The Nutritive and Immunoprotective Quality of Human Milk beyond 1 Year Postpartum: Are Lactation-Duration-Based Donor Exclusions Justified?

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Abstract:

Donor human milk is critical for the fragile preterm infant who does not have access to his or her mother's milk, improving survival rates and quality of survival and decreasing hospital stay. Despite the opening of donor milk banks around the world, shortages continue as demand for donor milk exceeds supply. One potential means of increasing supply is by reducing exclusion criteria that prohibit mothers from donating milk based on duration of lactation. Minimal research has been done on the composition of human milk during the second year of lactation, with most research focusing on the nutritive compounds and not the immunoprotective compounds. Several immunoprotective compounds, including lysozyme, lactoferrin, secretory immunoglobulin A, and oligosaccharides, are abundant in human milk compared to bovine-based infant formula and are partially or fully retained during Holder pasteurization, making them an important differentiating feature of donor milk. A PubMed search was conducted to review studies in human milk composition during the second year of lactation. Limitations of existing research include sample collection protocols, small study sizes, and use of populations that may have been at risk for nutritional deficiencies. Stable concentrations of several components were reported including protein, lactose, iron, copper, lactoferrin, and secretory immunoglobulin A. Lysozyme concentration increased during extended lactation, while zinc and calcium concentrations declined into the second year. Conflicting findings were reported on fat content, and no information was available regarding oligosaccharide content. More research is needed to create evidence-based guidelines regarding the nutritive and immunoprotective value of donor milk throughout the course of lactation.

Keywords: breastfeeding | donor | extended | human milk | immunoprotective | lactation | prolonged | quality

Article:

Background

Human milk is not only a source of essential nutrients for the developing infant; it also provides numerous bioactive factors that enhance the immune response and stimulate development of the

immature gastrointestinal (GI) tract, providing a variety of well-documented health benefits to the infant.[1-3] Multiple studies have shown that human milk is especially important for the fragile preterm infant, with those receiving human milk less likely to develop necrotizing enterocolitis (NEC), a potentially life-threatening condition, compared to those receiving infant formula.[4-6] A systematic review of the use of donor milk with preterm infants showed that donor milk was associated with a lower risk of NEC compared to infant formula.[7] Human milk promotes development of the GI tract by quickly reducing intestinal permeability,[8] induces lactase activity,[9] and contains multiple factors to stimulate growth, motility, and maturation of the intestine.[10] Premature infants fed human milk have reduced incidence of sepsis[11-13] and other infections.[14] Human milk is also used in the treatment of metabolic disorders,[15] chronic renal failure,[16] and failure to thrive.[17]

The recipients with the greatest need for donor milk are very low birth weight (VLBW) infants whose mothers cannot produce milk or may have a delay in producing sufficient milk due to illness or death, use of medications, or poor breastfeeding support.[18] Therefore, these infants must rely on donor milk, which is collected, processed, and distributed by a human milk bank, if they are to receive human milk.

Recent years have seen the opening of new milk banks around the world to keep up with growing demand for this critical product, with new banks added in countries as diverse as Canada, Cape Verde, India, and Australia.[19-22] Despite the increasing number of human milk banks, shortages continue to be reported, primarily in the United States, due to growing demand.[23,24]

Table 1. Examples of Lactation-Duration Exclusions by Milk Bank or Milk Bank Network[a]

Milk Bank or Milk Bank Network	Lactation-Duration-Based Exclusion
PREM Bank (Western Australia)[29]	"We do not accept new donor mothers to the milk bank who have started their babies on solids or are still breastfeeding their babies after 12 months of age."
Brazil (government run)[30]	No lactation-duration exclusion
French Human Milk Bank Association (ADLF)[31]	No lactation-duration exclusion
Associazione Italiana Banche del Latte Umano Donato (AIBLUD)[32]	Must begin donating before infant is 6 months old; no information on how long donation can continue
Milk Matters (Cape Town, South Africa)[33]	No lactation-duration exclusion
United Kingdom Association for Milk Banking[34]	Usually must begin donating before infant is 6 months old and "continue for as long as they wish"
Human Milk Bank Association of North America (HMBANA)[73-78]	Practices vary with many milk banks excluding donors beyond 1 year

[a] Based on information on milk bank websites.

