Maternal and Child Health Journal (2019) 23:1339–1347
https://doi.org/10.1007/s10995-019-02787-4

Early Term Delivery and Breastfeeding Outcomes

Lauren S. Keenan-Devlin[1,2] · Yetunde F. Awosemusi[2] · William Grobman[3,4] · Hyagriv Simhan[5,6] · Emma Adam[7] · Jennifer Culhane[8,9] · Gregory Miller[10] · Ann E. B. Borders[1,2,11]

Published online: 19 June 2019

Abstract

Objective Higher rates of adverse outcomes have been reported for early term (37 0 to 38 6 weeks) versus full term (≥ 39 0 weeks) infants, but differences in breastfeeding outcomes have not been systematically evaluated. This study examined breastfeeding initiation and exclusivity in early and full term infants in a large US based sample.

Methods This secondary analysis included 743 geographically- and racially-diverse women from the Measurement of Maternal Stress Study cohort, and 295 women from a quality assessment at a hospital-based clinic in Evanston, IL. Only subjects delivering ≥ 37 weeks were included. Initiation of breastfeeding (IBF) and exclusive breastfeeding (EBF) were assessed via electronic medical record review after discharge. Associations of IBF and EBF with early and full term delivery were assessed via univariate and multivariate logistic regression.

Results Among 872 women eligible for inclusion, 85.7% IBF and 44.0% EBF. Early term delivery was not associated with any difference in frequency of IBF ($p = 0.43$), but was associated with significantly lower odds of EBF (unadjusted OR 0.61, 95% CI 0.466, 0.803, $p < 0.001$). This association remained significant (adjusted OR 0.694, 95% CI 0.515, 0.935, $p = 0.016$) after adjusting for maternal diabetes, hypertensive disorders of pregnancy, cesarean delivery, maternal age, race/ethnicity, parity, Medicaid status, NICU admission, current smoking, and delivery hospital.

Conclusions for Practice Despite comparable breastfeeding initiation frequencies, early term infants were significantly less likely to be exclusively breastfed compared to full term infants. These data suggest that women with early term infants may benefit from counseling regarding the potential for breastfeeding difficulties as well as additional breastfeeding support after delivery.

Keywords Breastfeeding · Breastfeeding initiation · Disparities · Early term · Exclusive breastfeeding

Significance

What is already known on this subject?

Prior studies have found lower rates of breastfeeding initiation and reduced duration of breastfeeding for babies born during the early term. Exclusive breastfeeding is associated with longer breastfeeding duration.

What this study adds?

This study found that early term delivery is associated with decreased likelihood of exclusive breastfeeding after delivery, which may reduce duration of breastfeeding. Adjusting for health-related factors for mom and baby, our analysis suggests that early term mother-infant dyads may experience more breastfeeding challenges and may benefit from increased counseling.

Objectives

Breastfeeding has long been recognized to have multiple short and long term benefits for both mothers and babies (Heinig and Dewey 1997; Hoddinott et al. 2008; Horta et al. 2007; Ip et al. 2007). A 2012 review by Kramer and Kakuma found a dose-dependent effect of breastfeeding on disease rates, with the protective effects of exclusive breastfeeding increasing over each additional month between three and 6 months of age (Kramer and Kakuma 2012). Despite the known benefits of breastfeeding, in 2015 only 51.8% of women were still breastfeeding at 6 months postpartum and only 22.3% were breastfeeding exclusively (CDC

✉ Lauren S. Keenan-Devlin
lkeenan-devlin@northshore.org

Extended author information available on the last page of the article

2016). Breastfeeding duration and exclusivity are interrelated issues, as formula supplementation during the first few days and weeks of lactation reduces the frequency of breast stimulation required to establish breast tissue development and milk production (Neville 2001; Peaker and Wilde 1996). Daily supplementation with formula in the first week of life has been found to significantly shorten overall breastfeeding duration (Holmes et al. 2011), and exclusive breastfeeding at the time of hospital discharge is an independent protective factor against early weaning (Dewey et al. 2003; Frota and Marcopito 2004; McDonald et al. 2012; Perrine et al. 2012; Semenic et al. 2008). Previous studies have identified health-related factors including maternal obesity, maternal smoking, history of depression and anxiety, cesarean delivery, and neonatal intensive care unit (NICU) admission with earlier use of formula; other socioeconomic and cultural factors associated with formula use include younger maternal age, low income status, poor social support, and less education (Jessri et al. 2013; Kehler et al. 2009; Pierro et al. 2016; Wallwiener et al. 2016). Women who report difficulties with breastfeeding, including painful breasts and nipples, concern for inadequate milk production and infant satiety, and infant fussiness are also more likely to supplement with formula in the first few days after delivery (McFadden et al. 2017; Pierro et al. 2016).

