Predictors of breastfeeding non-initiation in the NICU

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Abstract

This study compared predictors of breastfeeding non-initiation between infants who were and were not admitted to the NICU so that interventions can target high-risk mothers whose infants desperately need breastmilk. This was a population-based retrospective cohort study of singleton Ohio live births using birth certificates, 2006–2015. In babies who were and were not admitted to the NICU, a multivariable logistic regression model assessed the association between breastfeeding non-initiation and predictors relating to the mother, neonate, and labour and delivery events while adjusting for covariables. Of 1,463,506 births, 76,855 infants were admitted to the NICU (5.8% of study population), and breastfeeding was not initiated in 39.4% of them, compared with 31.5% of infants in the newborn nursery, $p < 0.001$. Apart from abnormal newborn conditions, smoking during pregnancy was the most significant risk factor for not breastfeeding in the NICU (RR 1.91 [95% CI 1.82–2.02]) and newborn nursery (RR 2.10 [95% CI 2.08–2.13]), followed by socioeconomic factors and multiparity. Limited prenatal visits (≤ 5) were a significantly higher risk factor in the NICU (RR 1.41 [95% CI 1.34–1.49]) than in the newborn nursery (RR 1.24 [95% CI 1.22–1.26]). Intentional home birth and use of infertility treatment were associated with breastfeeding initiation. The rate of breastfeeding initiation is lower in infants admitted to the NICU than those who are not, especially among mothers with limited prenatal care. Interventions should target mothers who smoke because they are least likely to breastfeed, and their babies, who are prone to serious health conditions, could especially benefit from breastmilk.

KEYWORDS

breastfeeding, breastfeeding initiation, breast milk, NICU, prenatal care, smoking

1 | INTRODUCTION

Because of increased awareness of the benefits premature infants receive from breastfeeding that can ultimately lower hospital costs, recent studies have sought to identify populations less likely to breastfeed to target educational interventions and support efforts (Johnson, Patel, Bigger, Engstrom, & Meier, 2014). In 2011, the Surgeon General announced a call to action to support breastfeeding (Office of the Surgeon General, 2011). During the 10-year study period, breastfeeding rates significantly increased in both the wellborn and NICU branches of the study cohort. However, breastfeeding rates in

the NICU only climbed to 56%. We can do better, especially considering the unique value of breastfeeding for mother and child. Some of the immediate health benefits of breastfeeding for the infant include decreased rates of respiratory infections, otitis media, and gastrointestinal infections due to passive immunity transferred from the mother's milk (Bartick et al., 2017; Leon-Cava, Lutter, Ross, & Martin, 2002; Victora et al., 2016). Infants who are breastfed also have a lower risk of sudden infant death syndrome (Bartick et al., 2017). Breastfeeding is also associated with maternal health benefits. When mothers initiate breastfeeding immediately after delivery, it facilitates uterine contraction and expulsion of the placenta, which reduce postpartum bleeding

(Leon-Cava et al., 2002). Long-term maternal benefits include lower rates of ovarian cancer, premenopausal breast cancer, hypertension, diabetes, and myocardial infarction (Bartick et al., 2017; Leon-Cava et al., 2002; Victora et al., 2016). Additionally, breastfeeding helps to naturally space births, which reduces the pregnancy risks associated with short birth intervals (Bartick et al., 2017; Leon-Cava et al., 2002).

Breastfeeding is especially important for babies admitted to the NICU, who have susceptible immune systems and specific nutritional needs. Among this especially vulnerable population, breastfeeding has been associated with lower risks of retinal detachment and necrotizing enterocolitis as well as improved neurodevelopmental outcomes (Bharwani et al., 2016; Isaacs et al., 2010; Maffei & Schanler, 2017; Okamoto et al., 2007; Sisk, Lovelady, Dillard, Gruber, & O'Shea, 2007; Vohr et al., 2006).

Despite these findings, breastfeeding rates are significantly lower in developed countries such as the United States than in low-income countries (Victora et al., 2016), and in many U.S. hospitals, women have been even less likely to breastfeed if their infant is admitted to the NICU (Callen & Pinelli, 2005; Kachoria & Oza-Frank, 2015). This study aims to identify factors that influence the rate of breastfeeding non-initiation in babies admitted to the NICU across all hospitals in Ohio to estimate U.S. trends. Including data from all hospitals in Ohio ensures a large and socioeconomically diverse sample that can provide insight into NICU breastfeeding initiation trends across the United States despite birth certificate variability that prevents the execution of a more comprehensive, state-wide study. Breastfeeding data from the CDC National Immunization Survey estimate breastfeeding rates by state and confirm that the breastfeeding rates in Ohio approximate the national average during the study interval, although these data likely overestimates national breastfeeding rates by relying on telephone sampling, information recall, and self-reported data (National Center for Chronic Disease Prevention and Health Promotion, 2018). The study objective is to identify a population of mothers who may particularly benefit from breastfeeding education and support interventions in a hospital environment with accessible breastfeeding resources already in place. Furthermore, identifying risk factors for not breastfeeding can help tailor intervention programs to best reach as many mothers as possible. For infants in the NICU, any intervention that has the potential to improve their health outcomes is extremely important. Because breastfeeding has already been proven to positively impact infants in numerous ways, it is critical that more focus is placed on advocating for breastfeeding in the NICU. This study will identify if there are any maternal risk factors for breastfeeding non-initiation that are different between the NICU and newborn nursery and will thus need additional attention in the NICU setting.

2 | METHODS

This was a population-based retrospective cohort study of all live births in Ohio from 2006 to 2015 based on deidentified vital statistics birth certificate records from the Ohio Department of Health. The protocol for this study was approved by the Ohio Department of Health human subjects institutional review board. This study was

Key messages

- Although ill infants in the NICU could especially benefit from breastmilk, breastfeeding initiation rates remain lower in the NICU than in the newborn nursery. The NICU is especially well suited for educational interventions because mothers are in frequent contact with the healthcare staff and oftentimes have access to lactation consultants and other breastfeeding resources. To better utilize this opportunity to promote breastfeeding, hospitals should be aware of the population of mothers who are unlikely to breastfeed so that educational and support interventions can be tailored to help overcome the barriers preventing that population from breastfeeding.
- Breastfeeding intervention efforts should target mothers who smoke because not only are they least likely to breastfeed but also their babies are prone to serious health conditions. Aside from anomalies and abnormal newborn conditions, smoking during pregnancy is the most significant risk factor for not breastfeeding in the NICU and the newborn nursery.
- Hospitals should identify mothers with low educational attainment and limited prenatal care so they can be educated perhaps for the first time about the benefits of breastfeeding. Limited prenatal care is a significantly higher risk factor for not breastfeeding in the NICU than in the newborn nursery. Gastroschisis and extremely low birth weight are protective for breastfeeding, likely because physicians advocate for these patients in particular, which show that education can protect infants who need breastmilk.

exempt from review by the institutional review board at the University of Cincinnati, Cincinnati, Ohio.

