile 5 (highest)	58 489 (13.9)	449 (24.6)	58 040 (13.8)	
Missing	20 800 (4.9)	109 (6.0)	20 691 (4.9)	
Maternal race				
White	166 531 (39.4)	886 (48.5)	165 645 (39.4)	0.2
Asian	67 274 (15.9)	263 (14.4)	67 011 (15.9)	
Black	16 639 (3.9)	44 (2.4)	16 595 (3.9)	
Other	15 208 (3.6)	76 (4.2)	15 132 (3.6)	
Missing	156 558 (37.1)	558 (30.5)	156 000 (37.1)	
Nulliparous	203 406 (48.2)	1140 (62.4)	22 266 (48.1)	0.3
Prepregnancy BMI, kg/m^2, median (IQR)	23.4 (20.9–27.2)	23.2 (20.7–27.0)	23.4 (20.9–27.2)	0.05
Gestational weight gain‡				
Less than recommended	100 444 (23.8)	336 (18.4)	100 108 (23.8)	0.2
Within recommended range	81 936 (19.4)	333 (18.2)	81 603 (19.4)	
More than recommended	199 721 (47.3)	929 (50.8)	198 792 (47.3)	
Missing	40 109 (9.5)	229 (12.5)	39 880 (9.5)	
Conception type				
In vitro fertilization	5484 (1.3)	122 (6.7)	5362 (1.3)	0.3
Intrauterine insemination and other ART	5678 (1.3)	38 (2.1)	5640 (1.3)	
Spontaneous	404 200 (95.7)	1645 (90)	402 555 (95.8)	
Missing	6848 (1.6)	22 (1.2)	6826 (1.6)	
Maternal drug use during pregnancy§	8601 (2.0)	31 (1.7)	8570 (2.0)	0.05
Maternal alcohol use during pregnancy§	9637 (2.3)	56 (3.1)	9581 (2.3)	0.05
Maternal smoking§¶	43 374 (10.3)	154 (8.4)	43 220 (10.3)	0.06
Maternal anxiety§**	34 571 (8.2)	257 (14.1)	34 314 (8.2)	0.2
Maternal depression§**	30 676 (7.3)	151 (8.3)	30 525 (7.3)	0.04

Table 1 (part 2 of 2): Characteristics of women with low-risk singleton pregnancies resulting in a live or intrapartum stillbirth delivery in Ontario, Canada, between 2012 and 2018, by planned mode of delivery

Characteristics	No. (%) of pregnancies* *n* = 422 210	No. (%) of planned CDMR* *n* = 1827	No. (%) of planned vaginal delivery* *n* = 420 383	SMD
Labour type				
Spontaneous	321 253 (76.1)	154 (8.4)	321 099 (76.4)	4.6
Induced	97 603 (23.1)	0 (0.0)	97 603 (23.2)	
No labour	3322 (0.8)	1673 (91.6)	1649 (0.4)	
Missing	32 (0.0)	0 (0.0)	32 (0.0)	
Antenatal health care provider††				
Family physician only	54 849 (13.0)	60 (3.3)	54 789 (13.0)	0.6
Obstetrician only	233 439 (55.3)	1445 (79.1)	231 994 (55.2)	
Family physician and obstetrician	58 909 (14.0)	234 (12.8)	58 675 (14.0)	
Midwife	64 429 (15.3)	61 (3.3)	64 368 (15.3)	
None	S	S	1530 (0.4)	
Other	6694 (1.6)	19 (1.0)	6675 (1.6)	
Missing	S	S	2352 (0.6)	
Maternity hospital level of care‡‡				
Maternal Level I	56 385 (13.4)	134 (7.3)	56 251 (13.4)	0.4
Maternal Level IIa	47 765 (11.3)	134 (7.3)	47 631 (11.3)	
Maternal Level IIb	133 875 (31.7)	431 (23.6)	133 444 (31.7)	
Maternal Level IIc	108 030 (25.6)	629 (34.4)	107 401 (25.5)	
Maternal Level III	76 099 (18.0)	499 (27.3)	75 600 (18.0)	
Missing	56 (0.0)	0 (0.0)	56 (0.0)	
Infant sex, male	215 860 (51.1)	943 (51.6)	214 917 (51.1)	0.04
Infant birth weight, g, mean ± SD	3462.3 ± 448.3	3430.2 ± 427.1	3462.5 ± 448.4	0.07
Gestational age, wk, median (IQR)	39.9 (39.1–40.7)	39.0 (38.7–39.4)	39.9 (39.1–40.7)	0.8