Gestational age at delivery has been identified as another key factor for breastfeeding success. Babies delivered before 37 weeks gestation are more likely to experience health complications and breastfeeding difficulties than their term peers, resulting in earlier supplementation (Eidelman 2016). Two international studies suggest that even at term, earlier gestational age at delivery (between 37 0/7 and 38 6/7 weeks) may be associated with lower rates of breastfeeding initiation compared to babies delivered full term (39 0/7 weeks and beyond) (Donath and Amir 2008; Lutsiv et al. 2013). A recent study by Hackman et al. found that early term birth predicted earlier termination of breastfeeding by 1 month postpartum (Hackman et al. 2016). However, none of these existing studies examined different breastfeeding intensities as outcomes (some breastfeeding vs. exclusive breastfeeding). Our objective in this study was to compare rates of breastfeeding initiation and exclusivity in early term versus full term infants in a large US based sample, and to identify demographic, health, and potentially modifiable factors associated with the breastfeeding patterns observed.

Methods

This retrospective cohort study entailed secondary analyses of data from two cohorts: (1) a quality improvement study of Medicaid-eligible patients receiving prenatal care from a suburban, hospital based clinic and (2) the Measurement of Maternal Stress (MOMS) Study cohort including a diverse sample of women from 4 sites in the United States. Because the data from both cohorts were de-identified, the IRB at NorthShore University HealthSystem determined that no human subjects research approval was required.

Measurement of Maternal Stress (MOMS) Study Cohort

The MOMS Study, a sub-study of the National Children's Study (NCS), aimed to systematically develop reliable and cost-efficient measures of maternal stress and stress biology during pregnancy. The study sample of 744 participants was recruited over an 8-month time period between June 2013 and March 2015. Women were enrolled from prenatal clinics as part of a multisite prospective cohort study that included 4 geographically and racially diverse regions (Pittsburgh PA, Chicago IL, Schuylkill County PA, and San Antonio TX). None of the participating delivery hospitals had Baby Friendly Status at the time of the study, which is a designation provided to hospitals that maintain a specific set of practices known to be supportive of exclusive breastfeeding, including routine practice of skin to skin, rooming in of mother and baby, avoidance of pacifier use, etc. Women were included in the MOMS study if they were 18 years or older, had a single intrauterine pregnancy of less than 21 weeks, and were English-speaking; women were excluded from MOMS participation if they had major fetal congenital anomalies or chromosomal anomalies, progesterone treatment after 14 weeks' gestation, or chronic corticosteroid treatment. Once MOMS study participants delivered, chart reviews were completed at each of the participating medical centers within a month after delivery using a specific set of variables determined by consensus of the site PIs. Protocols were developed at each institution to systematize the method of chart review for each medical records system. Data from the MOMS study was de-identified at the time that this analysis was conducted.

Resident Medicaid Clinic (RMC) Cohort

These data came from a quality improvement study examining income-related disparities in breastfeeding rates at a teaching hospital in suburban Illinois. As part of the original retrospective chart review, 295 Medicaid-eligible women who delivered at the hospital between October 1, 2014 and February 1, 2017 were included in the analysis. Women were included in the sample if they had received prenatal care from the hospital's affiliated low-income clinic. The list of patients was generated from the hospital's Electronic Data Warehouse, and the same list of variables and definitions utilized in the MOMS study were gathered via systematic chart review by two investigators (LKD and YA).

Key Variables

The outcomes variables of interest were initiation of breastfeeding and exclusive breastfeeding. Initiation of breastfeeding was defined as at least 1 recorded successful feeding either at the breast or with expressed breastmilk from a bottle during inpatient admission after delivery. Exclusive breastfeeding at hospital discharge was defined as an infant receiving only breastmilk during the inpatient admission. Feeding data for the infant was abstracted from flowcharts in the electronic medical records.

Key covariates available in both cohorts included maternal demographics recorded in the medical chart, namely maternal age, race, and insurance status. Relevant medical variables included parity (number of live births), cesarean delivery, smoking during pregnancy, maternal hypertensive disorders during pregnancy including preeclampsia and eclampsia, maternal diabetes during pregnancy (type 1, type 2, and gestational diabetes), and NICU admission for the infant.

As this assessment examined differences in breastfeeding outcomes for term births, subjects delivering before 37 weeks' gestation were excluded from analysis. Gestational age at delivery for term births was examined as both a continuous variable (weeks gestation + days gestation/7) and as categorical variables, early term (between 37 0/7 weeks and 38 6/7 weeks) and full term (39 0/7 weeks and beyond). Relationships between exclusive breastfeeding, gestational age at delivery, demographics, and other key variables were assessed via univariate and multivariate logistic regression. Four participants were missing race/ethnicity data, and four were missing insurance status. All analyses were done with IBM SPSS Statistics Software Version 22 (SPSS Inc., Chicago, IL).

Results

Breastfeeding and delivery data were available for 980 subjects across both cohorts, and of those, 872 delivered at term so were included in this analysis. Table 1 outlines the composite demographic and medical characteristics of the sample (Table 1). The average gestational age at delivery for term subjects was 39.4 ± 1.1 weeks. 55.5% of the sample delivered full term or beyond ($\geq$ 39 weeks 0 days), and 44.5% of the sample delivered in the early term (between 37 weeks 0 days and 38 weeks 6 days). As can be seen in Table 1, there were several differences between subjects delivering in the early term (388) versus full term (484). Women who delivered early term were more likely to be privately insured (53.9% vs. 43.2%, $p = 0.002$) and were more likely to be multiparous (65.7% vs. 54.5%, $p = 0.001$). Women delivering at the RMC site were more likely to deliver at full term (68% at RMC vs. 52% at the Philadelphia site, 48% at the Chicago site, 56% at the Pittsburgh site, and 45% at the San Antonio site, $p < 0.001$). Finally, early term deliveries were more likely among those diagnosed with diabetes (68.5 vs. 31.5%, $p < 0.001$) or hypertensive disorders (17.5 vs. 5.8%, $p < 0.001$) during pregnancy. Those delivering in the early term were no more likely to deliver via cesarean, smoke during pregnancy, or have an infant admitted to the NICU, nor were any racial or ethnic groups more likely to deliver in the early term.

