# Consumption of Mother's Own Milk by Infants Born Extremely Preterm Following Implementation of a Donor Human Milk Program: A Retrospective Cohort Study

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**Objective** To compare mothers' own milk (MOM) consumption by infants born extremely preterm before and after implementation of a donor human milk (DHM) program and determine healthcare provider's knowledge and practices regarding DHM.

**Study design** One hundred fifty-seven infants born at <30 weeks of gestation were enrolled during 3 time-periods. Group 1: before DHM program implementation, Group 2: the year following implementation, and Group 3: the second year after implementation. The proportion of feeds consisting of MOM for 6 weeks following birth was analyzed using a generalized linear mixed model. The study's second phase surveyed healthcare providers regarding knowledge and practices concerning DHM.

**Results** Group 1 consumed feeds with a greater proportion of MOM than Group 3 during weeks 1 ($P < .001$) and 3 ($P = .007$) and more than both Group 2 ($P = .033$) and 3 ($P = .021$) in week 4. During the first 14 days, Group 1 consumed feeds with 23.6% more MOM than Group 3 ($P = .002$) and had a greater odds of consuming feeds with > 90% MOM ($P < .001$) than Group 3. During days 1-28, Group 1 consumed feeds with 22% more MOM than Group 3 ($P = .003$) and had greater odds of consuming feeds with >90% MOM than Group 2 ($P = .020$) and 3 ($P = .004$). Knowledge regarding DHM was inconsistent among providers and they were unlikely to communicate potential risks and benefits of DHM to mothers.

**Conclusions** Following implementation of a DHM program, MOM consumption decreased over 2 years. Strategies focused on lactation success are necessary to increase MOM consumption. *(J Pediatr 2019;211:33-8)*.

The health benefits of feeding mother's own milk (MOM) to infants born preterm are well established and include a decreased incidence of necrotizing enterocolitis (NEC), late-onset sepsis, retinopathy of prematurity, and rehospitalization and improved neurodevelopmental outcomes.[1-6] Current recommendations suggest all infants born preterm weighing less than 1500 g receive MOM and if unavailable, pasteurized donor human milk (DHM) should be provided.[7] The availability and use of DHM has increased dramatically in recent years, and it is now considered standard care in many neonatal intensive care units (NICUs).[8,9] Although provision of MOM clearly reduces the risk of prematurity-related morbidity, the health benefits of DHM are less clear.[10,11]

Pasteurization of DHM may reduce or eliminate many of the protective elements in MOM, including lactoferrin, alkaline phosphatase, immunoglobulins, lysosymes, and anti-inflammatory cytokines thought to decreaseprematurity-specific complications related to an immature immune system.[12,13] Pasteurization also eliminates the microbiota present in MOM, which contributes to a more commensal intestinal microbiome, theoretically providing protection against neonatal morbidities such as NEC.[14,15] Finally, due to diminished protein content and decreased fat absorption from inactivation of bile salt-stimulating lipase by pasteurization, infants fed DHM, especially those born weighing <1000 g, may have suboptimal growth[12,16,17] that may predispose them to neurodevelopmental delays.[18]

Whether the availability of DHM affects consumption of MOM among infants born extremely preterm in the NICU is unclear. Although support from healthcare providers is essential for lactation success, little is known about the views and practices of neonatal healthcare providers about the use of DHM.[19,20] The objective of this retrospective cohort study was to compare consumption of MOM by infants born extremely preterm

| | |
|---|---|
| DHM | Donor human milk |
| GLMM | Generalized linear mixed model |
| MOM | Mother's own milk |
| NEC | Necrotizing enterocolitis |
| NICU | Neonatal intensive care unit |

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Sponsored by the University of Florida, who had no involvement in the (1) study design; (2) the collection, analysis, and interpretation of data; (3) the writing of the report; and (4) the decision to submit the manuscript for publication. The authors declare no conflicts of interest.


https://doi.org/10.1016/j.jpeds.2019.03.040

before and after implementation of a DHM program in a level 4 NICU. A secondary purpose was to determine healthcare provider's views and practices regarding the use of DHM in the NICU.

