**Exclusive breastfeeding among women with type 1 and type 2 diabetes mellitus**

Leandro Cordero¹*, Michael R. Stenger¹, Mark B. Landon² and Craig A. Nankervis¹

**Abstract**

**Objective:** To compare exclusive breastfeeding (BF) and BF initiation among 185 women with Type 1 and 212 women with Type 2 pregestational diabetes who intended exclusive or partial BF and delivered at ≥34 weeks of gestation.

**Methods:** Retrospective cohort study. At discharge, exclusive BF is direct BF or BF complemented with expressed breast milk. BF initiation is defined by exclusive or partial BF.

**Results:** Type 1 and Type 2 groups were similar in prior BF experience (69 vs 67%) but were different in intention to BF exclusively (92 vs 78%) and partially (8 vs 22%). Women in the Type 1 group were younger (median age 30 vs 33y), likely to be primiparous (47 vs 25%), have a lower median BMI (32 vs 36 kg/m²) and deliver by primary cesarean (37 vs 26%). Infants born to Type 1 women were more likely to be admitted to the NICU (44 vs 18%) and to have hypoglycemia (59 vs 41%). At discharge, exclusive BF among Type 1 was higher (34 vs 23%), partial BF was similar (47 vs 46%) while FF (formula feeding) was lower (19 vs 31%) than in the Type 2 group. BF initiation occurred in 81% of Type 1 and 69% of Type 2 women.

**Conclusion:** Intention to BF exclusively was higher in Type 1 women compared to Type 2. At discharge, exclusive BF and BF initiation were lower and FF higher in the Type 2 group highlighting the need for different strategies if lactation in this special population is to be improved.

**Keywords:** Exclusive breastfeeding and type 1 and type 2 diabetes mellitus

---

**Background**

Pregestational diabetes mellitus (Type 1 and Type 2) affects 1–1.5% of all pregnant women and may lead to adverse maternal and neonatal outcomes [1]. Other investigators noted an increase in pregestational diabetes as well as preeclampsia, chronic hypertension and obesity among women hospitalized for delivery in the US from 2005 through 2014 [2]. Additionally, investigators in California observed an alarming rise in the prevalence of Type 1 and Type 2 diabetes as well as racial/ethnic disparities in pregnant women from 1996 through 2014 [3]. Of the patients studied, 24% were classified as Type 1 and 76% as Type 2. Women in the Type 2 group tended to be older, African American or Hispanic, multiparous, had a high BMI and delivered by cesarean [3].

Earlier publications on breastfeeding (BF) focused mainly on women with Type 1 or reported small samples of Type 1 and Type 2 [4, 5]. A collaborative study confirmed that the duration of exclusive and overall BF was shorter in Type 1 than in non-diabetic women [6]. More recently, Herskin et al. compared 105 Type 1 with 44 Type 2 dyads and reported different BF rates at hospital discharge (76 vs 45%) and at 4 months postpartum (49 vs 23%) [7].

Lactation is critical because it provides short- and long-term health benefits to mothers and their infants...
following healthy pregnancies as well as those compromised by gestational and pregestational diabetes [8–11]. Despite the above, comparisons of exclusive BF and BF initiation rates among women with Type 1 and Type 2 diabetes remain scarce and deserves further study.

**Objective**

To compare exclusive BF and BF initiation among 185 women with Type 1 and 212 women with Type 2 diabetes who intended exclusive or partial BF.

**Subjects and methods**

This retrospective cohort investigation was approved by the Institutional Review Board at The Ohio State University Wexner Medical Center. Electronic maternal and neonatal records (2013–18) were reviewed. Type 1 and Type 2 pregestational diabetes, chronic hypertension (CHTN) and preeclampsia were diagnosed and treated in accordance with established guidelines [1, 12]. Women were categorized by prepregnancy BMI as normal (18–24.9 kg/m²), overweight (25–29.9 kg/m²), obese (30–39.9 kg/m²), morbidly obese (40–49.9 kg/m²) or extremely obese (≥ 50 kg/m²) [13].

All women delivered singleton infants at ≥34 weeks gestation and those affected by major fetal malformations were not included. Upon arrival to labor and delivery, each woman described her past BF experience and her intention to BF. In our institution, maternity practices include BF within 1 h, no formula supplementation unless indicated, rooming in, on demand BF, full-time lactation consultants and post discharge BF support [14–16]. Furthermore, our institution reports BF data to the Joint Commission as required for hospital accreditation [15].