Note: ART = assisted reproductive technologies, BMI = body mass index, CDMR = cesarean delivery on maternal request, IQR = interquartile range, SD = standard deviation, SMD = standardized mean difference.
*Unless otherwise indicated. Column statistics are provided. Numbers are suppressed (S) for small cell sizes ($n < 6$).
†Percentage of college and university degrees among adults aged 25–64 years.
‡Based on 2009 Institute of Medicine recommendations.
§Self-reported variables.
¶Captures any smoking at the first prenatal visit or at the time of labour or admission for delivery.
**Constitute concerns that were pre-existing, diagnosed during pregnancy or active during pregnancy.
††If a woman had a midwife in addition to other health care providers, she was assigned to the midwife group. The assumption was that most of the antenatal care would have been provided by the midwife.
‡‡Maternal hospital level of care classification based on newborn and maternal needs, risk and illness as defined by The Provincial Council for Maternal and Child Health in Ontario.

Results

A total of 422 210 pregnancies met our inclusion criteria, of which 1827 (0.4%) and 420 383 (99.6%) were categorized as planned CDMR and planned vaginal delivery (including unplanned cesarean deliveries), respectively (Table 1).

Our cohort included 46 533 cesarean deliveries, of which 1827 (3.9%) were planned CDMR, and 44 706 (96.1%) were unplanned cesarean deliveries. The proportion of all deliveries that were planned CDMR was 0.5% in the first and last fiscal years of our study (2012/13 and 2017/18) and the proportion remained stable across all fiscal years ($p = 0.3$).

Planned CDMR was associated with late maternal age (≥ 35 yr), being White, living in a neighbourhood of a higher educational quintiles, gaining more than the recommended weight in pregnancy, nulliparity, conception by in vitro fertilization, anxiety, not attending prenatal classes, delivering at a hospital that provides maternal level IIc or III care and receiving antenatal care from obstetricians (Table 2).

Adverse outcomes and CDMR

Overall, the AOI was lower in women with planned CDMR (3.8%) than those with planned vaginal deliveries (8.3%) (Table 3). The frequencies of adverse maternal and neonatal outcomes were both lower for women with planned CDMR than those with planned vaginal deliveries. The most common maternal adverse outcomes were unanticipated operative procedures (1.2%, $n = 21$) for women who planned

Table 2 (part 1 of 2): Factors associated with planned CDMR in Ontario, Canada, between 2012 and 2018*

