Low rates of predominant breastfeeding in hospital after gestational diabetes, particularly among Indigenous women in Australia

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Abstract

Objectives: To investigate rates of 'any' and 'predominant' breastfeeding in hospital among Indigenous and non-Indigenous women with and without gestational diabetes mellitus (GDM).

Methods: A retrospective study of singleton infants born from July 2007 to December 2010 at Cairns Hospital, Australia, following GDM pregnancy, using linked hospital and birth data (n=617 infants), with a subsample of medical record reviews (n=365 infants). Aggregate data were used to compare to breastfeeding rates among infants born following non-GDM pregnancy (n=7,894 infants).

Results: More than 90% of all women reported any breastfeeding before hospital discharge. About 80% of women without GDM reported predominant breastfeeding. Despite significant increases over time ($p<0.0001$), women with GDM were less likely to predominantly breastfeed (OR 0.32, 95%CI 0.27-0.38, $p<0.0001$); with lower rates among Indigenous women (53%) compared with non-Indigenous (60%) women (OR 0.78, 0.70-0.88, $p<0.0001$); and women having a caesarean birth or pre-term infant.

Conclusions: Rates of predominant in-hospital breastfeeding were lower among women with GDM, particularly among Indigenous women and women having a caesarean or pre-term birth.

Implications: Strategies are needed to support predominant in-hospital breastfeeding among women with GDM.

Key words: breastfeeding, Gestational Diabetes Mellitus, Type 2 Diabetes Mellitus, pregnancy, Aboriginal, Indigenous, diabetes

Gestational diabetes mellitus (GDM), defined as diabetes diagnosed during pregnancy[1] is increasing in prevalence.[2] In addition to serious complications in pregnancy and birth,[3] GDM is associated with an increased risk of developing type 2 diabetes (T2DM) postpartum,[4] with Indigenous mothers particularly at risk.[5] Exposure to maternal hyperglycaemia and GDM *in utero* may be associated with increased risks of obesity and diabetes for infants,[6-9] creating a compounding inter-generational effect thought to be a driver of the high prevalence of diabetes among Indigenous populations.[10] Breastfeeding can improve glucose metabolism and insulin sensitivity, which leads to a reduction in the risk of developing T2DM for mothers[11] and their infants.[12]

Prior to colonisation, Indigenous women in Australia exclusively breastfed their infants for six months and continued to breastfeed for 2–4 years.[13] However, with the exception of small remote populations where traditional practices are maintained,[13] studies suggest breastfeeding rates are now lower among Indigenous mothers than non-Indigenous mothers in Australia,[14] and are likely to be associated with low socio-economic status.[15] To our knowledge there has been only one small study reporting breastfeeding rates among 26 Indigenous women with GDM,[16] which observed lower rates of breastfeeding among Indigenous women with GDM than non-Indigenous women with GDM.

Objectives

This paper presents secondary analysis of data from a study investigating postpartum screening for T2DM after GDM,[17] and progression from GDM to T2DM,[5] among Indigenous and non-Indigenous women with GDM giving birth at Cairns Hospital in Far North Queensland, Australia. This study aimed to: 1. Investigate rates of breastfeeding among Indigenous and non-Indigenous women, with and without GDM around the time of discharge from Cairns Hospital; 2. Identify factors associated with breastfeeding around the time of discharge among Indigenous and non-Indigenous women with GDM; and 3. Describe reasons recorded for administration of infant formula and special care unit admissions in a sample of medical records among Indigenous and non-Indigenous women with GDM.

* *'Indigenous' is used when referring to Aboriginal and Torres Strait Islander peoples in Australia collectively and Indigenous peoples in other countries. This is for ease of reading in this paper only and we respectfully acknowledge the diversity and autonomy of different communities included in this broad term.*

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Methods

Study setting and sample

This retrospective cohort study included all infants born at Cairns Hospital in Far North Queensland, Australia, from 1 July 2007 to 31 December 2010. Cairns Hospital is the only referral hospital in a vast region in north-east of Australia covering almost 300,000 km^2. The region has a population of more than 230,000, of whom about 40,000 (17%) are Aboriginal and Torres Strait Islander people.[18] More than 80% of women in the region give birth at Cairns Hospital, which includes almost all women giving birth with pre-existing and gestational diabetes. The study setting and design details for the primary analysis have been described in detail elsewhere.[19]

Ethics

This study was conducted with advice and assistance from staff at Cairns Diabetes Centre and Apunipima Cape York Health Council. Ethics approval was granted by the Cairns Hospital and Hinterland Research Ethics Committee (53738) and the Monash University Human and Research Ethics Committee (2011001190). The project was led by Indigenous researchers and three Indigenous researchers are included in the authorship team (CC, SC, SE).

Data collection and coding

For this secondary analysis, aggregated breastfeeding data were obtained from the Queensland Perinatal Data Collection (PDC) by Indigenous and GDM status for each year from 1 July 2007 to 31 December 2010 among live-born infants at Cairns Hospital discharged home. Individual-level data for women with GDM included in the primary study were obtained from the Cairns Hospital Clinical Coding System (CHCCS) and linked with pregnancy and birth data from the Queensland PDC, which is mandatorily collected by clinicians at birth. Due to substantial changes in breastfeeding data coding in 2007, data prior to 1 July 2007 could not be included in this analysis. PDC reporting included infant feeding in the 24 hours prior to hospital discharge. One item 'Types of fluid baby received in the 24 hours prior to discharge' had one or more possible responses ('breast milk/colostrum', 'artificial milk/formula [AF]' or 'water, fruit juice or water-based products').