Per our hospital practice, symptomatic infants were directly transferred from the delivery room to the NICU for further care. Following delivery if the condition of the mother and her infant allowed, maternal-infant interactions such as holding, skin-to-skin contact, and BF were encouraged. Asymptomatic infants able to feed were transferred to the newborn nursery for routine care and glucose monitoring [17].

Screening for hypoglycemia (blood glucose < 40 mg/dl) was done via serial point of care testing (Accu-Chek®) or by plasma glucose measurement in the laboratory (Beckman Coulter AU5800, Beckman Coulter Inc., Brea, CA, USA) starting within the first hour of life after the first feeding and every 2–4 h thereafter as needed. Asymptomatic infants in the newborn nursery with hypoglycemia were promptly BF or formula fed (FF) and those with recurrent hypoglycemia were transferred to the NICU for further care. On admission to the NICU, most infants were started on intravenous (IV) dextrose while those who were able to feed were BF or FF [17].

BF was considered early if given within the first two postpartum hours. Exclusive BF was defined as direct feedings from the breast, expressed breast milk (EBM) alone or in combination with direct BF or with donor human milk while hospitalized. Partial BF was defined as formula supplementation with direct BF or with EBM. BF was considered initiated if, during the 24 h preceding hospital discharge, infants were BF exclusively or BF partially [17]. Due to the retrospective study design, no follow-up information was available on infant feeding practices after hospital discharge.

**Statistical analysis**

Comparisons between women with Type 1 and Type 2 pregestational diabetes were made with Mood’s median tests for continuous variables and Chi square tests for categorical variables. Significance was established at a p value < 0.05. To assess the normality of quantitative variables, we examined quantile-quantile (‘Q-Q’) plots for visible deviations from model assumptions. No such issues were seen. Univariate and multivariate stepwise logistic regression were used to ascertain the strength of association of Type 1 and Type 2 diabetes with exclusive BF and BF initiation at discharge controlling for maternal variables (CHTN, preeclampsia, mothers age, race, BMI, elevated hemoglobin A1c (HbA1c) levels (≥ 7.0%), multiparity, mode of delivery, prior BF, intention to BF exclusively, breastfed < 2 h from birth) and neonatal variables (gestational age, preterm, admission to NICU, neonatal hypoglycemia and infant length of stay). To test for collinearity between independent variables, we removed each one at a time from the full adjusted models presented and confirmed that the remaining estimates did not change drastically, which was always the case.

**Results**

The study population consisted of 185 women with Type 1 and 212 women with Type 2 pregestational diabetes who intended to BF.

**Comparison of women with type 1 and type 2 diabetes**

Clinical and demographic characteristics of women with Type 1 and Type 2 diabetes are shown in Table 1. The prevalence of CHTN alone (10 vs 18%) and preeclampsia superimposed on CHTN (8 vs 8%) were similar for Type 1 and Type 2 women. Preeclampsia as a single co-morbidity was more common among Type 1 than Type 2 women (21 vs 7%, p 0.0001). Preeclampsia alone or superimposed on CHTN combined affected 53 (29%) of Type 1 and 30 (14%) of Type 2 women. All women with
preeclampsia with severe features received magnesium sulfate neuroprophylaxis for 24 h.

Women with Type 2 diabetes tend to be older, multiparous, less often white, more often Hispanic and of other ethnicities. Median pregestational BMI was higher among African Americans (36.2 kg/m²) and Hispanics (35.0 kg/m²) than among whites (34.0 kg/m²) and women in the miscellaneous group (30.9 kg/m²). Normal/overweight (BMI ≤ 29 kg/m²) women were more common in Type 1 (35 vs 13%), obese women (BMI 30–39 kg/m²) were equally represented (47 vs 47%) and morbidly/extremely obese (BMI ≥ 40 kg/m²) women were more common in Type 2 (40 vs 18%). Single HbA1c determinations were recorded from all 185 Type 1 and from 98% of 212 Type 2 women. HbA1c tests were done after 20 weeks of gestation in 99% of the Type 1 and in 99% of the Type 2 women. Gestational age at the time of testing was a median 31 weeks (8-39w) for Type 1 and 32 weeks (15-39w) for Type 2 women. Elevated HbA1c (≥ 7.0%) was found in 43 of 185 Type 1 (23%) and in 39 of 207 (19%) of Type 2. Regression analysis showed that after adjusting for confounders, elevated HbA1c (≥ 7.0%) was not an independent predictor of exclusive BF or BF initiation for either Type 1 or Type 2 diabetic women.

