



# Association of Caesarean delivery and breastfeeding difficulties during the delivery hospitalization: a community-based cohort of women and full-term infants in Alberta, Canada

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## Abstract

**Objective** Breastfeeding difficulties are the most common reason for breastfeeding cessation, particularly in the early postpartum. Caesarean delivery is associated with earlier breastfeeding cessation than is the case with vaginal delivery, but differences in breastfeeding difficulties by mode of delivery have not been thoroughly examined. Our objective was to explore the association between Caesarean delivery and types of breastfeeding difficulties.

**Methods** We conducted a secondary analysis of data from a prospective cohort study of mothers who delivered full-term, singleton infants in Calgary, Alberta, Canada ( $N = 418$ ). Women completed self-report questionnaires during the delivery hospitalization. Mode of delivery was defined as vaginal or Caesarean, and further classified as planned or unplanned Caesarean. Breastfeeding difficulties were measured using the Breastfeeding Experiences Scale and operationalized with binary variables for presence of various types of maternal (i.e. physical, supply, social) and infant (i.e. latch, behaviour/health) difficulties that were reported as moderate to unbearable. Multivariable logistic regression was used to estimate adjusted odds ratios (AORs) and 95% confidence intervals (CIs).

**Results** Overall, 37.1% of women had a Caesarean delivery and 80.9% experienced a breastfeeding difficulty during the delivery hospitalization. Of the difficulties studied, Caesarean delivery was significantly associated with low milk supply (AOR = 1.62, 95% CI = 1.16–2.28) and infant behaviour/health difficulties (AOR = 1.33, 95% CI = 1.01–1.75). The association with low milk supply persisted when examining both planned (AOR = 2.42, 95% CI = 1.19–4.92) and unplanned (AOR = 2.21, 95% CI = 1.16–4.22) Caesarean deliveries.

**Conclusion** Mothers who deliver by Caesarean have higher odds of reporting low milk supply and infant behaviour/health difficulties than women who deliver vaginally.

## Résumé

**Objectif** Les difficultés d'allaitement sont la principale raison de l'arrêt de l'allaitement, surtout au début de la période du postpartum. L'accouchement par césarienne est associé à un arrêt de l'allaitement plus précoce qu'avec l'accouchement par voie vaginale, mais les différences dans les difficultés d'allaitement selon la voie d'accouchement n'ont pas été étudiées à fond. Nous avons voulu explorer les associations entre l'accouchement par césarienne et les types de difficultés d'allaitement.

**Méthode** Nous avons effectué une analyse secondaire des données d'une étude prospective de cohortes de mères ayant accouché à terme d'un bébé unique à Calgary (Alberta) au Canada ( $N = 418$ ). Les femmes ont rempli des questionnaires d'autoévaluation durant leur hospitalisation après l'accouchement. Pour la voie d'accouchement, les répondantes avaient le choix entre un

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accouchement par voie vaginale ou par césarienne, puis par césarienne planifiée ou non planifiée. Les difficultés d'allaitement ont été mesurées à l'aide d'une échelle de l'expérience d'allaitement (Breastfeeding Experiences Scale) et opérationnalisées avec des variables binaires pour détecter la présence de divers types de difficultés éprouvées par les mères (c.-à-d. physiques, sociales, de production de lait) et par les nourrissons (c.-à-d. prise du sein, comportement/santé) déclarées par les mères comme étant de modérées à insupportables. Une analyse de régression logistique multivariée a servi à estimer les rapports de cotes ajustés (RCa) et les intervalles de confiance de 95 % (IC).

**Résultats** Dans l'ensemble, 37,1 % des femmes avaient accouché par césarienne, et 80,9 % avaient éprouvé une difficulté d'allaitement durant leur hospitalisation après l'accouchement. De toutes les difficultés étudiées, l'accouchement par césarienne présentait une corrélation significative avec la faible production de lait (RCa = 1,62, IC de 95 % = 1,16-2,28) et avec les difficultés de comportement/de santé du nourrisson (RCa = 1,33, IC de 95 % = 1,01-1,75). L'association avec la faible production de lait est demeurée lorsque nous avons examiné les accouchements par césarienne planifiés (RCa = 2,42, IC de 95 % = 1,19-4,92) et non planifiés (RCa = 2,21, IC de 95 % = 1,16-4,22).