Factor	No. of pregnancies* *n* = 422 210	No. (%) of planned CDMR *n* = 1827	Adjusted OR (95% CI)†
Maternal age, yr			
< 19	12 462	29 (0.23)	0.53 (0.37 to 0.77)
20–34	334 278	1140 (0.34)	Reference
35–39	63 896	459 (0.72)	2.11 (1.88 to 2.37)
≥ 40	11 393	195 (1.71)	4.33 (3.67 to 5.11)
Neighbourhood family income quintile			
Quintile 1 (lowest)	92 362	365 (0.40)	Reference
Quintile 2	76 406	288 (0.38)	0.94 (0.79 to 1.10)
Quintile 3	80 216	307 (0.38)	0.91 (0.78 to 1.06)
Quintile 4	91 771	414 (0.45)	0.96 (0.83 to 1.11)
Quintile 5 (highest)	57 372	332 (0.58)	0.93 (0.79 to 1.11)
Neighbourhood education level quintile‡			
Quintile 1 (lowest)	82 632	246 (0.30)	Reference
Quintile 2	88 891	306 (0.34)	1.06 (0.89 to 1.27)
Quintile 3	84 780	294 (0.35)	1.02 (0.85 to 1.22)
Quintile 4	86 618	423 (0.49)	1.30 (1.10 to 1.54)
Quintile 5 (highest)	58 489	449 (0.77)	1.78 (1.48 to 2.15)
Maternal race			
White	166 531	886 (0.53)	Reference
Non-White	99 121	383 (0.39)	0.60 (0.53 to 0.68)
Missing	156 558	558 (0.36)	0.87 (0.78 to 0.97)
Parity			
0	203 406	1140 (0.56)	2.25 (2.02 to 2.50)
≥ 1	218 804	687 (0.31)	Reference
Prepregnancy BMI, kg/m^2			
Underweight (< 18.5)	24 499	123 (0.50)	1.24 (0.99 to 1.57)
Normal weight (18.5 to 24.9)	211 790	896 (0.42)	Reference
Overweight (25.0 to 29.9)	89 491	348 (0.39)	0.93 (0.81 to 1.07)
Obese (≥ 30)	56 322	231 (0.41)	1.00 (0.87 to 1.16)
Gestational weight gain§			
Less than recommended	100 444	336 (0.33)	0.88 (0.75 to 1.04)
Within recommended range	81 936	333 (0.41)	Reference
More than recommended	199 721	929 (0.47)	1.18 (1.04 to 1.34)
Conception type			
In vitro fertilization	5484	122 (2.22)	2.64 (2.15 to 3.24)
Intrauterine insemination and other ART	5678	38 (0.67)	1.05 (0.75 to 1.45)
Spontaneous	404 200	1645 (0.41)	Reference
Maternal anxiety¶**			
No	387 639	1570 (0.41)	Reference
Yes	34 571	257 (0.74)	2.07 (1.79 to 2.40)
Maternal depression¶**			
No	391 534	1676 (0.43)	Reference
Yes	30 676	151 (0.49)	0.97 (0.81 to 1.17)

Table 2 (part 2 of 2): Factors associated with planned CDMR in Ontario, Canada, between 2012 and 2018*

Factor	No. of pregnancies* *n* = 422 210	No. (%) of planned CDMR *n* = 1827	Adjusted OR (95% CI)†
Attended prenatal class			
No	288 368	1283 (0.44)	Reference
Yes	101 394	392 (0.39)	0.59 (0.52 to 0.67)
Antenatal health care provider††			
Family physician only	54 849	60 (0.11)	0.21 (0.16 to 0.27)
Obstetrician only	233 439	1445 (0.62)	Reference
Family physician and obstetrician	58 909	234 (0.40)	0.72 (0.63 to 0.83)
Midwife	64 429	61 (0.09)	0.16 (0.13 to 0.21)
None	S	S	S
Other	6694	19 (0.28)	0.48 (0.30 to 0.76)
Maternal hospital level of care‡‡			
Level I	56 385	134 (0.24)	Reference
Level IIa	47 765	134 (0.28)	0.86 (0.68 to 1.10)
Level IIb	133 875	431 (0.32)	0.91 (0.75 to 1.12)
Level IIc	108 030	629 (0.58)	1.57 (1.30 to 1.91)
Level III	76 099	499 (0.66)	1.51 (1.24 to 1.85)
Infant sex			
Male	215 860	943 (0.44)	Reference
Female	206 101	884 (0.43)	0.97 (0.89 to 1.07)
Birth weight, g			
< 2500	4259	10 (0.23)	0.50 (0.27 to 0.93)
2500 to 3999	368 153	1643 (0.45)	Reference
≥ 4000	49 782	174 (0.35)	0.87 (0.74 to 1.02)