2.1 | Sample

Births were excluded from the study prior to analysis if the infant was not living or if data were missing about whether the infant was living at the time the birth certificate was generated. Infants born before 23 weeks gestational age, and infants born with anencephaly were excluded from study because these conditions are considered not compatible with life and typically result in mortality within hours of birth, thus prohibiting assessment of the outcome, breastfeeding initiation. Multiple gestation births were also excluded from the study to prevent double counting of an individual mother and to eliminate a potential confounding variable. Births to Ohio resident mothers outside of Ohio were not included in the study due to interstate birth certificate variability. Analyses were limited to births with complete breastfeeding and NICU admission data.

2.2 | NICU admission and breastfeeding

The first part of the study analysed the cohort of infants admitted to the NICU. On the birth certificate, "NICU admission" is an option under the category "abnormal conditions of the newborn" that is checked if it applies to the infant. The primary outcome was no breastfeeding initiation, which is addressed on the birth certificate by the question, "Is the infant being breastfed at discharge? (yes/no)" (National Center for Health Statistics, 2003). This question does not gather information about whether the breastfeeding was exclusive or supplemented or whether it involved direct breastfeeding, pumped milk, or donor milk. There are no data about breastfeeding duration after hospital discharge. Therefore, this study analyses initiation of any of the above forms of breastfeeding within the first 48 hr postpartum, when the birth certificates are typically generated.

2.3 | Measures

The predictors of breastfeeding non-initiation fell into three broad categories relating to the mother, the neonate, and labour and delivery events. The predictors of breastfeeding non-initiation fell into three broad categories relating to the mother, the neonate, and labour and delivery events, and they are enumerated in the Supporting Information section. The maternal variables that were analysed included age, race/ethnicity, county of residence, completed education level, Medicaid receipt, marital status, prenatal care, smoking during pregnancy, prepregnancy weight, parity, pregnancy interval, previous preterm birth, previous C-section, prepregnancy or gestational diabetes, chronic or gestational hypertension, eclampsia, infection during pregnancy, and use of infertility treatment. Counties of maternal residence were categorized as urban, suburban, or rural according to the 2013 rural-urban continuum code made by the United States Department of Agriculture (Economic Research Service, 2016). Metro counties ranked 1–3 by the continuum code were considered urban; nonmetro counties ranked 4–6 were considered suburban, and nonmetro counties ranked 7–9 were considered rural. Infections of interest included gonorrhoea, syphilis, chlamydia, hepatitis B, or hepatitis C. Variables related to labour and delivery events included spinal or epidural anaesthesia administration, onset of labour, induction or augmentation of labour, tocolysis, cervical cerclage, antibiotic administration, maternal complication, method of delivery, and place where birth occurred. Maternal complications included maternal transfusion, third or fourth degree perineal laceration, ruptured uterus, unplanned hysterectomy, admission to intensive care unit, or unplanned operating room procedure following delivery. The neonatal variables analysed were birthweight, gestational age at delivery, gender, low Apgar score, assisted ventilation, surfactant replacement therapy, antibiotic administration, seizure or serious neurological dysfunction, significant birth injury, and various congenital anomalies. Significant birth injuries included skeletal fracture(s), peripheral nerve injury, or soft tissue/solid organ haemorrhage, which required intervention, as recorded in the certificate of live birth. All births during the study period utilized the 2003 version of the U.S. birth certificate (National Center for Health

Statistics, 2003). Standardized guidelines for completing the birth certificate are based on the National Vital Statistics Guide to Completing the Facility Worksheets for the Certificate of Live Birth and Report of Fetal Death (National Center for Health Statistics, 2016).

2.4 | Statistical analysis

Statistical analyses were performed using STATA v15.0 software (StataCorp, College Station, TX). Demographic characteristics were compared between neonates who were breastfed or not using the χ^2 or t test. Associations between the above predictors and breastfeeding non-initiation were computed using a multivariable logistic regression model. Factors that were highly predictive of not breastfeeding based on statistical significance in univariate comparisons were included in a multivariable logistic regression model to adjust for potential confounding risks. These covariables included maternal age, race, education, Medicaid receipt, marital status, prenatal care, smoking habits, BMI, parity, presence of infection during pregnancy, and use of infertility treatment, as well as infant birth weight and place where birth occurred. Factors were removed from the multivariable logistic regression model via backward selection if they no longer had significance when added to the model. Birth interval was not included in the adjusted model because of collinearity with parity, and gestational age was not included in the adjusted model because of collinearity with infant birth weight (birth weight was a stronger and more accurate measure than gestational age). Abnormal conditions of the newborn and congenital anomalies were not included in the adjusted model because of variability in the ability of the infant to receive nutrition by mouth. However, crude relative risks of breastfeeding non-initiation were calculated for these conditions. Results of the statistical analyses are reported as crude and adjusted relative risks ratios with 95% confidence intervals.

We then compared predictors of breastfeeding non-initiation in an exposure group of babies admitted to the NICU with a reference group of babies who remained in the newborn nursery in a similar fashion. Predictors were considered significantly different between the exposure and reference groups if there was no overlap between the confidence intervals for each of the relative risks.

3 | RESULTS

The total number of Ohio live births from 2006 to 2015 was 1,463,506. After exclusions, 1,317,535 births were analysed in this study. There were minimal missing data (<5%) for all variables except use of infertility treatment (30.3%) and spinal or epidural anaesthesia administration (10.1%). As shown in Figure 1, 76,855 (5.8%) infants were admitted to the NICU, and 1,240,680 (94.2%) infants were not. Breastfeeding was not initiated in 390,972 (31.5%) infants in the reference group (no NICU admission), compared with 30,283 (39.4%) infants in the exposure group (NICU admission), $p < 0.001$.

Most mothers in the exposure and reference groups were non-smoking multiparas between 20 and 34 years of age with at least some college education. The majority (76.1%) of mothers were non-

^aSome births meet more than one exclusion criterion.

FIGURE 1 Flow diagram of study cohort

Hispanic White, and the largest minority (15.9%) were non-Hispanic Black. Within this socioeconomically diverse population, almost four in every 10 women received Medicaid, and over four in every 10 women were unmarried. Additional characteristics of the study population are shown in Tables 1, 2, and 3.