Table 2 illustrates differences in breastfeeding outcomes by predictors and covariates (Table 2). In the sample, 85.7% of subjects attempted to breastfeed at least once during their admission, and 44.0% of subjects breastfed exclusively. Initiation of breastfeeding was more likely among primiparous women (90.6% vs. 82.3%, $p = 0.001$) and those insured through Medicaid (88.4% vs. 82.5%, $p = 0.014$). Initiation of breastfeeding differed by study site, with women delivering at the rural Pennsylvania hospital least likely to initiate breastfeeding at 67%, and those delivering at the Chicago-based hospital most likely to initiate breastfeeding at 95%. Cesarean delivery, smoking during pregnancy, diabetes during pregnancy, parity, and maternal age were not significantly associated with breastfeeding initiation.

Exclusive breastfeeding was more likely among primiparous women compared to multiparous women (49.1% vs. 40.5%, $p = 0.011$) and among women between the ages of 20 and 40. Subjects insured via Medicaid were less likely to exclusively breastfeed compared to those with private insurance (37.8% vs. 50.5%, $p < 0.001$), as were those who delivered via cesarean section (35.9% vs. 47.2%. $p = 0.003$). Newborn NICU admission was associated with lower rates of exclusive breastfeeding (25.4%, vs. 46.8%, $p < 0.001$), as was maternal diabetes during pregnancy (19.4% vs. 80.6%, $p < 0.001$) and maternal hypertensive disorders of pregnancy (25.9% vs. 45.2%, $p < 0.001$). There were significant differences in exclusive breastfeeding by study site, with women delivering at the RMC and the San Antonio site the least likely to exclusively breastfeed at 32% and 34%, respectively, and women delivering at the Pittsburgh site most likely to exclusively breastfeed at 63%. Smoking during pregnancy was not significantly associated with exclusive breastfeeding.

Race/ethnicity was a significant predictor of breastfeeding outcomes; women who identified as white (81.5%) were less likely to breastfeed compared with women who identified as black (89.6%), Hispanic (90.8%), and "other races" (89.2%). However, the same pattern did not hold for exclusive breastfeeding. White women (57.5%) were far more likely to exclusively breastfeed than Hispanic women (33.0%) and those of "other" races (36.9%), and black women had the lowest rates of exclusive breastfeeding at only 28.9% ($p < 0.001$).

Table 1 Comparison of demographic, maternal, and infant factors by full term and early term delivery

	Total n (%)	Full term ≥ 39 0 n (%)	Early term 37 0 to 38 6 n (%)	p
Maternal insurance status				
Medicaid	450 (51.8)	272 (56.5)	178 (46.0)	0.002
Private insurance	418 (48.2)	209 (43.5)	209 (54.0)	
Maternal age				
< 20	37 (4.2)	21 (4.3)	16 (4.1)	REF
20–30	486 (55.7)	278 (57.4)	208 (53.6)	1.000
31–40	323 (37.0)	176 (36.4)	147 (37.9)	0.994
41+	26 (3.0)	9 (1.9)	17 (4.4)	0.302
Maternal race				
Non-Hispanic white	449 (51.5)	245 (50.9)	204 (52.7)	REF
Non-Hispanic black	173 (19.8)	97 (20.2)	76 (19.6)	0.987
Other	65 (7.5)	41 (8.7)	20 (5.2)	0.244
Hispanic	185 (21.2)	98 (20.4)	87 (22.5)	0.983
Parity				
Primiparous	352 (40.4)	219 (45.3)	133 (34.3)	0.001
Multiparous	519 (59.6)	264 (54.7)	255 (65.7)	
Maternal smoking in pregnancy				
Yes	76 (8.7)	40 (8.3)	36 (9.3)	0.598
No	796 (91.3)	444 (91.7)	352 (90.7)	
Maternal diabetes in pregnancy				
Yes	108 (12.4)	34 (7.0)	74 (19.1)	< 0.001
No	764 (87.6)	450 (93.0)	314 (80.9)	
Maternal hypertension in pregnancy				
Yes	96 (11.0)	28 (5.8)	68 (17.5)	< 0.001
No	776 (89.0)	456 (94.2)	320 (82.5)	
Cesarean birth				
Yes	245 (29.8)	124 (25.6)	121 (31.2)	0.069
No	627 (76.4)	360 (74.4)	267 (68.8)	
NICU admission				
Yes	114 (13.1)	55 (11.4)	59 (15.2)	0.095
No	758 (86.9)	429 (88.6)	329 (84.8)	
Breastfeeding status				
No breastfeeding	125 (14.3)	70 (14.5)	55 (14.2)	REF
Initiation of breastfeeding	747 (85.7)	414 (85.5)	333 (85.8)	0.904
Exclusive breastfeeding	384 (44.0)	239 (49.4)	145 (37.4)	< 0.001
Delivery hospital				
RMC	249 (28.6)	79 (20.4)	170 (35.1)	REF
Rural Schuylkill County, PA	153 (17.5)	74 (19.1)	79 (16.3)	0.009
Chicago	165 (18.9)	86 (22.2)	79 (16.3)	< 0.001
Pittsburgh	163 (18.7)	71 (18.3)	92 (19.0)	0.118
San Antonio	142 (16.3)	78 (20.1)	64 (13.2)	< 0.001

