

Early readmission of exclusively breastmilk-fed infants born by means of normal birth or cesarean is multifactorial and associated with perinatal maternal mental health concerns

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Abstract

Background: Late preterm and full-term infants comprise the majority of births in our hospital which serves a multicultural lower socioeconomic community. Patients give birth vaginally (normal birth, NB) or by cesarean birth (CB), and the majority of neonates are exclusively breastmilk fed until discharge. In this study we examined what factors within these two birth modes and feeding regimes of exclusive breast milk were associated with early postnatal readmission. Ideally, findings will aid initiatives to decrease readmission rates.

Methods: A retrospective cohort study was performed on maternal–infant pairs. All neonates from 2016 to 2018, exclusively breastmilk fed at discharge, born by NB ($n=4245$) or CB ($n=1691$), were grouped as non-Readmitted (Reference) or Readmitted within 30 days of discharge. Readmission reason was determined, and potential associations were identified using univariate analysis and multi-variable logistic regression.

Results: Rates of readmission were similar for both NB and CB infants (6.8% vs. 7.3%). In order, NB concerns were jaundice, infection, and feeding—this was reversed for the CB Group. NB readmission bilirubin levels were higher (293 ± 75 vs. 236 ± 112 , $\mu\text{mol/L}$, NB:CB, $p < 0.001$). Factors associated with readmission for both groups were similar to previously published studies. Edinburgh Postnatal Depression Score (EPDS) was higher for Readmitted infant mothers. Importantly, for non-jaundice readmission EDPS categories indicated that both CB and NB mothers were more likely to have depression.

Conclusion: Early readmission of exclusively breastmilk-fed infants born by means of NB or CB is multifactorial. Early pregnancy mental health issues are associated with readmission, highlighting the potential effects of perinatal depression on neonatal health.

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KEYWORDS

normal birth, perinatal depression, readmission

1 | INTRODUCTION

Neonatal readmission to hospital within the first month following initial discharge is not uncommon, is disruptive to patients and families, and is a cost burden to healthcare systems. Early neonatal readmission research has focused on both neonatal and maternal factors. In addition, the relative rate of readmissions is seen as a measure of the quality of hospital care with such readmission rates used routinely as a comparative perinatal performance indicator.^{1,2}

Initial studies examined infant-specific causes of readmission for preterm, high-risk infants discharged from Neonatal Intensive Care Units (NICU) with later research expanded to include late preterm infants. Most studies have been multicenter, state or nation-wide. Findings have been occasionally contradictory—in the late preterm infant, risk factors for readmission include infants with short NICU stays,³ but length of stay (LOS) has also been deemed not to be a factor.⁴ Otherwise, risk factors associated with readmission include the following: breastfeeding,⁴ gestational age (GA) between 35 and 36 weeks,⁵ jaundice,⁶ infectious diseases, and respiratory conditions.⁷

There is a growing consensus that neonatal readmission in the early postnatal period is complex and multifactorial. For example, readmission for neonatal jaundice has been associated with breastfeeding and neonatal dehydration as well as Asian and Caucasian ethnicity.⁸ Lower family income, residential geography such as lower socioeconomic and regionally isolated areas, and cesarean section have been described as having a role in readmission.⁹ Cesarean birth (CB) has been associated with increased levels of postnatal depression¹⁰ and with a negative effect on breastfeeding,¹¹ suggesting a possible link between maternal depression and neonatal readmission. Maternal mental health has an association with readmission: Lithium-managed mood disorder has a Special Care Nursery (SCN) readmission rate of 27.5% compared with 14.3% for nonlithium-treated mood disorder.¹² Untreated depression (compared with treated depression) results in an increased risk of CB as well as an increased neonatal readmission rate at 6 weeks of 3.9% versus 0.8%.¹³

Although several studies have examined neonatal readmission, these studies have invariably enrolled cohorts across all feeding regimes—formula, partial breast milk, and exclusive breastfeeding. In our healthcare

system, exclusive infant feeding by means of breast milk is actively promoted, so that infants who are on formula or partial breast milk often have feeding concerns. Consequently, exclusively breastmilk-fed infants represent a most successful outcome of obstetric and neonatal care. However, such infants are not infrequently readmitted to our unit. To our knowledge, there are few studies that have examined the characteristics of a cohort from birth to discharge, consisting solely of readmitted exclusively breastmilk-fed infants.

