Donor Human Milk Banking and the Emergence of Milk Sharing

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KEYWORDS

• Donor human milk banking • Premature infant • Necrotizing enterocolitis
• Risk management • Milk sharing

KEY POINTS

- Provide evidence for the safety and efficacy of feeding donor human milk to premature babies.
- Review current milk banking practices in North America.
- Review the effects of long-term storage, handling, and heat treatment methods on various components of donor human milk.
- Describe risk management and quality control methods in donor human milk banking.

INTRODUCTION

Today in North America, there are 13 donor milk banks that make up the Human Milk Banking Association of North America (HMBANA). These banks are located in San Jose, CA; Denver, CO; Indianapolis, IN; Coralville, IA; Kalamazoo, MI; Raleigh, NC; Columbus, OH; Austin, TX; Fort Worth, TX; Kansas City, MO; Newtonville, MA; Calgary, Alberta; and Vancouver, BC, Canada (https://www.hmbana.org). Four more milk banks scattered throughout North America are currently in development and scheduled to open in 2013. These banks are not-for-profit entities. In 2006, Prolacta Bioscience, Inc (Monrovia, CA, USA), was founded as a for-profit entity to provide a commercial alternative to human milk banking, specifically, formulations of human

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milk designed for premature and critically ill infants (http://www.prolacta.com). Donor human milk is now being provided to patients throughout North America from both sources. Since the 1990s, with evidence of safety and increased amount of research on the clinical benefits of feeding donor human milk, milk banking has proliferated globally. Milk banking now exists in many countries, including Australia, Brazil, France, Germany, Italy, Switzerland, Norway, Finland, United Kingdom, Bulgaria, Slovakia, and South Africa.

In the United States, HMBANA is responsible for human milk banking practices and procedures, but there is currently no official federal oversight or regulation of milk banking. The original HMBANA guidelines were written in 1985, with input from the Centers for Disease Control (CDC) and the Food and Drug Administration (FDA). All HMBANA milk banks function under the supervision of medical advisory boards. Prolacta Bioscience, Inc, reports following FDA regulations for both food and pharmaceuticals for their milk products. However, the FDA reviewed the practice of milk donor banking in the United States and decided against federal regulation of human milk banking (http://www.fda.gov/AdvisoryCommittees/CommitteesMeetingMaterials/PediatricAdvisoryCommittee/ucm201871.htm). Only a few states (eg, Texas) have regulations and state laws specifying guidelines related to procurement, processing, and distribution of human milk. New York and California have laws requiring milk banks to be licensed with the state before distributing milk, and California regulates milk banks in a manner similar to tissue banks.

In North America, not-for-profit milk banks (HMBANA) are generally community based or hospital based, function independently, and are operated with hospital or grant funding. Each bank charges a processing fee for dispensed donor milk, ranging from $3 to $5 per ounce. The milk banks serve not only hospitalized inpatients but also outpatients. Milk banks typically prioritize hospitals and neonatal intensive care units (NICUs) within their state but reach out to serve other states as well. For example, in the first decade of its existence the Mother's Milk Bank of Austin served 56 hospitals and NICUs throughout Texas, 11 in Florida, 10 in Midwestern states, and 8 in South Atlantic states.

The greatest barrier to the use of donor human milk in NICUs is the lack of consensus among neonatologists regarding the efficacy of donor human milk feedings for all preterm babies. The cost borne by hospitals for purchasing the milk is another significant barrier, as whether or not private and/or Medicaid insurance coverage exists for donor milk varies from state to state. In addition, hospitals continue to express concerns about the availability of donor milk (especially preterm donor milk), the need for small aliquot volumes, the lack of uniform NICU-based milk preparation and fortification protocols, and the additional burden to the hospital, such as the necessity of tracking recipients and documentation of informed consent.