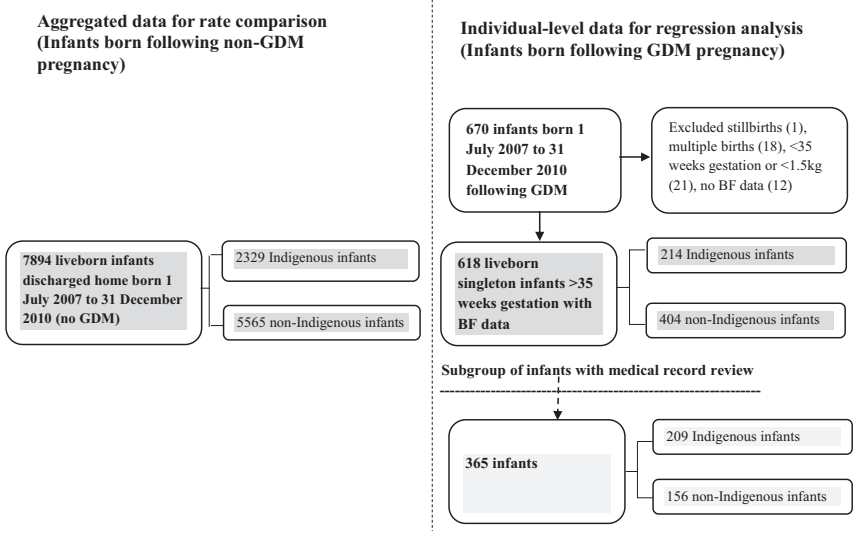
Available hospital medical records were reviewed for all Indigenous women coded as having GDM and a random sample of non-Indigenous women coded as having GDM, to validate the accuracy of GDM ascertainment and gather information on breastfeeding, reasons for admission to Special Care Nursery (SCN), reasons for administration of AF, body mass index (BMI) and diabetes treatment. "Reasons for SCN admission and AF administration" were collected as free text descriptions and coded independently by two researchers; with advice from a third researcher where discrepancies existed. The reasons for SCN admission were coded as 'Blood Glucose Level (BGL) monitoring' if that was the only reason described. Where infant illness, prematurity or other factors were listed in conjunction with BGL monitoring, these were coded as the 'primary reason for SCN admission'. The reasons for AF administration were similarly coded as 'neonatal hypoglycaemia' if that was the only factor identified. Where infant illness, prematurity or other factors were identified in conjunction with neonatal hypoglycaemia, these were coded as the 'primary reason for artificial formula administration'. The aim was to identify the proportion of infants experiencing SCN admission and AF administration with minimal complications.

In-hospital infant feeding methods were categorised as *predominant* breastfeeding ('breastmilk' or 'breast milk and water, fruit juice or water-based products'), and *any* breastfeeding ('breast milk' or 'breast and AF'), consistent with World Health Organization definitions.[20] Between seven and 10 antenatal visits are recommended in Australia, so the number of antenatal visits was coded as 'fewer than 8' or '8 or more'. Gestation was coded in relation to the presence of the newborn suck reflex (35 weeks), and the international definition of prematurity,[21] less than 37 weeks. Infants less than 35 weeks gestation, <1,500 g, and multiple births were excluded from individual-level data.

Data analysis

De-identified data were analysed in Stata 13.[22] In aggregate-level analysis, rates of breastfeeding (*predominant* breastmilk and *any* breast milk) among Indigenous and non-Indigenous women were compared by GDM status and infant's year of birth, using a logistic binomial regression model with interactions between pairs of these variables tested. Sensitivity analyses were conducted inclusive of pre-term and low birth weight infants among women with GDM. In individual-level analysis, logistic regression was used to describe associations of various factors with breastfeeding among women with GDM. Factors available among all Indigenous and non-Indigenous infants born to women with GDM included country of birth, Indigenous status, remoteness, age, parity, number of antenatal visits, smoking during pregnancy, medical complications, induction of labour, mode of birth, gestation, infant birth weight, and admission to special care nursery. Additional factors available in the subset of infants with medical record review included maternal BMI and diabetes treatment. Models were applied to Indigenous and non-Indigenous infants separately for each factor of interest. Difference in the strength of a factor's association with breastfeeding between Indigenous and non-Indigenous infants was assessed by including all infants in the analysis and including an interaction term between the factor and Indigenous status in the model, with a likelihood ratio test used to

Figure 1: Flow chart of included infants.



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calculate a single *p*-value for the interaction. Additional analyses used the same models but with adjustment for variables of interest. Two tailed tests were conducted and $p<0.05$ was considered statistically significant.

Results

From 1 July 2007 to 31 December 2010, 7,894 live-born infants were born at Cairns Hospital to mothers without GDM and discharged home (Indigenous=2,329, non-Indigenous=5,565); individual-level characteristics (other than GDM, Indigenous and breastfeeding status) were not available for these infants. Individual-level data were available for 670 infants born following a GDM pregnancy, identified in the CHCCS. We excluded infants stillborn (n=1), less than 35 weeks gestation or 1,500 g (n=21), where breastfeeding status was unknown (n=12), and multiple births (n=18) leaving 618 live-born singleton infants following GDM pregnancy, with individual level data (Indigenous=214, non-Indigenous=404). Medical record review data were extracted for almost all Indigenous infants (n=209) and a random sample of non-Indigenous infants (n=156) (Figure 1). The characteristics of included infants born to mothers with GDM are described in Supplementary Table 1.

Rates of breastfeeding among Indigenous and non-Indigenous women with and without GDM

Predominant breastfeeding (Figure 2)

About 80% of women without GDM reported *predominant* breastfeeding in the 24 hours prior to hospital discharge, with little change over time. Rates were significantly lower among women with GDM ($p<0.0001$), despite significant increases from 2007 to 2010 ($p<0.0001$), from 36% to 64% among Indigenous women, and 55% to 64% among non-Indigenous women. The *p*-value for the differing patterns of change over time by GDM status was $p^{interaction}=0.003$. Despite increases over time, women with GDM remained much less likely to *predominantly* breastfeed than women without GDM (OR 0.32, 95%CI 0.27-0.38, $p\leq0.0001$); and Indigenous women were less likely to *predominantly* breastfeed, compared with non-Indigenous women (OR 0.78, 95%CI 0.70-0.88, $p\leq0.0001$) (supplementary Table 2). No significant differences were seen in sensitivity analysis including pre-term and low birth weight infants among women with GDM.

