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ORIGINAL ARTICLE

Positive effect of NICU admission on breastfeeding of preterm US infants in 2000 to 2003

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Objective: We hypothesized that neonatal intensive care unit (NICU) admission reduces breastfeeding in a recent population of US infants, adjusting for confounding factors.

Study Design: Using pregnancy risk assessment monitoring system data from 27 states for the years 2000 to 2003, we determined the relationship between breastfeeding and gestational age (GA) stratified by NICU status. We fitted a proportional odds model for breastfeeding duration as a function of NICU status adjusted for other covariates. SAS 9.1.3 and SUDAAN 9.0 were used for the weighted analyses.

Result: In total 138 359 surveys, including 29 940 NICU-admitted infants, were analyzed. A total of 73% of mothers of nonadmitted infants initiated breastfeeding vs 70% of mothers of NICU-admitted infants. Mothers of GA <38 weeks NICU-admitted infants were 34% more likely to initiate breastfeeding and 21% more likely to breastfeed for 4 weeks than were mothers of nonadmitted preterm infants ($P<0.001$). However, mothers of term NICU-admitted infants were less likely to initiate and continue breastfeeding to 4 weeks than were mothers of term nonadmitted infants ($P<0.001$). Adjusting for GA, race, maternal age, maternal education, mode of delivery and Medicaid status, NICU admission was associated with increasing duration of breastfeeding (OR 1.10, CI 1.03, 1.17). Compared with mothers of term infants, mothers of <32-week infants were 40% more likely to continue breastfeeding for 4 weeks, mothers of 32 to 34 week infants were 13% less likely to continue and mothers of 35–37 week infants were 22% less likely to continue for at least 4 weeks ($P<0.001$).

Conclusion: NICU admission is now a positive influence on breastfeeding continuation, improving the overall likelihood by 10%. Mothers of preterm NICU-admitted infants were more likely than mothers of nonadmitted infants to continue breastfeeding for 4 weeks, while mothers of term NICU-admitted infants were less likely to continue. Breastfeeding support should be enhanced for term and late preterm infants.

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Introduction

Breastfeeding confers numerous short-term and longer-term health advantages on infants. In the healthy full-term population, breastfeeding has been associated with neurodevelopmental advantages,[1,2] lower rates of obesity[3,4] and lower incidence of atopic disorders.[5,6] Evidence also supports long-term cardiovascular benefits attributable to breastfeeding, including lower blood cholesterol levels in young adulthood[7] and lower blood pressure.[8] In the preterm hospitalized infant, breastfeeding decreases rates of life-threatening necrotizing enterocolitis[9,10] and infections,[11] and shortens hospital stays.[10]

The American Academy of Pediatrics recommends exclusive breastfeeding for all infants in the first 6 months of life and that minimum breastfeeding duration should be 12 months.[12] The US Department of Health and Human Services has highlighted the health importance of breastfeeding, making improvement in breastfeeding rates a goal of the Healthy People 2010 initiatives.[13]

In total 12% of infants born in the United States are born prematurely, and many of them require neonatal intensive care unit (NICU) care.[14] Approximately 10% of full-term infants require medical services more intensive than usual newborn care, and many of these infants are also admitted to NICUs. Infants admitted to NICUs represent a population at greater risk for adverse health outcomes than healthy full-term infants. Infants admitted to NICUs have been breastfed at lower rates than those who are healthy at birth. Ahluwalia *et al*.,[15] examined rates of breastfeeding in NICU-admitted infants in the 1990s, using data from the pregnancy risk assessment and monitoring system (PRAMS) survey in 10 states. They reported breastfeeding rates for infants admitted to NICUs in the 1990s that were significantly lower than those for healthy infants, with low birth weight (<2500 g) NICU infants breastfed at the lowest rates.[15] Knowledge of more current nationwide rates of breastfeeding behavior as affected by NICU admission is important in understanding the degree of breastfeeding disparity between NICU-admitted and healthy infants. If NICU-admitted infants continue to be breastfed at lower rates than healthy term infants,

this may represent a failing in the hospital environment. Describing any such discrepancy is a necessary step in designing interventions to eradicate it.

