

The Cost of Using Donor Human Milk in the NICU to Achieve Exclusively Human Milk Feeding Through 32 Weeks Postmenstrual Age

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Abstract

Objectives: Donor human milk (DHM) is increasingly being used in neonatal intensive care units (NICUs) to achieve exclusive human milk (EHM) feedings in preterm infants. The aim of the study was to determine the cost of DHM to achieve EHM feeding for very preterm infants. The hypothesis was that the cost of DHM per infant is modulated by the availability of mother's own milk (MOM).

Subjects and Methods: Preterm infants (<1,500 g at birth weight or <33 weeks in gestational age) were retrospectively evaluated for a 1-year interval. MOM, DHM, and formula feeding categories were determined. A DHM feeding log was retrospectively analyzed for feeding volumes (in milliliters) and duration (in days). Four categories were created, based on maternal ability to provide sufficient breastmilk volumes and her intention to breastfeed. The volume, duration, and cost of DHM were calculated for each category.

Results: Forty-six of the 64 (72%) infants admitted to the NICU who were <33 weeks in gestational age received DHM. Four categories of DHM use were observed. The mean costs of DHM were \$27 for infants of mothers who provided sufficient breastmilk through to discharge, \$154 for infants of mothers who had insufficient milk supply during admission, \$281 for infants of mothers who went home on formula but received any volume of MOM during admission, and \$590 for infants who received no MOM during admission.

Conclusions: Most NICU mothers (72%) of very preterm infants were unable to provide all of the milk necessary for an EHM diet. Few infants (15%) received exclusively DHM. The cost of DHM per NICU infant ranged from \$27 to \$590 and was influenced by the mother's willingness or ability to provide human milk.

Introduction

THE AMERICAN ACADEMY OF PEDIATRICS recommends donor human milk (DHM) ahead of formula for preterm infants when mother's own milk (MOM) is unavailable.¹ Preterm infants better tolerate human milk, which enables them to reach full enteral feeds more quickly. It also offers immunoprotective effects, particularly for the gastrointestinal tract.²⁻⁴ Despite the uncertainty about the suitability of human milk for the additional nutritive requirements needed for the growth of very preterm infants, recent findings suggest a dose-dependent association between exposure to human milk (MOM or DHM) and a reduction in necrotizing enterocolitis (NEC).⁴⁻⁸ It is postulated that this is not only due to the positive factors found in human milk, but as a result of reducing exposure to bovine proteins found in formula and human milk fortifier.^{2,4} Consequently, an exclusive human

milk (EHM) diet for preterm infants is promoted as one strategy in NEC prevention.^{4,6,9}

In the neonatal intensive care unit (NICU) environment, particularly with very preterm infants, it is not always possible for mothers to supply adequate volumes of expressed human milk.¹⁰ There are also situations where it is not possible for mothers to provide any human milk at all, for example, in cases of maternal drug abuse or where there is a maternal choice not to express. Therefore if EHM feedings are to be achieved in the NICU, another source of human milk is frequently needed. Pasteurized DHM obtained from a human milk bank is increasingly being used in NICUs throughout North America.¹¹ In North America milk donors are not paid; however, human milk banks have costs associated with the screening, pasteurization, testing, and shipping of human milk,¹¹ and this cost is passed on to the purchaser at an average price in 2008 of US \$4.077 per ounce (30 mL).¹²

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Theoretical cost estimates have been developed for preterm feedings of DHM in the NICU.^{10,12-14} These cost estimates harbor assumptions that do not necessarily reflect the use of DHM as it occurs in daily NICU practice. For example, one cost estimate of AUD \$1,200 (USD \$1,265) for 10,000 mL¹⁴ was based on what was described as a “standard feeding regimen” for a 24-week gestational age (GA) infant fed exclusively DHM. A second cost estimate of US \$907.60 for 9,900 mL was based on an exclusive DHM diet for 60 days from admission to discharge for an “average baby” weighing 1,100 g.¹³ A third cost estimate was US \$750 to feed a very low birth weight infant 7,500 mL of DHM for 2 months, until discharge.¹⁰ Collectively, these studies are based on hypothetical case-scenarios and share two problematic assumptions. First, they assume exclusive DHM feeding. This fails to account for maternal success or preparedness to express at least some of the total volume of breastmilk required and ignores the moderating effect of MOM volume on the cost of DHM per infant. Second, the models assume that DHM feeding commences from Day 1 of enteral feeds and finishes on the day of the infant’s discharge. This assumption excludes the transition period from DHM to formula during the days or weeks prior to discharge from NICU, which will reduce the amount of DHM consumed. In sum, existing cost analyses do not accurately reflect how DHM is used in practice. This conclusion was also reached in a systematic review of the cost-effectiveness of various interventions that promote or inhibit human milk feedings to preterm NICU infants. The review authors stated that, “without a more detailed costing study [of DHM], it is impossible to ascertain whether the actual resources that would be used in a real life situation are reflected in the analysis outcomes.”³ It follows, therefore, that until these data are available it is difficult to complete accurate cost-effectiveness studies into the role of DHM in achieving EHM feedings for very preterm infants as a strategy for NEC prevention.