**Neonatal outcomes of infants born to women with type 1 and type 2 diabetes**

Infants born to Type 1 women were of lower median gestational age (37 vs 38w) and of higher median birth-weight (3618 vs 3390 g) (Table 2). Both groups were similar in small for GA (3 vs 2%), large for GA (41 vs 37%) and appropriate for GA (57 vs 60%) infants. Of note, macrosomia (birthweight ≥4000 g) affected 23 and 22% of infants in Type 1 and Type 2 groups, respectively.

Neonatal hypoglycemia and admission to the NICU occurred more often among infants in the Type 1 group than in the Type 2 group. Considering the similarities in diagnoses, 82 infants from the Type 1 group and 38 infants from the Type 2 group admitted to the NICU were combined for analysis. Seventy-five of the 120 (63%) infants were admitted to the NICU directly from the delivery room while the remaining 45 (37%) stayed in the newborn nursery for a short time prior to transfer. Primary admission diagnoses to the NICU included hypoglycemia (62%), respiratory distress (33%) and

| Table 1 | Comparison of women with Type 1 and Type 2 Diabetes |
|---------|--------------------------------------------------|
|         | Type 1 | Type 2 | p       |
| Mother-Infant dyads no. | 185    | 212    |         |
| Pregestational DM without comorbidities no. (%) | 114 (62) | 144 (68) | NS |
| Chronic hypertension no. (%) | 18 (10) | 38 (18) | NS |
| Preeclampsia superimposed on CHTN no. (%) | 15 (8) | 16 (8) | NS |
| Preeclampsia no. (%) | 38 (21) | 14 (7) | 0.0001 |
| Mother’s age (y) median (IQR) | 30 (26,34) | 33 (29,36) | < 0.0001 |
| Race | | | |
| African American no. (%) | 40 (22) | 52 (25) | NS |
| White no. (%) | 133 (72) | 73 (34) | 0.0001 |
| Hispanic no. (%) | 7 (4) | 55 (26) | 0.0001 |
| Other no. (%) | 5 (3) | 32 (15) | 0.0001 |
| Smoking during pregnancy no. (%) | 10 (5) | 16 (8) | NS |
| Former smokers no. (%) | 22 (12) | 34 (16) | NS |
| BMI kg/m² median (IQR) | 32 (28,37) | 36 (31,42.5) | < 0.0001 |
| Normal/overweight-BMI kg/m² ≤ 29 no. (%) | 64 (35) | 28 (13) | 0.0001 |
| Obese-BMI kg/m² 30–39 no. (%) | 87 (47) | 100 (47) | NS |
| Morbidly/extremely obese-BMI ≥ 40 no. (%) | 34 (18) | 84 (40) | 0.0001 |
| Multiparous no. (%) | 98 (53) | 159 (75) | 0.0001 |
| Mode of Delivery | | | |
| Vaginal no. (%) | 67 (36) | 85 (40) | NS |
| Primary cesarean no. (%) | 68 (37) | 56 (26) | 0.03 |
| Repeat cesarean no. (%) | 50 (27) | 71 (34) | NS |
| Mother length of stay (d) median (IQR) | 4 (3.5) | 4 (3.4) | 0.002 |
apnea-bradycardia-cyanosis (5%). Additionally, temperature instability-hypotonia-poor feeding affected one-third of all infants. Twenty-two of the 120 infants (18%) stayed in the NICU for less than 1 day, 23 infants (19%) stayed 2 days and the remaining 75 (63%) stayed 3 days or longer. All mothers and their infants were discharged home in good condition.

Prior BF experience and early BF among women with type 1 and type 2 diabetes

The prevalence of multiparous women was lower in the Type 1 than in the Type 2 group (53 vs 75%), however, relevant to our study, prior BF experience among the multiparous women in either group was similar (69 vs 67%) (Table 3).

Table 2 Neonatal outcomes of infants born to women with Type 1 and Type 2 Diabetes

|                        | Type 1 | Type 2 | p     |
|------------------------|--------|--------|-------|
| Males no. (%)          | 94 (51)| 114 (54)| NS    |
| Birthweight (g) median (IQR) | 3618 (3172, 3959) | 3390 (3107, 3922) | 0.002 |
| Gestational age (w) median (IQR) | 37 (37,38) | 38 (37,39) | 0.02 |
| Preterm no. (%)        | 40 (22) | 34 (16) | NS    |