We undertook an analysis of PRAMS data from the years 2000 to 2003 to determine the effects of NICU admission on breastfeeding initiation and continuation, adjusting for gestational age (GA) and other factors. We hypothesized that mothers of infants admitted to NICUs are less likely to initiate breastfeeding than are those whose infants are not admitted, regardless of GA, and that mothers of infants admitted to NICUs are less likely to continue breastfeeding for at least 4 weeks.

Methods

PRAMS is a multistate surveillance project of the Centers for Disease Control and Prevention (CDC) and state health departments. The PRAMS survey instrument is used to collect population-based information about maternal experiences and attitudes before, during and immediately after pregnancy. In the 2000 to 2003 time period, 29 states participated in PRAMS. The PRAMS instrument is administered via standardized mail and telephone data collection methods in all participating states. The PRAMS sample, drawn from birth certificate registries in each state, is a stratified random sample of all births, with some groups deliberately oversampled. Many states oversample women who had low birth weight births, or minority women. Stratification schemes vary by state, but each state's data are representative of all live births in that state. The PRAMS data set consists of the questionnaire results as well as selected de-identified birth certificate data. PRAMS data are statistically weighted to adjust for the survey design, noncoverage and nonresponse.[16]

We used PRAMS data for the years 2000 through 2003, inclusive of 27 states with response rates of at least 70% during 1 or more of the 4 years. Permission to use these data was obtained from the CDC and all included states. PRAMS questionnaire version 4 was used in all states throughout this time period. States included in this analysis are: Alaska, Alabama, Arkansas, Colorado, Florida, Hawaii, Illinois, Louisiana, Maine, Michigan, Minnesota, Montana, North Carolina, North Dakota, Nebraska, New Jersey, New Mexico, New York, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, Utah, Vermont, Washington and West Virginia.

Definitions

NICU admission was assessed by the question, 'After your baby was born, was he or she put in an intensive care unit?' To assess breastfeeding initiation, we used the question, 'Did you ever breastfeed or pump breast milk for your baby after delivery?' For breastfeeding duration information, we used a PRAMS analytic variable that coded the breastfeeding duration as follows: never, breastfed for <1 week, number of weeks breastfeeding or still breastfeeding. Our cutoff of >4 weeks for breastfeeding continuation was chosen to be consistent with the definition used in a previous report for comparison.[17]

Statistical analysis

The data set for analysis was created for this project by PRAMS data analysts at the CDC. SAS version 9.1.3 (SAS Institute, Research Triangle Park, NC, USA) was used for data preparation and preliminary analyses. SUDAAN version 9.1 (Research Triangle Institute, Research Triangle Park, NC, USA) was used for weighted analyses to account for the complex survey design and generate accurate *P*-values.

Univariate analyses

The relationships between NICU admission status and GA, maternal age, maternal race, maternal education, WIC enrollment, Medicaid enrollment and mode of delivery were explored. These variables were chosen for analysis because they have been associated with breastfeeding rates in a CDC analysis of the 2004 National Immunization Survey.[18] GA was categorized as: <32 weeks, 32 to 34 weeks, 35 to 37 weeks and >37 weeks. Maternal age was categorized as <20, 20 to 24, 25 to 34 and 35 years or greater. Race was coded as African American, white or other. Maternal education was coded as less than high school, high school or more than high school. For all univariate categorical variable analyses χ^2 analysis was used. Odds ratios and 95% confidence intervals for NICU admission for these characteristics were generated using univariate logistic regression. Reference levels for each variable were chosen based on clinical or social relevance.

Analysis of the relationship between breastfeeding and NICU admission as modified by GA

Because the greatest contributing factor to NICU admission is GA, we performed a Mantel–Hantzel adjusted χ^2 analysis to determine the effect of NICU admission on breastfeeding duration, adjusted for GA grouping. This was performed in preparation for multinomial logistic modeling.