Any breastfeeding (Figure 3)

Rates of *any* breastfeeding remained high (82% to 96%) from 2007 to 2010 among all women in the 24 hours prior to hospital discharge. There were no significant changes over time. Among women without GDM there was no difference between Indigenous and non-Indigenous women. Among women with GDM, Indigenous women were less likely to report *any* breastfeeding than non-Indigenous women, $p^{interaction}=0.04$. However, this difference did not remain significant in sensitivity analysis including pre-term and low birth weight infants among women with GDM ($p^{interaction}=0.69$) (supplementary Table 3).

Associations with breastfeeding among Indigenous and non-Indigenous women with GDM

Predominant breastfeeding (Table 1)

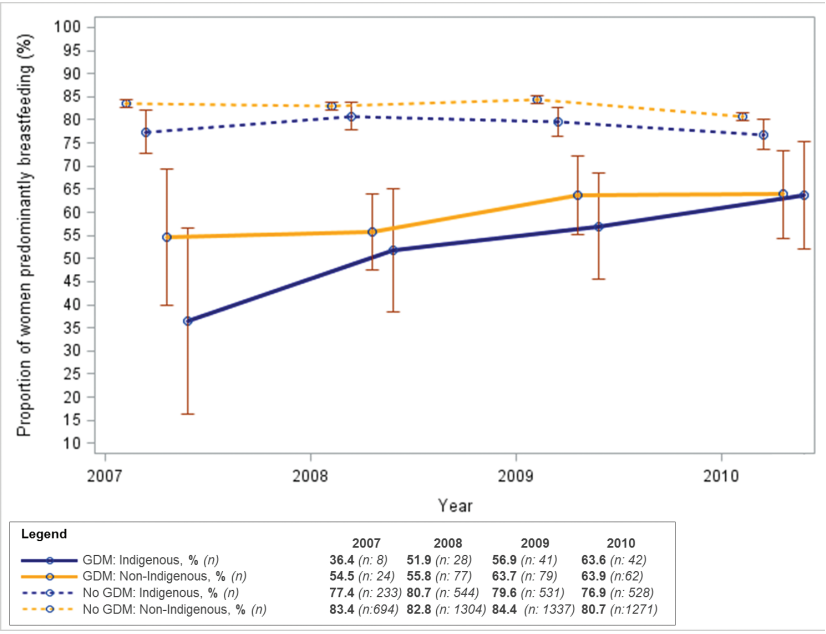
Among women with GDM, there was no significant difference in the rate of *predominant* breastfeeding among Indigenous women compared with non-Indigenous women when outcomes were adjusted for all available variables in multivariate analysis (maternal age, parity, remoteness, smoking, induction, caesarean, pre-term, low birth weight, abnormal BMI, or diabetes treatment) (OR 1.10, 95%CI 0.65-1.87, $p=0.73$). However, in subgroup analysis, *predominant* breastfeeding was less likely among women having a caesarean section than women having a vaginal birth, a relationship that held for both Indigenous (OR 0.53, 95%CI 0.30-0.91, $p=0.02$) and non-Indigenous (OR 0.63, 95%CI 0.41-0.96, $p=0.03$) women. Indigenous infants 35-36.9 weeks gestation were less likely than term Indigenous infants to receive *predominantly* breast milk (OR 0.22, 95%CI 0.07-0.70, $p=0.01$).

In sensitivity analysis conducted without infants born less than 37 weeks gestation and <2,500 g, the difference moved towards non-significance for non-Indigenous women having a caesarean birth (OR 0.65, 95%CI 0.42-1.01, $p=0.06$).

Any breastfeeding (Table 2)

Among women with GDM, there was no significant difference in the rate of *any* breastfeeding among Indigenous women compared with non-Indigenous women when outcomes were adjusted for all available variables in multivariate analysis (maternal age, parity, remoteness, smoking, induction, caesarean, pre-term, low birth weight, abnormal BMI, or diabetes treatment) (OR 0.76, 95%CI 0.25-2.29, $p=0.62$). However, in subgroup analysis, *any* breastfeeding was less likely among Indigenous women who smoked during pregnancy (OR 0.39, 95%CI 0.15-1.00, $p=0.05$) and more likely among Indigenous women who were induced (OR 3.81, 95%CI 1.09-13.39, $p=0.04$). There were no observed associations with *any*

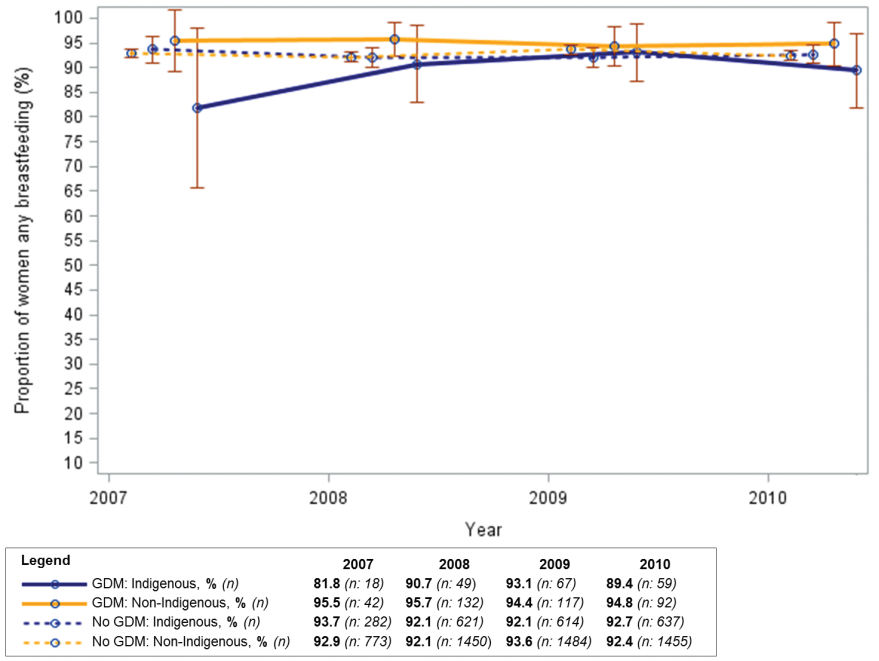
Figure 2: Proportion of infants of mothers with and without GDM reporting PREDOMINANT breastfeeding in the 24 hours prior to hospital discharge.