Intrauterine Growth

|                        | Type 1 | Type 2 | p     |
|------------------------|--------|--------|-------|
| Small for gestational age no. (%) | 5 (3) | 5 (2) | NS    |
| Large for gestational age no. (%) | 75 (41) | 79 (37) | NS    |
| Macrosomia no. (%)      | 43 (23) | 47 (22) | NS    |
| Admission to NICU no. (%) | 82 (44) | 38 (18) | 0.0001 |

*Neonatal hypoglycemia no. (%) | 109 (59) | 86 (41) | 0.0003 |

Infant length of stay (d) median (IQR) | 3 (3,4) | 3 (2.5,3.5) | 0.08 |

Discharged home with mother no. (%) | 173 (94) | 200 (94) | NS    |

*Includes infants cared for in the Newborn Nursery or the NICU

Eighty-two of the 185 Type 1 (44%) and 106 of 212 (50%) of Type 2 infants BF during the first 2 h from birth.

Analysis of mode of delivery on early BF showed that of 67 women from the Type 1 group who delivered vaginally, 41 (61%) were able to BF within 2 h from birth, similar to those 57 of 85 (67%) in the Type 2 group. Among 118 women from the Type 1 group who delivered by cesarean, 39 (33%) were able to BF within 2 h from birth, similar to 49 of 127 (39%) of those in the Type 2 group.

BF at discharge for women with type 1 and type 2 diabetes

At discharge, exclusive BF was 34% among Type 1 women and 23% for those in the Type 2 group (Table 4). In the Type 1 group were 171 women who intended exclusive BF, of them 61 (36%) were able to BF exclusively at discharge. Conversely, of 14 others who intended partial BF only one (7%) BF exclusively at discharge. In the Type 2 group

Table 3 Prior BF experience and early BF among women with Type 1 and Type 2 Diabetes

|                        | Type 1 | Type 2 | p     |
|------------------------|--------|--------|-------|
| Multiparous no. (%)    | 98 (53)| 159 (75)| 0.0001 |
| Prior breastfeeding no. (%) | 68 (69) | 107 (67) | NS    |
| Intended partial BF no. (%) | 14 (8) | 47 (22) | 0.0001 |
| Intended exclusive BF no. (%) | 171 (92) | 165 (78) | 0.0001 |

Time to First Breastfeeding

|                        | Type 1 | Type 2 | p     |
|------------------------|--------|--------|-------|
| < 1 h no. (%)          | 74 (40)| 87 (41) | NS    |
| 1–2 h no. (%)          | 8 (4)  | 19 (9)  | NS    |
| 3–4 h no. (%)          | 19 (10)| 15 (7)  | NS    |
| 5–6 h no. (%)          | 11 (6) | 10 (5)  | NS    |
| 7–24 h no. (%)         | 32 (17)| 32 (15) | NS    |
| ≥ 25 h no. (%)         | 20 (11)| 18 (8)  | NS    |
| Never breastfed no. (%) | 21 (12)| 31 (15) | NS    |
| Received lactation consult no. (%) | 174 (94) | 201 (95) | NS    |

Table 4 BF at discharge for women with Type 1 and Type 2 Diabetes

|                        | Type 1 | Type 2 | p     |
|------------------------|--------|--------|-------|
| Mother-Infant dyads no. | 185    | 212    |       |
| Multiparous no. (%)    | 98 (53)| 159 (75)| 0.0001 |
| Prior Breastfeeding no. (%) | 68 (69) | 107 (67) | NS    |

Infant Feeding at Discharge

|                        | Type 1 | Type 2 | p     |
|------------------------|--------|--------|-------|
| Exclusive total no. (%) | 62 (34)| 49 (23) | 0.02  |
| Direct BF no. (%)      | 40 (65)| 46 (94) | 0.0001 |
| Expressed breast milk/Donor no. (%) | 22 (35) | 3 (6) | 0.0001 |
| Partial total no. (%)  | 87 (47)| 98 (46) | NS    |
| Direct BF & Formula no. (%) | 77 (89) | 94 (96) | NS    |
| Expressed breast milk & Formula no. (%) | 10 (11) | 4 (4) | NS    |
| Formula feeding no. (%) | 36 (19)| 65 (31) | 0.01  |
| Breastfeeding initiation no. (%) | 149 (81) | 147 (69) | 0.01  |
were 165 women who intended exclusive BF, of them 47 (28%) BF exclusively at discharge. In contrast, of 47 others who intended partial BF only 2 (4%) BF exclusively at discharge. Regression analysis showed that the stronger predictor of failure to exclusive BF at discharge for Type 1 women was neonatal hypoglycemia a OR 0.34 CI 95% (0.17, 0.68) and for Type 2 women were intention to partially BF a OR 0.10 CI 95% (0.02, 0.44) and neonatal hypoglycemia a OR 0.35 CI 95% (0.15, 0.79).