**Conclusion** Chez les mères ayant accouché par césarienne, la probabilité de déclarer une faible production de lait et des difficultés de comportement/de santé du nourrisson est plus élevée que chez les femmes ayant accouché par voie vaginale.

**Keywords** Breastfeeding · Caesarean section · Postpartum period · Lactation · Infant, newborn · Alberta

**Mots-clés** Allaitement · césarienne · période du postpartum · lactation · nourrisson, nouveau-né · Alberta

## Introduction

Caesarean sections are a major obstetrical surgery that can save lives when medically indicated. The World Health Organization (WHO) recommends a Caesarean rate of 10–15% (WHO, 2015), yet rates of Caesarean section vary widely around the globe and have gradually risen over the past several decades (Betrán et al., 2016). In Canada, Caesarean section increased from 18.7% of births in 1997 to 29.9% of births in 2019 (Canadian Institute for Health Information, 2020). This procedure is not without short- and long-term risks for maternal and newborn health. Caesarean delivery is associated with higher risk of maternal mortality and morbidity (e.g. hemorrhage, uterine rupture, urinary infection; Korb et al., 2019) and neonatal respiratory distress (Li et al., 2019). Longer-term risks include greater likelihood of complications in subsequent pregnancies and health conditions in children, including asthma and obesity (Keag et al., 2018).

Research has consistently shown that Caesarean delivery negatively impacts breastfeeding; women delivering by Caesarean have lower odds of initiating breastfeeding and generally discontinue breastfeeding earlier than women who give birth through vaginal delivery (Prior et al., 2012). Some evidence suggests this disparity is specific to planned Caesarean, while others suggest both planned and unplanned Caesareans can impede breastfeeding efforts (Cohen et al., 2018; Hobbs et al., 2016; Prior et al., 2012). Caesarean surgery can place high stress on both the mother and infant, and post-operative recovery is often characterized by maternal pain, limited mobility, and separation from the infant to encourage mothers to rest and heal (Consaes et al., 2020; Tully & Ball, 2014). Mothers who undergo planned or unplanned

Caesarean delivery are less likely to experience skin-to-skin contact immediately after delivery, to breastfeed their infants within an hour after giving birth, and to share a room with their infant after delivery compared to mothers who give birth vaginally (Prado et al., 2018).

Breastfeeding and lactation difficulties are the most frequent reasons women cite for stopping breastfeeding earlier than desired, of which the most common in the early postpartum period are difficulties with infant latch, milk supply, sub-optimal infant weight gain, and underlying medical conditions (Li et al., 2008; Odom et al., 2013). In Canada, the most common reasons for early breastfeeding discontinuation are insufficient milk production and difficulty with techniques in breastfeeding, such as infant positioning and latch at the breast (Public Health Agency of Canada, 2018). Yet few studies have examined how the presence of breastfeeding difficulties differs in the context of a vaginal versus Caesarean birth. For example, Hobbs et al. (2016) reported descriptive data on the prevalence of breastfeeding difficulties varying by mode of delivery. Compared to mothers delivering vaginally or by planned Caesarean, a higher proportion of mothers who delivered by unplanned Caesarean reported infant difficulties such as trouble latching and other difficulties such as not producing enough milk. However, additional research that accounts for the severity of difficulties and potential for confounding bias is needed. Moreover, the timing of difficulties is important to study, as challenges that present shortly after birth may undermine early maternal confidence to breastfeed and pose the greatest detriment to breastfeeding establishment if not promptly addressed with hospital and public health support. Evidence on differences in early breastfeeding difficulties based on mode of delivery may help to identify interventions

that can reduce feeding disparities in mothers delivering by Caesarean. Therefore, our objective was to explore the association between Caesarean delivery and types of breastfeeding difficulties experienced by mothers of full-term infants during the delivery hospitalization.