The aim of this study is not to demonstrate if NEC can be reduced through EHM feedings in preterm infants. Rather, the present study aims to determine the cost of using DHM to achieve EHM feedings. This study uses empirical data of how DHM is actually used in everyday NICU infant feeding practices. It builds a typology and subsequent cost analysis for DHM feedings for infants less than 33 weeks GA or weighing less than 1,500 g. The cost analysis presented in this study differs from those reviewed thus far as it takes into account whether the volume of MOM supplied was sufficient and therefore the modulating effect this had on the volumes of DHM required to achieve EHM feeding. Thus rather than a theoretical cost model based on hypothetical case scenarios, the typology developed in this study reflects the intricacy of how DHM is used in actual practice.

Materials and Methods

Study site and NICU infant feeding protocol

The study NICU is located in the midwestern region of the United States. In an attempt to minimize NEC in the highest-risk population of preterm infants, the Level III NICU in this study adopted an EHM feeding policy for all very preterm infants (≤ 32 weeks postmenstrual age [PMA]) or low birth weight infants ($\leq 1,500$ g). All NICU mothers were encouraged by a team of neonatologists, neonatal nurses, and lac-

tation consultants to express their breastmilk using a hospital-grade electric breast pump. In support of mothers attempting to express milk, breast pumps were made available to all mothers irrespective of their insurance coverage. In addition, lactation consultants were available on-call, around the clock, 7 days per week.

Although MOM was the first priority for infant feeding in the study NICU, when MOM was insufficient to meet the feed volumes required by the infant, DHM was provided to infants (with parental consent) in order to maintain EHM feedings until 32 completed weeks PMA. Ten percent of parents did not consent to DHM and were not included in the study. The nutrition practices of the study NICU are detailed elsewhere.¹⁵ However, of relevance to the current study is that parenteral nutrition was discontinued when full enteral feeding was achieved at 140–150 mL/kg/day, and infants were fed at 150–160 mL/kg/day through 33 weeks PMA. To ensure no exposure to bovine proteins, fortification of MOM and/or DHM with bovine products was delayed until 33 weeks PMA or establishment of full enteral feedings, whichever came later. The present study does not include the cost of fortification with human milk-based products before 33 weeks PMA. After 33 weeks PMA, bovine-derived fortifiers were introduced, and if MOM volumes remained insufficient or a mother was intending to formula feed, the infant was slowly transitioned from feeds of DHM to feeds using formula. Thus formula was only offered to infants of breast-feeding mothers when MOM production was insufficient.

DHM and the human milk bank

All DHM was ordered and purchased from the Indiana Mother’s Milk Bank (IMMB) at the price of US \$4.00/ounce (30 mL). Although there may be a cost differential between term and preterm milk in other North American human milk banks, they were identically priced by the IMMB throughout the study period. Preterm milk was less reliably available than term milk, and therefore preterm milk was rarely used during the study period. The cost of DHM was calculated based on the volume of DHM consumed and did not include the shipping charge.

The amount and pattern of donor milk use in the study NICU were analyzed over a period of 12 months (December 28, 2010 until December 27, 2011). Two databases, the donor milk log and electronic medical record, were accessed in order to examine donor milk use in the NICU. Institutional Review Board approval was granted by Indiana University (protocol number 1106005888) for records examined contemporaneously with the hospital admission. The requirement for informed consent was not required for records evaluated retrospectively. The entire study was reviewed and approved by the Research Institute of Deaconess Clinic in accordance to the policy and procedures of the Research Oversight and Privacy Committee of Deaconess Health System.

Inclusion criteria

Study inclusion criteria were as follows: all infants admitted to the NICU from December 28, 2010 to December 27, 2011 and (1) whose birth weight was $\leq 1,500$ g or whose GA was ≤ 32 weeks and (2) received any amount of DHM during their NICU admission.

Procedures for analysis of patterns of DHM use

DHM use for each NICU infant was recorded in the donor milk log ("the log") located in the milk preparation room of the study NICU. The log documented each instance of DHM feeding and included the following data points: (1) date and time DHM was used in the NICU, (2) the recipient infant's name, (3) the volume (in milliliters) of DHM fed to the infant, and (4) the IMMB batch number. The total volume of DHM fed to each infant in the study sample was recorded in a spreadsheet for analysis.