Of the 62 Type 1 infants in the exclusive BF subgroup, 40 received direct BF, 16 exclusive EBM and 6 exclusive donor human milk. Of the 49 infants in the Type 2 exclusive BF subgroup, 46 received direct BF, 2 exclusive EBM and 1 exclusive donor human milk. Partial BF rates were similar (47 vs 46%), formula feeding was lower (19 vs 31%) and BF initiation at discharge was higher (81 vs 69%) among Type 1 compared to Type 2 women. Regression analysis showed that the stronger predictors of BF initiation for Type 1 were BMI a OR 0.92 CI 95% (0.87, 0.99) and mothers age (a OR 1.07 CI 95% (0.99, 1.15). For infants in the Type 2 group the stronger predictors of BF initiation failure were intention to partially BF a OR 0.22 CI 95% (0.10, 0.50) and neonatal hypoglycemia a OR 0.35 CI 95% (0.15, 0.79).

Regardless of mode of delivery, 82 women from the Type 1 group (44%) and 106 women from the Type 2 group (50%) BF during the first 2 h. At discharge, 76 of 82 (93%) Type 1 and 91 of 106 (86%) Type 2, respectively, initiated BF. On the other hand, 73 of 103 (71%) women from the Type 1 and 49 of 106 (46%) women from the Type 2 group who did not BF within 2 h initiated BF at discharge.

A comparison of Type 1 and Type 2 women combined according to race, showed that BF initiation at discharge was observed in 85% of 206 whites, in 66% of 92 African Americans, in 64% of 62 Hispanics and in 81% of 37 women from the other group. Concurrently, the rate of exclusive BF was 29% for whites, 27% for the miscellaneous groups, 20% for African Americans and 19% for Hispanics. Logistic regression analysis showed that exclusive BF among Type 1 women was less likely among non-white women a OR 0.44 CI 95% (0.19, 1.00).

**Prior BF experience, exclusive BF and BF initiation in women with type 1 and type 2 diabetes**

Inspite of the different prevalence of multiparous women, prior BF experience was similar among Type 1 and Type 2 groups. Further analysis showed that 68 Type 1 women with prior BF experience had higher exclusive BF (41 vs 29%) and BF initiation rates (88 vs 76%) than 117 others without prior BF experience. Among Type 2 women, 107 with prior experience had higher exclusive BF (27 vs 19%) and BF initiation rates (78 vs 61%) than 105 without prior BF experience. Logistic regression showed that prior BF was a strong predictor of exclusive BF among Type 1 a OR 4.07 CI 95% (1.21, 13.65) and among Type 2 a OR 3.96 CI 95% (1.82, 8.62). Similar analysis showed that prior BF was also a strong predictor of BF initiation among Type 1 a OR 4.12 CI 95% (1.10, 15.47) and among Type 2 women a OR 4.17 CI 95% (1.88, 9.28).

**Maternal obesity, type of diabetes and BF initiation**

Sixty-four of 185 (35%) Type 1 and 28 of 212 (13%) Type 2 women were normal or overweight (BMI < 29 kg/m²). At discharge, exclusive BF (39 vs 36%) and BF initiation (87 vs 79%) were similar for both groups. Eighty-seven of 185 Type 1 (47%) and 100 of 212 (47%) of Type 2 women were obese (BMI 30–39.9 kg/m²). At discharge exclusive BF was higher (35 vs 22%, p 0.05) in the Type 1 group but BF initiation (80 vs 78%) was similar for both groups. Thirty-four of 185 (18%) Type 1 women and 84 of 212 (40%) Type 2 were morbidly/extremely obese (BMI ≥ 40 kg/m²).

At discharge, exclusive BF (21 vs 20%) and BF initiation (71 vs 68%) were similar for both groups.

**Discussion**

The American Academy of Pediatrics and the Academy of Breastfeeding Medicine recommend exclusive BF for all healthy infants during birth hospitalization and beyond [16, 18]. Since January 2014, the joint commission mandated exclusive BF during hospitalization for healthy infants to retain their maternity accreditation [15]. These organizations acknowledged that other nutritional options may be needed to temporarily replace or supplement BF under well-defined circumstances (i.e., maternal and neonatal illness, late preterm infants) [15, 18]. In a recent study of maternity care practices and policies in 1305 hospitals in the United States, the mean percentage of in-hospital exclusive BF infants in the general population was 51.4% [19]. Recently, we reported exclusive BF rates in women with mild (47%) and severe CHTN (50%) [20], with preeclampsia (39%) and with severe preeclampsia (37%) [21], with preeclampsia superimposed on gestational diabetes (18%) [22], with CHTN superimposed on gestational diabetes (19%) [23], with gestational diabetes with (33%) and without prior BF experience (11%) [24]. The low exclusive BF rates for Type 1 (34%) and Type 2 (23%) women reported here are similar to those of women with gestational diabetes with superimposed comorbidities described above [22–24].