Brazil is considered a global leader in donor milk banking. To compare the theoretical capacity of Brazil's donor milk banking system to the theoretical capacity in North America, we compared the volume of donor milk collected to the number of preterm births.[25-28] In 2011, Brazil collected 593 mL of donor milk per preterm birth (165 702 L total) compared to 125 mL per preterm birth in North America (64 557 L total). One factor that may be contributing to this difference in volume is varying practices regarding the acceptance of donor milk from mothers who have been lactating for more than 1 year (extended lactation). We contacted all 13 milk banks in the Human Milk Banking Association of North America (HMBANA) network between November 2012 and March 2013 to ask if they accepted donors beyond 1 year and found that 8

of the banks excluded mothers from donating once their baby turned 1 year old. Brazil does not have a similar lactation-duration-based exclusion, and policies and practices vary at milk banks around the world (Table 1).[29-34] Informal observations of social media discussion boards indicate that extended-lactation mothers are interested in donating milk and are frustrated with being turned away from donor milk banks in North America.

Limited research has been done on the compositional changes to human milk during extended lactation, which likely contributes to the variation in milk bank practices around the world, and most research has focused on the nutritional composition and not the immunoprotective compounds. Immunoprotective compounds that have been discovered in human milk include, but are not limited to, secretory immunoglobulin A (sIgA), lysozyme, lactoferrin, human milk oligosaccharides, growth factors, hormones such as prolactin and progesterone, enzymes such as amylase and lipase, cytokines, and fatty acids.[35] Several bioactive compounds are present in significantly higher concentrations in human milk compared to bovine milk-based infant formulas,[36,37] including lysozymes, lactoferrin, sIgA, and human milk oligosaccharides (HMOs) (Table 2). Lysozymes and lactoferrin are antimicrobial proteins that disrupt the cell wall of bacteria[38]; sIgA is an immunoglobulin protein customized to bind pathogens found in the mother's (and thus the baby's) environment[39]; and HMOs are short-chain, indigestible sugars that appear to have several functions in the development of the infant GI tract including pathogen binding, immune system development, and serving as a growth factor for bifidobacteria colonization.[40,41] These bioactive compounds have been shown to have partial or complete retention after Holder pasteurization,[42,43] making them important differentiating factors in the composition of pasteurized donor milk as an alternative to infant formula.

Table 2. Select List of Bioactive Factors in Human Milk as Compared to Bovine Milk and Their Retention after Holder Pasteurization

Bioactive Factor	Role[38-41]	Concentration in Human Milk Compared to Bovine Milk[36,37]	% Reduction after Holder Pasteurization[42,43]
Lysozymes	Antimicrobial protein	3000 times more in human milk	No effect to 24%-60% reduction
Lactoferrin	Antimicrobial protein	75 times more in human milk	57%-80% reduction
Secretory immunoglobulin A	Antibody that protects epithelial tissue from pathogens	5000 times more in human milk	0%-48% reduction
Human milk oligosaccarides	Serve as prebiotic for development of commensal gut microflora; pathogen	Third most abundant ingredient (5-10 g/L) in human milk compared to trace amounts in bovine milk	No effect

It is important to understand how human milk changes during extended lactation in order to create evidence-based recommendations regarding the potential nutritive and immunoprotective value of donor milk beyond 1 year of lactation. This review will summarize existing research on human milk composition beyond 1 year of lactation and will identify areas where additional research is needed.

Method

A PubMed search was conducted using the terms *prolonged lactation, extended lactation, late lactation*, and *second year of lactation*. Only studies that analyzed nutritive and select immunoprotective compounds in human milk based on duration of lactation that extended

beyond 1 year postpartum were included in the review. The immunoprotective factors considered include lactoferrin, lysozyme, sIgA, and HMOs because these are abundant in human milk compared to infant formula and are known to be partially retained during pasteurization. Additional studies were located by reviewing the references of the initial studies. Studies were excluded if the sample size in the second year of lactation was smaller than 5,[44] yielding a total of 12 studies[45-56] that were conducted between 1970 and 2012 (Table 3). Ten of the studies measured nutritive compounds in milk (fats, lipids, carbohydrates, vitamins, and minerals), and 2 studies looked at immunoprotective compounds.