Multinomial analysis of the relationship between breastfeeding duration and NICU admission, adjusted for multiple confounding factors

Multinomial logistic regression was used to fit a proportional odds model with cumulative logit link to model increasing breastfeeding duration. Increasing breastfeeding duration was modeled with NICU admission as the predictor variable of interest, adjusting for all factors used in univariate analyses.

Results

The PRAMS data set used contained 138 359 survey respondents for whom complete data were available on both NICU admission status and breastfeeding behavior. This represents 94% of the full data set (146 726).

Factors associated with NICU admission

Table 1 presents the characteristics of women whose infants were admitted to the NICU for comparison with those whose infants were not NICU admitted. In total 27.6% of all infants were admitted to NICUs at birth (29 940/138 359). The strongest univariate predictor of NICU admission was prematurity of the infant. Mothers at either end of the child-bearing spectrum (⩽19 or ⩾35 years) were more likely to have infants admitted than mothers in the 20 to 34 year age range. Minority infants were more likely to be admitted than white infants. African-American infants had a 59% higher risk of NICU admission than whites (14.75 vs 10.09%, OR 1.59, 95% CI 1.50, 1.68). Maternal enrollment in Medicaid or Special Supplemental Nutrition Program for Women, Infants and Children (WIC) during pregnancy was also associated with greater likelihood of NICU admission, as was less maternal education. Mode of delivery was also associated with NICU admission, with infants born by cesarean section twice as likely to require NICU care.

Table 1 Characteristics of mothers of NICU-admitted infants compared with mothers of nonadmitted infants: PRAMS, 2000–2003

Characteristics	*% NICU-admitted*[a] *(95% CI)*	*% Nonadmitted*[b] *(95% CI)*	*OR (95% CI)*
Gestational age, weeks (n)			
<32 (8902)	95.2 (94, 96.2)	4.8 (3.8, 6.0)	225 (173, 292)
32–<35 (5416)	89.6 (87.8, 91.1)	10.4 (8.9, 12.2)	103 (86, 124)
35–<38 (17 760)	37.2 (35.9, 38.6)	62.8 (61.4, 64.1)	7.1 (6.6, 7.6)
⩾38 (10 6281)	7.1 (6.9, 7.4)	92.9 (92.6, 93.1)	1
Maternal age, years (n)			
⩽19 (19 148)	12.3 (11.6, 13)	87.7 (87, 88.4)	1.26 (1.17, 1.35)
20–24 (36 694)	11.2 (10.7, 11.7)	88.8 (88.3, 89.3)	1.11 (1.04, 1.18)
25–34 (65 350)	10.5 (10.2, 10.9)	89.5 (89.1, 89.8)	1
⩾35 (17 167)	11.9 (11.2, 12.6)	88.1 (87.4, 88.8)	1.16 (1.07, 1.25)
Maternal race (n)			
White (90 462)	10.2 (10.0, 10.5)	89.8 (89.5, 90.0)	1
African American (23 149)	15.1 (14.5, 15.7)	84.9 (84.3, 85.5)	1.59 (1.5, 1.68)
Other (24 749)	11.1 (10.3, 11.9)	88.9 (88.1, 89.7)	1.21 (1.11, 1.31)
Maternal education (n)			
<High school (25 822)	13.5 (12.9, 14.2)	86.5 (85.8, 87.1)	1.52 (1.43, 1.63)
High school (47 154)	11.2 (10.8, 11.7)	88.8 (88.4, 89.2)	1.18 (1.11, 1.25)
>High school (63 740)	10.0 (9.7, 10.4)	90.0 (89.7, 90.3)	1
Medicaid participation (n)			
Yes (60 783)	12.8 (12.4, 13.2)	87.2 (86.8, 87.6)	1.37 (1.30,1.44)
No (77 341)	9.9 (9.6, 10.3)	90.1 (89.8, 90.4)	1
WIC participation (n)			
Yes (64 377)	12.4 (12.0, 12.8)	87.6 (87.2, 88.0)	1.31 (1.25, 1.38)
No (73 009)	10.1 (9.8. 10.4)	89.9 (89.6, 90.2)	1
Mode of delivery (n)			
Vaginal (98 621)	8.9 (8.7, 9.2)	91.1 (90.1, 91.3)	1
Cesarean (39 160)	17.5 (16.9, 18.0)	82.6 (82.0, 83.1)	2.04 (1.93, 2.15)
Ever breastfed (n)			
Yes (101 086)	10.7 (10.5, 11.0)	89.3 (89.0, 89.6)	0.94 (0.89, 0.99)
No (38 661)	11.3 (10.9, 11.8)	88.7 (88.2, 89.1)	1