Note: ART = assisted reproductive technologies, BMI = body mass index, CDMR = cesarean delivery on maternal request, CI = confidence interval, OR = odds ratio.
*Counts included in table are identical to Table 1 and are based on data before imputation. Row percentages are presented. Adjusted relative risk estimates were calculated using data imputed using fully conditional specification. Numbers are suppressed (S) for small cell sizes ($n < 6$).
†A multivariate logistic regression model was used to estimate the adjusted odds ratios. The multivariate logistic regression model included maternal age, neighbourhood income level, neighourhood education level, race, parity, BMI, gestational weight gain, method of conception, prenatal class attendance, anxiety, depression, antenatal health care provider, maternal hospital level of care, infant sex and infant birth weight. If one independent variable was treated as the main predictor, the other variables were automatically treated as covariates or confounders. C-statistic = 0.746.
‡Percentage of college and university degrees among adults 25–64 years old.
§Based on 2009 Institute of Medicine recommendations.
¶Self-reported variables.
**Constitute concerns that were pre-existing, diagnosed during pregnancy or active during pregnancy.
††If a woman had a midwife in addition to other health care providers, she was assigned to the midwife group. The assumption was that most of the antenatal care would have been provided by the midwife.
‡‡Maternal hospital level of care classification based on newborn and maternal needs, risk and illness as defined by The Provincial Council for Maternal and Child Health in Ontario.

CDMR, and third- or fourth-degree perineal tear (3.3%, *n* = 13 686) for women who planned vaginal deliveries. Admission or transfer to the neonatal intensive care unit (NICU) was the most common neonatal outcome for both the planned CDMR and planned vaginal delivery groups.

Women who planned CDMR were less likely to have adverse maternal (adjusted RR 0.41, 95% CI 0.30 to 0.57) and neonatal outcomes (adjusted RR 0.42, 95% CI 0.33 to 0.53) than those who planned vaginal deliveries. Accordingly, the risk of any AOI outcome was lower for women who planned CDMR than women who planned vaginal deliveries (adjusted RR 0.42, 95% CI 0.33 to 0.54).

The WAOS was lower in women with planned CDMR than in those with planned vaginal deliveries (mean difference [MD] −1.28, 95% CI −2.02 to −0.55) (Figure 2), largely because of a lower neonatal WAOS score (MD −1.35, 95% CI −2.00 to −0.69). There was no statistically significant difference in the overall severity of adverse outcomes as measured

Table 3: Adverse outcomes after planned CDMR and planned vaginal delivery among women with low-risk singleton pregnancies resulting in a live or intrapartum stillbirth delivery in Ontario, Canada, between 2012 and 2018 (*n* = 422 210)

AOI component	No. (%) of planned CDMR* *n* = 1827	No. (%) of planned vaginal delivery* *n* = 420 383	Planned CDMR v. planned vaginal delivery*	
			Crude RR* (95% CI)	Adjusted RR† (95% CI)
Maternal component				
Maternal death	0 (0.0)	14 (0.0)	—	—
Uterine rupture	0 (0.0)	100 (0.0)	—	—
Maternal intensive care unit admission	S	446 (0.1)	S	S
Unanticipated operative procedure	21 (1.2)	2212 (0.5)	2.18 (1.42 to 3.35)	2.00 (1.30 to 3.08)
Blood transfusion	19 (1.0)	3057 (0.7)	1.43 (0.91 to 2.24)	1.46 (0.93 to 2.30)
3rd or 4th degree perineal tear	0 (0.0)	13 686 (3.3)		
Any maternal components	37 (2.0)	18 336 (4.4)	0.46 (0.34 to 0.64)	0.41 (0.30 to 0.57)
Fetal or neonatal components				
Intrapartum or in-hospital newborn death with birth weight ≥ 2500 g, with no congenital anomalies	0 (0.0)	301 (0.1)	—	—
Birth trauma, ≥ 2000 g	0 (0.0)	2439 (0.6)	—	—
NICU admission > 2 d or transfer within 24 h of birth to a facility with a NICU for an infant ≥ 2500 g	30 (1.6)	12 479 (3.0)	0.55 (0.39 to 0.79)	0.52 (0.36 to 0.74)
5-minute Apgar score < 7	S	5353 (1.3)	S	S
Any neonatal component	34 (1.9)	17 899 (4.3)	0.44 (0.31 to 0.61)	0.42 (0.30 to 0.58)
Any AOI component	70 (3.8)	34 999 (8.3)	0.46 (0.37 to 0.58)	0.42 (0.33 to 0.54)