## Methods

For the primary objective, participants were infants born at <30 weeks of gestation admitted to a level 4, 72-bed NICU. This NICU is a referral center associated with a labor and delivery unit. Infants who died within 7 days of birth were excluded. Subjects were enrolled over 3 time periods to determine whether differences in consumption of MOM changed over time. Group I was enrolled before the implementation of a DHM program (November 2012 to November 2013), Group 2 was enrolled immediately following implementation of the DHM program (December 2013 to December 2014), and Group 3 was enrolled the second year after implementation (December 2015 to December 2016). Infants were eligible for DHM if they were born at <30 weeks of gestation. Parental informed consent was not required for infants to receive DHM, and the NICU did not have guidelines concerning parental counseling regarding the use of DHM. Infants in Group 1 received preterm formula if MOM was unavailable. Infants in Groups 2 and 3 were fed DHM if MOM was unavailable until 34 weeks of postmenstrual age and then transitioned to preterm formula.

All feeding decisions including initiation, advancement, fortification, and discontinuation of feedings were based on the established nutrition guidelines of the NICU. Based on these guidelines, feedings were initiated within the first 24 hours following birth and advanced by 20 mL/kg/d. Lactation support and education did not change over the study period and included an initial visit by a lactation consultant before the mother's discharge from the hospital and additional consultation at the request of the nurse. Approval for the study was obtained from the institutional review board at the University of Florida. Due to the retrospective nature of the study, consent was not obtained.

Infant characteristics including race, sex, gestational age, and birth weight were collected retrospectively from the medical records. The proportion of daily feeds consisting of MOM was collected for the first 6 weeks after birth. Data for each week were included in the analysis if the infant was not discharged and was enterally fed. The proportion of feedings consisting of MOM was calculated by summing the proportion of feedings consisting of MOM over the aggregate time period and calculating a proportion using the summed weekly total possible.

For the secondary objective, in September 2017, an anonymous online survey was sent to NICU healthcare providers to determine their knowledge, beliefs, and practices regarding the use of DHM in the NICU in infants born extremely preterm. The survey was developed by the investigative team in consultation with a team of experts, including neonatologists, registered nurses, nurse practitioners, and lactation consultants. The survey was then pilot tested with 4 healthcare providers and revised before data collection. The survey consisted of 13 multiple-choice questions in 4 parts: Part 1 collected demographic information (1 question) including the participant's role in the NICU. Other demographic information was not collected to maintain anonymity. Part 2 (4 questions) gathered information regarding participants' understanding of the differences between MOM and DHM. Part 3 (4 questions) collected information regarding participants' knowledge of the evidence supporting the use of DHM including safety issues and nutritional adequacy. Part 4 (2 questions) asked providers about any risks and/or benefits of DHM and Part 5 (2 questions) asked if participants discussed potential risks and/or benefits with the mother. Questions in Part 2-4 used a 5-point scale ranging from "strongly disagree" to "strongly agree" whereas questions in Part 5 used a "yes" or "no" response. Neonatologists, neonatal fellows, nurse practitioners, nurses, and pediatric residents were invited by e-mail to complete the online survey using Qualtrics Software (Qualtrics, Provo, Utah) in September 2017. Participants were given 2 weeks to complete the survey, and a reminder was sent after week 1. Approval for the survey was obtained from the institutional review board at the University of Florida. Consent to participate was implied if the subject completed the survey, and all survey responses were anonymous.

### Data Analyses

Data were examined for distribution of values, including outliers and patterns of missing values using descriptive statistics appropriate for measurement level. Due to the small cell sizes for some race groups, race was dichotomized into white and nonwhite. Given the repeated measures design and measurement of MOM consumption as a proportion (proportion of feedings containing MOM), a generalized linear mixed model (GLMM) was used to address study aims. A GLMM approach allows for missing data and can accommodate measurements at different time points, time varying covariates, flexible covariance structures, and a variety of dependent variable distributions.[21,22] Information criteria (eg, Bayes information criterion for mixed or quasi information criteria for generalized estimating equations) were evaluated as a measure of model and covariance structure conformance to the data. Application of contrasts and simple main effects techniques were used to test hypotheses about moderating (interaction) effects. The GLMM contained group (a between-subjects factor with 3 levels), week (a within-subjects factor with up to 6 levels), group by week interaction, and selected covariates. Race, gestational age, and birth weight were evaluated for inclusion within the model and were retained if there was a statistically significant independent association between the covariate and outcome.