## Methods

### Study design

We conducted a secondary analysis of data from the Happy Baby Study, which was a prospective community-based cohort study in Calgary, Alberta, Canada (Chaput et al., 2016). The objective of this parent study was to assess the association between breastfeeding difficulties and postpartum depression risk and the moderating role of breastfeeding support. Data on demographic characteristics, peripartum events, breastfeeding difficulties and outcomes, mental health, and health service use were collected via self-report questionnaires at three time points postpartum: the delivery hospitalization, 6 weeks postpartum, and 6 months postpartum. This analysis only used cross-sectional data from the delivery hospitalization to focus on breastfeeding difficulties that emerge immediately after birth when in-hospital and early community-based intervention is most readily available through Canada's universal healthcare and public health system.

### Sample

Convenience sampling was used to recruit women from postpartum units at all tertiary care hospitals providing delivery care in the Calgary Health Region between June and October 2010. All of the hospitals had integrated some or all of the steps from the WHO Baby-Friendly Hospital Initiative; however, none were accredited at the time of the study. Research assistants approached women and invited them to participate in the study within 72 h of giving birth. Women were eligible if they were aged 18 or older; delivered a full-term, singleton infant; and planned to breastfeed. Exclusion criteria were prenatal plans to formula-feed, inability to communicate in English, and a neonatal intensive care unit stay > 24 h. Overall, 446 women enrolled in the study and completed the first questionnaire, and 360 women completed all 3 questionnaires. Our sample for this analysis excluded participants with incomplete data on mode of delivery ( $n = 23$ ) or incomplete data on breastfeeding difficulties ( $n = 5$ ), resulting in an analytic sample size of 418.

### Mode of delivery

The exposure was mode of delivery, measured categorically as vaginal, planned Caesarean, or unplanned Caesarean (with

or without spontaneous labour). Planned Caesarean was defined as Caesarean section based on the participant's request or advice of the health team due to medical indications prior to the onset of labour, which occurred on a scheduled date. Unplanned Caesarean (also termed emergency) was defined as Caesarean section that was not scheduled prior to the delivery hospitalization and was due to peripartum complications.

### Breastfeeding difficulties

The outcome was presence of breastfeeding difficulties measured using the Breastfeeding Experiences Scale (BES; Chaput et al., 2016; Wambach, 1997). The BES is a validated, 18-item measure for breastfeeding difficulties with a 5-point rating scale for each difficulty's experienced severity ranging from "not at all" (0) to "unbearable" (4). For this analysis, individual difficulties were grouped together into types based on clinical similarities in the nature of the difficulty; the grouping of difficulties into six types is outlined in Table 1. A composite variable was developed for each difficulty type based on the presence of one or more pertinent difficulties rated as moderate, severe, or unbearable.

### Covariates

We developed a directed acyclic graph (DAG) using literature searching and subject matter expertise to identify potential confounders for this analysis (Bandoli et al., 2016; Supplemental Figure 1). Continuous covariates were body mass index ( $\text{kg}/\text{m}^2$ ) and maternal age at time of delivery (years). Dichotomous covariates were psychosocial vulnerability, socioeconomic status, and parity. Psychosocial vulnerability was defined as the presence of depression (a score of  $\geq 10$  on the Edinburgh Postnatal Depression Scale) and/or low social support (dissatisfaction with support received from partner, family, or friends). Socioeconomic status was measured using a composite variable developed previously to capture confounding related to breastfeeding in the Happy Baby Study, defined as experiencing  $\geq 2$  of the following: not owning a home, being single, annual household income < \$60,000 (the threshold for subsidized housing at time of recruitment), and/or having a low education (high school or less; Chaput et al., 2016; Braveman et al., 2005). Parity was defined as the number of live births and categorized as primiparous (no previous births) or multiparous (one or more previous births). Gestational age was controlled for by restricting the sample to full-term birth (37 weeks gestation or greater) at the time of data collection. Data on pregnancy complications were not collected.