Note: AOI = Adverse Outcome Index, BMI = body mass index, CDMR = cesarean delivery on maternal request, CI = confidence interval, NICU = neonatal intensive care unit, RR = relative risk.
*Numbers are suppressed (S) for small cell sizes (*n* < 6).
†Adjusted for gestational age, maternal age, pre-pregnancy BMI, neighbourhood education quintile, maternal race, parity, conception type, anxiety, maternal substance use during pregnancy (includes self-reported alcohol, smoking and drug use during pregnancy), antenatal health care provider and maternal hospital level of care. C-statistic: 0.643.

by the SI between women with planned CDMR and planned vaginal deliveries (MD 3.6, 95%CI −7.4 to 14.5). However, the severity of maternal outcomes was greater for planned CDMR than planned vaginal deliveries (MD 20.1, 95% CI 10.6 to 29.7).

Sensitivity analyses

Restriction of our cohort to nulliparous women yielded similar results, as did separating unplanned cesarean deliveries from the planned vaginal delivery group and removing cases with missing data. The risk of adverse outcomes among women with planned cesarean deliveries for medical indications was lower than that observed for women with planned vaginal deliveries. The findings of our sensitivity analyses are detailed in Appendix 5, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.202262/tab-related-content.

Interpretation

In this population-based study of 422 210 deliveries, we showed that rates of planned CDMR in Ontario, Canada, have remained stable at 3.9% of cesarean deliveries from 2012 to 2018. Factors associated with CDMR included late maternal age, being White, higher education, self-reported anxiety, nulliparity, conception by in vitro fertilization and obstetrician-based antenatal care. In this cohort of low-risk pregnancies, we found that planned CDMR was accompanied by a decreased risk of adverse outcomes. The AOI and WAOS were lower for women with planned CDMR than women with planned vaginal deliveries, and the risk of adverse outcomes was lower after adjusting for confounding factors.

Few others have attempted the intent-to-treat framework to study CDMR,[15,19,38] and differences in case ascertainment and statistical approaches make it difficult to compare findings across studies. Our findings are similar to those of a retrospective analysis of 66 226 nulliparous women in China. Although the authors identified no differences in risk of maternal morbidities between the planned CDMR and vaginal delivery groups, CDMR was associated with neonatal benefits,[38] including a lower risk of birth trauma, infection, meconium aspiration syndrome and NICU admission. A population-based study from Denmark of low-risk nulliparous women found no differences in the risk for major maternal morbidities between planned CDMR and planned vaginal delivery.[15] However, the authors noted increases in the risk for anal sphincter tears among women with planned vaginal