Table 3. Studies of Nutritive and Immunoprotective Compounds in Human Milk beyond 1 Year

Study	Design	Size	Duration	Measurements	General Notes
Underwood et al, 1970[45]	Longitudinal	133	6 weeks to 24 months postpartum	Protein, total fat, and fatty acid profile	Study conducted among poor Pakistani mothers
Lauber & Reinhardt, 1979[46]	Cross-sectional and longitudinal	33	1 month to 23 months postpartum	Protein, total fat, fatty acid profile, lactose, iron (Fe), zinc (Zn), copper (Cu), magnesium (Mg), vitamin C	Study conducted among Ivory Coast mothers on a plant-based diet
Vaughan et al, 1979[47]	Semi-longitudinal	38	Up to 31 months postpartum	Zn, Cu, Fe, calcium (Ca), Mg	Mothers had good nutritional status
Goldman et al, 1983[48]	Cross-sectional	15	12 months to 24 months postpartum	Lactoferrin, lysozyme, secretory immunoglobulin A (sIgA)	No additional information
Dewey et al, 1984[49]	Semi-longitudinal	46	1 month to 20 months postpartum	Protein, total fat, lactose, total energy, Ca, Zn, Fe, Cu, Mg, sodium (Na), potassium (K)	Study conducted among mothers in the United States
Prentice et al, 1984[50]	Semi-longitudinal	152	Up to 26 months postpartum	Lactoferrin, lysozyme, sIgA	Gambian mothers received supplements to increase caloric intake
Karra et al, 1986[51]	Semi-longitudinal	40	7 months to 25 months postpartum	Zn, Ca, vitamin B_6, vitamin C, folate	Study conducted among mothers in United States with financial means for nutritionally adequate diet
Bates & Tsuchiya, 1990[52]	Semi-longitudinal	56	0 to 99 weeks postpartum	Zn	Gambian mothers received iron and riboflavin supplements
Laskey et al, 1990[53]	Cross-sectional	216	2 weeks to 26 months postpartum	Ca	Gambian mothers had calcium-poor diet; mothers from UK had calcium-rich diet
Mandel et al, 2005[54]	Cross-sectional	61	2 months to 39 months postpartum	Total fat and total energy	No additional information
Shehadeh et al, 2006[55]	Cross-sectional	84	3 months to > 1 year postpartum	Protein, total fat, fatty acid profile, lactose, Ca	No additional information
Lubetzky et al, 2012[56]	Cross-sectional	55	2 months to > 1 year postpartum	Fatty acid profile	No additional information

Results

Nutritive Changes

Protein. Four studies[45,46,49,55] were identified that examined total protein content in human milk beyond 1 year, and the picture that emerges is one of declining protein content during the first 6 months of lactation, followed by stabilization at 1.0 to 1.2 g/dL, and then increased protein content during gradual weaning approaching 2 g/dL. This agrees with other studies that analyzed milk composition and the impact of weaning.[57,58] A cross-sectional study[55] found a 17% decline in total protein content from women lactating over 1 year (1.0 g/dL) compared to women lactating for 3 months (1.2 g/dL). A 2-year longitudinal study of Pakistani women[45] reported similar declines in protein content from 6 weeks to 12 months postpartum, with protein values then increasing at 18 and 24 months postpartum. This late-lactation increase in protein was also associated with weaning in a semi-longitudinal study conducted in the United States of 46 women from 7 months to 20 months postpartum.[49] Under weaning conditions (milk volumes < 300 mL/day), total protein increased to 2.0 g/dL, while in "full lactation" (milk volumes > 500 mL/day), the protein content was stable between 7 and 20 months, at approximately 1.2 g/dL. Finally, a longitudinal study of mothers in rural Ivory Coast found a decline in protein content during the first 6 months of lactation and then concentrations stabilized at approximately 1.0 g/dL.[46] Garza et al looked at weaning effects in mothers who weaned prior to 1 year postpartum and observed similar elevations in protein content, suggesting that the protein content during weaning was similar to the protein content from the milk of women delivering preterm infants.[57]

