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# Impact of Neonatal Intensive Care Unit (NICU) Environment on Maternal Breast Milk Utilization:

### A Retrospective Study

Leia Heckman, MS, CCC-SLP, CLC, OMT;[1] Kelsey Flynn, MS, CCC-SLP, CLC, CNT;[1] Amy Mackley, RN;[2] Kelley Kovatis, MD[2]

1. Department of Speech Pathology, ChristianaCare

2. Department of Neonatology, ChristianaCare

## Abstract

**Introduction.** Prematurity remains a significant cause of infant and childhood morbidity and mortality. Infants who are exclusively breastfed during the first 6 months of life have improved outcomes. A majority of premature infants are discharged home on formula. Neonatal Intensive Care Unit (NICU) design may influence parental involvement and, in turn, affect breast milk utilization. This study assesses breast milk utilization at discharge, before, and after transitioning from a traditional open-bay NICU to a private, single-family room (SFR) NICU. **Methods.** This is a retrospective observational study of infants born at <32 weeks gestation admitted to a level III NICU before and after a transition from a traditional open-bay to a SFR NICU. Infants who received care in both NICU environments were excluded. The primary outcome was breast milk utilization at discharge. Standard descriptive statistics were used. **Results.** A total of 276 infants were included in the analysis. Demographic and clinical variables did not differ except for increased socioeconomic disadvantage and eligibility for donor breast milk. There was a significant increase in overall breast milk utilization (p=.04) but not maternal breast milk (p=0.61) in the SFR. Infants admitted to the traditional open-bay unit were younger at first oral feeding attempt (34.2 weeks (2.9)) compared to infants in the SFR room (35.2 weeks (2.4), p=0.007). **Conclusion.** Transition from a traditional open-bay model to a single-family room (SFR) model affected the time of oral feeding initiation but did not significantly impact breast milk exposure, breastfeeding attempts, or parental involvement in feeding. Breastfeeding outcomes may be more strongly influenced by clinical practices and support systems rather than by the physical environment. Understanding the impact of the NICU environment on feeding practices can inform institutional policies aimed at optimizing breast milk utilization.

## Introduction

Prematurity remains a significant cause of infant and childhood morbidity and mortality. Premature infants who are fed breast milk have lower rates of infection, decreased incidence of necrotizing enterocolitis (NEC), and reduced odds of retinopathy of prematurity (ROP).[1] Human milk is associated with improved long-term outcomes, including decreased incidence of respiratory and gastrointestinal illnesses, lower risk of metabolic diseases, and improved neurocognitive performance.[1,2] Recognizing these benefits, the American Academy of Pediatrics (AAP) recommends exclusive breast milk feeding during the first six months of life.[3]

Despite the AAP recommendations, most infants admitted to the Neonatal Intensive Care Unit

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(NICU) are not fed human milk exclusively during the first six months of life and are frequently discharged on formula. Among infants born between 24 and 35 weeks gestation, 21% do not receive any breast milk during their NICU admission.[4] Between 52% and 77% of very low birth weight (VLBW) infants are discharged on formula only.[4,5,6,7]

The cause of reduced breast milk utilization in the NICU is multifactorial. The NICU environment may influence parental involvement and, in turn, affect breast milk utilization. Single-family room (SFR) NICUs may provide more opportunities for skin-to-skin contact and maternal-infant bonding, factors known to support lactation and breastfeeding.[8] In contrast, open-bay NICUs, which accommodate multiple infants in a shared space, may limit privacy and contribute to maternal discomfort, reducing opportunities for breastfeeding and milk expression.[4]

To date, limited research has examined the impact of NICU design on parental involvement and human milk utilization. In April 2020, our level III NICU transitioned from a traditional open bay layout to a private SFR model, providing a unique opportunity to evaluate how NICU design influences feeding practices. We hypothesize that premature infants admitted to the SFR NICU will demonstrate greater parental involvement and increased human milk utilization compared to those cared for in the open bay setting.

## Methods

### Study Design

This is a retrospective observational study conducted at a Level III NICU in Newark, Delaware. The Institutional Review Board determined this study exempt from review.

The study included infants born at <32 weeks gestation admitted to and discharged from the open-bay NICU (January 1, 2018 – April 26, 2018) and from the SFR NICU (September 7, 2020 – December 23, 2021)). Infants who received care in both NICU environments were excluded.