Note: Data are offset in order to display the 95 % confidence interval error bars clearly. The sample size varied from year to year, generally 2,100-2,400 births per year, for example in 2010 there were 1,574 non-Indigenous mothers without GDM, 687 Indigenous without GDM, 97 non-Indigenous with GDM, and 66 Indigenous with GDM. The generalised linear model included a linear term for year, i.e. assumed a constant change per year. Indicator variables were included for Indigenous status and GDM status. Each interaction between pairs of these three variables was included in the model as a multiplicative term involving the two relevant variables (see Supplementary Tables 2 and 3).

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Figure 3: Proportion of infants of mothers with and without GDM reporting any breastfeeding in the 24 hours prior to hospital discharge.



Legend	2007	2008	2009	2010
GDM: Indigenous, % *(n)*	**81.8** *(n: 18)*	**90.7** *(n: 49)*	**93.1** *(n: 67)*	**89.4** *(n: 59)*
GDM: Non-Indigenous, % *(n)*	**95.5** *(n: 42)*	**95.7** *(n: 132)*	**94.4** *(n: 117)*	**94.8** *(n: 92)*
No GDM: Indigenous, % *(n)*	**93.7** *(n: 282)*	**92.1** *(n: 621)*	**92.1** *(n: 614)*	**92.7** *(n: 637)*
No GDM: Non-Indigenous, % *(n)*	**92.9** *(n: 773)*	**92.1** *(n: 1450)*	**93.6** *(n: 1484)*	**92.4** *(n: 1455)*

Note: Data are offset in order to display the 95 % confidence interval error bars clearly. The sample size varied from year to year, generally 2100-2400 births per year, for example in 2010 there were 1574 non-Indigenous mothers without GDM, 687 Indigenous without GDM, 97 non-Indigenous with GDM, and 66 Indigenous with GDM. The generalised linear model included a linear term for year, i.e. assumed a constant change per year. Indicator variables were included for Indigenous status and GDM status. Each interaction between pairs of these three variables was included in the model as a multiplicative term involving the two relevant variables (see Supplementary Tables 2 and 3).

breastfeeding among non-Indigenous women. A possible tendency in Indigenous women towards a lower rate of *any* breastfeeding among those aged over 25 years compared to those <25 years (OR 0.16, 95%CI 0.02-1.26, *p*=0.08) was opposite to the observed relationship in non-Indigenous women, for whom the older women had a higher rate than their counterparts <25 years (OR 2.15, 95%CI 0.60-7.78, p=0.2; *p*-value for interaction between age and Indigenous status = 0.02).

In sensitivity analysis excluding infants born less than 37 weeks gestation and <2,500 g, the associations trended towards less significance for smoking during pregnancy (OR 0.32, 95%CI 0.15-1.09, p=0.07) and having an induction (OR 3.25, 95%CI 0.91-11.57, *p*=0.07) among Indigenous women. Non-Indigenous women with more than one infant were significantly less likely to breastfeed than women having their first birth (OR 0.20, 0.05-0.88, *p*=0.03).

Review of medical records

Documented reasons for Special Care Nursery (SCN) admission

Medical records for 365 mothers of infants born following GDM were reviewed and 338 infants (92.6%) were coded as experiencing a SCN admission. In line with hospital policy prior to 2010 for infants born to mothers with GDM, in 288 (85.2%) infants the primary documented reason for SCN admission was for BGL monitoring, and 171 (50.6%) of infants admitted for monitoring had no neonatal hypoglycaemia. Other primary reasons for SCN admission included prematurity (5.9%), medical conditions (4.7%), and other reasons (0.6%); with 3.6% coded as 'unspecified' (supplementary Table 4).

Documented reasons for administration of Artificial Formula (AF)

One hundred and fifty-six (42.7%) infants with medical record review received AF, with 92 (25.2%) receiving AF only. Neonatal hypoglycaemia and excessive weight loss were the most frequent reasons described for 50 (32.1%) infants receiving AF. Other primary reasons included maternal request (26.3%), prematurity (3.9%), maternal breastfeeding problems (6.4%), and maternal medical problems (1.9%); with 26.3% unspecified (supplementary Table 5).

Discussion

Most women giving birth at Cairns Hospital reported *any* breastfeeding around the time of discharge, and there were no significant differences observed by GDM or Indigenous status. However, despite increases over time, rates of *predominant* breastfeeding among women with GDM were significantly lower than rates among women without GDM; with the lowest rates observed among Indigenous women with GDM. These differences by Indigenous status were not seen when outcomes were adjusted for all variables in multivariate analysis, however, the significance in the context of marked inequities experienced by Indigenous people in Australia is unclear. It is possible these lower breastfeeding rates are confounded by lower socio-economic status.[15] There were few significant associations with *any* or *predominant* breastfeeding in subgroup analyses.