In our hospital, the majority of births are by means of normal birth (NB) and infants are exclusively breastmilk fed and have a relatively uneventful postnatal stay. The second largest group are born by means of CB and also exclusively breastmilk fed. We were interested to know what factors influenced readmission among NB exclusively breastmilk-fed infants and how these factors compared with readmission among the arguably higher risk group of exclusively breastmilk-fed CB infants. Given the link between maternal mental health and CB birth, we hypothesized that this may be a factor even with exclusively breastmilk-fed infants. We hoped the identification of these factors will inform future initiatives to decrease readmission rates.

2 | METHODS

2.1 | Study design

Retrospective cohort study.

2.2 | Setting

The Northern Hospital (TNH) provides healthcare to one of the most multicultural municipalities in Australia and one of the fastest growing municipalities in Australia. TNH has a level 5 SCN that treats infants from 31 weeks' gestation. Standard maternal care includes a 2-night stay for NB and a 3-night stay for CB.

2.3 | Participants

All live-born infants delivered at TNH between 1 January 2016 and 31 December 2018, who were exclusively breastmilk fed (solely fed expressed breast milk and/or

exclusively breastfed) from birth until discharge from the postnatal ward or SCN and were born by means of either NB or CB. Infants that died during the birth admission were excluded, as were all instrumental vaginal births.

2.4 | Data collection

Maternal–infant paired data were extracted from the hospital's administrative database. Infants were divided into NB and CB Groups and were then further subdivided into Readmitted and non-Readmitted (Reference Group).

2.5 | Variables of interest

Maternal variables included: age, parity, marital status, country of birth, body mass index (BMI), mode of delivery, and Maternal Edinburgh Postnatal Depression Scale (EPDS)—completed at the antenatal clinic booking-in visit. Country of birth was divided into regions. The reference region was Australia, New Zealand, and the Pacific Islands. East and South East Asia (E&SE Asia) includes China, Japan, Korea, Taiwan, and South East Asian countries such as Vietnam, Cambodia, Thailand, Malaysia, and Indonesia. Infant variables included: GA, gender, birth weight, LOS, and feeding status during birth admission. Additional variables retrieved from individual patient files included length of time between discharge and readmission and primary readmission diagnosis.

2.6 | Variables defined

Readmission refers to any neonate that was born at *TNH*, discharged from *TNH*, and then subsequently readmitted back to *TNH* within a 30-day postbirth discharge. Inter-hospital transfers were not included. Only the first readmission was included. There is no formal record kept of infants born and admitted to another hospital—it is highly unlikely that any such infants would have been included in the study due to the 30-day postbirth criteria.

Non-Readmitted infants of either birth mode are referred to hereafter as the Reference Group.

NB is defined as birth without induction of labor, any form of anesthesia, episiotomy, assistance by means of forceps or vacuum, or CB. Due to a natural birth, being exclusively breastmilk fed and having a relatively uneventful postnatal stay, the NB Group was considered to be the normal risk group.

CB refers to cesarean birth. The CB Group is considered higher risk due to the aforementioned established maternal and neonatal risks.¹³

LOS is the number of days between discharge and birth.

Small or large for gestational age is defined as infant birth weight <10th/>90th centile for GA and gender based on the Fenton preterm growth charts.¹⁴

Days between discharge and readmission are calculated as readmission date less discharge date.

Primary reasons for readmission were established as infection; jaundice; feeding or growth concerns; and others. These categories were based on previous studies that highlighted the most common reasons for neonatal readmission.^{3,15,16}

2.7 | Statistical methods

A 30-day readmission rate for each delivery group was calculated. Descriptive statistics were used to summarize the maternal and neonatal characteristics between the 30-day Readmitted and Reference cohorts of each delivery group. Significance was determined between the two cohorts using a chi-squared test for categorical variables, a Student's *t*-test for normally distributed continuous variables, and a Mann–Whitney test for non-normally distributed variables. Variables with a $p < 0.2$ in univariate analysis were included in the multivariable logistic regression model. A backward stepwise regression was used until all variables had at least one category as significant. $p < 0.05$ indicated statistically significant. Statistical analyses were performed using IBM SPSS 26. It is noted that as this is a retrospective cohort study where the incidence of the outcome (re-admissions) is known, the ORs can be approximated to Relative Risk given the outcome is rare (<10%).¹⁷

2.8 | Patient and public involvement

Patients were not involved in the design of this study.

3 | RESULTS

3.1 | Overview

There were a total of 10,978 live births between 2016 and 2018. There were 22 deaths during birth admission. 62.8% were exclusively breastmilk fed during the birth admission, 55.5% were born by means of NB ($n = 4245$), and 31.5% were born by means of CB ($n = 1691$) with the remainder born by assisted delivery. Due to missing data, the actual numbers analyzed were slightly less than these numbers (see table notes). The number of neonates

readmitted within 30 days was 308 for the NB Group and 108 for the CB Group, with readmission rates of 7.3% and 6.8%, respectively. Results are presented in Tables 1–4 and Figure 1.