Within the adjusted model, the greatest risk factors for breastfeeding non-initiation in the NICU were smoking during pregnancy (aRR 1.91 [95% CI 1.82–2.02]), multiparity (aRR 1.72 [95% CI 1.64–1.79]), being unmarried (aRR 1.68 [95% CI 1.60–1.77]), Medicaid recipient (aRR 1.51 [95% CI 1.44–1.58]), no high school diploma

(aRR 1.48 [95% CI 1.40–1.57]), and ≤ 5 prenatal visits (aRR 1.41 [95% CI 1.34–1.49]). Other maternal risk factors for breastfeeding non-initiation in the NICU were infection present and/or treated during pregnancy (aRR 1.32 [95% CI 1.21–1.44]), young maternal age <20 years (aRR 1.30 [95% CI 1.21–1.40]), and maternal obesity with prepregnancy BMI ≥ 40.0 (aRR 1.26 [95% CI 1.16–1.37]). The most significant risk factors for breastfeeding non-initiation are represented by the adjusted model in Table 4.

Limited prenatal visits (≤ 5) were a significantly higher risk factor for breastfeeding non-initiation in the NICU (aRR 1.41 [95% CI

TABLE 1 Maternal characteristics: exposure and reference groups

Maternal characteristics	Newborn nursery	NICU admission	p value
Demographic			
Age (year):			<0.001
<20	112,604 (9.1%)	7,908 (10.3%)	
20–34	980,281 (79.0%)	58,542 (76.2%)	
≥35	147,753 (11.9%)	10,399 (13.5%)	
Race:			<0.001
Non-Hispanic White	950,130 (76.6%)	53,098 (69.1%)	
Non-Hispanic Black	191,247 (15.4%)	17,786 (23.1%)	
Hispanic	57,021 (4.6%)	3,460 (4.5%)	
Other	33,827 (2.7%)	1,855 (2.4%)	
Socioeconomic			
County of residence: ^a			<0.001
Urban	960,485 (77.4%)	62,621 (81.5%)	
Suburban	225,796 (18.2%)	10,393 (13.5%)	
Rural	25,285 (2.0%)	862 (1.1%)	
Out-of-state	20,699 (1.7%)	2,188 (2.9%)	
Education level:			<0.001
No high school diploma	193,090 (15.6%)	14,178 (18.5%)	
High school diploma	315,845 (25.5%)	21,362 (27.8%)	
Some college	274,698 (22.1%)	17,944 (23.4%)	
College degree	449,945 (36.3%)	22,669 (29.5%)	
Medicaid	463,573 (37.4%)	35,009 (45.6%)	<0.001
Unmarried	521,875 (42.1%)	40,305 (52.4%)	<0.001
Prenatal care			
Limited prenatal visits (≤5)	91,844 (7.4%)	13,295 (17.3%)	<0.001
Smoked during pregnancy	217,165 (17.5%)	17,533 (22.8%)	<0.001
Maternal health indicators			
Prepregnancy BMI:			<0.001
<18.5 (underweight)	50,051 (4.0%)	3,643 (4.7%)	
18.5–24.9 (normal)	566,636 (45.7%)	31,757 (41.3%)	
25.0–29.9 (overweight)	288,524 (23.3%)	17,182 (22.4%)	
30.0–39.9 (obese)	229,123 (18.5%)	15,660 (20.4%)	
≥40.0 (morbidly obese)	56,244 (4.5%)	4,933 (6.4%)	
Parity:			<0.001
Primiparous	484,865 (39.1%)	34,075 (44.3%)	
Multiparous	742,463 (59.8%)	41,922 (54.6%)	
Birth interval (months):			<0.001
<18	81,809 (6.6%)	5,867 (7.6%)	
18–23	101,754 (8.2%)	4,809 (6.3%)	
24–59	349,527 (28.2%)	17,041 (22.2%)	
59–71	43,970 (3.5%)	2,616 (3.4%)	
>72	106,779 (8.6%)	7,687 (10.0%)	
Previous preterm birth	44,648 (3.6%)	8,039 (10.5%)	<0.001
Previous C-section	162,307 (13.1%)	13,252 (17.2%)	<0.001

(Continues)

TABLE 1 (Continued)

Maternal characteristics	Newborn nursery	NICU admission	<i>p</i> value
Diabetes:			
Prepregnancy	8,489 (0.7%)	2,302 (3.0%)	<0.001
Gestational	69,817 (5.6%)	6,777 (8.8%)	<0.001
Hypertension:			
Chronic	22,767 (1.8%)	4,057 (5.3%)	<0.001
Gestational	57,934 (4.7%)	8,774 (11.4%)	<0.001
Eclampsia	5,302 (0.4%)	2,372 (3.1%)	<0.001
Infection present and/or treated during pregnancy: ^b	40,583 (3.3%)	4,682 (6.1%)	<0.001
Current pregnancy result of infertility treatment	9,614 (0.8%)	838 (1.1%)	<0.001

^aCounty of residence info provided by United States Department of Agriculture.

^bInfections included gonorrhoea, syphilis, chlamydia, hepatitis B, or hepatitis C.

There was minimal missing data, which are not represented here but were part of the study calculations.

TABLE 2 Labour and delivery event characteristics: exposure and reference groups

Labour and delivery events	Newborn nursery	NICU admission	<i>p</i> value
Spinal or epidural anaesthesia	832,495 (67.10%)	53,325 (69.4%)	<0.001
Onset of labour:			<0.001
PROM	30,912 (2.5%)	12,079 (15.7%)	
Precipitous (without PROM)	39,969 (3.2%)	2,638 (3.4%)	
3–20 hr (without PROM)	1,155,020 (93.1%)	60,808 (79.1%)	
Prolonged (without PROM)	14,743 (1.2%)	1,328 (1.7%)	
Induction of labour	407,776 (32.9%)	17,312 (22.5%)	<0.001
Augmentation of labour	315,482 (25.4%)	15,416 (20.1%)	<0.001
Tocolysis	21,246 (1.7%)	5,707 (7.4%)	
Cervical cerclage	3,061 (0.3%)	831 (1.1%)	
Antibiotics administered	336,779 (27.1%)	37,144 (48.3%)	<0.001
Maternal complication: ^a	32,363 (2.6%)	3,948 (5.1%)	
Method of delivery:			<0.001
Vaginal	896,015 (72.2%)	39,085 (50.9%)	
Caesarean	344,013 (27.7%)	37,724 (49.1%)	
Place where birth occurred:			<0.001
Hospital	1,222,710 (98.6%)	76,476 (99.5%)	
Freestanding birth centre	5,204 (0.4%)	20 (0.03%)	
Home (intended)	10,310 (0.8%)	68 (0.09%)	
Home (not intended or intention unknown)	1,427 (0.1%)	192 (0.3%)	
Clinic/doctor's office	301 (0.02%)	30 (0.04%)	
Other	722 (0.06%)	69 (0.09%)	

Note. PROM: premature rupture of membranes.