Figure 1 illustrates the patterns of infant feeding by week gestation at delivery (Fig. 1). Compared with those who delivered 37 and 38 weeks' gestation, a greater percentage of women who delivered at or after 39 weeks' gestation provided only breast milk to their infants prior to discharge (OR 0.612, 95% CI 0.466, 0.803; $p < 0.001$). The associations between gestational age at delivery and exclusive breastfeeding can be found in Table 3 (Table 3). After adjusting for maternal diabetes during pregnancy, hypertensive disorders of pregnancy, cesarean delivery, maternal race/ethnicity, parity, Medicaid status, NICU admission, current smoking, and study site, delivery between 37 and 38

Table 2 Comparison of demographic, maternal, and infant factors by breastfeeding outcomes

	Total n (%)	Initiation of breastfeeding n (%)	p	Exclusive breastfeeding n (%)	p
Maternal insurance status					
Medicaid	450 (51.8)	398 (88.4)	0.014	170 (37.8)	< 0.001
Private insurance	418 (48.2)	345 (82.5)		211 (50.5)	
Maternal age					
< 20	37 (4.2)	31 (83.8)	1.000	9 (24.3)	0.040
20–30	486 (55.7)	410 (84.4)	REF	227 (46.7)	REF
31–40	323 (37.0)	284 (87.9)	0.490	142 (44.0)	0.101
41+	26 (3.0)	22 (84.6)	1.000	6 (22.1)	0.083
Maternal race					
Non-Hispanic white	449 (51.5)	366 (81.5)	REF	249 (55.5)	REF
Non-Hispanic black	173 (19.8)	155 (89.6)	0.049	50 (28.9)	< 0.001
Other	65 (7.5)	58 (89.2)	0.456	24 (36.9)	0.036
Hispanic	185 (21.2)	168 (90.8)	0.013	61 (33.0)	< 0.001
Parity					
Primiparous	352 (40.4)	319 (90.6)	0.001	173 (49.1)	0.011
Multiparous	519 (59.6)	427 (82.3)		210 (40.5)	
Maternal smoking in pregnancy					
Yes	76 (8.7)	66 (83.5)	0.759	39 (49.4)	0.182
No	796 (91.3)	681 (85.6)		345 (43.3)	
Maternal diabetes in pregnancy					
Yes	108 (12.4)	93 (86.1)	0.888	21 (19.4)	< 0.001
No	764 (87.6)	15 (13.9)		87 (80.6)	
Maternal hypertension in pregnancy					
Yes	96 (11.0)	83 (86.5)	0.814	28 (29.2)	0.002
No	776 (89.0)	664 (85.6)		356 (45.9)	
Gestational age (weeks)					
37	98 (11.2)	88 (89.8)	REF	34 (34.7)	REF
38	162 (18.6)	140 (86.4)	0.944	58 (35.8)	1.000
39	334 (38.3)	280 (83.8)	0.575	139 (41.6)	0.736
40	211 (24.2)	177 (83.9)	0.641	115 (54.5)	0.009
41+	67 (7.7)	62 (92.5)	0.988	38 (56.7)	0.039
Cesarean birth					
Yes	245 (29.8)	214 (87.3)	0.376	88 (35.9)	0.003
No	627 (76.4)	533 (85.0)		296 (47.2)	
NICU admission					
Yes	114 (13.1)	98 (86.0)	0.922	29 (25.4)	< 0.001
No	758 (86.9)	649 (85.6)		355 (46.8)	
Delivery hospital					
RMC	249 (28.6)	224 (90.0)	REF	79 (31.7)	REF
Rural Schuylkill County, PA	153 (17.5)	103 (67.3)	< 0.001	79 (51.6)	0.001
Chicago	165 (18.9)	158 (95.8)	0.430	76 (46.1)	0.027
Pittsburgh	163 (18.7)	133 (81.6)	0.102	102 (62.6)	< 0.001
San Antonio	142 (16.3)	128 (90.8)	0.999	48 (33.8)	0.994

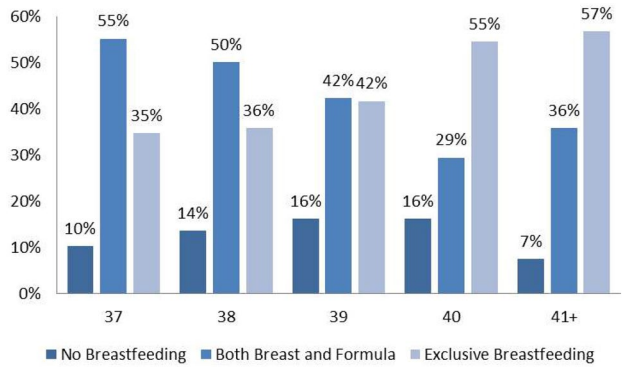

Fig. 1 Infant feeding method by weeks' gestation for term infants

6/7 weeks' gestation remained significantly associated with a lower rate of exclusive breastfeeding compared to delivery at or after at 39 weeks' gestation (OR 0.694, 95% CI 0.515, 0.935, p = 0.016).