3.2 | Maternal and infant characteristics by birth mode for the Readmitted and Reference Groups

Table 1 presents side-by-side descriptive statistics of maternal and infant characteristics by birth mode for the Readmitted and Reference Groups.

3.3 | Identifying associations for readmission—comparing Readmitted and Reference cohorts

The question we wished to explore with the data analysis in Tables 2 and 3 is: Does a difference exist in the characteristics of the Reference and Readmitted Groups with respect to birth mode?

3.3.1 | Comparing NB—Reference versus readmitted

Male gender, GA \leq 38 weeks, being of Aboriginal/Torres Strait Islander ethnicity, maternal birthplace identified as South Asian, single/separated marital status, induced labor

onset, lower birth and discharge weight, had increased odds of being readmitted, whereas multiparous, being married, normal maternal BMI and spontaneous labor onset, were protective (Table 2). Additional factors highlighted as being significant were: both E & SE Asian and South Asian maternal birthplace had higher odds of readmission; LOS was a significant contributor to readmission with a shorter LOS being at higher odds of readmission (Table 3).

3.3.2 | Comparing CB—reference versus readmitted

GA \leq 38 weeks, maternal partner status as single, positive maternal smoking status, an emergency CB, APGAR $<$ 7 at 5 min, and a lower birth weight all increased odds of readmission (Table 2). Multiparous mothers who were married and who gave birth to a neonate at a gestational age 39–40 weeks had decreased odds of neonatal readmission. Given the lower numbers in this cohort compared with the NB cohort, the only factors that were significant in the multivariable analysis were GA, parity, and marital status (Table 3).

3.4 | The when, why, and who of readmission

These results are detailed in Table 4 and below.

The data analysis presented in Table 4 revealed that the majority of babies were admitted within the first week for

TABLE 1 Maternal and infant characteristics by birth mode for the Readmitted and Reference Groups.

	Readmitted		Reference	
	NB	CB	NB	CB
Readmission rate	7.3% ($n=308$)	6.4% ($n=108$)		
Gestation age (weeks), mean \pm SD	38.6 \pm 1.3	38.7 \pm 1.4	39.3 \pm 1.2	39.0 \pm 1.6
Maternal age (years), mean \pm SD	29.4 \pm 5.3	29.6 \pm 4.7	29.3 \pm 4.9	30.8 \pm 4.9
Maternal BMI, mean \pm SD	27.1 \pm 6.0	27.5 \pm 6.5	26.2 \pm 5.7	27.5 \pm 6.2
Maternal birthplace				
East & South East Asia, %	8.5	9.3	6.2	5.9
South Asia, %	25.4	24.1	20.5	28.5
Middle East, %	13.4	12.0	17.0	14.2
Australia/New Zealand/Pacific, %	47.2	47.2	50.1	46.7
Birthweight (g), mean \pm SD	3305 \pm 435	3250 \pm 480	3372 \pm 438	3353 \pm 484
Discharge weight (g), mean \pm SD	3059 \pm 440	2985 \pm 431	3160 \pm 436	3115 \pm 422
Weight loss (%), mean \pm SD	−6.0 \pm 2.9	−6.9 \pm 4.1	−5.0 \pm 5.5	−6.4 \pm 4.7
LOS (days), mean \pm SD	1.8 \pm 1.9	3.3 \pm 2.4	1.8 \pm 1.7	3.2 \pm 2.7

Note: Reference Group NB, $n=3937$. Reference Group CB, $n=1583$. Readmit NB, $n=308$. Readmit CB, $n=108$. Weight Loss = Weight Loss over birthweight at discharge. East & South East Asia (China, Taiwan, Malaysia, Singapore, etc.). South Asia (Indian subcontinent, Sri Lanka).

TABLE 2 Characteristics of the Reference and Readmitted Groups for birth mode.