Total fat. Evaluating fat composition is historically difficult, given that the fat content of human milk changes both within a feeding cycle and diurnally.[59] Five studies[45,46,49,54,56] examined total fat content in human milk beyond the first year of lactation with equivocal results. One cross-sectional study involving 61 mothers showed that the percentage fat content was significantly higher in women lactating for longer than 1 year (10.65% ± 5.07%) compared to those lactating between 2 and 6 months (7.36% ± 2.65%),[54] while another cross-sectional study involving 84 mothers showed no change in total fat between the milk of mothers nursing longer than 1 year (3.7 ± 1.9 g/dL) and those exclusively breastfeeding for 3 months (3.6 ± 1.6 g/dL).[55] A longitudinal study conducted in the Ivory Coast through 23 months postpartum showed no change in total fat content in nonweaning mothers,[46] while another longitudinal study conducted in Pakistan[45] showed a trend toward increased lipid concentrations, with approximately 60% or more of the samples having a fat content greater than 3.3 g/dL after 18 months, compared to approximately 30% of the samples exceeding 3.3 g/dL at 6 months. This study also showed significant inter-individual variations in fat content. A semi-longitudinal study of 46 women in the United States concluded that fat content did not change between 4 and 20 months postpartum, though the study data actually showed a trend toward increased fat content in mothers producing greater than 500 mL of milk per day (3.45 g/dL + 1.53 at 7 to 11 months, compared to 4.84 g/dL + 1.19 at 12 to 20 months).[49] Some of the observed study differences may be associated with differences in sample collection protocols.[60] For example, some studies provided very specific instructions for sample collection (eg, collect from 1 breast 3 minutes after the start of lactation until the breast is completely emptied), while other studies provided more general instructions (eg, collect milk mid-lactation). No consistent observations have been made regarding whether there is a weaning effect on total fat concentrations.[49,57,58] There is evidence based on 4 studies[45,46,55,56] that the fatty acid profile of milk changes during the second year of lactation. One study measured a small but significant decline in long-chain fatty acids,[55] and 3 studies showed a shift toward an increase in 14-carbon myristic acid.[45,46,56] A possible explanation for this shift is that medium-chain fatty acids are synthesized by the

mammary gland, while long-chain fatty acids come from dietary sources and may be reduced as mothers lose weight.

Lactose. The lactose content of human milk during extended lactation was analyzed in 2 studies[46,49] and no significant changes were observed, with lactose concentrations remaining steady at approximately 7 g/dL. A third study reported total carbohydrate content in human milk and also found that this remained stable in the second year of lactation.[55] Decreases in lactose content associated with gradual weaning have been observed when milk volumes fell below 300 to 400 mL/day.[49,58]

Zinc. It is well documented that zinc is an important mineral associated with growth and development in children.[61] A review of research done on zinc composition during the first year of lactation concluded that milk concentrations vary between individuals and fall sharply in the first weeks of lactation, followed by a more gradual decline throughout the first year.[62] Four semi-longitudinal studies[47,49,51,52] into the second year of lactation describe a similar, time-dependent decline in zinc concentrations, with steep declines ranging from 35% to 50% between 1 month and 6 months postpartum, followed by more gradual declines thereafter. Zinc concentrations in the second year were observed to be 56% to 71% lower than concentrations in the first month of lactation.[46,47,52] A small cross-sectional analysis involving 33 women from the Ivory Coast suggested that zinc concentrations were similar at 12 months and 18 months postpartum.[46] Weaknesses of this study include the small sample size and the cross-sectional design that could mask the effects of inter-individual differences. A weaning effect was observed in 2 extended lactation studies where zinc concentrations fell with a decline in total daily milk volume[49] and total number of feedings.[51] Similar weaning effects on zinc concentration have been reported in another study where weaning occurred before 1 year postpartum.[57]

Calcium. A review of research regarding calcium in human milk shows significant variation by geography, with few variables, besides adolescent motherhood and medical conditions, consistently impacting these variations.[63] Five studies[47,49,51,53,55] done in the second year of lactation reported a decline in calcium concentrations compared to levels during earlier lactation. A cross-sectional study of Gambian mothers showed a decline in calcium concentration, stabilizing at 9 to 12 months postpartum, while in British mothers, where diets were higher in calcium and breast milk concentrations were higher to start with, calcium levels continued to fall into the second year, with both groups reaching approximately 175 mg/L at 25 months.[53] Another cross-sectional study of 84 women found that the calcium concentration of milk in the second year of lactation was 27% lower than concentrations at 3 months postpartum.[55] A semi-longitudinal study of 38 women reported a 23% decline in the first 18 months,[47] while another semi-longitudinal study of 40 mothers from the United States described a 24% decline between month 7 and month 22.[51] A semi-longitudinal study of 46 Gambian mothers described calcium concentrations as unchanged, but their data conflicted with this assessment, showing trends toward lower mean calcium levels in milk samples collected 12 to 20 months postpartum (209 ± 36 mg/L) compared to those collected 4 to 6 months postpartum (248 ± 37 mg/L), with a significant decrease associated with weaning (160 ± 37 mg/L), when milk volumes fell below 300 mL/day.[49] Other studies that initiated weaning before 1 year postpartum suggest that calcium concentration is not affected by weaning.[57,58]