Conclusions for Practice

This investigation found that early term delivery was independently associated with lower rates of exclusive breastfeeding (37.4%) compared to delivery after 39 weeks' gestation (49.4%), though there were no apparent differences in the rate of breastfeeding initiation between these groups (85.8% vs. 85.5%, respectively). Our findings extend the literature on this topic in several ways. First, this investigation is to our knowledge the first to examine exclusive breastfeeding as an outcome in a large, diverse US sample. Exclusive breastfeeding prior to hospital discharge is a core maternal-child healthcare quality indicator because it is a critical precursor of sustaining the behavior post-discharge (Dewey et al. 2003; Frota and Marcopito 2004; McDonald et al. 2012; Perrine et al. 2012; Semenic et al. 2008). Chantry et al. found that among women who intended to exclusively breastfeed, those who supplemented with formula prior to hospital discharge were 2.7 times more likely to discontinue breastfeeding by 60 days postpartum compared to those who did not supplement with formula (Chantry et al. 2014). The 30% reduction in exclusive breastfeeding we found among early term infants in this investigation may translate into a significant reduction in breastfeeding duration across the first few months of life.

Additionally, our study is the second to use a large diverse US sample to examine breastfeeding outcomes by gestational age, and is unique in using medical chart review as the data source rather than recall. Hackman et al. also found no significant differences in breastfeeding initiation between early term (98.1%) and full term (98.2%) infants in their 2016 study of 2772 US women, but their study was unable to assess exclusive breastfeeding (Hackman et al. 2016). By contrast, a 2008 study of 3600 Australian births observed initiation of breastfeeding at 92% among babies born between 37 0 and 39 6 weeks compared to 93.9% among infants born ≥ 40 weeks (Donath and Amir 2008), and a 2013 Canadian population-based study of 93,364 term infants found significantly increased breastfeeding rates with each additional week of gestation, from 84% at 37 weeks and 85.2% at 38 weeks to 86.7% at 39 weeks and 88% at 40 weeks (Lutsiv et al. 2013). The apparent divergence between our study and that of Hackman et al., compared to the international cohort studies may reflect differences in breastfeeding support practices in the United States compared to Canada and Australia (AHM Conference 2009; Gionet 2013).

Finally, this analysis was strengthened by the inclusion of high-risk maternal conditions that increase odds of earlier delivery and may interfere with breastfeeding. Infants born to women with gestational diabetes are more likely to receive formula supplementation for glucose stabilization (Wight and Marinelli 2014), and infants born to women with hypertensive disorders of pregnancy, including preeclampsia and eclampsia, may be given formula due to maternal antihypertensive medications, or due to delay in breastfeeding or pumping following maternal ICU admission or prolonged recovery (Oza-Frank et al. 2016; Townsend et al. 2016). Neither maternal hypertensive disorders nor maternal diabetes

Table 3 Odds ratios of any breastfeeding and exclusive breastfeeding by continuous gestational age and early term birth in the sample

	Initiation of breastfeeding		Exclusive breastfeeding	
	Unadjusted OR (95% CI)	Adjusted* OR (95% CI)	Unadjusted OR (95% CI)	Adjusted* OR (95% CI)
Continuous GA at delivery (weeks)	0.968 (0.814, 1.151), p = 0.711	0.911 (0.750, 1.107), p = 0.349	1.344 (1.184, 1.525), p < 0.001	1.195 (1.040, 1.372), p = 0.012
Early term delivery	1.024 (0.699, 1.499), p = 0.904	1.178 (0.783, 1.772), p = 0.433	0.612 (0.466,0.803), p < 0.001	0.694 (0.515, 0.935), p = 0.016

*Adjusted for Cesarean delivery, maternal age, race/ethnicity, diabetes during pregnancy, hypertensive disorders of pregnancy, parity, Medicaid eligibility, NICU admission, smoking during pregnancy, and delivery site

explained the independent association between early delivery and exclusive breastfeeding found here.