Characteristic	Normal birth, exclusively breastmilk fed (<i>n</i> = 4245)			LUSCS delivery, exclusively breastmilk fed (<i>n</i> = 1691)			
	Reference (<i>n</i> = 3937)	Readmitted (<i>n</i> = 308)	Odds ratio (95% CI)	Reference (<i>n</i> = 1583)	Readmitted (<i>n</i> = 108)	Odds ratio (95% CI)	<i>p</i> -Value
Season born							
Summer, %	25.2	24.0	0.94 (0.72–1.23)	25.8	20.4	0.74 (0.46–1.19)	0.21
Winter, %	25.2	24.4	0.95 (0.73–1.25)	24.4	30.6	1.36 (0.89–2.09)	0.15
Male, %	49.0	58.4	1.46 (1.16–1.85)	53.8	48.1	0.80 (0.54–1.18)	0.25
Gestation in weeks (mean ± SD)	39.0 ± 1.2	38.3 ± 1.4		38.7 ± 1.4	38.4 ± 1.4		<0.01
Gestational age at birth (weeks completed)							
<37, %	2.2	5.8	2.75 (1.63–4.63)	3.8	8.3	2.35 (1.13–4.87)	<0.05
37–38, %	31.2	48.7	2.10 (1.66–2.65)	33.2	42.6	1.50 (1.01–2.23)	<0.05
39–40, %	58.6	40.3	0.48 (0.38–0.60)	54.7	44.4	0.67 (0.45–0.99)	<0.05
>40, %	8.1	5.2	0.63 (0.37–1.05)	8.8	4.6	0.51 (0.21–1.28)	0.15
Small for gestational age & gender, %	3.2	2.3	0.71 (0.33–1.53)	3.4	3.7	1.11 (0.39–3.13)	0.78
Large for gestational age & gender, %	7.3	8.8	1.22 (0.81–1.84)	8.7	4.6	0.51 (0.21–1.28)	0.21
Singleton, %	99.7	99.0	0.31 (0.09–1.11)	98.0	99.1	2.14 (0.29–15.81)	0.45
Aboriginal/Torres Strait Islander, %	1.6	4.2	2.67 (1.45–4.91)	1.5	0.9	0.61 (0.08–4.57)	0.13
Maternal age in years (mean ± SD)	29.2 ± 4.9	29.4 ± 5.3		30.8 ± 4.9	29.6 ± 4.7		<0.01
Maternal age (years)							
<20, %	1.6	2.3	1.41 (0.64–3.10)	0.4	0.9	2.10 (0.26–17.26)	0.41
20–30, %	59.6	56.8	0.89 (0.71–1.13)	47.3	53.7	1.29 (0.87–1.91)	0.20
>30, %	38.8	40.9	1.09 (0.86–1.38)	52.2	45.4	0.76 (0.51–1.12)	0.17
Multiparous, %	70.8	62.0	0.67 (0.53–0.85)	64.4	49.1	0.53 (0.36–0.79)	<0.001
Maternal birthplace							
Australia/New Zealand/Pacific, %	48.2	45.3	0.89 (0.70–1.12)	46.7	47.2	1.03 (0.70–1.53)	0.88
East & South East Asia, %	6.2	8.4	1.39 (0.91–2.12)	5.7	9.3	1.67 (0.84–3.32)	0.14
South Asia, %	20.5	25.4	1.32 (1.01–1.73)	28	24.1	0.82 (0.52–1.28)	0.38

TABLE 2 (Continued)

Characteristic	Normal birth, exclusively breastmilk fed (<i>n</i> = 4245)			LUSCS delivery, exclusively breastmilk fed (<i>n</i> = 1691)			
	Reference (<i>n</i> = 3937)	Readmitted (<i>n</i> = 308)	Odds ratio (95% CI)	Reference (<i>n</i> = 1583)	Readmitted (<i>n</i> = 108)	Odds ratio (95% CI)	<i>p</i> -Value
Middle East, %	17.0	13.4	0.76 (0.54–1.06)	13.9	12.0	0.85 (0.47–1.54)	0.59
Maternal marital status							
Married/De facto, %	85.3	80.2	0.70 (0.52–0.93)	87.7	79.6	0.55 (0.33–0.89)	<0.05
Single/Separated, %	14.6	19.2	1.39 (1.03–1.87)	12.0	20.4	1.88 (1.15–3.07)	<0.01
Booking- in BMI							
BMI (mean ± SD)	26.2 ± 5.6	27.1 ± 6.0	<0.01	27.5 ± 6.5	27.5 ± 6.5		0.97
Underweight (<18.5), %	3.5	2.0	0.55 (0.24–1.26)	2.3	3.7	1.65 (0.58–4.73)	0.32
Normal (18.5–24.9), %	42.1	35.3	0.75 (0.59–0.96)	33.6	33.3	0.99 (0.66–1.50)	0.96
Overweight (25–29.9), %	30.1	35.3	1.26 (0.99–1.61)	33.3	32.4	0.96 (0.63–1.46)	0.85
Obese (≥30), %	24.2	27.5	1.18 (0.91–1.54)	30.8	30.6	0.99 (0.65–1.51)	0.95
Maternal smoking, %	8.2	7.8	0.96 (0.62–1.47)	5.7	11.1	2.07 (1.10–3.92)	<0.05
Mode of delivery							
Emergency cesarean section, %				55.3	65.7	1.55 (1.03–2.33)	<0.05
Labor onset							
Spontaneous, %	65.0	50.6	0.55 (0.44–0.70)	21.7	20.4	0.93 (0.57–1.50)	0.75
Induced, %	35.0	49.4	1.81 (1.43–2.28)	22.9	27.8	1.29 (0.84–2.00)	0.25
No labor, %	-	-		55.4	51.9	0.87 (0.59–1.28)	0.47
APGAR at 1 minute <7, %	4.1	4.6	1.13 (0.64–1.97)	7.6	11.1	1.52 (0.81–2.86)	0.19
APGAR at 5 minutes <7, %	0.5	0.7	1.22 (0.29–5.22)	0.6	2.8	4.50 (1.22–16.58)	<0.05
Birthweight (mean ± SD) (g)	3372 ± 438	3305 ± 435	<0.01	3353 ± 484	3250 ± 480		<0.05
Discharge weight (mean ± SD) (g)	3160 ± 434	3059 ± 440	<0.05	3115 ± 422	2985 ± 431		<0.01