MANAGEMENT OF DONOR MILK BANKS

Within North America, milk banking guidelines and procedures are largely standardized and evidence-based. Donor selection occurs after careful characterization of the potential donor's health history. Donors must be in good health, taking no medications or herbals and nursing an infant less than 1 year old. Lactating women who have extra milk after feeding their own infant or who have experienced perinatal loss donate to milk banks. Donor screening is rigorous and involves verbal and written questionnaires and laboratory serologic blood testing (cost, $150–$300 per donor) for human immunodeficiency virus (HIV)-1, HIV-2, human T-lymphotropic virus (HTLV)-I and II, hepatitis B virus (HBV), hepatitis C virus (HCV), syphilis, and tuberculosis. Donors with positive test results are excluded. Other donor exclusion criteria include

high-risk behaviors for HIV, use of illegal drugs, smoking or use of tobacco products, drinking more than 2 alcoholic drinks per day, a history of organ or tissue transplant, any blood transfusion in the prior 12 months, tattoo or body piercing within the last 12 months, and past travel to UK for more than 3 months or to Europe for more than 5 months, from 1980 to 1996. These are the same donor exclusion criteria used by American Association of Blood Banks (AABB; www.aabb.org). Prolacta Bioscience, Inc, uses some additional techniques for donor screening and quality control, including donor milk drug testing, DNA fingerprinting to ensure that the donor milk belongs to the screened donor, a cold chain delivery system and data logging technology, and polymerase chain reaction (PCR) testing for infectious agents in milk pools both before and after pasteurization.

Donor education for proper collection, storage, and transport of milk is paramount. In North America, donors are given instructions and specific protocols for expressing milk, proper hygiene, handling, and labeling. The milk is stored at −20°C in polyethylene containers and transported on dry ice, and long-term freezing at −20°C occurs at each milk bank. Frozen milk is later defrosted, pooled, and mixed, using universal precautions. Some milk banks conduct prepasteurization bacteriologic screening, which screens for donor technique and possible trends in colonization of pathogens. HMBANA milk banks perform heat processing with the Holder method using a commercial pasteurizer (62.5°C for 30 minutes). Prolacta Bioscience uses the high-temperature, short-time (HTST) pasteurization method (72°C for 16 seconds). All milk banks perform postpasteurization bacteriologic testing, which verifies pasteurization. No milk with any positive culture results after pasteurization is dispensed from HMBANA banks. Pasteurized milk is then chilled and stored for later use and dispensed with a physician's prescription.

FACTORS AFFECTING THE SAFETY OF DONOR MILK

Many factors influence the current safety of donor human milk. These include the nature of donor screening, donor honesty (about unknown medications or herbal exposure), potential infectious agents, milk changes from storage and preservation, milk component changes from heat treatment methods, and quality control of milk banking techniques. Infection risks associated with donor human milk feedings are thought to be negligible. There have been no reported cases of viral transmission or infection from the feeding of pasteurized donor human milk. However, many hospitals and neonatologists prefer to obtain informed consent for the remote possibility of infection and for the possibility of unknown drug or herbal exposure. Others assume donor milk feeding is the standard of care and obtain consent for its use only as part of the general consent for medical treatment.

Concerns remain regarding donor milk, as neonatologists aim to safeguard infants against the potential for exposure to pathogens, such as gram-negative organisms, methicillin-resistant *Staphylococcus aureus*, and group B beta-hemolytic *Streptococcus*. Neonatologists do not uniformly understand that mother's own milk is frequently colonized with bacteria, nor do most know that pasteurized donor milk is dispensed as a sterile product.[1] In fact, prepasteurization bacteriologic screening studies have shown that a wide variety of bacteria are present in donor human milk.[2] However, Holder pasteurization is an effective means to remove any detectable bacteria from donor milk.[2,3] In addition, pasteurized donor milk (without fortifiers or other additives) remains culture-negative for 24 hours after thawing and routine handling in the NICU.[4] The HTST treatment method has also shown to be effective in eradicating pathogenic bacteria within the first 12 seconds of heating.[5]

Physicians commonly express concern about possible viral transmission, especially cytomegalovirus (CMV) and HIV. Hamprecht and colleagues[6] have compared the effects of 2 heat treatment methods (Holder vs HTST, in this study 72°C for only 5 seconds) on CMV infectivity and on milk components. Both heat treatment methods effectively inhibited CMV, as measured by PCR, CMV-RNA assay, and microculture assay for infectivity.[6] Another study also found the HTST process to be highly effective in eradicating HIV and marker viruses for HBV and HCV.[5]