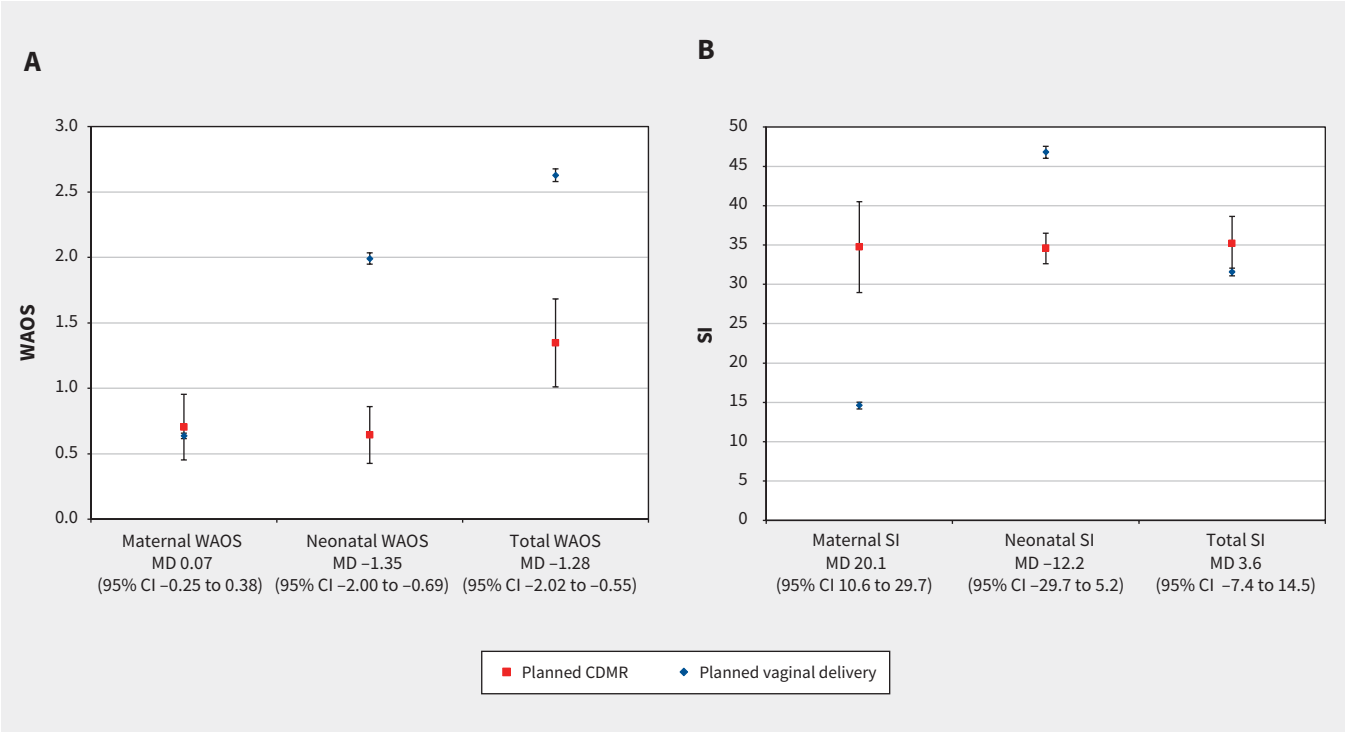

Figure 2: Weighted Adverse Outcome Scores (WAOS) and Severity Index (SI) scores for adverse outcomes after planned cesarean delivery on maternal request (CDMR) and planned vaginal delivery among women with low-risk singleton pregnancies resulting in a live or intrapartum stillbirth delivery in Ontario, Canada, between 2012 and 2018 (n = 422 210). (A) Maternal component, neonatal component and total WAOS scores; (B) Maternal component, neonatal component and total SI scores. Note: CI = confidence interval, MD = mean difference.

deliveries, and for wound infection among those with planned CDMR, both expected risks associated with these modes of delivery. This is consistent with our findings of a greater frequency of perineal tears for women with planned vaginal deliveries and a greater risk of unanticipated operative procedures for those with planned CDMR, such as cesarean hysterectomy. Unfortunately, there are no published data from randomized controlled trials addressing the impact of CDMR on maternal or neonatal outcomes. Feedback from health care providers and women suggests that such a trial would not be ethically or practically feasible without a patient preference arm.[39,40]