Demographics and clinical data were obtained from the electronic medical record. All data were de-identified after demographic and clinical data were extracted from the chart.

### Outcomes

The primary outcome was breast milk utilization at discharge. This was defined as utilization of breast milk in 80% of feedings for 48 hours prior to discharge.

Secondary outcomes included growth parameters, postmenstrual age (PMA) at first feed, PMA at first oral feed, feeding method (breastfeeding or bottle feeding), breast milk utilization during admission, breastfeeding attempts per eligible days, length of stay, family participation and involvement in infant feeding.

The frequency of breastfeeding attempts was standardized among patients by calculating the total number of breastfeeding attempts documented during the total number of days after the first oral feeding. Breast milk utilization during admission was defined as the infant receiving donor breast milk or maternal breast milk during a single feeding, as documented in the patient's electronic health record, and calculated over the infant's length of stay.

Family participation was defined by recording the presence of the family/family members at the bedside. Area Deprivation Index (ADI) is a validated, multifaceted, geo-mapping tool used to rank neighborhoods by their level of socioeconomic disadvantage. It is measured on a scale of 1 to 100, where a higher number represents a higher level of disadvantage. A score greater than 75 defines a high-risk group for poor health outcomes. A higher deprivation score is associated with lower breastfeeding rates.[9]

### Statistical Analysis and Sample Size

Using previously published data on improving breast milk utilization, we estimated a sample size of at least 250 infants (125 in each group) to detect a 30% increase in breast milk utilization.[10]

Baseline and demographic characteristics for each infant were summarized by standard descriptive statistics. Point estimates are reported with 95% confidence intervals and exact p-values. Linear regression models were used to evaluate the relationship between independent and dependent variables.

## Results

A total of 275 infants were included in the analysis (140 traditional and 135 SFR). Demographic and clinical variables did not differ between the two groups, except more infants in the SFR were eligible for donor milk due to a change in unit-wide donor breast milk eligibility criteria (Table 1). Infants were eligible for donor breast milk if < 34 weeks gestation and/or weighing < 1500 grams.

Table 1. Characteristics of Study Population

| | Traditional Open NICU (n=140) | Single Family Room NICU (n=135) | P |
|---|---|---|---|
| Maternal Age, years | 29.65(±6.06) | 30.74 (±7.06) | 0.19 |
| Maternal Gravida | 3.24(±2.46) | 3.29 (±2.43) | 0.88 |
| GA at Birth, wks | 29.5 (±2.6) | 29.2 (±2.3) | 0.28 |
| Female | 65 (46%) | 71 (53%) | 0.31 |
| Delivery Method, Cesarean | 87 (62%) | 93 (69%) | 0.31 |
| Singleton | 116 (83%) | 103 (76%) | 0.18 |
| Race, Black, % | 73% | 68% | 0.97 |
| ADI National, >75 | 8 (±5.7) | 15 (±11.1) | 0.11 |
| Birth Weight, grams | 1293 (±461) | 1237 (±362) | 0.27 |
| Birth HC, cm | 26.7 (±3.3) | 26.4(±2.6) | 0.36 |
| Birth Length, cm | 37.9(±5.2) | 36.8(±5.0) | 0.08 |
| Discharge CGA, wks | 38.0 (±3.1) | 38.7 (±3.3) | 0.08 |
| Discharge Weight, g | 2667 (±724) | 2802 (±719) | 0.16 |
| Discharge HC, cm | 32.3(±2.8) | 32.74 (±3.0) | 0.23 |
| Discharge Length, cm | 45.2 (±3.3) | 45.2 (±5.3) | 0.99 |
| LOS, days | 58 (±33) | 66 (±34) | 0.07 |
| **Eligible for DBM** | **114(81%)** | **128 (94%)** | **<0.01** |

There was no difference in breast milk utilization (Traditional 43% vs SFR 44%, p=0.53) at discharge. Fewer infants were breastfeeding at discharge in the SFR (21% vs 14%, p=.05) (Table 2). Neither the mean chronological Trad 1.56 days (±1.6) vs SFR 1.94 days (±2.2), p=0.32 nor corrected gestational age (CGA) Trad 29.8(±2.5) weeks vs SFR 29.5(±2.5) weeks, p=0.32 at first enteral feed differed significantly between groups. There was a significant increase in overall breast milk utilization (maternal or donor breast milk, p=0.04) in the SFR group but this was driven by the use of donor breast milk rather than maternal breast milk utilization. There was no difference in breast milk use (Trad 54% vs SFR 64%, p=0.75) or percentage of infants that breastfed at the first oral feed (Trad 8% vs SFR 16%, p=0.87).