Concerns have been raised about the adverse effects of milk storage and processing on the antiinfective properties of donor milk. Concentrations of immunomodulatory proteins (lysozyme, lactoferrin, lactoperoxidase, and secretory IgA) are reduced 50% to 80% by pasteurization, and to a lesser extent by frozen storage, when compared with fresh milk.[7,8] The levels of other immunoactive cytokines (interferon, tumor necrosis factor, and interleukin) and many important growth factors (granulocyte colony-stimulating factor, hepatocyte growth factor, heparin-binding epidermal-like growth factor, transforming growth factor, and erythropoietin) are significantly reduced by Holder pasteurization.[9,10] In addition, antioxidants are measurably altered by heat treatment.[11] HTST pasteurization, when compared with Holder pasteurization, has been shown to be less harmful in reducing enzymes that mark the immunologic quality of the milk.[6] Studies comparing heat treatment methods (Holder vs HTST) in their alteration of bactericidal and antioxidant capacities of human milk have shown that only short heating methods, 62°C to 72°C for 5 seconds, preserve the concentrations of growth factors in human milk.[12]

RECOMMENDATIONS AND CURRENT CLINICAL USES OF DONOR HUMAN MILK

In 2003, the World Health Organization and United Nations Children's Fund (UNICEF) recommended that for health situations where infants cannot or should not be breastfed, the best alternative to expressed breast milk from an infant's own mother is breast milk from a healthy wet nurse or human milk bank. American Academy of Pediatrics (AAP) policy supports the use of pasteurized donor milk when mother's own milk is not available (**Box 1**).[13] Human milk banks in North America adhere to guidelines for quality control of screening and testing donors and pasteurize all milk before distribution. The AAP, CDC, and FDA do not recommend feeding fresh human milk from unscreened donors because of the risk of transmitting infectious agents.

Box 1
Recently updated AAP policy recommendations (Pediatr 2012;129:e827–41)

1. "The potent benefits of human milk are such that all preterm infants should receive human milk. Mother's own milk, fresh or frozen, should be the primary diet for preterm infants, and it should be fortified appropriately for the infant born weighing less than 1,500 grams."
2. "If mother's own milk is unavailable despite significant lactation support, pasteurized donor milk should be used."
3. "Quality control of pasteurized donor milk is important and should be monitored."

Donor milk is most often used for the nutritional support of very premature infants and infants with malabsorption syndromes and/or severe feeding intolerance. Preventative uses include necrotizing enterocolitis (NEC) and inflammatory bowel disease. In North America, other common clinical therapeutic uses for donor milk include short gut syndrome (post-NEC), infectious diseases (acute gastroenteritis, sepsis, and pneumonia), postsurgical gut healing (omphalocele, gastroschisis, bowel obstruction,

and intestinal fistulas), immunologic diseases (severe allergies and IgA deficiency), chronic renal failure, congenital heart disease, inborn errors of metabolism, and failure to thrive.

CLINICAL STUDIES OF DONOR MILK USE

A recent Cochrane Database systematic review of 8 randomized controlled trials found that feeding very preterm infants (<32 weeks gestation and <1800 g birth weight) formula compared with donor milk resulted in higher rates of growth in the short term. Weight gain, linear growth, and head growth were improved in infants fed formula compared with infants who received donor milk. There was no evidence of an effect on long-term growth rates or on neurodevelopmental outcomes.[14]

Most compelling is the finding of this Cochrane review, as well as 2 other systematic reviews indicating a 4-fold increased risk of NEC in preterm or low birth weight infants fed formula compared with those fed donor human milk (**Table 1**).[15,16] Some of these older studies, however, did not include a large proportion of extremely premature infants, and nutritional protocols did not evaluate human milk fortifiers (HMFs) or contemporary preterm formula.

Studies have not proved conclusively that donor milk feeding reduces infection in preterm babies. Although a large national cohort of extremely low-birth-weight preterm babies found that early feedings with either donor or mother's own milk were associated with decreased rates of late-onset sepsis,[17] a randomized controlled trial found that infants fed donor milk, supplementing their mother's own milk, had similar rates of late-onset sepsis, compared with infants fed preterm formula and mother's own milk,[18] and a systematic review did not find that donor milk reduces sepsis in preterm infants.[19]