These findings support those of other studies reporting high rates of *any* breastfeeding around the time of discharge among Indigenous and non-Indigenous women in Australia and overseas.[23] Our findings of lower rates of *predominant* breastfeeding among Indigenous compared with non-Indigenous women in Australia; and women with GDM compared with women without GDM, reinforce earlier studies.[14,24] Importantly, these findings build on the previous small study demonstrating lower rates of breastfeeding among Indigenous Australian women with GDM,[16] highlighting a priority area for intervention. As far as we are aware, this study is the first to report associations with breastfeeding among Indigenous Australian women with GDM.

Major strengths of this study are that it uses data linkage and included all women identified with GDM giving birth at Cairns Hospital, thereby minimising selection bias; a critical consideration in studies of breastfeeding behaviour that is strongly influenced by confounders. However, there are a number of limitations. First, reporting and coding of infant feeding data in the PDC is variable and significant changes occurring during the study period precluded use of data prior to July 2007, which reduced the study power and our capacity to detect significant associations. Second, these data only illustrated the 24 hours prior to discharge; longer-term follow up may have increased our understanding of breastfeeding practices in this cohort.[25] Finally, this study involves secondary analysis of data from women with GDM with limited data on characteristics of women who didn't breastfeed; only aggregate data were available for women without GDM.

This study reinforces the importance of supporting women with GDM to breastfeed

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their infants predominantly with breastmilk in hospital, particularly for Indigenous women. The risks of AF for infants are well understood,[26] and supporting women to breastfeed is particularly important for preventing T2DM among women and their infants who are already at high risk of developing T2DM following GDM,[11] particularly Indigenous women. Primary analysis of our data demonstrated that Indigenous women with GDM had a four-fold risk of developing T2DM compared with non-Indigenous women, but rates of progression were halved for women who predominantly breastfed in hospital.[5]

There are complex psychosocial, physiological and practical challenges for breastfeeding among women with GDM. A study among Indigenous women with GDM in the United States reported a high 'perception of risk' coupled with low levels of self-efficacy for preventing cardio-metabolic disease,[27,28] a combination associated with avoidance behaviour.[29] This suggests recommendations to include confidence-building ('strengths-based') strategies in breastfeeding support[30] may be particularly important for Indigenous women with GDM. Women with GDM experience delayed lactogenesis (onset of lactation)[31] and increased risks of caesarean section. In addition to the discomfort of having a caesarean and the challenges of enabling early skin-to-skin contact in an operating theatre, having a caesarean may further delay lactogenesis,[32] and was associated with lower rates of predominant breastfeeding in this study. Delayed lactogenesis compounds the already increased risk of neonatal hypoglycaemia for infants born to women with GDM[3] that was identified as a major documented reason for provision of AF in this study.

Pregnancy and early childhood offer a 'window of opportunity' to provide support for women with GDM,[5] and breastfeeding is recognised as an important and feasible strategy[33] to mediate health risks after GDM for women and their infants.[34] Supporting Indigenous women with GDM to breastfeed has been shown to be acceptable and effective in achieving measurable and improved infant outcomes in the United States.[35] Strategies to support breastfeeding in hospital among Indigenous women in Australia should form an important element of strategies to improve health equity.

Strategies to increase support for women with GDM and Indigenous women to exclusively breastfeed in hospital involve as much focus on hospital policies and practices as they do on the behaviour of women themselves, and many initiatives have already been implemented in Far North Queensland. We found very high rates of infant SCN admissions (93%) after GDM pregnancy, consistent with hospital policy; with the predominant documented reason being for BGL monitoring. Among infants of mothers with GDM given AF, the primary documented reasons were for treatment of neonatal hypoglycaemia, followed by maternal request. In 2010, state-wide guidelines for neonatal hypoglycaemia management were

Table 1: Associations with reporting PREDOMINANT breastfeeding in 24 hours prior to hospital discharge among women with GDM.

Maternal and Infant Characteristics	Indigenous				Non-Indigenous				Indigenous and non-Indigenous ORs: Evidence of a difference
	n	OR	(95%CI)	*p*	n	OR	(95%CI)	*p*	*p*
All	**214**				**403**				
Age (Years)									
<25	46	Ref			32	Ref			
25+	168	1.1	(0.6–2.1)	0.9	371	1.00	(0.5–2.2)	0.9	1
Parity									
Primiparous (1)	41	Ref			41	Ref			
Multiparous (2+)	173	1	(0.5–1.9)	0.9	173	1.00	(0.5–1.9)	0.6	1
Remoteness[a]									
Remote/Very remote	80	Ref			15	Ref			
Cairns	134	1.3	(0.8–2.3)	0.3	387	0.5	(0.2–1.7)	0.3	0.2
Number of antenatal visits									
<8	70	Ref			55	Ref			
8+	143	1.1	(0.6–1.9)	0.8	341	1.2	(0.7–2.2)	0.5	0.7
Smoking after 20 weeks									
No	116	Ref			333	Ref			
Yes	98	0.7	(0.4–1.1)	0.1	68	1.00	(0.6–1.7)	1	0.3
Medical complications[b]									
No	106	Ref			303	Ref			
Yes	108	0.7	(0.4–1.3)	0.3	100	0.7	(0.5–1.1)	0.1	0.9
Induction of labour									
No	136	Ref			209	Ref			
Yes	78	1	(0.6–1.7)	0.9	193	0.9	(0.6–1.4)	0.7	0.9
Mode of birth									
Unassisted vaginal	110	Ref			187	Ref			
Assisted vaginal	4	1.8	(0.2–17.7)	0.6	39	0.6	(0.3–1.2)	0.1	0.5
Caesarean	100	0.5	(0.3–0.9)	0.02	177	0.6	(0.4–1.0)	0.03	
Gestation (weeks)									
37+	197	Ref			384	Ref			
35-36.9	17	0.2	(0.1–0.7)	0.01	19	1.1	(0.4–3.0)	0.8	0.03
Birth weight (grams)									
2500-3999	175	Ref			357	Ref			
1500-2499	4	0.2	(0.0–2.4)	0.2	14	0.9	(0.3–2.6)	0.8	
4000+	35	0.7	(0.3–1.4)	0.3	32	1.3	(0.6–2.7)	0.5	0.3
Admission SCN									
No	15	Ref			67	Ref			
Yes	199	0.6	(0.2–1.8)	0.4	336	0.6	(0.3–1.1)	0.07	1
Medical record review	**209**				**156**				
BMI at 1st antenatal visit (kg/m^2)									
18.5-24	27	Ref			46	Ref			
<18.5	5	4.3	(0.4–43.7)	0.2	1	NA			
25-29	53	1.4	(0.6–3.6)	0.5	38	0.8	(0.3–2.0)	0.7	
30+	121	1.5	(0.6–3.4)	0.9	70	0.5	(0.2–1.1)	0.1	0.3
DIP Treatment									
Diet only	87	Ref			56	Ref			
Insulin	84	0.7	(0.4–1.3)	0.3	84	0.7	(0.3–1.4)	0.3	
Oral Meds	9	1.4	(0.3–5.7)	0.7	1	NA			0.8[c]
Insulin and Oral Meds	24	2.6	(0.7–5.6)	0.7	8	1.9	(0.4–10.5)	0.4	