Our findings with respect to race differ somewhat from existing research. Previous studies have demonstrated significant disparities in breastfeeding initiation in US samples, with white women more likely to initiate breastfeeding than black women (Jones et al. 2015; Ryan et al. 2002), but in our sample white women were least likely to initiate breastfeeding compared to all other racial groups, and initiation for black women was on par with that of other non-white subjects. We suspect that this pattern may have been driven by site differences, as the Pennsylvania site included a predominantly low-income white population, which had the lowest breastfeeding initiation across all study sites. Additionally, a large proportion of the black subjects in this sample delivered at two of the five sites, so rates of breastfeeding may additionally reflect hospital-specific practices around breastfeeding support. Consistent with the existing literature is our finding that women who identified as Hispanic and "other races" were more likely to attempt breastfeeding compared to white and black women. Previous research has indicated that Hispanic women and recent immigrants (a significant proportion of whom made up the "other" racial/ethnic population of the RMC cohort) are more likely to breastfeed for a variety of cultural reasons, which includes beliefs about the benefits of breastfeeding and the frequency of breastfeeding in their countries of origin (Jones et al. 2015). Exclusive breastfeeding rates by mother's race and ethnicity were consistent with existing research, with similar proportions of white women (57.5%), Hispanic women (52.0%), and women identifying as other races (57.4%) exclusively breastfeeding compared to a much lower proportion of black women (32.2%) ($p < 0.001$) (Jones et al. 2015; Ryan et al. 2002). There were no significant differences in average gestational age at delivery between racial/ethnic groups to account for this disparity.

As a secondary analysis, this study was limited in its ability to identify specific infant, maternal, and hospital-level mechanisms of action to fully explain lower rates of exclusive breastfeeding among early term infants. Variables including breastmilk feeding mode (bottle or directly from the breast), lactation support provided in the hospital, and documented breastfeeding issues were not available to identify possible interventions to improve exclusivity during the inpatient admission. Maternal factors including education, social support for breastfeeding, or breastfeeding history are known to influence breastfeeding behavior but were also unavailable. It is possible that there are physiological differences between women delivering in the early term versus full term (i.e. labor status) that may delay lactogenesis; we relied on proxy variables of maternal hypertensive disorders, gestational diabetes, and cesarean section to account for those groups who were most likely to be delivered earlier and who were less likely to experience labor. Additionally, while we could not examine differences in hospital practices that can influence breastfeeding behavior, we included delivery site as a variable in the adjusted analyses and found that it did not change the relationship between early term delivery and exclusive breastfeeding. Finally, this study was limited by a lack of post-discharge data to assess long-term EBF and breastfeeding duration differences between the two groups. Though the differences in breastfeeding initiation in Donath and Amir's Australian cohort were small (92 vs. 93.9%), they found that breastfeeding at 6 months was significantly lower for early term infants compared to term infants, with an OR of 0.80 (95% CI 0.69 to 0.93) (Donath and Amir 2008). Hackman et al. similarly found negligible differences in initiation between early term (98.1%) and full term (98.2%), infants, but found that breastfeeding at 1 month postpartum was significantly reduced among early term infants (OR 0.77, 95% CI 0.60, 0.99) (Hackman et al. 2016). Differences in breastfeeding exclusivity during the first days of life may explain these patterns, but were unmeasured in these studies. Thus, future studies would benefit from both pre- and post-discharge data on duration of exclusive and non-exclusive breastfeeding in socioeconomically and racially diverse populations to discern the role of social, cultural, biological, and economic conditions that influence infant feeding practices and assess whether the differences observed pre-discharge persist post-discharge.

While physiologic data were not available in this study, it is possible that physiological differences between early and full term infants may underlie the differences in exclusive breastfeeding outcomes. Infants delivered in the early term are noted to have higher occurrences of difficulty latching, hypotonia, and fatigue resulting from immature neurodevelopment status (Eidelman 2016; Hackman et al. 2016). It is possible that the effects of early term delivery on exclusive breastfeeding may be a reflection of developmental immaturity of these physiological pathways, and future research is required to more adequately explore this explanation.

Beyond the effects of gestational age at delivery and mother's race/ethnicity, Medicaid status was the strongest predictor of exclusive breastfeeding in this sample. Those insured with Medicaid at the time of delivery were substantially less likely to exclusively breastfeed compared to those covered with private insurance (37.8% vs. 50.5%, $p < 0.001$), despite the fact that Medicaid patients were no more likely than private-pay patients to deliver via cesarean section, smoke during pregnancy, have a baby admitted to the NICU, or to deliver early-term.

Given the well-documented benefits of breastfeeding, it is important to consistently educate patients during the prenatal and postpartum period. Importantly, providers must be aware of the possible impact that early term delivery may have on a mother's ability to breastfeed exclusively during

the delivery admission. Women at high risk for early cessation of breastfeeding should be targeted with interventions shown to improve breastfeeding rates. Breastfeeding peer counselor programs, breastfeeding specific clinical appointments, and group prenatal education are among the interventions proven to work in improving breastfeeding initiation, duration and exclusivity (Chapman and Perez-Escamilla 2012).

That early term birth may reduce the likelihood of exclusive breastfeeding is a relatively novel concept with limited research. Most NICUs have programs in place for women delivering preterm, providing increased counseling and support for breast pumping and breastfeeding to ensure preterm infants receive the benefits of breast milk. However, women delivering early term have not historically received additional resources post-delivery in anticipation of increased breastfeeding difficulties. Knowledge that early term infants also have significantly lower rates of exclusive breastfeeding should encourage providers to institute focused counseling and additional breastfeeding support for women with early term deliveries. Future work should focus on improving our understanding of interventions that increase exclusive breastfeeding rates for all mothers and babies, including those most at risk of breastfeeding difficulties.