(Continues)

TABLE 2 (Continued)

Characteristic	Normal birth, exclusively breastmilk fed (<i>n</i> = 4245)			LUSCS delivery, exclusively breastmilk fed (<i>n</i> = 1691)			
	Reference (<i>n</i> = 3937)	Readmitted (<i>n</i> = 308)	Odds ratio (95% CI)	Reference (<i>n</i> = 1583)	Readmitted (<i>n</i> = 108)	Odds ratio (95% CI)	<i>p</i> -Value
% Weight loss at discharge (Mean ± SD)	-5.0 (4.7)	-6.0 (2.9)		-6.4 (5.5)	-6.9 (4.1)		0.40
Length of stay (days) (mean ± SD)	1.84 ± 1.7	1.81 ± 1.9		3.2 ± 2.7	3.3 ± 2.4		0.97
Length of stay (days)							
0, %	5.5	4.9	0.87 (0.51–1.49)	0.2	0		1.00
1, %	29.8	28.2	0.93 (0.72–1.20)	1.7	0.9	0.54 (0.07–4.00)	1.00
2, %	55.5	60.1	1.20 (0.95–1.53)	19.2	22.2	1.20 (0.75–1.92)	0.44
3, %	6.0	5.2	0.86 (0.51–1.45)	68.1	65.7	0.90 (0.60–1.36)	0.61
>3, %	3.1	1.6	0.51 (0.21–1.26)	10.8	11.1	1.03 (0.56–1.92)	0.92

Note: *p*-Values by means of Student's *t*-test or chi-squared test. East & South East Asia (China, Taiwan, Malaysia, Singapore, etc.). South Asia (Indian subcontinent, Sri Lanka).

both groups. The key readmission concerns for NB babies were in decreasing frequency order: jaundice, infection, and feeding or growth concerns—all jaundice readmissions occurred in the first week. Readmission reasons for the CB Group in decreasing frequency order were: feeding or growth concerns, infection, and jaundice. Comparing the distribution of readmission between the birth modes during the first and subsequent weeks revealed significantly different readmission patterns—in terms of both frequency and jaundice level.

A comparison was made between NB and CB for each ethnic group with the following significant findings: Jaundice readmission rates were significantly higher for NB compared with CB for the Australian/New Zealand/Pacific (52.0% vs. 24.2%, $p < 0.0001$), E & SE Asia (70.7% vs. 45.5%, $p < 0.05$), and Middle East (47.4% vs. 21.2%, $p < 0.01$) groups, whereas feeding issues were significantly lower for the Australian/New Zealand/Pacific (17.8% vs. 31.3%, $p < 0.01$), E & SE Asian (2.4% vs. 27.3%, $p < 0.05$), and Middle Eastern (19.3% vs. 39.4%, $p < 0.05$) groups. For the Australian/New Zealand/Pacific grouping only, infection rate was lower (21.3% vs 35.4%, $p < 0.01$) for the NB compared with the CB.