To test for differences in odds for high proportion of MOM feedings, the outcome was dichotomized into <90% MOM and ≥90% MOM. A GLMM incorporating generalized estimating equations was used, and race, gestational age, and birth weight were evaluated for inclusion within the model and were retained if there was a statistically significant independent association between the covariate and outcome.

For the survey responses, statistics appropriate for measurement level were used to summarize participants' current role in the NICU, as well as their views and practices regarding the use of DHM in extremely premature infants in the NICU.

## Results

Demographic characteristics of the 157 infants in the study are compared for the 3 groups in Table I. Over the entire study period, 22 (2.6%) feeding weeks were excluded from analyses (weeks that infants were discharged or not enterally fed).

Results of the final mixed model including adjusted (least square) means and the 95% CIs are presented in Table II. Because the outcome was a proportion, an arcsine square root transformation was applied to the outcome variable. To provide a more easily interpretable value, untransformed values also are provided in Table II. An autoregressive covariance structure provided best fit based on the Bayes information criterion value. Of the 3 covariates and 4 interactions with group in the initial full model, only the group-by-week interaction ($P = .011$) and gestational age ($P = .048$) were retained in the final model. Simple main effects analysis for the group-by-week interaction indicated differences between group means in weeks 1, 3, and 4. A modified Bonferroni adjustment (adjusted $P$ value for statistical significance = .033) for multiple comparisons was used to provide an overall .05 type I error rate within weeks. Qualitatively, Group 1 had the greatest mean proportion of MOM feedings in each week. Group 1 consumed a statistically significant greeter mean proportion of MOM feedings than Group 3 in weeks 1, 3, and 4 and greater than Group 2 in week 4. There was a general trend for decreasing mean proportion of feedings consisting of MOM over the 6-week study.

During days 1-14, the difference in least square mean proportion of feedings consisting of MOM between Groups 1 and 2 was 11.1%, but this was not statistically significant ($P = .153$). During that same time-period, Group 3 least square mean percent of MOM feedings was smaller than Group 1 (difference = 23.6%, $P = .002$). Moreover, during days 1-28, compared with Group 1, infants in Group 2 consumed feedings with 13.1% less MOM ($P = .081$) and those in Group 3 consumed feedings with 22.0% less MOM ($P = .003$) (Table II).

Results of the GLMM using generalized estimating equations are presented in Table III. No covariates were retained in the model. Overall, there was a difference in odds for high MOM feedings ($P = .027$), with Group 1 qualitatively having greater odds of high MOM feedings. During the first 14 days, the OR for Group 1 compared with Group 3 was statistically significant (OR = 3.52, $P < .001$). Over days 1-28, Group 1 had greater odds for high MOM feedings compared with Group 2 (OR = 2.32, $P = .020$) and Group 3 (OR = 2.87, $P = .004$).

For the study's second objective, the survey was sent via e-mail to 230 nurses, residents, neonatologists/fellows, and neonatal nurse practitioners with a response rate of 39% (n = 89). The current roles of the participants (Part 1 question) were pediatric residents (n = 25, 28%), nurse practitioners (n = 8, 9%), neonatologists or neonatal fellows (n = 6, 7%), nursing administrator (n = 1, 1%), and bedside nurses (n = 49, 55%). Responses to the questions in Parts 2-5 of the survey are shown in Table IV. Among the healthcare providers who participated, >22% either did not know or agreed that the protective elements in DHM were equivalent to MOM, and 25.2% agreed it was as beneficial as MOM. When specifically asked whether they thought DHM provided as much protection against NEC and late-onset sepsis, 25.9% stated it was as protective against NEC and 20.3% stated it was as protective against late-onset sepsis. Only 21.9% agreed that DHM did not contain sufficient nutrition for growth, and 75.7% agreed it was superior to formula. Although 53.6% of those surveyed indicated there were potential risks associated with providing DHM, only 34.6% discussed these risks with the infant's mother. Similarly, 87.8% indicated there were possible benefits of DHM but only 53.1% discussed these benefits with the mother.