**Table 1** Grouping of breastfeeding difficulties from the Breastfeeding Experiences Scale (BES) into types

Type	BES item	Prevalence (%)	
Maternal difficulties	Physical	Sore nipples	42.2
		Cracked nipples	11.4
		Flat or inverted nipples	6.0
		Tired/fatigued	33.6
		Overall	58.9
	Low milk supply	Not enough milk	16.6
		Overall	16.6
	High milk supply	Swollen engorged breast(s)	12.5
		Blocked milk duct	3.6
		Mastitis (breast infection)	0.5
		Leaky breast(s)	8.6
		Overall	17.7
	Social	Inconvenience	3.4
		Feeling embarrassed when nursing	4.6
		Family members don't like it	0.7
Overall		6.6	
Infant difficulties	Latch	Infant having trouble latching on	35.4
		Difficulty positioning infant	20.7
		Overall	39.8
Perceived behaviour/health	Infant too sleepy	32.5	
	Infant too fussy	11.7	
	Infant nursing too frequently	14.4	
	Worry about infant's weight gain/loss	17.2	
	Overall	54.9	

## Statistical analysis

We used descriptive statistics including proportions, means, and standard deviations to summarize participant characteristics by mode of delivery. We then used multivariable logistic regression modelling to quantify the association between mode of delivery and types of breastfeeding difficulties shortly after birth, using vaginal delivery as the referent group. Composite variables for each of the six difficulty type groupings were used to ensure adequate statistical power, due to low cell counts for some individual difficulties. Models were adjusted for confounders identified using the DAG. Missing covariate data were handled using multiple imputation. Statistical significance was defined as results with a 95% CI that did not include a null value of one (corresponding to a  $p$  value  $< 0.05$ ). All data cleaning and analyses were completed using Stata/IC 13.1.

## Ethics approval

The Happy Baby Study was approved by the Conjoint Health Research Ethics Board at the University of Calgary (REB-ID 21754).

## Results

### Sample characteristics

Overall, 37.1% of women in the Happy Baby Study had a Caesarean delivery, of which most were unplanned. Table 2 displays sample characteristics by mode of delivery. The majority of participants had postsecondary education, had a household income  $\geq$  \$60,000, were white, and were married or co-habiting. The mean age was 31.4 years. Approximately half of the participants were multiparous; a greater proportion of women with an unplanned Caesarean delivery were primiparous (63.6%), whereas a greater proportion of women with a planned Caesarean delivery were multiparous (81.2%), compared to the vaginal delivery group. Approximately 42.9% of participants received lactation consultant support, which was more common among the Caesarean delivery groups. The prevalence of breastfeeding difficulties is displayed in Table 1. Overall, 80.9% of women reported experiencing at least one moderate to unbearable breastfeeding difficulty shortly after birth. The most common difficulty type was maternal physical difficulties (58.9%), followed by infant behaviour/health difficulties (54.9%) and infant latch difficulties (39.8%).

**Table 2** Characteristics of participants ( $N = 418$ )

	Vaginal $N = 261$ $n$ (%)	Unplanned Caesarean $N = 88$ $n$ (%)	Planned Caesarean $N = 69$ $n$ (%)
Age in years, mean (SD)	30.6 (5.0)	32.1 (4.8)	33.9 (4.9)
Parity			
Primiparous	137 (52.7)	56 (63.6)	13 (18.8)
Multiparous	123 (47.3)	32 (36.4)	56 (81.2)
Education			
High school or less	39 (15.4)	9 (10.5)	6 (8.7)
Some/completed postsecondary	215 (84.6)	77 (89.5)	63 (91.3)
Household income			
Low (< \$60,000/year)	59 (24.2)	19 (22.3)	13 (19.1)
High ( $\geq$ \$60,000/year)	185 (75.8)	66 (77.6)	55 (80.9)
Ethnicity			
White	191 (75.5)	69 (80.2)	51 (73.9)
BIPOC	62 (24.5)	17 (19.8)	18 (26.1)
Canadian born			
Yes	198 (78.0)	64 (74.4)	52 (75.4)
No	56 (22.0)	22 (25.6)	17 (24.6)
Psychosocial vulnerability			
Yes	49 (19.3)	21 (24.7)	19 (27.9)
No	205 (80.7)	64 (75.3)	49 (72.1)
Marital status			
Single	7 (2.7)	1 (1.2)	0 (0.0)
Married/co-habiting	248 (97.3)	85 (98.8)	69 (100.0)
BMI ( $\text{kg}/\text{m}^2$ ), mean (SD)	25.5 (4.3)	27.4 (6.1)	26.6 (5.2)
Primary language			
English	220 (86.3)	75 (87.2)	58 (84.1)
Non-English	35 (13.7)	11 (12.8)	11 (15.9)
Received lactation consultant support			
Yes	97 (37.3)	50 (56.8)	32 (46.4)
No	163 (62.7)	38 (43.2)	37 (53.6)