The patient's electronic medical record provided information on GA, birth weight, feeding type during admission, and discharge feeding orders of all infants who received DHM over the 12-month period. Feedings during admission (MOM, DHM, and/or formula) and discharge (human milk, formula, or human milk + formula) were recorded for each infant. Infants who received any volume of DHM during admission were identified and allocated to one of the four categories as determined by feeding discharge orders and exposure to MOM during admission. This provided a retrospective picture with regard to maternal intention to express or breastfeed and whether or not adequate volumes of MOM were provided during admission. The four categories and associated assumptions are described in Table 1.

For each category, the mean, median, and range of total DHM volumes and days fed DHM were calculated. The days fed DHM was defined as the number of days the infant received DHM and did not need to be consecutive days of feeding. Descriptive statistics were used to calculate patterns of DHM use.

Cost analysis

The study NICU obtained DHM from the IMMB at a cost of US \$4.00 per ounce (30 mL). This was paid for by the hospital NICU budget and was not passed on to parents or insurance companies. The mean DHM volume for each category was calculated and then multiplied by \$4 per 30 mL to provide the total cost of DHM, per infant. The cost of postage/shipping DHM from the IMMB to the hospital was not included in the analysis. Descriptive statistics were used to calculate costs. All costs are presented in USD at 2011 prices.

Results

Study cohort

During the 12-month study period there were in total 340 NICU admissions, of which 64 were ≤ 32 weeks GA or $\leq 1,500$ g in birth weight. Of these 64 infants, 46 (72%) received DHM. The parents of six infants (9%) declined donor milk. Therefore, the total number of infants who met the study inclusion criteria was 46 (100%), of whom 26 infants (57%) were in the $\leq 1,500$ g category and 41 (89%) were ≤ 32 weeks GA. There was some overlap of weight and GA categories, with 22 infants (48%) being both $\leq 1,500$ g and ≤ 32 weeks GA. Thirty-four of the study infants were of a multiple birth (74%). The mean GA was 30 weeks (range, 25–32 weeks), and the mean birth weight was 1,427 g (range, 574–2,345 g). Thirty-nine (85%) of the infants who received DHM also received MOM. Seven infants (15%) did not consume any MOM because maternal preference was not to pump or feeding MOM was contraindicated.

Typology and cost of DHM use in the NICU

For the total study cohort, the mean volume of DHM used per baby per stay was 3,007 mL (range, 3–9,271 mL) (Table 2). The mean duration of DHM feeding was 12 days (Table 3), with an average cost of \$236.90 per infant per stay. The total cost to the hospital in 1 calendar year was \$10,898. However, each category of infants demonstrated variation in the mean volumes of DHM consumed and the mean number of days fed DHM (Tables 2 and 3). For example, the cohort of infants who were discharged on EHM feedings ($n=14$, 30%) had a mean DHM consumption of 202.8 mL (range, 3–1,369 mL) and a mean number of days of 4 (range, 1–32 days). The mean cost of DHM for this cohort was \$27.04. Yet for the infants who were discharged on formula feeding only and whose mothers ceased pumping during their infant's NICU admission ($n=20$, 43%), their mean DHM volume requirements and days fed were higher at 2,103 mL per baby (range, 18–7,950 mL) over 13 days (range, 2–34 days). Subsequently the mean cost of DHM for this category was 10 times higher (\$280.51).

Discussion

The results from this study have provided a cost analysis of DHM based on empirical data from a Level III NICU that

TABLE 1. FEEDING CATEGORY

Number of subjects	Discharge feeding category	Conditions
14	Breastmilk only	The mother intended to breastfeed the infant upon discharge <i>and</i> the mother had a sufficient milk supply, the baby was growing sufficiently well, and there was no recommendation to supplement with formula.
5	Breastmilk + formula	The mother intended to breastfeed the infant upon discharge; in addition, the physician ordered supplementation with formula because the breastmilk supply or the infant's growth was perceived to be inadequate.
20	Formula only (MOM during admission)	Baby received MOM during the NICU admission. Mother ceased breastfeeding and pumping before discharge, for any reason.
7	Formula only (no MOM during admission)	The baby did not receive any MOM, but the mother consented to use donor milk. The mother either declined to pump to provide her own milk or was unsuccessful with pumping, or use of MOM was contraindicated.

MOM, mother's own milk; NICU, neonatal intensive care unit.

TABLE 2. VOLUME OF DONOR HUMAN MILK FED TO INFANTS

	Mean	Range	Median
All infants ≤ 32 weeks gestational age or $< 1,500$ g	3,007	3–9,271	771
Discharge feeding category			
Breastmilk only	203	3–1,369	28
Breastmilk and formula	1,159	16–2,820	730
Formula (MOM during admission)	2,103	18–7,950	1,644
Formula (no MOM during admission)	4,432	953–9,271	3,945

Data are expressed in milliliters.
MOM, mother's own milk.

utilizes DHM to achieve an EHM diet through 33 weeks PMA. The cost analysis took into account the maternal preparedness to provide human milk and ability to produce adequate volumes of human milk. Based on the price of DHM at US \$4.00/ounce and the variable amounts of MOM that is supplied to NICU infants, the mean cost of providing DHM is between US \$27.04 and \$590.90 per infant.