3.5 | Readmission and perinatal depression

When all Reference Group mothers were compared with all Readmitted mothers (NB + CB for both), there was a statistically significant increase in EPDS score for the Readmitted Group (median 5 vs. 6, $p < 0.01$). Further analysis showed that the CB Reference Group had a significantly increased EPDS score compared with the Reference NB Group (median 5 vs. 6, $p < 0.05$) and when the Reference CB Group was compared with the Readmitted CB Group there was a further significant increase in EPDS score (median 6 vs. 7, $p < 0.05$). With regard to readmission reasons, categorized as either jaundice or other, there was no difference in the EPDS score of NB mothers (median 6 vs. 5 for Jaundice: Other, $p = 0.50$). However, when the reason for readmission for CB mothers was compared, the result was significant (median 5 vs. 8 for Jaundice: Other reasons, $p < 0.05$). Despite the statistical significance reported here, it should be noted that these are median values and that EDPS scores in the range 5–7 would not be expected to trigger any clinical intervention.

An alternative way of assessing the relevance of these findings is to categorize the EPDS scores. An EPDS score of <8 represents an unlikely risk of depression, and an EPDS score ≥ 12 corresponds to either a fairly high probability of depression (EPDS score 12–13) or probable

TABLE 3 Odds ratios (& 95% confidence intervals) of characteristics associated with 30-day neonatal readmission across the two delivery groups (multivariable logistic regression).

	Normal birth exclusively breastmilk fed (<i>n</i> = 4223)		CB delivery, exclusively breastmilk fed (<i>n</i> = 1691)	
	Odds ratio (95% CI)	<i>p</i> -Value	Odds ratio (95% CI)	<i>p</i> -Value
Male	1.49 (1.17–1.90)	<0.001		
Gestational age at birth (weeks completed)		<0.001		0.001
<37	4.74 (2.65–8.48)	<0.001	2.89 (1.33–6.22)	<0.01
37–38	1.95 (1.50–2.53)	<0.001	1.66 (1.09–2.53)	<0.05
39–40	REF		REF	
>40	0.81 (0.47–1.40)	0.45	0.46 (0.18–1.20)	0.11
Aboriginal/Torres Strait Islander	2.67 (1.41–5.07)	<0.01		
Multiparous	0.60 (0.46–0.77)	<0.001	0.47 (0.32–0.71)	<0.001
Maternal birthplace		0.081		
Australia/New Zealand/Pacific Islands	REF			
East & South East Asia	1.78 (1.12–2.83)	<0.05		
South Asia	1.37 (1.01–1.87)	<0.05		
Middle East	0.94 (0.65–1.36)	0.73		
Maternal marital status				
Married/De facto			REF	
Single/Separated			1.79 (1.09–2.96)	<0.05
Booking-in BMI		0.005		
Underweight (<18.5)	0.57 (0.24–1.33)	0.19		
Normal (18.5–24.9)	REF			
Overweight (25–29.9)	1.53 (1.15–2.04)	<0.01		
Obese (≥30)	1.42 (1.04–1.95)	<0.05		
Labor onset				
Spontaneous	REF			
Induced	1.48 (1.15–1.90)	<0.01		
Length of stay (days):		0.079		
0	3.76 (1.24–11.4)	<0.05		
1	3.70 (1.38–9.91)	<0.01		
2	3.50 (1.34–9.17)	<0.01		
3	2.45 (0.84–7.17)	0.10		
>3	REF			

Note: REF—Reference Group. All variables with a $p < 0.2$ from univariate analysis were originally included in this model. A backward stepwise regression was then used to obtain a model that included all variables that had at least one category that was statistically significant ($p < 0.05$). The multivariable model shown includes all variables shown in the table. East & Southeast Asia (China, Taiwan, Malaysia, Singapore, etc.). South Asia (Indian subcontinent, Sri Lanka).

Abbreviation: CI, confidence interval.

depression (>13).¹⁸ When all Reference Group mothers were compared with all Readmitted mothers (NB + CB for both), there were significantly less Readmitted mothers with an EPDS score < 8 (67.9% vs. 61.5%, $p < 0.05$). There was no significant difference between the NB Reference and Readmitted (68.8% vs. 63.9%, $p = 0.10$), but the NB Reference and CB Readmitted comparison was significant (68.6% vs. 55.1%, $p < 0.01$). Similar calculations for an EPDS score ≥ 12 were not significant.

Figure 1 presents the EPDS data for mothers with a high probability of depression or probable depression with respect to readmission reason—either jaundice or other. There is a differentiation between readmission reasons with significantly more NB mothers having infants readmitted for non-jaundice concerns. Despite a difference of 10% between jaundice and non-jaundice for CB EPDS score ≥ 12, the result was not significant. This is possibly due to low data numbers (NB grouping $n = 238$, CB grouping $n = 89$).