Abbreviation: NICU, neonatal intensive care unit; WIC, Special Supplemental Nutrition Program for Women, Infants and Children.
[a]Total NICU-admitted infants = 29 940.
[b]Total nonadmitted infants = 108 419.

NICU admission and breastfeeding, PRAMS 2000 to 2003

In univariate analysis, mothers of all NICU-admitted infants were less likely than those of nonadmitted infants to initiate breastfeeding (70 vs 73%, $P<0.0001$). However, GA modified this relationship. Mothers of infants admitted to NICUs initiated breastfeeding at similar rates across all GA groups, (69 to 70%). In contrast, initiation of breastfeeding among mothers of nonadmitted infants was related to GA, with fewer mothers of nonadmitted preterm infants initiating breastfeeding when compared to mothers of nonadmitted term infants (63.5 vs 73.4%, $P<0.0001$).

Adjusting for GA, mothers of NICU-admitted infants were more likely to initiate breastfeeding than were mothers of nonadmitted infants ($P<0.01$) (Table 2). All preterm (<38 weeks) NICU-admitted infants were more likely ever to breastfeed (OR 1.34, CI 1.21, 1.48) and to breastfeed for 4 weeks (OR 1.21, CI 1.1, 1.33) than were nonadmitted preterms. Term NICU-admitted infants, however, were less likely ever to be breastfed, and to have continued

Table 2 Breastfeeding duration among mothers of NICU-admitted and nonadmitted infants, by gestational age: PRAMS, 2000–2003[a]

	Breastfeeding duration (%)			
Gestational age (weeks)	*Ever*	*<1 week*	*1–4 weeks*	*>4 weeks*
(a) NICU-admitted infants, n = *29 940*				
<32 (*n* = 8686)	70.3	1.8	17.9	50.5
32–<35 (*n* = 4949)	70.2	2.3	18.8	49.1
35–<38 (*n* = 8159)	68.7	2.9	18.1	47.6
⩾38 (*n* = 8146)	70.4	3.6	15.7	50.9
(b) Infants not admitted to NICU, n = *10 8419*				
<32 (*n* = 216)	63.9	1.9	16.7	45.4
32–<35 (*n* = 467)	55.3	2.4	17.8	35.1
35–<38 (*n* = 9601)	64	4.4	16.1	43.5
⩾38 (*n* = 98 135)	73.4	3.9	13.6	56.2

Abbreviation: NICU, neonatal intensive care unit.
[a]All differences in breastfeeding duration percentages between respective cells for NICU-admitted and nonadmitted infants are statistically significant at the $P<0.01$ level.

Table 3 Odds ratios for predictors of breastfeeding duration in multinomial logistic regression model

Variable	*Continuation >4 weeks*	
	OR	*95% CI*
NICU-admitted	1.10	1.03, 1.17
Gestational age (weeks)		
<32	1.40	1.27, 1.53
32–<35	0.87	0.78, 0.97
35–<38	0.78	0.73, 0.83
⩾38	1	NA
Maternal race		
White	1	NA
African American	0.48	0.46, 0.50
Other	1.51	1.42, 1.61
Maternal age (years)		
⩽19	0.64	0.61, 0.68
20–24	0.75	0.72, 0.79
25–34	1	NA
⩾35	1.11	1.05, 1.18
Maternal education		
<High school	0.45	0.43, 0.48
High School	0.47	0.45, 0.49
>High School	1	NA
Cesarean delivery	0.77	0.74, 0.81
Medicaid participation	0.73	0.70, 0.77

Abbreviations: NA, not available; NICU, neonatal intensive care unit.

to 4 weeks than were term nonadmitted infants ($P<0.001$). The majority of mothers who initiated breastfeeding continued to do so for at least 4 weeks, regardless of NICU admission status or GA group (63.6 to 76%).