**Table I. Descriptive statistics for demographic variables**

| Variables | Group 1 (n = 52) | Group 2 (n = 52) | Group 3 (n = 53) | Group comparison *P* value |
|---|---|---|---|---|
| Gestational age | 27.6 (1.83) | 27.2 (1.67) | 26.7 (2.15) | .043 |
| Birth weight | 1045.8 (272.6) | 998.3 (226.5) | 907.6 (214.5) | .013 |
| Sex | | | | |
| Male | 25 (48%) | 28 (54%) | 29 (55%) | .779 |
| Female | 27 (52%) | 24 (46%) | 24 (45%) | |
| Race | | | | |
| White | 22 (43%) | 27 (52%) | 24 (45%) | .656 |
| Nonwhite | 29 (57%) | 25 (48%) | 29 (55%) | |
| Missing | 1 (2%) | 0 | 0 | |

Data are presented as the mean (SD) or frequency (%).

## Discussion

Although the use of DHM in NICUs has dramatically increased over the last decade, the effect of its availability on consumption of MOM by infants born extremely preterm remains unclear.[8,10] We investigated changes in MOM consumption for 2 years following implementation of a DHM program. In this pre–post observational cohort study, we found MOM consumption by infants born extremely preterm decreased following implementation of a DHM program and continued to decrease over time. Infants born in the second year following implementation consumed feeds with a significantly lower proportion of MOM compared with those born before implementation. In addition, infants

**Table II. Generalized mixed model analysis results for arcsine square root transformed proportion of MOM feedings**

| Effect | *P* value | Least square means (95% CI) Group 1 | Group 2 | Group 3 |
|---|---|---|---|---|
| Group (across weeks) | .029 | 1.18 (1.03-1.33) | 0.972 (.824-1.12) | 0.905 (.757-1.05) |
| | | 75.61 (65.7-85.5) | 61.32 (51.5-71.1) | 57.81 (48.0-67.6) |
| Week (across groups) | <.001 | | | |
| Gestational age | .048 | | | |
| Group*week | .011 | | | |
| Simple main effects* | | | | |
| Week 1 | .001 | 1.30 (1.12-1.47)[a] | 1.03 (0.859-1.21)[ac] | 0.831 (0.659-1.00)[bc] |
| | | 83.0 (71.3-94.6)† | 66.1 (54.4-77.7)† | 54.3 (42.9-65.7)† |
| Week 2 | .082 | 1.29 (1.12-1.47) | 1.21 (1.04-1.38) | 1.02 (0.846-1.19) |
| | | 82.4 (70.9-94.0)† | 77.2 (65.8-88.7)† | 63.9 (52.4-75.3)† |
| Week 3 | .028 | 1.28 (1.10-1.45)[a] | 1.10 (0.929-1.27)[ac] | 0.939 (0.766-1.11)[bc] |
| | | 81.4 (69.9-92.9)† | 69.3 (57.8-80.7)† | 59.2 (47.6-70.7)† |
| Week 4 | .037 | 1.22 (1.04-1.39)[a] | 0.950 (0.778-1.12)[b] | 0.924 (0.750-1.10)[b] |
| | | 77.5 (66.0-89.1)† | 59.4 (47.9-70.8)† | 59.0 (47.5-70.6)† |
| Week 5 | .262 | 1.01 (0.833-1.19) | 0.826 (0.652-0.999) | 0.835 (0.660-1.01) |
| | | 64.9 (53.0-76.8)† | 52.3 (40.8-63.9)† | 53.9 (42.3-65.5)† |
| Week 6 | .076 | 1.00 (0.814-1.19) | 0.706 (0.528-0.884) | 0.884 (0.708-1.06) |
| | | 64.3 (51.9-76.7)† | 43.6 (31.8-55.5)† | 56.5 (44.9-68.2)† |
| Custom contrasts | | | | |
| Day 1-14 | | 1.29 (1.13-1.46)[a] | 1.12 (0.958-1.29)[ab] | 0.925 (0.76-1.09)[b] |
| | | 82.7 (71.6-93.8)† | 71.6 (60.6-82.6)† | 59.1 (48.2-70.0)† |
| Day 1-28 | | 1.27 (1.11-1.43)[a] | 1.07 (0.920-1.23)[ab] | 0.928 (0.773-1.08)[b] |
| | | 81.1 (70.7-91.4)† | 68.0 (57.7-78.2)† | 59.1 (48.8-69.4)† |