TABLE 4 NB and CB—Reason for readmission—first-week readmissions compared with subsequent weeks 2, 3, and 4.

Main reason for readmission	NB, n	%NB (1st week)	% NB (Weeks 2, 3, 4)	CB, n	% CB (1st Week)	% CB (Weeks 2, 3, 4)	OR (95% CI)	p-Value
Overall	308	96.4	3.6	108	67.6	32.4	0.08 (0.04–0.16)	<0.001
JAUNDICE	163	100	0	27	92.6	7.4	–	<0.05
Bilirubin (mean ± SD)		293 ± 75			236 ± 112			<0.001
NOT JAUNDICE	145	92.4	7.6	81	56.5	43.5	0.11 (0.05–0.22)	<0.001
Infection	64	85.9	14.1	35	51.5	48.5	0.17 (0.07–0.46)	<0.001
Feeding issues	59	96.6	3.4	37	73.0	27.0	0.09 (0.02–0.46)	<0.001
Other	22	100	0	9	33.3	66.7	–	<0.001

Note: Bilirubin units $\mu\text{mol/L}$ (values on readmission). Bilirubin *p*-value by means of Student *t* test. All other *p*-values by means of chi-square. OR derived from comparing whether readmissions for NB or CB occurred in the first week or later.

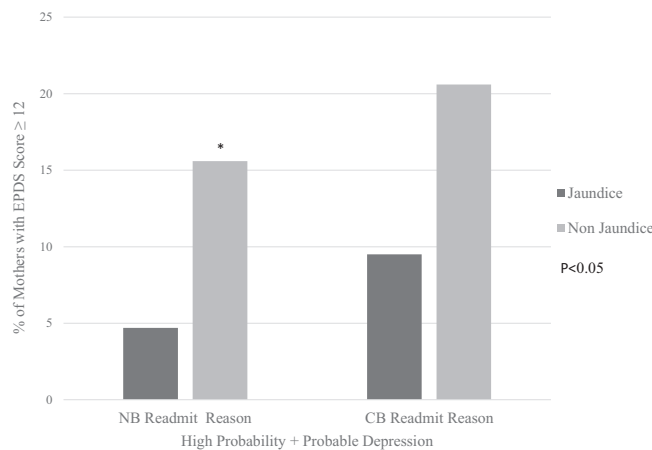


FIGURE 1 Reason for readmission versus EPDS category.

4 | DISCUSSION

To our knowledge, this study is atypical in relation to readmission of infants following postnatal discharge, in that unlike most studies, the normal risk group against which comparisons are made is not heterogeneous across birth modes and feeding regimes, but is restricted to normal birth infants who have been exclusively breastmilk fed until discharge—infants whose birth and early postnatal history have had minimal concerns. Our study provides a valuable insight into the associations for readmission, in a multiethnic, lower socioeconomic region of a large Australian city.

Interest in the effects of shorter postnatal stay for mothers and babies on early neonatal readmission has been researched for over two decades. Factors identified include the following: earlier birth GA^{5,6}; lower birthweight⁶; LOS¹⁹; Asian parentage and readmission for jaundice^{5,8}; a differential in time between admissions of jaundice and non-jaundice concerns¹⁹; gender^{8,19}; primiparity¹⁹; maternal diabetes¹⁹; an association between exclusive breastfeeding, infant weight loss, jaundice, and readmission.²⁰ Our results as presented in Tables 1–4 overlapped with most of the above key findings such as multiparity, ethnicity (E & SE Asian parentage was associated with 62% jaundice readmission, but only 17% for infection), onset of labor as well as infant gender, GA, neonatal weight loss, and hospital LOS. Elevated BMI was highlighted in our study as an association and therefore a potential risk factor—interestingly, a comprehensive 2015 study on maternal obesity and neonatal outcomes did not report readmission risk.²¹

Due to its prevalence as a readmission concern, several studies have focused on jaundice. An Australian study²² found readmission for jaundice was more likely for babies with Asian parentage and for those delivered vaginally compared with CB. Breastfed babies are reported to be at

risk of weight loss and severe hyperbilirubinemia, with the total serum bilirubin levels correlating with weight loss and CB being protective.²³ The results from our study are consistent with such findings. The majority of readmissions for jaundice for the NB Group and almost all for the CB Group occurred in the first week. The overall incidence of readmission for jaundice was significantly greater for the NB Group compared with the CB Group for the Australian/New Zealand/Pacific, E&SE Asian, and Middle Eastern categories. A possible new finding is that the level of bilirubin as measured at readmission was significantly lower for the CB (Table 4). A possible factor for the lower jaundice readmission incidence and total bilirubin differential is the longer LOS for CB mothers and babies (3.2 vs. 1.8 days), providing extra time for jaundice identification as well as breastfeeding establishment.