Iron and copper. Iron and copper were analyzed in 3 extended lactation studies[46,47,49] and showed similar patterns of change. Two studies described iron and copper levels declining during the first few months of lactation, with concentrations then stabilizing through 20 or more months postpartum.[46,47] Observed iron concentration declines ranged from 20% to 25%, while copper concentration declines were reported as 35% to 70%. A semi-longitudinal study of 46 Gambian women reported stable copper concentrations between 7 and 20 months, but iron concentrations showed a significant increase in the second year of lactation compared to levels at 4 to 6 months.[49] This rise in iron concentrations in the second year may be explained by a weaning effect, which was observed in 2 studies.[49,57] There were no reported effects of weaning on copper concentrations.

Immunoprotective Changes

Immunoproteins. Only 2 studies[48,50] examined the change in lactoferrin, lysozyme, and sIgA in the second year of lactation, indicating that this is an important area for future research. A semi-longitudinal study of 152 Gambian women found that lactoferrin and sIgA levels declined approximately 25% in the first months postpartum and then remained stable up to 26 months.[50] Lysozyme levels in this study rose substantially over the course of lactation, with a 220% increase at 15 to 18 months compared to concentrations at 0 to 3 months. Similarly, a cross-sectional study of 15 mothers showed that the concentration of sIgA, lactoferrin, and lysozyme remained stable between 12 and 24 months postpartum.[48] While immunoprotein levels during the first year of lactation were not reported in this study, an earlier study by the same authors reported a significant increase in lysozyme levels at 6 months compared to early lactation levels.[64] The effects of weaning on these proteins were reported in a small study where weaning began before 1 year postpartum. Concentrations remained stable, or even rose in some subjects, with the sIgA antibody titers to *Escherichia coli* increasing 4-fold.[65]

Human milk oligosaccharides. No studies were found that looked at HMO concentrations during the second year of lactation. Given the growing evidence of the important immunoprotective and trophic roles that HMOs play in the developing neonate, this is an important area for future research. A longitudinal study that looked at HMO changes from week 1 to week 49 postpartum showed that concentrations decreased by more than half, while the profile changed, with a decrease in 2'-fucosyllactose and an increase in 3'-fucosyllactose.[66] This study also showed that there were large inter-individual variations in oligosaccharide quantities and profiles. As HMOs are the third most abundant ingredient in human milk and present only in trace amounts in bovine-based formula, this represents an important area for future research.

Discussion

Human milk is a dynamic fluid that changes significantly in its composition at the onset of lactation and then again during the late-weaning phase, when volumes drop below 300 to 400 mL/day and the mammary gland goes through changes in secretory function.[51] Understanding the changes in human milk composition throughout the duration of lactation is important for defining appropriate policies for donor milk banking. This review exposes a need for research related to the compositional changes in human milk at 1 year of lactation and beyond. Allowing mothers to donate milk beyond 1 year postpartum could increase the amount of milk available

for fragile infants. However, while preterm and VLBW infants are the main recipients, donor milk is prophylactic against diseases for term infants and older children[18] as well as adults.[67] If it is shown that milk from mothers who are greater than 1 year postpartum has less nutritive and bioactive factors, milk from extended lactation could potentially be used for recipients other than preterm and VLBW infants if the milk banks have the resources to do so. It is also important to consider the immunoprotective capacity of donor milk beyond 1 year compared to the immunoprotective capacity of infant formula—the alternative when freezers are empty at donor milk banks—when making decisions about the value of accepting donations into the second year of lactation.