A limitation of this study is that it provides cost data for DHM with the assumption that after 33 weeks PMA it was acceptable to introduce bovine products to preterm infants and therefore withdraw the use of DHM. The aim of this study was not to demonstrate if NEC could be reduced through using DHM to achieve an EHM diet. In order to do so the study would have had to perform a randomized control trial with a much larger sample. Therefore the present study is unable to comment on the value of using EHM diet on NEC reduction. There is scant research on the safety of bovine proteins for the preterm gut and at what GA and to what degree bovine proteins can be safely introduced. Consequently arbitrary NICU feeding protocols that use bovine products exist nationwide despite evidence showing that the avoidance of bovine protein may reduce rates of NEC in very preterm infants.^{16,17} Until large studies are completed about the safety of bovine products for the preterm infant *and* the efficacy of an EHM diet for NEC prevention, it is difficult to complete an accurate cost-effectiveness study on DHM and NEC reduction. In relation to the cost analysis presented in the present study, changes in the target PMA for permitting the introduction of dietary bovine protein will necessarily alter the total cost of providing DHM to achieve EHM feeds.

TABLE 3. INTERVALS (DAYS) INFANTS WERE FED DONOR BREASTMILK AND COST

	Days of DBM use	Mean cost
All infants	12 (1–84)	\$236.90
Discharge feeding		
Breastmilk only	4 (1–32)	\$27.04
Breastmilk and formula	9 (2–23)	\$154.49
Formula (MOM during admission)	13 (2–84)	\$280.51
Formula (no MOM during admission)	29 (12–60)	\$590.90

DBM, donor breastmilk; MOM, mother's own milk.

Others³ have argued that the most cost-effective use of DHM is for infants weighing less than 1,750 g due to their increased chance of NEC. If, as the current study has demonstrated, the costs of DHM during the highest NEC risk period are between \$27.04 and \$590.90, it would be logical to conclude that a relatively small financial outlay would reap great rewards in relation to the cost of medical and surgical NEC. NEC is estimated to cost US \$75,000 for medical NEC and \$200,000 for surgical treatment.^{2,18} However, research suggests that after the cost of DHM is accounted for, between US \$8167 and \$9,669 can be saved per NICU infant^{2,10} by reducing the incidence NEC and total parenteral nutrition days.^{2–4,10,13,14,19,20}

DHM was classified by the study hospital as a non-reimbursable expense and was accommodated through hospital profits. The study NICU did not pass on the total annual cost of DHM (\$10,898) to parents, nor was the hospital reimbursed by insurance companies. In most cases insurance companies will not reimburse hospitals for the cost of using DHM, and in some cases this means that philanthropic funding sources are sought, or the cost will be passed on to parents.²¹ Given DHM's therapeutic potential and its role in the reduction of larger financial burdens, it is surprising that insurance companies have yet to provide coverage for the use of DHM throughout the NICU admission. However the results of this study provide managers and policy makers with realistic cost data obtained from the actual practice of using DHM to achieve EHM feeding in very premature infants. Moreover, the cost figures provided by this study incorporate actual volumes of DHM used, the duration of its use, and the moderating effect of MOM supply.

Conclusions

This study has provided a cost analysis of using DHM in a Level III NICU in order to achieve an EHM feeding protocol for preterm infants who are at greatest risk for acquiring NEC: ≤ 32 weeks GA or $\leq 1,500$ g. This empirical study is based on a feeding protocol that uses DHM when MOM volume is either insufficient or unavailable, with the aim of providing EHM feeding for preterm and very low birth weight infants until 33 weeks PMA. The majority of study infants (85%) received DHM in addition to MOM in order to achieve EHM feedings. There is variation in the mean DHM volumes required to achieve EHM feedings (range, 202.8–4431.8 mL), and subsequently the study found a corresponding variation in the mean cost of DHM per baby (range, \$27.04–\$590.90).

The variation in DHM volumes fed during NICU admission can be attributed to maternal preparedness or ability to provide sufficient volumes of MOM. Therefore a key finding of this study is that the cost of DHM cannot be isolated from maternal choice to breastfeed or pump or from the quantity of MOM provided. Similarly, these variables cannot be isolated from maternal socioeconomic, cultural, and familial breastfeeding and lactation support structures and the investments in breastfeeding made by the community and hospital. However, unlike previous cost analyses, the current study has accounted for the intricacy of infant feeding as it occurs in practice and therefore provides critical information for health providers and managers who are seeking to implement and provide cost estimates for EHM feeding protocols for very preterm or low birth weight infants in the NICU.

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Disclosure Statement

No competing financial interests exist.

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