^aMaternal complications during labour and delivery included maternal transfusion, third or fourth degree perineal laceration, ruptured uterus, unplanned hysterectomy, admission to intensive care unit, or unplanned operating room procedure following delivery.

TABLE 3 Neonatal characteristics: exposure and reference groups

Neonatal characteristics	Newborn nursery	NICU admission	p value
Birthweight (grams):			<0.001
<1,000 (ELBW)	406 (0.03%)	3,910 (5.1%)	
1,000–1,499 (VLBW)	1,150 (0.09%)	5,949 (7.7%)	
1,500–2,499 (LBW)	45,423 (3.7%)	24,456 (31.8%)	
2,500–3,999 (NBW)	1,085,257 (87.5%)	38,296 (49.8%)	
≥4,000 (HBW)	107,987 (8.7%)	3,978 (5.2%)	
Gestational age at delivery (weeks):			<0.001
23–27 (extremely preterm)	2,062 (0.2%)	4,000 (5.2%)	
28–31 (very preterm)	5,801 (0.5%)	7,536 (9.8%)	
32–36 (moderate to late preterm)	82,227 (6.6%)	28,587 (37.2%)	
≥37 weeks (term)	1,149,566 (92.7%)	36,542 (47.6%)	
Gender:			<0.001
Male	630,822 (50.8%)	43,038 (56.0%)	
Female	609,856 (49.2%)	33,816 (44.0%)	
Apgar score less than 7 (at 5 min) ^a	15,963 (1.3%)	10,778 (14.0%)	<0.001
Abnormal conditions of the newborn			
Assisted ventilation required	35,500 (2.9%)	21,616 (28.13%)	<0.001
Surfactant replacement therapy	617 (0.1%)	3,860 (5.02%)	<0.001
Antibiotics for suspected neonatal sepsis	5,998 (0.5%)	15,322 (19.9%)	<0.001
Seizure or serious neurologic dysfunction	75 (0.01%)	259 (0.3%)	<0.001
Significant birth injury ^b	659 (0.05%)	172 (0.2%)	<0.001
Congenital anomalies			
Meningomyelocele/spina bifida	85 (0.01%)	227 (0.3%)	<0.001
Cyanotic congenital heart disease	104 (0.01%)	654 (0.9%)	<0.001
Congenital diaphragmatic hernia	32 (0.00%)	153 (0.2%)	<0.001
Omphalocele	31 (0.00%)	126 (0.2%)	<0.001
Gastroschisis	47 (0.00%)	480 (0.6%)	<0.001
Limb reduction defect ^c	155 (0.01%)	66 (0.1%)	<0.001
Cleft lip with or without cleft palate	566 (0.05%)	210 (0.3%)	<0.001
Cleft palate alone	412 (0.03%)	219 (0.3%)	<0.001
Down syndrome (confirmed or pending)	428 (0.03%)	382 (0.5%)	<0.001
Hypospadias	848 (0.07%)	146 (0.2%)	<0.001

Note. ELBW: extremely low birth weight; VLBW: very low birth weight; LBW: low birth weight; NBW: normal birth weight; HBW: high birth weight.

^aApgar score: score given to newborn immediately after delivery to determine its overall well-being. Scale from 0 to 10; <7 indicates that the newborn needs medical attention.

^bSignificant birth injuries included skeletal fracture(s), peripheral nerve injury, or soft tissue/solid organ haemorrhage, which required intervention.

^cLimb reduction defect: excludes congenital amputation and dwarfing syndrome.

1.34–1.49]) than in the newborn nursery (aRR 1.24 [95% CI 1.22–1.26]). Women who smoked during pregnancy were also at the greatest risk of breastfeeding non-initiation in the newborn nursery (aRR 2.10 [95% CI 2.08–2.13]). Crude relative risks for the reference group are reported in the supporting information section as well as the crude results for the exposure group for comparison.

4 | DISCUSSION

In this contemporary cohort of live births, we found that significantly fewer mothers initiated breastfeeding for their newborns if they were admitted to NICU. There is a paucity of information about national rates of breastfeeding initiation for ill newborns admitted to the NICU, but

TABLE 4 Adjusted relative risks

Predictor of not breastfeeding	Newborn nursery		NICU	
	aRR	95% CI	aRR	95% CI
Maternal characteristics				
Young age (<20 years)	1.54	1.51–1.57	1.30	1.21–1.40
Black race	1.07	1.06–1.09	0.94	0.89–1.00
No high school diploma	1.57	1.54–1.59	1.48	1.40–1.57
Medicaid recipient	1.69	1.67–1.71	1.51	1.44–1.58
Unmarried	1.98	1.95–2.01	1.68	1.60–1.77
Limited prenatal visits (≤ 5)	1.24	1.22–1.26	1.41	1.34–1.49
Smoked during pregnancy	2.10	2.08–2.13	1.91	1.82–2.02
Underweight BMI (<18.5)	1.14	1.12–1.17	1.09	0.99–1.20
Morbidly obese BMI (≥ 40.0)	1.40	1.37–1.44	1.26	1.16–1.37
Multiparous	1.81	1.79–1.84	1.72	1.64–1.79
Infection present and/or treated during pregnancy: ^a	1.17	1.14–1.21	1.32	1.21–1.44
Current pregnancy result of infertility treatment	0.77	0.72–0.81	0.88	0.74–1.06
Labour and delivery events				
Intentional home birth	0.03	0.02–0.04	0.42	0.17–1.02
Neonatal characteristics				
Extremely low birth weight (<1,000 g)	1.51	1.12–2.03	0.77	0.69–0.85

^aInfections included gonorrhoea, syphilis, chlamydia, hepatitis B, or hepatitis C.

There was minimal missing data, which are not represented here but were part of the study calculations.