Our finding that CDMR rates have remained stable in Ontario provides reassurance to those concerned about the potential contribution of CDMR to rising cesarean delivery rates.[41,42] The low prevalence of CDMR in our cohort is consistent with other Canadian reports,[12,43] but lower than observations from other countries, where estimates of elective cesarean deliveries and CDMR vary from < 10% in the US[8–10] to 20%–50% in China and Brazil.[38,44–46] Our findings reaffirm those of others that CDMR is associated with late maternal age and higher socioeconomic status.[44,47] Primiparity and conception by in vitro fertilization were also determinants of CDMR, suggesting that women with first pregnancies or those who had fertility issues prefer CDMR. The role of care providers in facilitating or influencing a woman's preferred mode of delivery also warrants examination. Although care providers are supportive of a woman's right to choose CDMR,[25,26,48] surveys show variable willingness to comply with such requests. In our study, care from an obstetrician was a significant determinant of CDMR, suggesting that women who plan CDMR are more likely to seek out care from an obstetrician and that women preferring vaginal deliveries are more likely to seek antenatal care from a midwife.

In addition to the intent-to-treat design, strengths of our study include the use of population-based data, compiling 6 years of provincial data to generate a sample exceeding 750 000 births. Further, type (planned v. unplanned) and indications for cesarean deliveries (including maternal request), are variables that are routinely collected at BORN Ontario, making it one of few resources that can reliably be used to investigate CDMR.

Limitations

As an observational study, we cannot discount potential unmeasured confounders and bias in our data set. Coding errors and lack of acceptance of CDMR in certain facilities may have resulted in misclassification bias. Although we are unable to address reporting bias in our cohort, misclassification of CDMR as cases of cesarean delivery with medical indications would not have affected the findings of our primary analysis. Indeed, the findings of our sensitivity analysis comparing outcomes after cesarean deliveries because of medical or prelabour indications to planned vaginal delivery were not significantly different than our primary analysis. Given the lack of consensus among health care professionals and across

health care facilities on how to approach CDMR, the potential for misclassification is a challenge that is not unique to our cohort. We also cannot discount bias resulting from the removal of records with missing, ambiguous or discordant case information (< 1%) and exclusion of home births and deliveries at birth centres (< 3%). However, the proportion of excluded records was small and the likely impact on our effect estimates is minor. Given the relatively low incidence of CDMR in our population, our sample size for this group was small. We were unable to clarify many pressing questions related to the timing of maternal request, reasons for the request and provider influences on maternal preferences. Finally, the AOI is a standardized performance indicator developed to monitor 10 adverse events occurring during labour and delivery, at the hospital level.[34] It was not developed to provide measures of safety at the individual patient level. Dominant outcomes may influence the AOI and we caution readers against interpreting AOI findings independently of the WAOS and SI. Although limitations exist,[49,50] they are validated measures that provide insight into patient safety.

Conclusion

This analysis shows that planned CDMR is safe for low-risk pregnancies and may be associated with a lower risk of adverse delivery outcomes compared with planned vaginal deliveries. Although our study addresses concerns related to the immediate implications of planned CDMR, exploration of longer-term risks is needed, including its impact on breastfeeding,[51–54] and the child's risk for infection and respiratory illness.[55–57]

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Competing interests: None declared.

This article has been peer reviewed.

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Contributors: Yanfang Guo, Daniel Corsi, Mark Walker, Shi Wen and Darine El-Chaâr conceived and designed the study. Yanfang Guo, Malia Murphy, Erica Erwin, Romina Fakhraei and Darine El-Chaâr contributed to data acquisition, analysis and interpretation. Yanfang Guo and Malia Murphy drafted the manuscript. All of the authors revised the manuscript critically for important intellectual content, gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

Funding: This study was supported by a Canadian Institutes of Health Research Foundation Grant (FDN 148438).

Data sharing: Data sharing regulations prevent these data from being made available publicly due to the personal health information in the datasets. Enquiries regarding BORN data must be directed to BORN Ontario (Science@BORNOntario.ca).

Disclaimer: This study was supported by a Canadian Institutes of Health Research Foundation Grant. The funding agency was not involved in study design, analysis or interpretation of data. The agency was not involved writing of this manuscript or in the decision to submit the article for publication. The data analyzed for this study are held securely at the prescribed registry, BORN Ontario.

Accepted: Mar. 8, 2021

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