In the US 83.2% of newborns initiated BF by the time of discharge from the birth hospital [25]. In the present study we observed a BF initiation rate of 81% for Type 1 and 69% for Type 2 women. Obstacles known to associate with low BF initiation affecting our study
population included lack of prior BF experience, preeclampsia, CHTN, pregestational diabetes, obesity, complications of labor, cesarean delivery, premature birth, neonatal hypoglycemia, admission to NICU, late or absent BF, formula supplementation, delayed lactogenesis II and maternal infant separation [21, 26, 27]. Our regression analysis showed that the strong predictors of BF initiation for Type 1 were lower BMIs and younger maternal age, whereas among Type 2 predictors of BF initiation failure were intention to partially BF, higher BMI and neonatal hypoglycemia.

It is known that racial discrepancies in prevalence are accompanied by low rates of BF initiation and exclusive BF in African American and Hispanics as compared to non-Hispanic whites [28, 29]. In line with the above, our data on Type 1 and Type 2 combined also showed that exclusive BF and BF initiation among African American was lower than those of non-Hispanic white women.

Hypoglycemia, lack of early BF and admission to NICU are well known interrelated obstacles to exclusive BF and BF initiation among infants born to women with gestational and pregestational diabetes [17–26]. Timing of the first BF is important because many critical maternal and neonatal physiological interactions occur following delivery [17, 26, 30]. Persistent hypoglycemia is commonly found among infants born to women with Type 1 and Type 2 diabetes during the first hours after birth [17, 31]. Early BF or early FF may facilitate glycemic stability in infants born to women with pregestational diabetes and may prevent or correct hypoglycemia avoiding the need for dextrose gel, IV treatment or formula supplementation [17, 31].

Comorbidities like preeclampsia, CHTN, obesity, cesarean delivery, preterm birth, hypoglycemia, NICU admission and early BF may have all contributed to the low BF initiation observed in this investigation [20–23, 31, 32]. The high rate of cesarean deliveries in the Type 1 and Type 2 groups is not unexpected, especially if linked with delayed lactogenesis II, has a negative effect on rates of exclusive BF, BF initiation and BF duration [33]. The lack of association of elevated HbA1c with exclusive BF or BF initiation in this study population was not unexpected because HbA1c level alone does not take into account glycemic variability especially during the third trimester [38, 39].

The major limitation of this investigation is that the definition of exclusive BF and BF initiation at discharge used here may be applicable only to women with high risk obstetrical conditions for whom early mother-infant interactions may be delayed [27]. Another limitation is the lack of follow-up information regarding infant feeding choices after discharge from the hospital. The strength of this investigation rests on the size of the obstetrical and neonatal population and the fact that the data were obtained directly from medical records and not from maternal recall or via post-delivery questionnaires [40].

In conclusion, intention to BF exclusively was higher in Type 1 women compared to Type 2. Exclusive BF in women with either Type 1 or Type 2 diabetes fell short of expectations, raising concerns about long term BF duration. Women and infants who are not ready for direct BF can be helped by temporary alternatives such as EBM or donor human milk. At discharge, exclusive BF and BF initiation were lower and FF higher in the Type 2 group, highlighting the need for different strategies if lactation in these special populations is to be improved.

Acknowledgements

Statistical support was provided by the Ohio Perinatal Research Network (OPRN).
References

1. Practice ACOG. Bulletin #201. Pregestational diabetes mellitus. Obstet Gynecol. 2018;132:e228.

2. Admon LK, Winkelman TNA, Moniz MH, Davis MM, Heisler M, Dalton VK. Disparities in chronic conditions among women hospitalized for delivery in the United States, 2005-2014. Obstet Gynecol. 2017;130:1319–26.

3. Peng TY, Ehrlich SF, Crites Y, Kitzmiller JL, Kuzniewicz MW, Hedderson MM, et al. Trends and racial and ethnic disparities in the prevalence of pregestational type 1 and type 2 diabetes in northern California: 1996–2014. Am J Obstet Gynecol. 2017;216:177.e1–8. https://doi.org/10.1016/j.ajog.2016.10.007.