Acknowledgements Financial support for this research provided by the following sources: HHSN275201200007I–HHSN27500005. National Children's Study: Vanguard Study – Task Order 5: Stress and Cortisol Measurement for the National Children's Study. Principal Investigator: Ann E.B. Borders, MD, MSc, MPH. We are grateful for the support of the MOMS Study Collaboration including research staff and participants. We also appreciate the important contribution of the MOM-le pilot study collaboration.

References

AHM Conference. (2009). *Australian national breastfeeding strategy 2010–2015*. Canberra: Australian Government Department of Health and Ageing.

CDC. (2016). Breastfeeding Report Card. Accessed 5/10/2017. https://www.cdc.gov/breastfeeding/pdf/2016breastfeedingreportcard.pdf.

Chantry, C. J., Dewey, K. G., Peerson, J. M., Wagner, E. A., & Nommsen-Rivers, L. A. (2014). In-hospital formula use increases early breastfeeding cessation among first-time mothers intending to exclusively breastfeed. *The Journal of Pediatrics, 164*(6), 1339–1345. https://doi.org/10.1016/j.jpeds.2013.12.035.

Chapman, D. J., & Perez-Escamilla, R. (2012). Breastfeeding among minority women: Moving from risk factors to interventions. *Advances in Nutrition, 3*(1), 95–104. https://doi.org/10.3945/an.111.001016.

Dewey, K. G., Nommsen-Rivers, L. A., Heinig, M. J., & Cohen, R. J. (2003). Risk factors for suboptimal infant breastfeeding behavior, delayed onset of lactation, and excess neonatal weight loss. *Pediatrics, 112*(3 Pt 1), 607–619.

Donath, S. M., & Amir, L. H. (2008). Effect of gestation on initiation and duration of breastfeeding. *Archives of Disease in Childhood-Fetal and Neonatal Edition, 93*(6), F448–450. https://doi.org/10.1136/adc.2007.133215.

Eidelman, A. I. (2016). The challenge of breastfeeding the late preterm and the early-term infant. *Breastfeeding Medicine, 11,* 99. https://doi.org/10.1089/bfm.2016.29007.aie.

Frota, D. A., & Marcopito, L. F. (2004). Breastfeeding among teenage and adult mothers in Brazil. *Revista de Saude Publica, 38*(1), 85–92.

Gionet, L. (2013). Breastfeeding trends in Canada. *Statistics Canada Catalogue no 82-624-X, November*(Health at a Glance).

Hackman, N. M., Alligood-Percoco, N., Martin, A., Zhu, J., & Kjerulff, K. H. (2016). Reduced breastfeeding rates in firstborn late preterm and early term infants. *Breastfeeding Medicine, 11,* 119–125. https://doi.org/10.1089/bfm.2015.0122.

Heinig, M. J., & Dewey, K. G. (1997). Health effects of breast feeding for mothers: A critical review. *Nutrition Research Reviews, 10*(1), 35–56. https://doi.org/10.1079/NRR19970004.

Hoddinott, P., Tappin, D., & Wright, C. (2008). Breast feeding. *BMJ, 336*(7649), 881–887. https://doi.org/10.1136/bmj.39521.566296.BE.

Holmes, A. V., Auinger, P., & Howard, C. R. (2011). Combination feeding of breast milk and formula: Evidence for shorter breastfeeding duration from the National Health and Nutrition Examination Survey. *The Journal of Pediatrics, 159*(2), 186–191. https://doi.org/10.1016/j.jpeds.2011.02.006.

Horta, B. L., Bahl, R., Martines, J. C., & Victora, C. G. (2007). *Evidence on the long-term effects of breastfeeding: Systematic reviews and meta-analysis*. Geneva: World Health Organization.

Ip, S., Chung, M., Raman, G., Chew, P., Magula, N., DeVine, D., et al. (2007). Breastfeeding and maternal and infant health outcomes in developed countries. *Evid Rep Technol Assess (Full Rep), 153,* 1–186.

Jessri, M., Farmer, A. P., Maximova, K., Willows, N. D., Bell, R. C., & Team, A. P. S. (2013). Predictors of exclusive breastfeeding: observations from the Alberta pregnancy outcomes and nutrition (APrON) study. *BMC Pediatrics, 13,* 77. https://doi.org/10.1186/1471-2431-13-77.

Jones, K. M., Power, M. L., Queenan, J. T., & Schulkin, J. (2015). Racial and ethnic disparities in breastfeeding. *Breastfeeding Medicine, 10*(4), 186–196. https://doi.org/10.1089/bfm.2014.0152.

Kehler, H. L., Chaput, K. H., & Tough, S. C. (2009). Risk factors for cessation of breastfeeding prior to six months postpartum among a community sample of women in Calgary, Alberta. *Canadian Journal of Public Health, 100*(5), 376–380.

Kramer, M. S., & Kakuma, R. (2012). Optimal duration of exclusive breastfeeding. *Cochrane Database Systematic Reviews, 8,* CD003517. https://doi.org/10.1002/14651858.cd003517.pub2.