There are few recent trials of donor milk in preterm infants. One such trial in extremely preterm infants assigned infants to supplementation of mother's own milk feeding to either donor milk or formula. This study showed no significant difference in the rates of NEC and/or late-onset sepsis, measured together.[18] Further, it showed poor growth in infants who were supplemented with donor human milk compared with the formula-fed babies. However, limitations of this trial, including lack of measurement of the protein content of the donor milk used, were of concern.[20] Later studies have shown better growth in premature infants managed with adjustable, individualized fortification of donor human milk.[21]

The most recent trial of donor milk was a large multicenter randomized controlled trial conducted to examine the occurrence of NEC in extremely preterm infants fed an exclusively human milk–based diet.[22] Study infants were fed predominantly their

Table 1
Risk of necrotizing enterocolitis in preterm or low birth weight infants fed formula milk versus donor breast milk. (Reference # 14)

Study Author, Year	Formula Milk	Donor Breastmilk	Weight	Risk Ratio (95% CI)
Gross,[47] 1983	3/26	1/41	8.1%	4.73 (0.52,43.09)
Tyson et al,[48] 1983	1/44	0/37	5.7%	2.53 (0.11,60.39)
Lucas et al,[49] 1984	4/76	1/83	10.0%	4.37 (0.50,38.23)
Lucas et al,[49] 1984	5/173	2/170	21.0%	2.46 (0.48,12.49)
Schanler et al,[18] 2005	10/88	5/78	55.3%	1.77 (0.63,4.96)
Total	23/407	9/409	100%	2.46 (1.19,5.08)

Data from Quigley MA, Henderson G, Anthony MT, et al. Formula milk versus donor breast milk for feeding preterm or low birth weight infants. Cochrane Database Syst Rev 2007;(4):CD002971.

mother's own milk (70%–80%) and were randomly assigned to supplementation with bovine fortifier or with Prolact+H2MF (Prolacta Bioscience). Two groups received pasteurized donor human milk–based HMF when the enteral intake was approximately 25% (40 mL/kg/d) and approximately 65% (100 mL/kg/d) of full feedings. Both groups received pasteurized donor human milk when mother's milk was unavailable. The third group received bovine milk–based HMF when the enteral intake reached 100 mL/kg/d and preterm formula if no mother's milk was available. A remarkable 50% reduction in the rate of NEC and a 90% reduction in the rate of surgical NEC were seen among babies fed the human milk–based fortifier, donor human milk, and mother's milk. In this trial, rates of late-onset sepsis and bronchopulmonary dysplasia did not differ by study groups.[22]

As hospitals in the United States remain concerned about the cost of donor human milk, especially the high cost of the Prolacta human milk–based fortifier ($6.25/ml), the findings from the trial described earlier were used to determine the adjusted incremental costs of donor human milk, HMF, and preterm formula for extremely low-birth-weight infants.[23] Those fed human milk–based fortifier were found to have lower expected NICU length of stay and costs of hospitalization, resulting in net savings of almost 4 NICU days and $8167 (95% confidence interval, $4405–$11,930) per infant. Compared with feeding mother's milk fortified with bovine milk–based supplements, a completely human milk–based diet that includes mother's milk fortified with donor human milk–based HMF was predicted to result in potential net savings in the total cost of care. This study predicted the economic value of NEC risk reduction, which seems to justify the current cost of human milk–based fortifier.[23]

As a result, many neonatologists now confidently provide donor human milk to preterm babies when mother's own milk is unavailable. Hospitals often use specific criteria as indications for use of donor human milk, for example, all infants under a certain birth weight or gestational age, and for a specified period of hospital stay. Most NICUs routinely practice nutritional and growth monitoring and use individualized nutrient fortification when feeding donor human milk to extremely preterm babies.[24]

However, unless additional studies address concerns about growth and development of preterm babies fed donor human milk, some remain unconvinced of the cost-effectiveness of donor milk feedings for all preterm or extremely preterm infants.[25]

RECIPIENTS OF DONOR MILK

In the United States, most patients who receive donor human milk are very premature infants; however, large volumes of donor milk are consumed also by outpatients. From 1999 to 2010, the Mother's Milk Bank of Austin dispensed donor milk for use by outpatients for certain diseases, including feeding intolerance, failure to thrive, gastroesophageal reflux, postsurgical NEC, other postsurgical bowel abnormalities, congenital malformations, milk protein allergies, and chronic renal failure. These outpatients often received donor milk for 4 to 6 months. In addition, donor milk was distributed to 73 healthy, full-term adopted infants whose parents chose to purchase and feed donor milk. Thus, some have raised questions about the use of donor milk, a scarce commodity, for outpatients, as well as for older infants and children.[26]