4. Simmons D, Conroy C, Thompson CF. In-hospital breast-feeding rates among women with gestational diabetes and pregestational type 2 diabetes in South Auckland. Diabet Med. 2005;22:177–81.

5. Soltani H, Arden M. Factors associated with breastfeeding up to 6 months postpartum in mothers with diabetes. J Obstet Gynecol Neonatal Nurs. 2009;38:586–94. https://doi.org/10.1111/j.1552-6909.2009.00152.x.

6. Soriko S, Cuthbertson D, Barlund S, Reunanen A, Nucci AM, Berseth CL, et al. Breastfeeding patterns of mothers with type 1 diabetes: results from an infant feeding trial. Diabetes Metab Res Rev. 2010;26:206–11. https://doi.org/10.1002/dmrr.1074.

7. Herskin CW, Stage E, Barfend C, Emmermann P, Nichum VL, Damm P, et al. Low prevalence of long-term breastfeeding among women with type 2 diabetes. J Matern Fetal Neonatal Med. 2016;29:2513–6.

8. Gunderson EP, Hurston SR, Ning X, Lo JC, Crites Y, Walton D, et al. Lactation and progression to type 2 diabetes mellitus: a prospective cohort study. Ann Intern Med. 2015;163:889–98.

9. Stuebe A. Associations among lactation, maternal carbohydrate metabolism and cardiovascular health. Clin Obstet Gynecol. 2015;58:827–39. https://doi.org/10.1097/GOF.0000000000000155.

10. Binns C, Lee M, Low WN. The long-term public health benefits of breastfeeding. Asia Pac J Public Health. 2016;28:7–14.

11. Nguyen B, Jin K, Ding D. Breastfeeding and maternal cardiovascular risk factors and outcomes: a systematic review. Plos One. 2017;12(11):e0187923. https://doi.org/10.1371/journal.pone.0187923.

12. Practice ACOG. Bulletin #203. Chorionic villus sampling. Obstet Gynecol. 2019;133:e26.

13. World Health Organization. Body mass index. http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/healthy-lifestyle/body-mass-index-bmi. Accessed October 25, 201.

14. Nelson JM, Perrine CG, Freedman DS, Williams L, Morrow B, Smith RA, et al. Infant feeding-related maternity care practices and maternal report of breastfeeding outcomes. Birth. 2018;45:424–31. https://doi.org/10.1111/birt.12337.

15. JCAHO Specifications manual for national quality measures (v2015B). From https://manual.jointcommission.org. Accessed 1/19/2021.

16. Patterson JA, Keuler NS, Olson BH. The effect of baby-friendly status on exclusive breastfeeding in U.S. hospitals. Matern Child Nutr. 2018;14:e12589. https://doi.org/10.1111/mcn.12589.

17. Cordero L, Stenger MR, Landon MB, Nankervis CA. Early feeding, hypoglycemia, and breastfeeding initiation in infants born to women with gestational diabetes mellitus. J Neonatal Perinatal Med. 2018;11:357–64. https://doi.org/10.3233/NPM-17145.

18. Boies EG, Vaucher YE. ABM clinical protocol #10: breastfeeding the late preterm (34–36 6/7 weeks of gestation) and early term infants (37–38 6/7 weeks of gestation), second revision 2016. Breastfeed Med. 2016;11:494–500.

19. Barrera CM, Beauregard JL, Nelson JM, Perrine CG. Association of maternity care practices and policies with in-hospital exclusive breastfeeding in the United States. Breastfeed Med. 2019;14(4):243–8. https://doi.org/10.1089/bfm.2018.0196.

20. Cordero L, Stenger MR, Landon MB, Nankervis CA. Breastfeeding initiation among women with chronic hypertension. Int J Womens Health Wellness. 2021;7:118. https://doi.org/10.2337/2474-1353/1510118.

21. Cordero L, Stenger MR, Landon MB, Nankervis CA. Breastfeeding initiation among women with preeclampsia with and without severe features. J Neonatal Perinatal Med. 2020. https://doi.org/10.3233/npm-200508 Online ahead of print.

22. Cordero L, Stenger MR, Landon MB, Nankervis CA. Breastfeeding initiation among women with preeclampsia with severe features superimposed on diabetes mellitus. Int J Women's Health Wellness. 2021;6:115. https://doi.org/10.23937/2474-1353/1510115.