Values that are significant are bolded.

one study used data from 27 states to determine breastfeeding trends in the NICU from 2000 to 2003. The study showed that although NICU admission may have a positive influence on breastfeeding continuation, mothers of NICU infants were less likely to initiate breastfeeding than mothers of nonadmitted infants (Colaizy & Morriss, 2008). Although the gap between breastfeeding non-initiation in NICU-admitted and nonadmitted infants may be narrowing, our results show that breastfeeding is still not initiated in almost four in 10 infants admitted to the NICU (Kachoria & Oza-Frank, 2015). For many mothers, breastfeeding may not be a priority amidst the stress that comes along with having a child in the NICU, and a stressful labour and delivery experience is a risk factor for delayed onset of lactogenesis (difficulty with initial milk production; Bernaix, Schmidt, Jamerson, Seiter, & Smith, 2006; Dewey, Nommsen-Rivers, Heinig, & Cohen, 2003).

Some studies have described racial, cultural, and socioeconomic factors as predictors of not breastfeeding but have not specifically examined predictors of breastfeeding non-initiation among the sickest infants who may benefit from breastmilk the most, infants admitted to the NICU (Celi, Rich-Edwards, Richardson, Kleinman, & Gillman, 2005; Kelly, Watt, & Nazroo, 2006; McDowell, Wang, & Kennedy-Stephenson, 2008). Consistent with results for the general population analysed in these studies, socioeconomically disadvantaged mothers were significantly less likely to initiate breastfeeding in the NICU as well. However, while non-Hispanic Black race was a risk factor for breastfeeding non-initiation in the United States in these studies as well as in the reference group of this study, it was not a risk factor

in the adjusted model for infants admitted to the NICU. In both the reference and exposure groups of this study, smoking during pregnancy was the highest risk factor for breastfeeding non-initiation, even after adjustment for potential confounding variables. Intervention efforts should particularly target mothers who smoke because not only are they least likely to breastfeed but also their babies are prone to serious health conditions and could thus especially benefit from breastmilk. Mothers may be deterred from breastfeeding while smoking because of the idea that it is harmful for the baby, which may have some merit, according to studies that have shown that nicotine is several times more concentrated in the breastmilk of smokers than plasma (Napierala, Mazela, Merritt, & Florek, 2016). However, smoking during pregnancy also has negative effects on the developing fetus, such as fetal growth restriction, but most mothers who begin pregnancy smoking continue to smoke during pregnancy anyways (Blatt, Moore, Chen, Van Hook, & DeFranco, 2015). One study found that quitting smoking during pregnancy was associated with subsequent breastfeeding and that low-income women who intended to breastfeed were more likely to quit smoking during pregnancy (Carswell et al., 2018). Thus, identifying mothers who smoke while they are early in the pregnancy to support cessation and to educate about breastfeeding benefits may have a positive impact on both life-style choices. Part of the education process for women who smoke may involve the medicinal use of donor human milk to meet the nutritional needs of the infant when the mother is struggling to produce enough of her own milk, which is a challenging feat for mothers of

preterm infants (Callen & Pinelli, 2005). Advocation of supplemental donor milk in this population may lead to a need to expand the use of donor human milk services, which has been shown to increase the use of mother's own milk at discharge (Haslam et al., 2018; Parker, Burnham, Mao, Philipp, & Merewood, 2016).

Many of the risk factors for breastfeeding non-initiation are also risk factors for preterm birth, such as young maternal age, low socioeconomic and educational status, smoking, low BMI, intrauterine infection, and use of reproductive technology (Goldenberg, Culhane, Iams, & Romero, 2008; Vogel et al., 2018). Despite the association between these factors and preterm birth, they are independently associated with breastfeeding non-initiation after adjustment in a multivariable logistic regression model using gestational age and infant birth weight to represent prematurity.

Limited prenatal care (≤ 5 prenatal visits) was a greater risk factor for breastfeeding non-initiation in the NICU than in the newborn nursery, perhaps because mothers with less formal education may not know about the specific benefits of breastmilk for NICU babies. It is critical for the healthcare team to identify mothers with limited prenatal care, so they can be educated for potentially the first time about the benefits of breastfeeding, especially for sick infants. Babies with gastroschisis and extremely low or very low birth weight had an increased likelihood of being breastfed in the NICU, likely because physicians know they could benefit tremendously from breastmilk and advocate for them. Opportunities exist to educate mothers of all babies in the NICU to breastfeed.

Intentional home birth was also associated with an increased likelihood of being breastfed. There may be factors shared among women who choose home birth that also influence their choice to breastfeed. The results of the regression model demonstrating an association between the two do not infer that there is a cause and effect between either the decision to give birth at home or to breastfeed, but rather, the decision to do both may be inherently correlated. This correlation does not necessarily negate the influence of post-delivery counselling in the NICU on breastfeeding nor the importance of breastfeeding support services to NICU mothers to initiate and sustain breastfeeding. It is beyond the scope of this study to measure differences in outcomes of breastfeeding in NICU mothers based on the environment of birth and unknown resources associated with it.

Evidence suggests that some interventions specifically targeting mothers in the NICU have been successful (Fugate, Ivonne, Terri, Miladinovic, & Spatz, 2015; McInnes & Chambers, 2008; Meier, Engstrom, Mingolelli, Miracle, & Kiesling, 2004; Merewood et al., 2006; Pinelli, Atkinson, & Saigal, 2001). Education and support approaches range from meetings with lactation consultants and other healthcare professionals to peer counselling from mothers in the community and programs for fathers (Furman, Killpack, Matthews, Davis, & O'Riordan, 2016; McInnes & Chambers, 2008; Meier et al., 2004; Merewood et al., 2006; Pinelli et al., 2001). Some of these interventions involved socioeconomically advantaged mothers with strong support networks who already have an increased likelihood of breastfeeding, whereas others reached less advantaged inner-city populations (Balogun et al., 2016; Furman et al., 2016; Howe-Heyman &

Lutenbacher, 2016; Humphreys, Thompson, & Miner, 1998; Merewood et al., 2006; Pinelli et al., 2001). Mothers with higher socioeconomic status and mothers who already had intent to breastfeed benefitted less from intervention programs than inner-city mothers who did not initially intend to breastfeed (Furman et al., 2016; Humphreys et al., 1998; Merewood et al., 2006; Pinelli et al., 2001). Furthermore, the most effective intervention method varied depending on maternal characteristics. High-risk inner-city mothers benefitted more from peer involvement than healthcare staff support alone (Furman et al., 2016; Humphreys et al., 1998). Despite efforts to promote breastfeeding initiation, rates in the NICU remain below rates in the newborn nursery, suggesting that more targeted approaches are needed. Furthermore, many of these interventions focused on breastfeeding duration as a primary outcome, but research shows that early breastfeeding initiation is a key predictor of optimal breastfeeding behavior and decreases infant mortality (Debes, Kohli, Walker, Edmond, & Mullany, 2013; Dewey et al., 2003; Edmond et al., 2006). By developing a systematic way to identify mothers who are least likely to intend to breastfeed and by alerting healthcare professionals to high-risk populations for breastfeeding non-initiation, interventions can promote breastfeeding in these mothers even before the baby is born or within the baby's first hours of life.