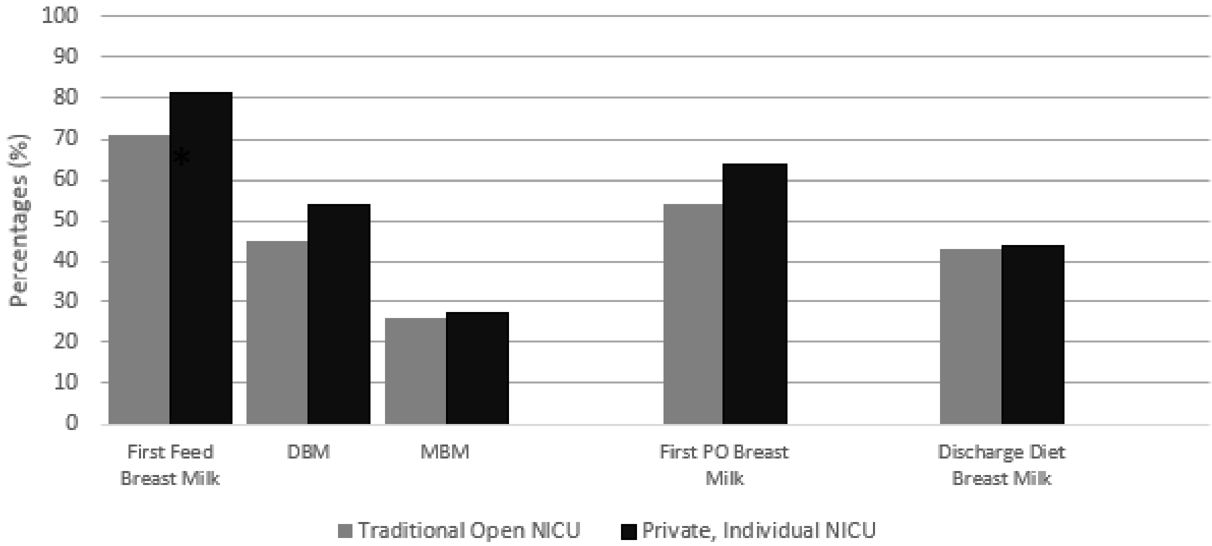
The CGA at the first oral (PO) feed differed between the groups (Trad 34.3 (±2.9) weeks vs SFR 35.2 (±2.4) weeks, p=.007). This remained statistically significant in linear regression modeling. There was a trend toward more parental participation in the first oral feed in the SFR NICU (13% vs 20%), although this did not meet statistical significance (p=0.11). The number of breastfeeding attempts over the length of stay was significantly higher in the traditional group compared to the SFR group (p=0.02). However, after adjusting for number of eligible PO feeding days, this was no longer statistically significant (p=0.43) (Figure 1). Infants in the SFR received more breast milk at the first feed (p=.04).

Table 2. Comparison of Breast Milk Utilization and Feeding Practice for Premature Infants Born at <32 Weeks Gestation in Traditional Open NICU to Private, Individual NICU.