23. Cordero L, Stenger MR, Landon MB, Nankervis CA. Breastfeeding initiation among women with chronic hypertension superimposed on pregestational diabetes mellitus. J Neonatal Perinatal Med. 2021;Online ahead of print. https://doi.org/10.3233/NPM-210738.

24. Cordero L, Stenger MR, Blaney SD, Finneman MM, Nankervis CA. Prior breastfeeding experience and infant feeding at discharge among women with pregestational diabetes mellitus. J Neonatal Perinatal Med. 2020;13:563–70. https://doi.org/10.3233/NPM-190308.

25. Centers for Disease Control and Prevention. Breastfeeding report card 2018. From https://www.cdc.gov/breastfeeding/pdf/2018/breastfeedingreportcard.pdf. Accessed 1/19/2021.

26. Cordero L, Thung S, Landon MB, Nankervis CA. Breastfeeding initiation failure in women with pregestational diabetes mellitus. Clin Pediatr. 2014;53:18–25.

27. Cordero L, Oza-Frank R, Moore-Clingenpeel M, Landon MB, Nankervis CA. Failure to initiate breastfeeding among high risk obstetrical patients who intended to breastfeed. J Neonatal Perinatal Med. 2016;9:401–9.

28. Louis-Jacques A, Debuel TF, Taylor M, Stuebe AM. Racial and ethnic disparities in U.S. breastfeeding and implications for maternal and child health outcomes. Semin Perinatol. 2017;41:299–307.

29. Beauregard JL, Hamer HC, Chen J, Avila-Rodriguez W, Elam-Evans LD, Perrine CG. Racial disparities in breastfeeding initiation and duration among U.S. infants born in 2015. MMWR Mortal Mortal Wkly Rep. 2019;68:745–6.

30. Robiquest P, Zamiara PE, Raika T, Deruelle P, Mestdagh B, Blondel G, et al. Observation of skin-to-skin contact and analysis of factors linked
to failure to breastfeed within 2 hours after birth. Breastfeed Med. 2016;11:126–32.
31. Harding JE, Harris DL, Hegarty JE, Alsweiler JM, McKinlay CJD. An emerg‑
ing evidence base for the management of neonatal hypoglycemia. Early
Hum Dev. 2017;104:51–6.
32. Hobbs AJ, Mannion CA, McDonald SW, Brockway M, Tough SC. The
impact of caesarean section on breastfeeding initiation, duration and dif‑
ficulties in the first four months postpartum. BMC Pregnancy Childbirth.
2016;16:90.
33. Ramji N, Challa S, Murphy PA, Quinlan J, Crane JMG. A comparison
of breastfeeding rates by obesity class. J Matern Fetal Neonatal Med.
2018;31:3021–4.
34. Keim SA, Boone KM, Oza-Frank R, Geraghty SR. Pumping milk without
ever feeding at the breast in the Moms2Moms study. Breastfeed Med.
2017;12:422–9.
35. Bai DL, Fong DY, Lok KY, Wong JH, Tarrant M. Prior breastfeeding
experience and duration of any and exclusive breastfeeding among
multiparous mothers. Birth. 2015;42:70–7.
36. Huang Y, Ouyang YQ, Redding SR. Previous breastfeeding experience and
its influence on breastfeeding outcomes in subsequent births: a system‑
atic review. Women Birth. 2019;32:303–9.
37. Colombo L, Crippa BL, Consonni D, Bettinelli ME, Agosti V, Mangino G,
et al. Breastfeeding determinants in healthy term newborns. Nutrients.
2018;10:48. https://doi.org/10.3390/nu10010048.
38. Edelson PK, James KE, Leong A, Arenas J, Cayford M, Callahan MJ, et al.
Longitudinal changes in the relationship between hemoglobin A1c and
glucose tolerance across pregnancy and postpartum. J Clin Endocrinol
Metab. 2020;105:e1999–2007.
39. Jotic A, Milicic T, Lalic K, Lukic L, Macesic M, Stanaric Gajovic J, et al.
Evaluation of glycaemic control, glucose variability and hypoglycaemia
on long-term continuous subcutaneous infusion vs. multiple daily
injections: observational study in pregnancies with pre-existing type
diabetes. Diabetes Ther. 2020;11:845–58. https://doi.org/10.1007/
s13300-020-00780-7.
40. Keenan K, Hipwell A, McAloon R, Hoffmann A, Mohanty A, Magee K.
Concordance between maternal recall of birth complications and data
from obstetrical records. Early Hum Dev. 2017;105:11–5. https://doi.org/
10.1016/j.earlhumdev.2017.01.003.

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in pub‑
lished maps and institutional affiliations.