BIPOC Black, Indigenous, people of colour, BMI body mass index

### Caesarean delivery and breastfeeding difficulties

Results for logistic regression modelling of Caesarean delivery (either planned or unplanned) and types of breastfeeding difficulties are shown in Table 3. There was a significant association between Caesarean delivery and low milk supply difficulties (AOR = 1.62, 95% CI = 1.16–2.28) and infant behaviour/health difficulties (AOR = 1.33, 95% CI = 1.01–1.75) in the adjusted models. No association was observed for maternal physical difficulties, high milk supply, social difficulties, or infant latch difficulties.

Results for the logistic regression modelling of planned and unplanned Caesarean delivery and types of breastfeeding difficulties are shown in Tables 4 and 5, respectively. Both planned Caesarean (AOR = 2.42, 95% CI = 1.19–4.92) and unplanned Caesarean (AOR = 2.21, 95% CI = 1.16–4.22)

were significantly associated with low milk supply difficulties in adjusted models. No associations were observed for the remaining maternal or infant difficulties. Of note, the association between planned Caesarean and infant behaviour/health difficulties (AOR = 1.66, 95% CI = 0.93–2.98) was near the threshold of significance.

### Discussion

Women of full-term infants who delivered by Caesarean were roughly twice as likely to report low milk supply difficulties shortly after birth than women who delivered vaginally. This is likely capturing a later onset of lactogenesis II (i.e. copious milk production) given the timing of data collection within

**Table 3** Association between Caesarean delivery versus vaginal delivery and breastfeeding difficulties shortly after birth

Breastfeeding difficulty	Vaginal, %	Caesarean, %	AOR <sup>a</sup>	95% CI
<b>Maternal difficulties</b>				
Physical	56.2	63.9	1.24	0.93, 1.64
Low milk supply	12.4	23.7	1.62	1.16, 2.28*
High milk supply	16.7	19.3	1.20	0.83, 1.74
Social	5.8	7.8	1.15	0.65, 2.02
<b>Infant difficulties</b>				
Latch	40.0	41.3	1.13	0.85, 1.51
Behaviour/health	50.6	62.6	1.33	1.01, 1.75*

AOR adjusted odds ratio, CI confidence interval

<sup>a</sup> Adjusted for psychosocial vulnerability, low SES, parity, body mass index, and age

\*Denotes statistical significance ( $p < 0.05$ )

72 h after birth. A delay in lactogenesis II that persists beyond 72 h has shown to be associated with premature cessation of breastfeeding (Brownell et al., 2012). Many circumstances surrounding a Caesarean delivery may contribute to later onset of lactogenesis II, including maternal physiologic stress from undergoing surgery (Tully & Ball, 2014; Uvnäs Moberg et al., 2020), delayed initiation of mother-infant skin-to-skin contact and delayed breastfeeding initiation (Dewey et al., 2003; Prado et al., 2018), and possible lower sucking capacity in infants born by Caesarean (Zhang et al., 2016). Low breastfeeding self-efficacy may also be a factor, given that low self-efficacy has been linked to both Caesarean delivery and perceived low milk supply, separately (Huang et al., 2021). The association with low milk supply was slightly larger in magnitude for planned Caesarean (AOR = 2.42) compared to unplanned Caesarean (AOR = 2.21), though confidence intervals were wide and overlapping. Planned Caesarean can occur due to medical concerns necessitating a scheduled delivery to reduce the risks of continued pregnancy