THE NUTRITIONAL CONTENT OF DONOR MILK

Neonatologists remain concerned about the lack of standardization of donor milk and its effects on managing the growth of very premature patients and have thus urged HMBANA milk banks to label the macronutrient and mineral content of the donor milk. Several recent publications document that there is considerable variation in

macronutrient content in donor milk (**Table 2**).[27,28] The variability of composition in donor milk is largely due to natural biologic variability, but some concern exists regarding the effects of heat treatment on nutritional composition. Valentine and colleagues[29] showed that pasteurization did not substantially alter the levels of donor milk fatty acids and amino acids, whereas others have reported an effect of pasteurization on milk macronutrient composition.[3,30] Further studies are needed to elucidate which nutritional components of donor milk may be altered by pasteurization.

INTERNET-BASED MILK SHARING

The emergence of donor human milk sharing via the Internet has become problematic. Internet-based and community sharing of donor human milk is now commonplace. In 1990, the first Internet-based milk-sharing network was called "Eats On Feets." At present, this network has chapters in almost every state throughout the United States. The Eats on Feets Web site (http://www.eatsonfeets.org) describes its mission as supporting the safe sharing of breast milk by facilitating (1) informed choice—mothers must understand the options, including risks and benefits, of all infant- and child-feeding methods; (2) donor screening—mothers must question donors about their health and lifestyle and may request blood screening test results; (3) safe handling—mothers are expected to handle their milk with clean hands and equipment and use proper storage methods; (4) home pasteurization—mothers may want to "pasteurize" milk at home, heating the milk using their stovetop to inactivate HIV or by using a single bottle pasteurizer that performs the Holder method of pasteurization.

Other Web sites, such as MilkShare (http://milkshare.birthingforlife.com), offer access to milk donors. Similarly, the Human Milk for Human Babies (HM4HB) global network (http://www.hm4hb.net) has online chapters that facilitate access to human milk and indicate that their purpose is to provide a "commerce-free space where women can share milk in a safe, ethical manner." This approach to donor milk distribution relies solely on the recipients and donors, for whom they list roles and responsibilities. The Web site provides a review of safety issues, recommendations for storage, and some educational videos that describe flash heating, a method of pasteurization that was developed in the context of HIV prevention in Africa and validated for home use by a mother using her own milk.[31] The safety of this process in the context of Internet milk sharing is unknown.

In 2011, the US FDA addressed this issue of Internet-based milk sharing and made recommendations that potential users first consult with a health care provider about using a source other than the baby's mother and consider the possible health and safety risks for the baby from exposure to infectious diseases or chemical contaminants, and advised against feeding infants breast milk acquired directly from

Table 2
Reported donor human milk composition

Macronutrients	Fat (g/dL)	Protein (g/dL)	Lactose (g/dL)	Calories (kcal/dL)
Preterm milk, Australia PREM, $N = 47$	4.16 ± 0.9	1.35 ± 0.3	6.7 ± 0.6	69.7 ± 8.7
Coefficient of variation (%)	21.5	24.5	8.9	—
Term milk, US, Prolacta, $N = 273$	3.22 ± 1.0	1.16 ± 0.25	7.8 ± 0.88	65 ± 11
Ranges	0.71–7.06	0.7–2.1	4.86–12.67	38–110

individuals or through the Internet. The FDA further advised that if parents decide to feed a baby with donor human milk, they should use milk only from a source that has screened its donors and taken other precautions to ensure milk safety. Parents were referred to human milk banks that screen donors, collect, process, handle, test, and store the milk, and to the HMBANA Web site. FDA has not been involved in establishing these voluntary guidelines or state standards.

MILK BANK MANAGEMENT: RESPONSE TO CLINICAL CONCERNS

Protecting Donor Milk Recipients from Risk

The reemergence of informal milk sharing and ongoing concerns expressed by clinicians regarding the safety of donor milk provide an opportunity to reexamine the way that contemporary human milk banks operate, providing an opportunity for milk banks to respond to these issues and consider approaches that may alleviate these concerns to provide greater consistency in the practice and management of milk banking.