[abc] Post-hoc paired comparisons using modified Bonferroni adjustment ($P < .033$) within week. Shared letter indicates paired comparison $P > .03$. For example, week 1, least squares mean for groups 1 and 2 (both contain [a]) and 2 and 3 (both contain [c]) are similar; 1 is different from 3 (1 contains [a], 3 does not).
*Testing differences in group means controlling for week.
†Raw values for reference only.

in the preimplementation group were significantly more likely to consume feeds with a high proportion of MOM (90%-100%).

These findings are consistent with those of Esquerra-Zwiers et al, who found the proportion of MOM consumed by infants <1500 g decreased during days 1-14 (85% vs 68%; $P < .01$) and days 1-28 (71% vs 61% $P = .04$) following implementation of a DHM program.[23] Others have reported a decrease from 40% to 13% (no *P* value reported) during days 1-28 when DHM was available[24] and a slight decrease from 63% to 60% during days 1-14 (no *P* value reported).[25] However, a single-center study found consumption of MOM during days 1-28 increased slightly from 66% to 70% and exclusive consumption increased from 38% to 55% following implementation of a DHM program (no *P* value reported).[26] Because exposure to MOM in the first days following birth may provide the greatest protection against prematurity-related complications, protecting consumption of MOM during this period is important.[27]

Although we did not collect data regarding MOM consumption at discharge, 2 large multicenter studies have reported increased MOM consumption when DHM was available.[28,29] However, consumption at discharge may be a poor indicator of lactation success because mothers are less likely to be lactating at discharge if their infants require prolonged hospitalization due to extreme prematurity or illness.

**Table III. Generalized mixed model analysis incorporating GEE results for high-proportion MOM feedings**

| Effect | *P* value | OR (95% CI) | | |
|---|---|---|---|---|
| Group (across weeks) | .027 | 2.21 (1.34-3.65) | 0.878 (0.557-1.38) | 0.987 (0.629-1.55) |
| Week (across groups) | <.001 | | | |
| Group*week | .017 | | | |
| Simple main effects | | Group 1 | Group 2 | Group 3 |
| Week 1 | .001 | 2.73 (1.40-5.34)[a] | 1.22 (0.692-2.14)[ac] | 0.514 (0.291-0.908)[bc] |
| Week 2 | .208 | 3.07 (1.55-6.07) | 1.60 (0.915-2.80) | 1.44 (0.834-2.50) |
| Week 3 | .098 | 2.92 (1.50-5.66) | 1.26 (0.730-2.18) | 1.24 (0.719-2.15) |
| Week 4 | .032 | 2.46 (1.29-4.69)[a] | 0.793 (0.459-1.37)[b] | 1.26 (0.726-2.19)[ab] |
| Week 5 | .112 | 1.38 (0.745-2.55) | 0.569 (0.320-1.01) | 0.983 (0.566-1.71) |
| Week 6 | .007 | 1.37 (0.737-2.54)[a] | 0.374 (0.197-0.707)[b] | 1.19 (0.683-2.06)[a] |
| Custom contrasts | | | | |
| Day 1-14 | | 2.81 (1.61-4.92)[a] | 1.42 (.832-2.42)[ab] | 0.799 (0.490-1.30)[b] |
| Day 1-28 | | 2.79 (1.63-4.76)[a] | 1.20 (0.749-1.93)[b] | 0.971 (0.608-1.55)[b] |

[abc] Post-hoc paired comparisons using modified Bonferroni adjustment ($P < .033$) within week. Shared letter indicates paired comparison $P > .03$. For example, week 1, least squares mean for groups 1 and 2 and 2 and 3 are similar; 1 is different from 3.