a Accessibility/Remoteness Index of Australia code

b Medical complications existing prior to pregnancy

c Treatment categories combined for likelihood ratio test (insulin, oral medication, and both).

SCN = Special Care Nursery, BMI=Body Mass Index, DIP=Diabetes in Pregnancy, NA=not assessable. Small amount of missing data not included therefore not all variable numbers add up to totals or make 100%

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introduced in Cairns Hospital[36] in line with international policy[37] and the Baby Friendly Hospital Initiative.[38] Prior to these guidelines, standard practice included admission of infants born following GDM to SCN for BGL monitoring, but this was changed so that infants were no longer routinely separated from their mothers. Cairns Hospital policy is to advise women to express colostrum in the antenatal period, to promote lactogenesis and ensure an alternative to formula milk is available to manage neonatal hypoglycaemia, however, the evidence of safety and efficacy remains unclear.[39] Research is needed to examine changes in duration of breastfeeding over time with the introduction of these guidelines. Other potentially effective initiatives include supporting early skin-to-skin contact for women having a caesarean, including in the operating theatre,[40] education and peer support[41] and telephone support.[42]

There is a complex relationship between maternal smoking and reduced breastfeeding – both are strongly influenced by confounders and recognised as 'proxy-measures' for lower socioeconomic status. It is unclear whether anti-smoking messages, including those that advise not smoking around the infant while breastfeeding, are negatively affecting breastfeeding intention among women who smoke during pregnancy.[43] We suggest this potential interaction requires further investigation.

Table 2: Associations with reporting ANY breastfeeding in the 24 hours before hospital discharge among women with GDM.

Maternal and Infant Characteristics	Indigenous				Non-Indigenous				Indigenous and non-Indigenous ORs: Evidence of a difference
	n	OR	(95%CI)	p	n	OR	(95%CI)	p	p
All	**214**				**403**				
Age (Years)									
<25	46	Ref			32	Ref			
25+	168	0.2	(0.0–1.3)	0.08	371	2.2	(0.6–7.8)	0.2	0.02
Parity									
Primiparous (1)	41	Ref			41	Ref			
Multiparous (2+)	173	0.4	(0.1–1.9)	0.3	173	0.3	(0.1–1.1)	0.06	0.8
Remoteness[a]									
Remote/Very remote	80	Ref			15	Ref			
Cairns	134	1.3	(0.5–3.2)	0.6	387	3.2	(0.7–15.0)	0.2	0.3
Number of antenatal visits									
<8	70	Ref			55	Ref			
8+	143	1	(0.4–2.7)	1	341	1.6	(0.5–5.0)	0.4	0.6
Smoking after 20 weeks									
No	116	Ref			333	Ref			
Yes	98	0.4	(0.2–1.0)	0.05	68	1.2	(0.3–4.1)	0.8	0.2
Medical complications[b]									
No	106	Ref			303	Ref			
Yes	108	0.7	(0.3–1.8)	0.5	100	1	(0.4–2.8)	1	0.7
Induction of labour									
No	136	Ref			209	Ref			
Yes	78	3.8	(1.1–13.4)	0.04	193	0.9	(0.4–2.3)	0.9	0.07
Mode of birth									
Unassisted vaginal	110	Ref			187	Ref			
Assisted vaginal	4	NA			39	NA			
Caesarean	100	0.8	(0.3–2.0)	0.7	177	0.9	(0.4–2.3)	0.9	0.8
Gestation (weeks)									
37+	197	Ref			384	Ref			
35-36.9	17	0.8	(0.2–3.8)	0.8	19	NA			NA
Birth weight (grams)									
2,500-3,999	175	Ref			357	Ref			
1,500-2,499	4	NA			14	0.7	(0.1–5.3)	0.7	0.8
4,000+	35	0.6	(0.2–1.8)	0.4	32	0.8	(0.2–3.4)	0.7	
Admission SCN									
No	15	Ref			67	Ref			
Yes	199	0.7	(0.1–3.3)	0.6	336	1.1	(0.3–4.0)	0.8	0.6
Medical record review	**209**				**156**				
BMI at 1st antenatal visit (kg/m^2)									
18-24	30	Ref			47	Ref			
<18	2	NA			0	NA			
25-29	53	0.9	(0.2–5.1)	0.9	38	0.8	(0.1–13.3)	0.9	1
30+	121	0.5	(0.1–2.3)	0.4	70	0.3	(0.0–3.3)	0.4	
DIP Treatment									
Diet only	87	Ref			56	Ref			
Insulin	84	0.7	(0.3–1.8)	0.4	84	1.5	(0.3–7.9)	0.6	0.45[c]
Oral Meds	9	0.8	(0.1–7.3)	0.9	1	NA			
Insulin and Oral Meds	24	NA			8	NA			

a Accessibility/Remoteness Index of Australia code

b Medical complications existing prior to pregnancy

c Treatment categories combined for likelihood ratio test (insulin, oral medication, and both).