on maternal or fetal health (Hanley et al., 2010). Pregnancy complications have been shown to adversely impact breastfeeding outcomes (Scime et al., 2021). It is possible that these complications might act in combination with circumstances surrounding Caesarean surgery to delay lactogenesis, explaining the slightly larger association we observed with planned Caesarean and low milk supply. Alternatively, this finding may be explained by the common obstetrical practice of performing repeat Caesarean (Gu et al., 2020), given that a larger proportion of women with planned Caesarean delivery were multiparous compared to women with unplanned Caesarean delivery. Additional research that further categorizes planned Caesarean based on maternal request, medical indication, or repeat Caesarean would be helpful to explore these interpretations further.

We also found that infant behaviour/health difficulties were 30% more common in women who delivered by Caesarean. Our definition of infant behaviour/health difficulties was heterogeneous, and future research with sufficient sample sizes to

**Table 4** Association between planned Caesarean delivery versus vaginal delivery on types of breastfeeding difficulties at delivery

Breastfeeding difficulty	Planned Caesarean, %	AOR <sup>a</sup>	95% CI
<b>Maternal difficulties</b>			
Physical	66.2	1.58	0.86, 2.90
Low milk supply	25.0	2.42	1.19, 4.92*
High milk supply	16.2	1.25	0.56, 2.82
Social	4.5	0.95	0.24, 3.75
<b>Infant difficulties</b>			
Latch	38.2	1.35	0.74, 2.47
Behaviour/health	61.8	1.66	0.93, 2.98

AOR adjusted odds ratio, CI confidence interval

<sup>a</sup> Adjusted for psychosocial vulnerability, low SES, parity, body mass index, and age

\*Denotes statistical significance ( $p < 0.05$ )

**Table 5** Association between unplanned Caesarean delivery versus vaginal delivery and types of breastfeeding difficulties at delivery

Breastfeeding difficulty	Unplanned Caesarean, %	AOR <sup>a</sup>	95% CI
<b>Maternal difficulties</b>			
Physical	62.1	1.15	0.68, 1.94
Low milk supply	22.7	2.21	1.16, 4.22*
High milk supply	21.8	1.61	0.83, 3.12
Social	10.5	1.94	0.78, 4.83
<b>Infant difficulties</b>			
Latch	43.7	1.02	0.60, 1.75
Behaviour/health	63.2	1.52	0.90, 2.57

AOR adjusted odds ratio, CI confidence interval

<sup>a</sup> Adjusted for psychosocial vulnerability, low SES, parity, body mass index, and age

\*Denotes statistical significance ( $p < 0.05$ )



examine each individual difficulty would help clarify the specific infant behaviours driving this association. Low milk supply difficulties following Caesarean likely contribute to infants showing heightened cues of hunger and distress. Perceived low milk supply may also influence maternal perceptions of infant behaviour, including a greater likelihood of reporting a lack of infant satisfaction, a higher need for formula, slow infant weight gain, and lack of breast fullness (Kent et al., 2021). Mothers who deliver by Caesarean report significantly higher pain compared to vaginal delivery, require more analgesic or anti-inflammatory drugs during their hospital stay (Zanardo et al., 2018), and have reported experiencing distress and shock following their operation, particularly when it was unplanned (Tully & Ball, 2013). It is therefore possible that maternal pain or stress following Caesarean surgery also contributes to women's heightened sensitivity to infant fussiness or irritability in response to breastfeeding.

We found no significant associations between Caesarean delivery and maternal physical difficulties (e.g. sore or cracked nipples, maternal fatigue), high milk supply difficulties (e.g. swollen breasts, blocked milk ducts), social difficulties (e.g. inconvenience or embarrassment when breastfeeding), or infant latch difficulties. Given our study's focus on experiences shortly after birth and prior to hospital discharge, null findings are expected as many of these difficulties (e.g. high milk production, breast pain, and blocked milk ducts) often present later in the postpartum period (Berens, 2015; Odom et al., 2013). It is reassuring that latch difficulties did not differ by mode of delivery, despite a high prevalence (approximately 40%) in this sample.