A strength of our study is that it analysed a wide array of breastfeeding non-initiation predictors to identify risk factors that have not been assessed in other studies, such as smoking during pregnancy, congenital anomalies, and county of maternal residence. One previously published study from Ohio assessed the association between breastfeeding initiation in the NICU and gestational age but did not analyse any other predictors (Kachoria & Oza-Frank, 2015).

Additional strengths of this study include a large sample size and a population-based cohort, which we believe make the results and implications of the study generalizable across the United States, especially because breastfeeding rates in Ohio approximate national breastfeeding rates. Studies that have analysed breastfeeding initiation in the NICU either studied a nondiverse population from one hospital and/or took place in Europe, where breastfeeding culture and rates are much different than those in the United States (Herich et al., 2017; Lessen & Crivelli-Kovach, 2007; Nielan-Vilén, Melender, Axelin, Loyttyniemi, & Salantera, 2016; Wallwiener et al., 2016). Because this study included birth data from all hospitals in the state of Ohio, it analysed a socioeconomically diverse population representative of much of the United States. This study would be difficult to execute across multiple U.S. states due to birth certificate variability and variation in birth certificate data collection policies. One previously published study from Ohio assessed the association between breastfeeding initiation in the NICU and gestational age but did not analyse any other predictors (Kachoria & Oza-Frank, 2015). Another strength of our study is that it analysed a wide array of breastfeeding non-initiation predictors to identify risk factors that have not been assessed in other studies, such as smoking during pregnancy, congenital anomalies, and county of maternal residence.

This study was limited by the type and quality of information recorded on Ohio birth certificate records. The primary outcome,

breastfeeding initiation, was assessed by a “yes” or “no” response to the question, “Is the infant being breastfed at discharge?” This question does not specify whether the breastfeeding was exclusive or supplemented or whether it involved direct breastfeeding, pumped milk, or donor milk. Many infants who are born prematurely have physiological barriers that inhibit their ability to breastfeed directly, which requires coordination of sucking, swallowing, and breathing using muscles and skills that mature with gestational age (Callen & Pinelli, 2005). These infants must receive nutrition by other methods, such as by hand or through gavage feeding. Because donor milk has benefits over preterm formula, it is the preferred alternative for preterm infants when mother’s own milk is not available (Sisk et al., 2017). The delivery of human milk through methods other than the breast has been referred to as breastmilk feeding, which this study also considers to be breastfeeding.

The birth certificate question, “Is the infant being breastfed at discharge?” does not provide information about breastfeeding duration either. However, this study not only focused on in-hospital breastfeeding initiation because of available data but also because of the aforementioned benefits specific to early breastfeeding initiation. In fact, the World Health Organization now not only recommends exclusive infant breastfeeding for the first 6 months of life but also recommends breastfeeding initiation within the first hour of life. Many of the risk factors for breastfeeding non-initiation are the same risk factors for early termination of breastfeeding, so interventions that promote breastfeeding in the hospital should provide support for mothers after discharge (Almqvist-Tangen, Bergman, Dahlgren, Roswall, & Alm, 2012; Thulier & Mercer, 2009; Valentine et al., 2019).

Exploration of the interplay between breastfeeding and additional variables such as drug and alcohol use was limited by the maternal information available on the birth certificate, but variables such as drug and alcohol use may not be accurately reported by mothers anyways. Although it is not possible to ensure that all birth certificate data are reported accurately, NICU admission and breastfeeding initiation are objective measures likely easily captured by vital statistics staff at the time the birth certificate is prepared. Self-reported variables, such as prepregnancy BMI, may contain inaccuracies, but they were not the primary focus of this study, and the frequency of data reporting errors likely does not differ notably between exposure and reference groups. Despite the chance that smoking during pregnancy may have been underreported, it still had a significant impact on breastfeeding rates. There are quality improvement efforts underway by the Ohio Perinatal Quality Collaborative to improve the data accuracy of the birth certificate, and it is a topic of ongoing research (Ohio Perinatal Quality Collaborative, 2018; Lannon et al., 2017).

5 | CONCLUSIONS

Despite recent research and media efforts to highlight the benefits of breastfeeding, initiation rates in the NICU remain low. After thoroughly accounting for confounding variables, we found that socioeconomically disadvantaged mothers who smoked during pregnancy are

the least likely to initiate breastfeeding at hospital discharge. Multiparity, young age, and limited prenatal care are also risk factors for breastfeeding non-initiation. Hospital intervention efforts should cater support and education programs toward the needs of these mothers so that their sick infants have the best possible chance of a healthy infancy and childhood by being breastfed.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

ED conceived of the presented idea. BG developed the theory, gathered the data, and performed the computations. ED verified the analytical methods and helped organize the findings of this work. BG composed the manuscript, and ED edited it.

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REFERENCES

- Almqvist-Tangen, G., Bergman, S., Dahlgren, J., Roswall, J., & Alm, B. (2012). Factors associated with discontinuation of breastfeeding before 1 month of age. *Acta Paediatrica*, 101, 55–60. <https://doi.org/10.1111/j.1651-2227.2011.02405.x>
- Balogun, O. O., O’Sullivan, E. J., McFadden, A., Ota, E., Gavine, A., Garner, C. D., ... MacGillivray, S. (2016). Interventions for promoting the initiation of breastfeeding. *Cochrane Database of Systematic Reviews*, (11). <https://doi.org/10.1002/14651858.CD001688.pub3>
- Bartick, M. C., Schwarz, E. B., Green, B. D., Jegier, B. J., Reinhold, A. G., Colaizy, T. T., ... Stuebe, A. M. (2017). Suboptimal breastfeeding in the United States: Maternal and pediatric health outcomes and costs. *Maternal & Child Nutrition*, 13, e12366. <https://doi.org/10.1111/mcn.12366>
- Bernaix, L. W., Schmidt, C. A., Jamerson, P. A., Seiter, L., & Smith, J. (2006). The NICU experience of lactation and its relationship to family management style. *The American Journal of Maternal Child Nursing*, 31, 95–100. <https://doi.org/10.1097/00005721-200603000-00008>
- Bharwani, S. K., Green, B. F., Pezzullo, J. C., Bharwani, S. S., Bharwani, S. S., & Dhanireddy, R. (2016). Systematic review and meta-analysis of human milk intake and retinopathy of prematurity: A significant update. *Journal of Perinatology*, 36, 913–920. <https://doi.org/10.1038/jp.2016.98>
- Blatt, K., Moore, E., Chen, A., Van Hook, J., & DeFranco, E. A. (2015). Association of reported trimester-specific smoking cessation with fetal