Limitations of this review include the fact that 5 of the 12 studies were conducted in rural communities where suboptimal maternal nutrition may have had an effect on results; there was a wide variety of milk collection protocols that may have influenced the composition of the samples analyzed; and the sample sizes of the studies were relatively small, which reflects the limited population of women who continued to breastfeed into the second year of their child's life. Additionally, because of the inter-individual variations in human milk that have been described,[44,47,68] studies that used cross-sectional designs may mask time-dependent trends in the population. Finally, the majority of studies were conducted 20 to 40 years ago, and more refined analytical techniques may lead to different conclusions today.

The body of existing research regarding human milk composition in the second year of lactation describes stable concentrations of several nutritive and immunoprotective components including protein, lactose, iron, copper, lactoferrin, and sIgA while milk volumes remain above 300 to 400 mL/day. Concentrations of the antimicrobial protein lysozyme appear to increase into the second year of lactation. There is conclusive evidence that zinc and calcium levels continue to decline in the second year of lactation, with zinc levels showing the sharpest decline from early lactation levels. It has been proposed that zinc is actively transported in milk bound to a specific ligand, which is likely to be the milk proteins.[69] As the mammary gland goes through involution during the weaning process, the mechanism of zinc secretion into human milk by binding to a ligand may decrease and zinc may increasingly be secreted into milk through the paracellular pathway.[51] Calcium may decrease during extended lactation due to the increase in casein levels in milk during weaning, which may bind more calcium and decrease the more bioavailable ionized calcium.[51]

While calcium and zinc concentrations decline in the second year of lactation, these minerals are more bioavailable in human milk than in bovine milk-based infant formulas. Calcium has a tendency to bind to casein, and because bovine milk is predominately casein, a substantial amount of the calcium is bound and less available for absorption.[70] Human milk contains less casein and more whey proteins, leaving more calcium available for absorption in the ionized form.[71] Zinc is more bioavailable in human milk than in bovine milk-based infant formulas because in human milk it is bound to the highly digestible proteins that may facilitate absorption.[69]

The immunoprotective compounds reviewed in this study are unique features in human milk that contribute to its superior nature over bovine-based infant formulas. Immunoprotective features are especially critical for the preterm infant with an immature GI tract and immune system.

Evidence of stable or rising immunoprotein levels during extended lactation provides an argument for allowing nonweaning mothers to donate milk during the second year postpartum. The components that appear to decline in the second year of lactation are minerals that can be added as supplements to an infant diet, while the immunoprotective compounds in human milk cannot be replicated.

As new pasteurization techniques are discovered that preserve a greater percentage of the bioactive compounds in human milk, this will further differentiate the quality of donor human milk over bovine-based infant formula. New tools to study the proteome of human milk will also shape future discoveries in human milk by providing a deeper look into milk composition. For example, a proteome study out of the Netherlands showed that of the 268 proteins identified in human milk, 121 of these proteins (45%) were not found in bovine milk.[36]

Recommendations

Conflicting findings exist regarding the fat concentration of human milk; therefore, more research is needed in this area, with special considerations to collection protocols, given the varying nature of fat composition in human milk. Future research should also differentiate between weaning and nonweaning conditions, as many compounds in human milk are known to be impacted by the weaning process. Additional research into immunoprotein levels during extended lactation is warranted to validate the findings of the limited number of existing studies. More research is needed on HMOs, as there is currently no information on HMO concentrations and profiles during the second year of lactation. Other areas of future research should include examining whether infants would benefit from consuming milk donated later than 1 year postpartum rather than bovine-based infant formula due to the higher bioavailability of the minerals in human milk, despite the decline in mineral concentrations. Research into the composition of donor milk in Brazil, where there are no lactation-duration-based exclusions, would also provide insight into how extended-lactation donors potentially impact the quality of the donor milk supplied by their milk bank network.

In 2011, *The Surgeon General's Call to Action to Support Breastfeeding* was released by the US Department of Health and Human Services.[72] The *Call to Action* describes ways in which people can participate in supporting the breastfeeding relationship between each mother and baby dyad. Action point 12 is to "identify and address obstacles to greater availability of safe banked donor milk for fragile infants." Allowing mothers to donate milk beyond 1 year postpartum could increase the supply of donor milk in the United States and other countries where lactation-duration-based exclusions are practiced, allowing greater access to donor milk for fragile infants. More research is needed to determine if this is a nutritionally safe and feasible option for increasing access to donor milk.

Declaration of Conflicting Interests

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