NICU admission and breastfeeding, adjusted for multiple confounders

Adjusting for GA, maternal age, maternal race, maternal education, mode of delivery and Medicaid status, NICU admission was a predictor of breastfeeding for at least 4 weeks in the multinomial logistic regression model (OR 1.10, 95% CI 1.03, 1.17) (Table 3).

Other predictors of breastfeeding, adjusted for multiple confounders

Examination of the multinomial logistic regression model also demonstrates the relationship between other variables and duration of breastfeeding, with adjustment for multiple factors (Table 3). Compared with the respective referent groups, white or African-American race were both associated with shorter duration of breastfeeding, as were younger maternal age (<25 years), lower maternal education and Medicaid coverage during pregnancy. Women delivering by cesarean section were only 75% as likely to breastfeed for at least 4 weeks, compared with women delivering vaginally. Compared with women delivering full-term infants, mothers of extremely premature (<32 weeks) infants were more likely to continue breastfeeding for at least 4 weeks (OR 1.40, 95% CI 1.27, 1.53), while mothers of infants between 32 and 34 weeks were less likely to continue (OR 0.87, 95% CI 0.78, 0.97), and mothers of late preterm infants (35 to 37 weeks) were the least likely of all to continue for at least 4 weeks (OR 0.78, 95% CI 0.73, 0.83).

Discussion

Our analysis of PRAMS data from 27 states over 4 years demonstrates that NICU admission does not negatively impact breastfeeding initiation and continuation to at least 4 weeks. After adjustment for multiple factors known to be related to breastfeeding rates, including infant GA, maternal age, education, race, mode of delivery and Medicaid status, NICU admission was a positive influence on breastfeeding continuation to at least 4 weeks, increasing the overall likelihood by approximately 10%. This finding is surprising, and is counter to our hypothesis that NICU admission would be associated with decreased breastfeeding.

Other investigators have demonstrated that infants commonly admitted to NICUs, particularly preterm infants, are not breastfed at the same rates as their full-term peers. Ryan *et al.*,[19] using the Ross Laboratories Mothers Survey from 2001, reported a 69% breastfeeding initiation rate among mothers of full-term infants, which agrees well with our findings. Breastfeeding rates at hospital discharge among mothers of preterm infants who initiated breastfeeding have been reported to be approximately 50%, in a body of small cohort studies.[20,21] Using multistate 1993 and 1998 PRAMS data published by Ahluwalia *et al.*,[15] overall breastfeeding initiation and continuation rates were higher in non-NICU infants of all GAs, in bivariate analyses.

Among mothers included in our study, the NICU experience appears to have different effects on breastfeeding behavior depending on the GA of the infant. Among mothers of preterm infants, NICU admission was associated with higher rates of initiation and continuation in univariate analyses in all GA groups, compared with care outside of a NICU. Mothers of term infants admitted to the NICU experienced rates of initiation and continuation similar to mothers of preterm NICU infants, but these rates were lower than in the healthy term population. Thus, the effect of NICU admission on breastfeeding success is attributable to the NICU experience effect on the preterm population.

The positive effect of NICU admission on breastfeeding among preterm infants may be partially due to exposure to positive messages and educational interventions promoting breastfeeding. A Cochrane review of 34 trials (29 385 dyads) showed a lower risk

of breastfeeding failure when any extra breastfeeding support was offered.[22] Many NICUs also have lactation consultant services available and actively promote breastfeeding. This low-tech intervention has been shown to increase breastfeeding rates. A study of 2132 NICU-admitted infants demonstrated that the odds of breastfeeding initiation were 1.34 times higher for mothers in hospitals that provided lactation consultant services in the NICU.[23] In a study of lactation consultant counseling in mothers of very low birth weight infants, after counseling was performed 85% of 81 mothers who initially planned to formula feed their infants initiated breastfeeding, and 100% of mothers who had initially intended to breastfeed were able to do so.[24] The investigators also demonstrated through psychological testing that this counseling did not increase maternal anxiety levels in either group. This runs counter to a belief that breastfeeding creates a burden on already-stressed mothers of NICU-admitted infants.