SCN = Special Care Nursery, BMI=Body Mass Index, DIP=Diabetes in Pregnancy, NA=not assessable. Small amount of missing data not included therefore not all variable numbers add up to totals or make 100%

Conclusion

While most women report *any* breastfeeding around the time of discharge from hospital, women with GDM were less likely to predominantly breastfeed, with the lowest rates seen among Indigenous women with GDM. To overcome numerous challenges, strategies are urgently needed to improve support for exclusive breastfeeding in hospital among women with GDM, particularly Indigenous women, who experience higher risks of developing T2DM. Potential strategies are likely to require tailoring to specific needs, including for women who have a caesarean birth or pre-term infant. They should be strengths-based to improve self-efficacy; in contrast to an emphasis on risks. Importantly, strategies to improve in-hospital breastfeeding will need to address hospital policies and practices as much as focus on women's behaviour.

Implications for public health

Women *with* gestational diabetes mellitus (GDM) are less likely to breastfeed than women *without* GDM. However, breastfeeding rates among Indigenous women with GDM are unknown, despite being particularly affected by diabetes. Our findings suggest that rates of predominant breastfeeding in hospital among Indigenous women with GDM are even lower than among non-Indigenous women with GDM. This is in contrast to anecdotal misconceptions that breastfeeding is somehow 'easy and natural' for Indigenous women. Strategies to increase rates of predominant breastfeeding in

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hospital are urgently needed to reduce the risks associated with GDM for women and their infants. This is particularly important for Indigenous women who experience the highest risks and have the lowest rates of predominant breastfeeding.