**Table IV. Neonatal healthcare provider survey results**

| Part 2-4 questions | Strongly disagree % (n) | Disagree % (n) | Unknown % (n) | Agree % (n) | Strongly agree % (n) |
|---|---|---|---|---|---|
| DHM is as beneficial as MOM (n = 87) | 19.5 (17) | 49.3 (43) | 5.75 (5) | 19.5 (17) | 5.7 (5) |
| The concentration of protective elements is equal in DHM and MOM (n = 85) | 20 (17) | 57.6 (49) | 12.9 (11) | 7.1 (6) | 2.4 (2) |
| DHM is as protective against NEC as MOM (n = 85) | 11.8 (10) | 38.8 (33) | 23.5 (20) | 24.7 (21) | 1.2 (1) |
| DHM is as protective against late onset sepsis as MOM (n = 83) | 11.8 (10) | 31.5 (28) | 30.3 (27) | 18 (16) | 2.3 (2) |
| Sufficient evidence exists to support the use of DHM (n = 82) | 0 (0) | 9.8 (8) | 28 (23) | 51.2 (42) | 9 (9) |
| DBM is safe (n = 82) | 1 (1) | 0 | 0 | 80.5 (66) | 18.2 (15) |
| Fortified DHM provides sufficient nutrition for growth (n = 82) | 2.4 (2) | 19.5% (16) | 12.2 (10) | 59.8 (49) | 6.1 (5) |
| DHM is superior to formula (n = 82) | 0 (0) | 12.2 (10) | 12.2 (10) | 59.8 (49) | 15.9 (13) |
| There are potential risks providing DHM to infants (n = 82) | 1.2 (1) | 15.9 (13) | 29.3 (24) | 45.1 (37) | 8.5 (7) |
| There are potential benefits providing DHM to infants. (n = 82) | 0 (0) | 0 (0) | 12.2 (10) | 70.7 (58) | 17.1 (14) |
| **Part 5 questions** | **Yes % (n)** | **No % (n)** | **N/A** | **N/A** | **N/A** |
| Do you discuss potential risks of DHM with the mother? | 34.6 (28) | 65.4 (53) | N/A | N/A | N/A |
| Do you discuss potential benefits of DHM with the mother? | 53.1 (43) | 46.9 (38) | N/A | N/A | N/A |

*N/A*, not available.

In addition, previously expressed MOM may be provided to infants long after mothers have ceased lactating.[30] Therefore, consumption at specific time periods during hospitalization may be a better indicator of lactation success.

The results of this survey suggest that neonatal healthcare providers have conflicting views regarding the differences between MOM and DHM. This is likely to be related to the lack of clear evidence regarding differences between the 2 types of human milk. We also found healthcare providers did not consistently communicate information regarding DHM to mothers of infants born extremely preterm. Protocols to promote standardized counseling to parents regarding the risks and benefits of DHM may assist parents in making decisions regarding the care of their infant.

Because DHM may provide less protection and be nutritionally inferior to MOM, the results of this study are discouraging and emphasize the need to identify and implement strategies to optimize the amount of MOM available for infant consumption. Limitations of this study include its retrospective nature, inclusion of a single NICU, and lack of information about consumption of MOM at infant discharge. In addition, we did not collect data on maternal demographics or health, which may have affected availability of MOM. Finally, there were limitations to our survey, including the low response rate, differences between the time period for the infant study and the survey of healthcare providers, and potential weaknesses in our survey design to best measure healthcare provider views regarding DHM.

In this study, we demonstrated that consumption of MOM by infants born extremely preterm decreased for 2 years following implementation of a DHM program in a level 4 NICU. Differences were especially pronounced during days 1-28, when the protective benefits of MOM may be most important. Strategies to increase lactation success in mothers of infants born extremely preterm are necessary to increase consumption of MOM and should include education of both mothers and healthcare providers regarding potential differences between MOM and DHM. ■

Submitted for publication Sep 3, 2018; last revision received Mar 7, 2019; accepted Mar 26, 2019.

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## Data Statement

Data sharing statement available at www.jpeds.com.

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