| | Traditional Open NICU (n=140) | Single Family Rooms NICU (n=135) | P |
|---|---|---|---|
| First Feed Age, days | 1.56 (±1.6) | 1.94 (±2.2) | 0.11 |
| First Feed CGA, wks | 29.8 (±2.5) | 29.5(±2.2) | 0.32 |
| **First Feed Breast Milk**<br>DBM<br>MBM | **100 (71%)**<br>63 (45%)<br>37 (26%) | **110 (81%)**<br>73 (54%)<br>37 (27%) | **0.04**<br>0.61 |
| **First PO Feed CGA, wks** | **34.3 (±2.9)** | **35.2 (±2.4)** | **0.007** |
| First PO Feed Performed by Parent | 18(13%) | 27 (20%) | 0.11 |
| First PO Feed Breast Milk<br>Bottle<br>Breast | 73 (54%)<br>62 (46%)<br>11 (8%) | 75 (64%)<br>63(47%)<br>12(16%) | 0.75<br>0.87 |
| **Breastfeeding Attempts over LOS, mean (SEM)** | **.11 (±.02)** | **.05 (±.02)** | **0.02** |
| Breastfeeding Attempts over PO eligible days, mean (SEM) | .05 (±.09) | .13 (±.03) | 0.43 |
| Discharge Diet Breast Milk | 60 (43%) | 60 (44%) | 0.53 |
| Breastfeeding at Discharge | 29 (21%) | 19 (14%) | 0.05 |
| **Lactation Consult** | **0.56 (±0.71)** | **0.26 (±0.51)** | **<0.01** |
| Lactation Note | 1.78 (±1.61) | 2.07 (±1.57) | 0.19 |

Figure 1. Comparison of Breast Milk Utilization and Oral Feeding Practices at First Enteral Feed, First Oral (PO), and Discharge for Infants Admitted to the Traditional Open NICU to Infants

Admitted to the Private, Individual NICU (SFR).




## Discussion

This study adds to the expanding literature on how NICU design influences feeding and neonatal care practices. In our cohort, transition from an open-bay NICU to a SFR design was not associated with improved breast milk utilization at discharge. Further, the SFR transition was associated with delayed initiation of oral feeding, without significant differences in breast milk exposure, breastfeeding attempts, or parental involvement in feeding. This contrasts with previous studies that have suggested SFR NICU design improves parental participation and maternal breast milk utilization.

The relationship between SFR design and human milk/breastfeeding outcomes is complex. In a prospective study comparing SFR and open-bay NICU care, SFR exposure was associated with earlier first milk expression, earlier first breastfeeding attempts, and increased odds of exclusive direct breastfeeding after discharge.[8] Other pre-post studies of SFR transitions have reported increased parental presence in the SFR unit.[11,12] However, skin-to-skin outcomes and other family-integrated measures have not consistently improved in the SFR design.[13] In contrast, our study demonstrated decreased breastfeeding and maternal breast milk utilization after SFR transition. The cause of this observation is not known. Mothers in open bay NICUs are surrounded by staff and other mothers which may impact breastfeeding through observation, role modeling, and verbal persuasion.[13-15]

We also observed increased donor human milk use in the SFR. Although mother's milk is optimal,[7,8,12,13,15-24] pasteurized donor human milk is the recommended alternative when maternal milk is unavailable or insufficient, however interaction between donor milk and maternal milk supply can vary. Similar to our findings, other studies have found a negative correlation between donor breast milk and maternal breast milk utilization. [25, 26] The availability of donor milk could potentially result in delayed establishment of breast milk supply which may negatively impact long-term breastfeeding success. While donor milk confers important clinical benefits, it should be implemented alongside collaborative lactation support to avoid unintentionally decreasing maternal breast milk utilization. Consistent with this observation, in our study fewer lactation orders were placed after the transition to the SFR unit. Our data cannot distinguish whether reduced lactation orders reflect fewer breastfeeding mothers, decreased resource utilization, or altered identification of need. Nonetheless, this finding identifies a targeted intervention for our unit.

Strengths of our study include evaluation within the same institution across close but separate time periods, reducing the likelihood that major shifts in policies or culture confounded results. However, limitations include a retrospective, single-center design, which may limit generalizability. Additionally, key breastfeeding related variables such as a qualified duration of skin-to skin care, timing and frequency of pumping/first breast milk expression, and granular measures of parental presence were not available.

Our findings suggest that breastfeeding outcomes and oral feeding progression may be more strongly influenced by clinical practices and support systems than by the physical environment alone. The observed delay in oral feeding initiation in the SFR setting highlights an opportunity for targeted interventions that are highly relevant to neonatal teams. Evidence-informed guidance supports use of standardized, cue-based approaches and objective feeding readiness assessment to individualize the transition from gavage to oral feeding, improve consistency across caregivers, and promote safe feeding advancement. Implementing structured feeding readiness tools and multidisciplinary feeding pathways tailored to unit specific design may help mitigate delays and optimize maternal breast milk utilization at discharge.

Dr. Kovatis may be contacted at kelley.kovatis@christianacare.org

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