Limiting the inclusion criteria allowed a comparison of infants being exclusively breastmilk fed at discharge with respect to the common birth modes of NB and CB. For Reference Groups: infants born by CB when compared to NB had similar birth weights, had lower discharge weights, suffered more weight loss on discharge and mothers tended to be older and have higher BMIs. Of particular note is that mothers of South Asia ethnicity had significantly more cesarean births than by means of NB, while mothers of Middle Eastern ethnicity had less. Although the percentage values in Table 1 do not represent the prevalence of NB or CB, but rather the relative proportions of ethnic groups in the cohort, the comparison does highlight differences. Interestingly, these results reflect trends in birth countries. In India, CB rates have been increasing with current urban rates estimated at 38%.²⁴ In the Middle East, cesarean rates have been reported as being generally 15% or less.²⁵ When CB was compared with NB for the Readmitted cohorts, apart from LOS, there were no differences. Possibly, this is due to readmission in both groups reflecting factors associated with neonatal morbidity—lower infant birth weights, lower gestational ages, lower discharge weights, increased discharge weight loss, and increased maternal BMI.

Maternal depression has been recognized as a factor in infant outcomes, such as poorer growth and diarrhea.²⁶ Depression in the postnatal period has been associated with multiple outcomes such as breastfeeding failure,²⁷ labor induction, longer LOS, and increased frequency of CB.¹³ Depression with peripartum onset can begin within pregnancy or the first 4 weeks postpartum.²⁸ Mothers in this study were screened for depression using the EPDS rating at the first antenatal booking visit. Mothers with an EPDS score ≥ 12 were required to have a follow-up interview with a social worker. To our knowledge, this is the first study that has shown an association between maternal depression assessed by means of EPDS rating in early

pregnancy and readmission. Comparing EPDS scores, overall, there was an increase in median scores for the mothers of Readmitted infants versus Reference Group infants and mothers of Readmitted infants who had a cesarean were more likely to have higher EPDS scores than either Reference Group mothers. However, in both these cases, despite statistical significance, the median EPDS scores did not suggest a clinical concern, being < 8 . When a comparison was done for the common readmission reason of jaundice versus all other reasons for CB mothers, 50% of mothers whose infants were readmitted had median EPDS scores above 8. Further analysis showed that for readmission reasons, NB mothers categorized by means of EPDS as having a high probability of depression or probable depression had significantly more infants readmitted for non-jaundice concerns. A potentially related finding in our study is that single or separated mothers had a significantly higher risk of readmission. A relationship between increasing depression and lower parental bonding has been observed, with cohabiting mothers 1.3 times and solo mothers up to 1.7 times more likely to report depression compared with married mothers.²⁹ We speculate that a possible explanation for the observed differential between jaundice and non-jaundice readmission and the EPDS findings is that while readmission for jaundice has a substantial “infant” component related to physiological events, non-jaundice readmissions such as infection and feeding issues have a substantial “maternal” component. Maternal depression has been associated with poor infant feeding as well as poor infant care and development concerns.³⁰ Maternal stress and mental illness affect both maternal and fetal health.³¹

Our study had several limitations. As with all retrospective studies, this study was influenced by incomplete data in medical records and was reliant on the accuracy of recorded information. Being a single-center study, we were unable to capture infants who were readmitted to other healthcare services. The difference in cohort sizes between the delivery groups limited the multivariable analysis. However, each group still held more than 1000 neonates, a strength of this study. In relation to the major finding of this study that maternal depression identified in early pregnancy is associated with readmission for non-jaundice causes, clearly further follow-up studies (preferably prospective randomized) are needed to confirm and quantify these findings.

5 | CONCLUSION

Our study has shown that NB and CB infants who have been exclusively fed breast milk from birth and represent the largest cohort and most successful graduates of

the postnatal ward and SCN share many of the associations for readmission within 30 days that previous studies have identified. These associations include multiparity, ethnicity (particularly E&SE Asian for jaundice management), onset of labor as well as infant gender, GA, neonatal weight loss, elevated maternal BMI, and hospital LOS. The majority of readmissions occurred within the first week and for jaundice.

The most important new finding in this study relates to maternal mental health. The data suggest a link between maternal depression present early in pregnancy and infant readmission months later for non-jaundice concerns—the majority being infection and feeding issues. This study suggests that maternal mental health concerns may be affecting neonatal readmissions to the hospital.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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