Lutsiv, O., Giglia, L., Pullenayegum, E., Foster, G., Vera, C., Chapman, B., et al. (2013). A population-based cohort study of breastfeeding according to gestational age at term delivery. *The Journal of Pediatrics, 163*(5), 1283–1288. https://doi.org/10.1016/j.jpeds.2013.06.056.

McDonald, S. D., Pullenayegum, E., Chapman, B., Vera, C., Giglia, L., Fusch, C., et al. (2012). Prevalence and predictors of exclusive breastfeeding at hospital discharge. *Obstetrics and Gynecology, 119*(6), 1171–1179. https://doi.org/10.1097/AOG.0b013e318256194b.

McFadden, A., Gavine, A., Renfrew, M. J., Wade, A., Buchanan, P., Taylor, J. L., et al. (2017). Support for healthy breastfeeding mothers with healthy term babies. *Cochrane Database Systematic Reviews, 2,* CD001141. https://doi.org/10.1002/14651858.cd001141.pub5.

Neville, M. C. (2001). Anatomy and physiology of lactation. *Pediatric Clinics of North America, 48*(1), 13–34.

Oza-Frank, R., Moreland, J., McNamara, K., Geraghty, S., & Keim, S. (2016). Early lactation and infant feeding practices differ by maternal gestational diabetes history. *Journal of Human Lactation*, *32*(4), 658–655.

Peaker, M., & Wilde, C. J. (1996). Feedback control of milk secretion from milk. *Journal of Mammary Gland Biology and Neoplasia, 1*(3), 307–315.

Perrine, C. G., Scanlon, K. S., Li, R., Odom, E., & Grummer-Strawn, L. M. (2012). Baby-Friendly hospital practices and meeting exclusive breastfeeding intention. *Pediatrics, 130*(1), 54–60. https://doi.org/10.1542/peds.2011-3633.

Pierro, J., Abulaimoun, B., Roth, P., & Blau, J. (2016). Factors associated with supplemental formula feeding of breastfeeding infants during postpartum hospital stay. *Breastfeeding Medicine, 11,* 196–202. https://doi.org/10.1089/bfm.2015.0091.

Ryan, A. S., Wenjun, Z., & Acosta, A. (2002). Breastfeeding continues to increase into the new millennium. *Pediatrics, 110*(6), 1103–1109.

Semenic, S., Loiselle, C., & Gottlieb, L. (2008). Predictors of the duration of exclusive breastfeeding among first-time mothers. *Research in Nursing & Health, 31*(5), 428–441. https://doi.org/10.1002/nur.20275.

Townsend, R., O'Brein, P., & Khalill, A. (2016). Current best practice in the management of hypertensive disorders in pregnancy. *Integrated Blood Pressure Control*, *9*, 79–94.

Wallwiener, S., Muller, M., Doster, A., Plewniok, K., Wallwiener, C. W., Fluhr, H., et al. (2016). Predictors of impaired breastfeeding initiation and maintenance in a diverse sample: What is important? *Archives of Gynecology and Obstetrics, 294*(3), 455–466. https://doi.org/10.1007/s00404-015-3994-5.

Wight, N., & Marinelli, K. A. (2014). ABM clinical protocol #1: Guidelines for blood glucose monitoring and treatment of hypoglycemia in term and late-preterm neonates. *Breastfeeding Medicine, 9*(4), 173–179.

Affiliations

Lauren S. Keenan-Devlin[1,2] · Yetunde F. Awosemusi[2] · William Grobman[3,4] · Hyagriv Simhan[5,6] · Emma Adam[7] · Jennifer Culhane[8,9] · Gregory Miller[10] · Ann E. B. Borders[1,2,11]

Yetunde F. Awosemusi
yetundeawosemusi@yahoo.com

William Grobman
w-grobman@northwestern.edu

Hyagriv Simhan
hsimhan@mwri.magee.edu

Emma Adam
ek-adam@northwestern.edu

Jennifer Culhane
jennifer.culhane@yale.edu

Gregory Miller
greg.miller@northwestern.edu

Ann E. B. Borders
borders.ann@gmail.com

[1] Department of Obstetrics and Gynecology, NorthShore University HealthSystem, 2650 Ridge Ave Walgreen Bldg, Ste 1507, Evanston, IL 60201, USA

[2] Department of Obstetrics and Gynecology, University of Chicago Pritzker School of Medicine, Chicago, IL, USA

[3] Division of Maternal–Fetal Medicine, Department of Obstetrics and Gynecology, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

[4] Center for Healthcare Studies – Institute for Public Health and Medicine, Northwestern University, Chicago, IL, USA

[5] Division of Maternal–Fetal Medicine, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA

[6] Division of Obstetrical Services, Magee Women's Hospital, Pittsburgh, PA, USA

[7] School of Education and Social Policy, Institute for Policy Research, Northwestern University, Evanston, IL, USA

[8] Division of Adolescent Medicine, Children's Hospital of Philadelphia, Philadelphia, PA, USA

[9] Department of Pediatrics, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, USA

[10] Department of Psychology, Institute for Policy Research, Northwestern University, Evanston, IL, USA

[11] Center for Healthcare Studies—Institute for Public Health and Medicine, Northwestern University, Chicago, IL, USA