- growth restriction. *Obstetrics and Gynecology*, 125, 1452–1459. <https://doi.org/10.1097/AOG.0000000000000679>
- Callen, J., & Pinelli, J. (2005). A review of the literature examining the benefits and challenges, incidence and duration, and barriers to breastfeeding in preterm infants. *Advances in Neonatal Care*, 5, 72–88. <https://doi.org/10.1016/j.adnc.2004.12.003>
- Carswell, A. L., Ward, K. D., Vander Weg, M. W., Scarinci, I. C., Girsch, L., Read, M., ... Chen, W. (2018). Prospective associations of breastfeeding and smoking cessation among low-income pregnant women. *Maternal & Child Nutrition*, 14, e12622. <https://doi.org/10.1111/mcn.12622>
- Celi, A. C., Rich-Edwards, J. W., Richardson, M. K., Kleinman, K. P., & Gillman, M. W. (2005). Immigration, race/ethnicity, and social and economic factors as predictors of breastfeeding initiation. *Archives of Pediatrics and Adolescent Medicine*, 159, 255–260. <https://doi.org/10.1001/archpedi.159.3.255>
- Colaizy, T. T., & Morriss, F. H. (2008). Positive effect of NICU admission on breastfeeding of preterm US infants in 2000 to 2003. *Journal of Perinatology*, 28, 505–510. <https://doi.org/10.1038/jp.2008.32>
- Debes, A. K., Kohli, A., Walker, N., Edmond, K., & Mullany, L. C. (2013). Time to initiation of breastfeeding and neonatal mortality and morbidity: A systematic review. *BMC Public Health*, 13, 519.
- 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, 607–619. <https://doi.org/10.1542/peds.112.3.607>
- Economic Research Service of US Department of Agriculture (2016). Rural-Urban Continuum Codes (2013 version). [Data file]. Retrieved from <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx>
- Edmond, K. M., Zandoh, C., Quigley, M. A., Amenga-Etego, S., Owusu-Agyei, S., & Kirkwood, B. R. (2006). Delayed breastfeeding initiation increases risk of neonatal mortality. *Pediatrics*, 117, e380–e386. <https://doi.org/10.1542/peds.2005-1496>
- Fugate, K., Ivonne, H., Terri, A., Miladinovic, B., & Spatz, D. (2015). Improving human milk and breastfeeding practices in the NICU. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, 44, 426–438. <https://doi.org/10.1111/1552-6909.12563>
- Furman, L., Killpack, S., Matthews, L., Davis, V., & O'Riordan, M. A. (2016). Engaging inner-city fathers in breastfeeding support. *Breastfeeding Medicine*, 11, 15–20. <https://doi.org/10.1089/bfm.2015.0092>
- Goldenberg, R. L., Culhane, J. F., Iams, J. D., & Romero, R. (2008). Epidemiology and causes of preterm birth. *The Lancet*, 371, 75–84. [https://doi.org/10.1016/S0140-6736\(08\)60074-4](https://doi.org/10.1016/S0140-6736(08)60074-4)
- Haslam, M. D., Gardner, F., Greecher, C., Stephens, H., Marvin, M., Hozella, A., & Doheny, K. (2018). The impact of a donor milk program on breast milk consumption, infection rates, and necrotizing enterocolitis in hospitalized neonates. *Pediatrics*, 142, 686.
- Herich, L. C., Cuttini, M., Croci, I., Franco, F., Di Lallo, D., Baronciani, D., ... Zeitlin, J. (2017). Maternal education is associated with disparities in breastfeeding at time of discharge but not at initiation of enteral feeding in the neonatal intensive care unit. *Journal of Pediatrics*, 182, 59–65. <https://doi.org/10.1016/j.jpeds.2016.10.046>
- Howe-Heyman, A., & Lutenbacher, M. (2016). The baby-friendly hospital initiative as an intervention to improve breastfeeding rates: A review of the literature. *Journal of Midwifery & Women's Health*, 61, 77–102. <https://doi.org/10.1111/jmwh.12376>
- Humphreys, A. S., Thompson, N. J., & Miner, K. R. (1998). Intention to breastfeed in low-income pregnant women: The role of social support and previous experience. *Birth*, 25, 169–174. <https://doi.org/10.1046/j.1523-536X.1998.00169.x>
- Isaacs, E. B., Fischl, B. R., Quinn, B. T., Chong, W. K., Gadian, D. G., & Lucas, A. (2010). Impact of breast milk on intelligence quotient, brain size, and white matter development. *Pediatric Research*, 67, 357–362. <https://doi.org/10.1203/PDR.0b013e3181d026da>
- Johnson, T. J., Patel, A. L., Bigger, H. R., Engstrom, J. L., & Meier, P. P. (2014). Economic benefits and costs of human milk feedings: A strategy to reduce the risk of prematurity-related morbidities in very-low-birth-weight infants. *Advances in Nutrition*, 5, 207–212. <https://doi.org/10.3945/an.113.004788>
- Kachoria, R., & Oza-Frank, R. (2015). Trends in breastfeeding initiation in the NICU by gestational age in Ohio, 2006–2012. *Birth*, 42, 56–61. <https://doi.org/10.1111/birt.12146>
- Kelly, Y. J., Watt, R. G., & Nazroo, J. Y. (2006). Racial/ethnic differences in breastfeeding initiation and continuation in the United Kingdom and comparison with findings in the United States. *Pediatrics*, 118, e1428–e1435. <https://doi.org/10.1542/peds.2006-0714>
- Lannon, C., Kaplan, H. C., Friar, K., Fuller, S., Ford, S., White, B., ... Iams, J. (2017). Using a state birth registry as a quality improvement tool. *The American Journal of Perinatology*, 34, 958–965.
- Leon-Cava, N., Lutter, C., Ross, J., & Martin, L. (2002). *Quantifying the benefits of breastfeeding: A summary of the evidence*. Washington, D.C.: PAHO.
- Lessen, R., & Crivelli-Kovach, A. (2007). Prediction of initiation and duration of breast-feeding for neonates admitted to the neonatal intensive care unit. *The Journal of Perinatal & Neonatal Nursing*, 21, 256–266. <https://doi.org/10.1097/01.JPN.0000285817.51645.73>
- Maffei, D., & Schanler, R. J. (2017). Human milk is the feeding strategy to prevent necrotizing enterocolitis! *Seminars in Perinatology*, 41, 36–40. <https://doi.org/10.1053/j.semperi.2016.09.016>
- McDowell, M. M., Wang, C., & Kennedy-Stephenson, J. (2008). Breastfeeding in the United States: Findings from the national health and nutrition examination surveys, 1999–2006. In *NCHS data briefs, no 5*. Hyattsville, MD: National Center for Health Statistics.
- McInnes, R. J., & Chambers, J. (2008). Infants admitted to neonatal units—Interventions to improve breastfeeding outcomes: A systemic review 1990–2007. *Maternal & Child Nutrition*, 4, 235–263. <https://doi.org/10.1111/j.1740-8709.2008.00150.x>
- Meier, P. P., Engstrom, J. L., Mingoelli, S. S., Miracle, D. J., & Kiesling, S. (2004). The Rush mothers' milk club: Breastfeeding interventions for mothers with very-low-birth-weight infants. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, 33, 164–174. <https://doi.org/10.1177/0884217504263280>
- Merewood, A., Chamberlain, L. B., Cook, J. T., Philipp, B. L., Malone, K., & Bauchner, H. (2006). The effect of peer counselors on breastfeeding rates in the neonatal intensive care unit. *Archives of Pediatrics & Adolescent Medicine*, 160, 681–685. <https://doi.org/10.1001/archpedi.160.7.681>
- Napierala, M., Mazela, J., Merritt, T. A., & Florek, E. (2016). Tobacco smoking and breastfeeding: effect on lactation process, breast milk composition and infant development. A critical review. *Environmental Research*, 151, 321–338. <https://doi.org/10.1016/j.envres.2016.08.002>
- National Center for Chronic Disease Prevention and Health Promotion (2018). *Results: Breastfeeding rates*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention.
- National Center for Health Statistics (2003). *Revisions of the U.S. standard certificates of live birth*. Hyattsville, MD: US Department of Health and Human Services, Centers for Disease Control and Prevention.
- National Center for Health Statistics (2016). *Guide to completing the facility worksheets for the certificate of live birth and report of fetal death (2003*