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References

1. World Health Organization. *Diagnostic Criteria and Classification Of Hyperglycaemia First Detected in Pregnancy*. Geneva (CHE): WHO; 2013.
2. Ferrara A. Increasing prevalence of gestational diabetes mellitus: A public health perspective. *Diabetes Care*. 2007;30 Suppl 2:141-6.
3. HAPO Study Cooperative Research Group. Hyperglycaemia and adverse pregnancy outcomes. *N Engl J Med*. 2008;358(19):1991-2002.
4. Bellamy L, Casas J-P, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: A systematic review and meta-analysis. *Lancet*. 2009;373(9677):1773-9.
5. Chamberlain C, Oldenburg B, Wilson A, Eades S, O'Dea K, Oats J, et al. Type 2 diabetes after gestational diabetes: Greater than a fourfold risk among Indigenous compared to non-Indigenous Australian women. *Diabetes Metab Res Rev*. 2016;32(2):217-27
6. Pettitt DJ, Nelson RG, Saad MF, Bennett PH, Knowler WC. Diabetes and obesity in the offspring of Pima Indian women with diabetes during pregnancy. *Diabetes Care*. 1993;16(1):310-14.
7. Vrachnis N, Antonakopoulos N, Iliodromiti Z, Dafopoulos K, Siristatidis C, Pappa KI, et al. Impact of maternal diabetes on epigenetic modifications leading to diseases in the offspring. *Exp Diabetes Res*. 2012;2012:e538474.
8. Donovan LE, Cundy T. Does exposure to hyperglycaemia in utero increase the risk of obesity and diabetes in the offspring? A critical reappraisal. *Diabet Med*. 2015;32(3):295-304.
9. Kim SY, Sharma AJ, Callaghan WM. Gestational diabetes and childhood obesity: What is the link? *Curr Opin Obstet Gynecol*. 2012;24(6):376-81.
10. Osgood ND, Dyck RF, Grassmann WK. The inter- and intragenerational impact of gestational diabetes on the epidemic of type 2 diabetes. *Am J Public Health Res*. 2011;101(1):173-9.
11. Gunderson E, Hurston S, Ning X, Lo J, Crites Y, Walton D, et al. Lactation and progression to type 2 diabetes mellitus after gestational diabetes mellitus. *Ann Intern Med*. 2015;163:889-98.
12. Plagemann A, Harder T, Schellong K, Schulz S, Stupin JH. Early postnatal life as a critical time window for determination of long-term metabolic health. *Best Pract Res Clin Endocrinol Metab*. 2012;26(5):641-53.
13. Eades SJ, Read AW, McAullay D, McNamara B, O'Dea K, Stanley FJ. Modern and traditional diets for Noongar infants. *J Paediatr Child Health*. 2010;46(7-8):398-403.
14. Australian Bureau of Statistics. *4704.0 - The Health and Welfare of Australia's Aboriginal and Torres Strait Islander Peoples, Oct 2010* [Internet]. Canberra (AUST): ABS; 2011 [cited 2016 Aug 4]. Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/lookup/4704.0Chapter620Oct+2010
15. Amir LH, Donath SM. Socioeconomic status and rates of breastfeeding in Australia: Evidence from three recent national health surveys. *Med J Aust*. 2008;189(5):254-6.
16. Simmons D, Khan MA, Teale G, Simmons D, Khan MA, Teale G. Obstetric outcomes among rural Aboriginal Victorians. *Aust N Z J Obstet Gynaecol*. 2005;45(1):68-70.
17. Chamberlain C, McLean A, Oats J, Oldenburg B, Eades S, Sinha A, et al. Low rates of postpartum glucose screening among Indigenous and non-Indigenous women in Australia with gestational diabetes. *Matern Child Health J*. 2015;19(3):651-63.
18. Queensland Health. *Cairns Base Hospital and Associated Services Clinical Services Plan*. Cairns (AUST): State Government of Queensland; 2008.
19. Chamberlain C, Fredericks B, Davis B, Mein J, Smith C, Eades S, et al. Postpartum care for Aboriginal and non-Aboriginal women with gestational diabetes mellitus across urban, rural and remote locations: A protocol for a cohort linkage study. *Springerplus*. 2013;2:576.
20. World Health Organization. *Indicators for Assessing Infant and Young Child Feeding Practices: Part 1, Definitions*. Geneva (CHE): WHO; 2008.
21. World Health Organization. *Preterm Birth* [Internet]. Fact Sheet No.: 363. Geneva (CHE): WHO: 2015 [cited 2016 Jan 5]. Available from: http://www.who.int/mediacentre/factsheets/fs363/en/
22. *STATA:* Statistical Software. Release 13. College Station (TX): Stata Corporation; 2013.
23. Callen J, Pinelli J. Incidence and duration of breastfeeding for term infants in Canada, United States, Europe, and Australia: A literature review. *Birth*. 2004;31(4):285-92.
24. Oza-Frank R, Chertok I, Bartley A. Differences in breast-feeding initiation and continuation by maternal diabetes status. *Public Health Nutr*. 2015;18(4):727-35.
25. Quinlivan J, Kua S, Gibson R, McPhee A, Makrides M. Can we identify women who initiate and then prematurely cease breastfeeding? An Australian multicentre cohort study. *Int Breastfeed J*. 2015;10:16.
26. Binns CW, Lee MK. Exclusive breastfeeding for six months: The WHO six months recommendation in the Asia Pacific region. *Asia Pac J Clin Nutr*. 2014;23(3):344-50.
27. Jones EJ, Appel SJ, Eaves YD, Moneyham L, Oster RA, Ovalle F. Cardiometabolic risk, knowledge, risk perception, and self-efficacy among American Indian women with previous gestational diabetes. *J Obstet Gynecol Neonatal Nurs*. 2012;41(2):246-57.
28. Carson LD, Henderson JN, King K, Kleszynski K, Thompson DM, Mayer P. American Indian diabetes beliefs and practices: Anxiety, fear, and dread in pregnant women with diabetes. *Diabetes Spectrum*. 2015;28(4):258-63.
29. Rimal RN. Perceived risk and self-efficacy as motivators: Understanding individuals' long-term use of health information. *J Commun*. 2001;51(4):633-54.
30. Demirtas B. Strategies to support breastfeeding: A review. *Int Nurs Rev*. 2012;59(4):474-81.
31. DeBortoli J, Amir LH. Is onset of lactation delayed in women with diabetes in pregnancy? A systematic review. *Diabet Med*. 2016;33(1):17–24.
32. Rowe-Murray HJ, Fisher JRW. Baby friendly hospital practices: Cesarean section is a persistent barrier to early initiation of breastfeeding. *Birth*. 2002;29(2):124-31.
33. Murphy S, Wilson C. Breastfeeding promotion: A rational and achievable target for a type 2 diabetes prevention intervention in Native American communities. *J Hum Lact*. 2008;24(2):193-8.
34. Ramos DE. Breastfeeding: a bridge to addressing disparities in obesity and health. *Breastfeed Med*. 2012;7(5):354-7.
35. Karanja N, Aickin M, Lutz T, Mist S, Jobe JB, Maupome G, et al. A community-based intervention to prevent obesity beginning at birth among American Indian children: Study design and rationale for the PTOTS study. *J Prim Prev*. 2012;33(4):161-74.
36. Statewide Maternity and Neonatal Clinical Guidelines Program. *Neonatal Hypoglycaemia and Blood Glucose Level Monitoring*. Brisbane (AUST): State Government of Queensland; 2010.
37. United Nations International Children's Emergency Fund. *Guidance on the Development of Policies and Guidelines for the Prevention and Management of Hypoglycaemia of the Newborn*. New York (NY): UNICEF; 2007.
38. United Nations International Children's Emergency Fund, World Health Organization. *Baby-Friendly Hospital Initiative. Revised, Updated and Expanded for Integrated Care*. Geneva (CHE): WHO; 2009.
39. East CE, Dolan WJ, Forster DA. Antenatal breast milk expression by women with diabetes for improving infant outcomes (Cochrane Review). In: *The Cochrane Database Systematic Reviews;* 2014; (7): CD010408. Chichester (UK): Wiley; 2014.
40. Stevens J, Schmied V, Burns E, Dahlen H. Immediate or early skin-to-skin contact after a caesarean section: A review of the literature. *Matern Child Nutr*. 2014;10(4):456-73.
41. Chapman DJ, Morel K, Bermúdez-Millán A, Young S, Damio G, Pérez-Escamilla R. Breastfeeding education and support trial for overweight and obese Women: A randomized trial. *Pediatrics*. 2013;131(1):e162-e70.
42. Carlsen EM, Kyhnaeb A, Renault KM, Cortes D, Michaelsen KF, Pryds O. Telephone-based support prolongs breastfeeding duration in obese women: A randomized trial. *Am J Clin Nutr*. 2013;98(5):1226-32.
43. Amir LH, Donath SM. Does maternal smoking have a negative physiological effect on breastfeeding? The epidemiological evidence. *Birth*. 2002;29(2):112-23.

Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Maternal and infant characteristics among women with GDM, by breastfeeding category and Indigenous status.

Supplementary Table 2: Predominant breastfeeding interactions.

Supplementary Table 3: Any Breastfeeding interactions.

Supplementary Table 4: Primary reasons for Special Care Nursery (SCN) admission among women with GDM whose medical records were reviewed (n=365)

Supplementary Table 5: Primary reasons for artificial formula administration among women with GDM whose medical records were reviewed (n=156).

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