Our findings indicate that prompt hospital or public health support targeted towards promoting milk supply shortly after birth might help to improve women's breastfeeding experiences following Caesarean delivery. Hospital policies that promote rooming in, skin-to-skin contact, and pre-discharge lactation assessment, as well as community-based educational and counselling initiatives, have been shown to be effective at improving self-efficacy, actual and perceived low milk supply, and breastfeeding outcomes (Galipeau et al., 2018; Sinha et al., 2015). Pharmacological intervention through use of galactagogues, such as domperidone, may also be considered in certain circumstances where low milk supply has been objectively confirmed (Brodribb, 2018). Support with interpreting and responding to infant behaviours and cues may also ameliorate breastfeeding challenges shortly after birth (Committee on Obstetric Practice Breastfeeding Expert Work Group, 2021).

Our study has several limitations to consider. The Happy Baby Study was comprised of adult mothers of full-term infants, and thus, our results are not generalizable to adolescent mothers or the preterm population. Recruitment dates back to 2010, and while the Happy Baby Study's sample was representative of the general maternal population in Alberta at that time (Chaput et al., 2016), findings should be considered in light of

changing Caesarean and lactation practices that may have occurred over the last decade, including rising rates of Caesarean deliveries and increased implementation of breastfeeding-friendly practices (Alberta Health Services, 2014; Canadian Institute for Health Information, 2020). Data on pregnancy complications were not collected and may be a source of unmeasured confounding. Despite the modest sample size, cell sizes were insufficient to model each of the 18 items in the BES separately. Grouping difficulties into types introduced heterogeneity into outcome measurement, which may have affected or obscured the strength and significance of associations across difficulties. We also acknowledge limited statistical power for some of the models stratified by Caesarean subtype, as evidenced by low precision (wide CIs) and associations at the threshold of significance (for example, infant behaviour/health).

## Conclusion

Women who deliver by planned or unplanned Caesarean section are approximately twice as likely to report low milk supply shortly after birth than women who deliver vaginally. Infant behaviour/health difficulties were also more commonly reported following Caesarean, though to a lesser degree. Supportive hospital and public health interventions that can address low milk supply, whether perceived or actual, are recommended to ameliorate the breastfeeding experiences of mothers following Caesarean.

## Contributions to knowledge

What does this study add to existing knowledge?

- Caesarean delivery is associated with reduced breastfeeding initiation and earlier discontinuation compared to vaginal delivery, but differences in breastfeeding difficulties by mode of delivery have seldom been explored.
- We found that mothers who experience Caesarean delivery have significantly higher odds of reporting low milk supply and perceived infant behavioural/health difficulties shortly after birth than women who deliver vaginally.

What are the key implications for public health interventions, practice, or policy?

- Interventions that are effective at improving actual or perceived low milk supply in the hospital and community may help to alleviate breastfeeding difficulties for mothers following a Caesarean delivery.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.17269/s41997-022-00666-0>.

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**Author contributions** JS completed this project for her undergraduate thesis with supervision from NVS and KHC. All authors contributed to the study conception and design. Data analysis was conducted by JS with mentorship from NVS. The first draft of the manuscript was written by JS; NVS and KHC provided critical feedback to the manuscript. All authors read and approved the final manuscript.

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**Data availability** Requests for data from the Happy Baby Study can be directed to the principal investigator, Kathleen Chaput, at khchaput@ucalgary.ca.

**Code availability** Not applicable.

## Declarations

**Ethics approval** The Happy Baby Study was approved by the Conjoint Health Research Ethics Board at the University of Calgary (REB #21754).

**Consent to participate** Informed consent was obtained from all individual participants included in the Happy Baby Study.

**Consent for publication** Not applicable.

**Conflict of interest** The authors declare no competing interests.

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