It is particularly concerning that late preterm infants (35 to 37 weeks) were the least likely of any GA group to be breastfed for at least 4 weeks, adjusting for NICU admission and multiple maternal factors (Table 3). These infants represent the majority of preterm infants in our study (55%), and the majority of those born in the United States.[14] Although typically regarded as small term infants, late preterm infants are physiologically immature, and at elevated risk for morbidity compared to term infants.[25–27] Late preterm infants have elevated risk of complications in the neonatal period, including respiratory distress, hypoglycemia, temperature instability, hyperbilirubinemia, immature sleep–wake cycles and ineffective suckling.[25–28] Our analysis demonstrates that breastfeeding behavior is poor in late preterm dyads when compared to term dyads, and that NICU admission is associated with improved breastfeeding initiation and continuation in the late preterm population.

Characteristics of both mothers and infants in late preterm dyads contribute to a higher risk of breastfeeding failure compared to healthy term dyads. Late preterm mothers are at increased risk of delayed development of a full milk supply due to pregnancy complications that result in late preterm birth, and the stress of such a delivery.[29,30] This is compounded by the late preterm infant's immature sucking ability.[31,32] Ineffective milk removal due to poor infant suckling downregulates maternal milk production, further endangering breastfeeding success. Term dyads are typically comprised of a mother who makes adequate milk, and an infant capable of removing it, whereas late preterm dyads may be impaired at both infant and maternal level. NICU admission may improve breastfeeding rates in this population by providing: (1) the expertise to assess and support establishment of an adequate milk supply, via access to appropriate breast pumping supplies and information and (2) the expertise to assist in the breastfeeding in the neurologically immature infant, via International Board Certified Lactation Consult (IBCLC) and nursing providers accustomed to the breastfeeding challenges of prematurity.[33–35]

Our study contains several limitations. The PRAMS instrument is self-administered and anonymous, making it impossible to validate the data collected at the subject level, excepting those data also collected as part of the birth certificate. For instance, the question regarding NICU admission is very simply worded, After your baby was born, was he or she put in an intensive care unit? The CDC–PRAMS Working Group and RTI international have pretested and evaluated this question, and have found it to be valid.[36] However, due to the anonymity of PRAMS, there is no way to determine how respondents interpreted this question with respect to their infant's care. It is possible that some mothers interpreted a normal newborn nursery to be intensive care, and that others failed to interpret a level II NICU as intensive care. If mothers misclassified their infants randomly, our results would be an underestimate of the true effect size of NICU admission. If more mothers interpreted normal newborn nursery care as intensive care, our effect size for NICU admission is inflated. If more mothers failed to recognize level II NICUs as intensive care units, our results might be limited in generalizability to infants admitted to level III NICUs.

We speculate that the positive effect we found for NICU admission on breastfeeding continuation, adjusted for multiple other factors, is due to increased exposure to positive messages regarding breastfeeding and higher levels of direct breastfeeding assistance received during the infant's hospital stay. In addition, understanding of the breastfeeding risks of prematurity are likely enhanced in the NICU environment, with concomitant knowledge to aid mothers in establishing a milk supply and feeding an immature infant. PRAMS does not include information to test this hypothesis, another limitation of our study.

It is important that factors associated with successful breastfeeding for preterm infants, both those admitted to the NICU and those cared for in a normal newborn nursery environment, are further investigated, particularly for the late preterm population. In addition, factors associated with breastfeeding continuation in mothers of term NICU-admitted infants should be determined. Our analysis of PRAMS data suggests that there are aspects of the NICU environment that promote early breastfeeding success for preterm infant/mother dyads. These factors should be identified so that interventions targeting preterm infants cared for in all health-care environments and term NICU-admitted infants can be developed to aid mothers in successfully breastfeeding their infants.

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