- revision). Hyattsville, MD: US Department of Health and Human Services, Centers for Disease Control and Prevention.
- Nielan-Vilén, H., Melender, H. L., Axelin, A., Loyttyniemi, E., & Salanterä, S. (2016). Predictors of breastfeeding initiation and frequency for preterm infants in the NICU. *Journal of Obstetric, Gynecologic, and Neonatal Nursing*, 45, 346–358. <https://doi.org/10.1016/j.jogn.2016.01.006>
- Office of the Surgeon General (US) (2011). *The Surgeon General's call to action to support breastfeeding*. Rockville, MD: Office on Women's Health, Centers for Disease Control and Prevention.
- Ohio Perinatal Quality Collaborative (OPQC). (2018). Birth registry accuracy. Retrieved from <https://opqc.net/projects/BirthRegistryAccuracyResources>.
- Okamoto, T., Shirai, M., Kikubo, M., Takahashi, S., Kajino, M., Takase, M., ... Oki, J. (2007). Human milk reduces the risk of retinal detachment in extremely low-birthweight infants. *Pediatrics International*, 49, 894–897. <https://doi.org/10.1111/j.1442-200X.2007.02483.x>
- Parker, M. G. K., Burnham, L., Mao, W., Philipp, B. L., & Merewood, A. (2016). Implementation of a donor milk program is associated with greater consumption of mother's own milk among VLBW infants in a US, level 3 NICU. *Journal of Human Lactation*, 32, 221–228. <https://doi.org/10.1177/0890334415598305>
- Pinelli, J., Atkinson, S. A., & Saigal, S. (2001). Randomized trial of breastfeeding support in very low-birth-weight infants. *Archives of Pediatrics & Adolescent Medicine*, 155, 548–553. <https://doi.org/10.1001/archpedi.155.5.548>
- Sisk, P. M., Lambeth, T. M., Rojas, M. A., Lightbourne, T., Barahona, M., Anthony, E., & Auringer, S. T. (2017). Necrotizing enterocolitis and growth in preterm infants fed predominantly maternal milk, pasteurized donor milk, or preterm formula: A retrospective study. *American Journal of Perinatology*, 34, 676–683. <https://doi.org/10.1055/s-0036-1597326>
- Sisk, P. M., Lovelady, C. A., Dillard, R. G., Gruber, K. J., & O'Shea, T. M. (2007). Early human milk feeding is associated with a lower risk of necrotizing enterocolitis in very low birth weight infants. *Journal of Perinatology*, 27, 428–433. <https://doi.org/10.1038/sj.jp.7211758>
- Thulier, D., & Mercer, J. (2009). Variables associated with breastfeeding duration. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, 38, 259–268. <https://doi.org/10.1111/j.1552-6909.2009.01021.x>
- Valentine, G. C., Burgess, A., Ford, S., Gandhi, M., Hagan, J., Hurst, N., ... Hair, A. (2019). Mother's own milk use during hospitalization predicts later expressed breast milk feeds at hospital discharge. *American Journal of Obstetrics and Gynecology*, 220, S603.
- Victora, C. G., Bahl, R., Barros, A. J. D., Franca, G. V. A., Horton, S., Krasevec, J., ... Rollins, N. C. (2016). Breastfeeding in the 21st century: Epidemiology, mechanisms, and lifelong effect. *The Lancet*, 387, 475–490. [https://doi.org/10.1016/S0140-6736\(15\)01024-7](https://doi.org/10.1016/S0140-6736(15)01024-7)
- Vogel, J. P., Chawanpaiboon, S., Moller, A., Watananirun, K., Bonet, M., & Lumbiganon, P. (2018). *The global epidemiology of preterm birth*. Best Practice & Research Clinical Obstetrics & Gynaecology (ed., Vol. 52) (pp. 3–12). <https://doi.org/10.1016/j.bpobgyn.2018.04.003>
- Vohr, B. R., Poindexter, B. B., Dusick, A. M., McKinley, L. T., Wright, L. L., Langer, J. C., & Poole, W. K. (2006). Beneficial effects of breast milk in the neonatal intensive care unit on the developmental outcome of extremely low birth weight infants at 18 months of age. *Pediatrics*, 118, 115–123.
- Wallwiener, S., Muller, M., Doster, A., Plewniok, K., Wallwiener, C. W., Fluhr, H., ... Reck, C. (2016). Predictors of impaired breastfeeding initiation and maintenance in a diverse sample: What is important? *Maternal-Fetal Medicine*, 294, 455–466.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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