Human milk provides multiple levels of protection from infection that are important for the newborn human infant,[32] including secretory immunoglobulin A (sIgA) and, in lower concentrations, IgG and IgM,[33] which protect against infections caused by viruses, bacteria, or parasites.[32] Fatty acids and monoglycerides released from milk fat by the action of lipase[32] have antibacterial, antifungal, and antiviral activities.[32] Glycosylated proteins and oligosaccharides provide specific protection against infectious agents or bacterial toxins. Many other breast milk components act as antiinflammatory agents and immunomodulators,[32] including cytokines, growth factors, hormones, leukocytes, macrophages, neutrophils, and lymphocytes.[33] However, breast milk also commonly contains bacteria, occasionally fungi and viruses, and rarely other infectious agents (eg, prions). There may also be pharmacologically active chemicals (medicines and environmental toxins) that may present a risk to breast milk–fed infants. Apart from significant viruses such as HIV and some medications, these biologic or chemical contaminants are rarely of concern for a mother of a breastfeeding infant. However, a donor milk bank must consider the risk presented to its recipient population by the potential presence of these factors in donated milk. In most circumstances, milk banks screen the donor population in a manner that minimizes the introduction of risk. However, as the milk is expressed, it comes in contact with a pump and storage bottles and is pooled, stored (refrigerated and frozen), thawed, and usually pasteurized before being fed to preterm infants. Each of these steps may introduce new risks to the product and has the potential to alter or destroy components that provide the levels of immunologic protection. Thus, milk banks must define a process that balances both product quality and safety for the intended recipient.

The requirements of HMBANA milk banks have been described here and elsewhere.[34] Published descriptions of international milk banking practices are also available, for example, those from Sweden,[35] Italy,[36] United Kingdom,[37] Norway,[38] and Australia.[27] Brazil has the largest network of breast milk banks in the world; their operations are regulated by city, state, and national agencies and supported by public systems of milk donation, storage, and transportation (http://www.brasil.gov.br/sobre/health/programs-and-campaigns/milk-banks). Many developed countries around the world have established donor milk banks; some dispense raw milk, and others pasteurize the donor milk. The new Human Milk Banking Association of South Africa (http://hmbasa.org.za) provides online resources for milk banks in low resource areas and instructions on a modified version of the flash-heating technique. Most international milk banks routinely pasteurize the milk,[27,35–37] but some provide raw

unpasteurized donor milk,[38] whereas others do both.[35] All the milk banks screen donors for antibodies HIV-1 and HIV-2, HCV, and HBV surface antigen. Some also screen for HTLV-I, HTLV-II,[27,34,35,37,38] and syphilis[27,34,37]; one requires a chest radiograph for active tuberculosis[35]; and those not pasteurizing may screen for CMV.[38]

Thus, the practice of milk banking varies internationally, as does the risk environment with respect to the donor population, for example, the prevalence of infectious diseases. These potential risks may have different significance where the recipient population varies (eg, extremely preterm, late preterm, full-term newborns, or older individuals). Therefore, it is impossible to propose a single model of milk banking that is appropriate in all international settings. It is therefore interesting to consider how milk banks can respond to develop practices that maintain quality and safety in different contexts. It would be beneficial to define a methodology for the ongoing assessment of quality and safety in human milk banking.

Toward Standard Practice in Donor Human Milk Banking

An increasingly common approach by milk banks is to assess the hazards during processing using risk management tools developed by the food industry.[27,36,37] Thus, there has been increasing application of Hazard Analysis Critical Control Point (HACCP) in milk banking, a methodology described in the food industry (www.codexalimentarius.org) and also in the milk banking literature.[27,36,37] HACCP is a system that identifies, evaluates, and controls hazards that are significant for food safety in a systematic manner, defining 5 preliminary steps and 7 principles that must be undertaken.[27,36] HACCP also provides a systematic way to document this approach allowing transparency. This transparency provides a great benefit to human milk banking, which has maintained a long history of safe operation but has failed to communicate how this safety record has been achieved.

An underlying "quality principle" for donor screening is that milk banks must ensure that infectious agents, medicines, and/or chemicals, if present in donor human milk, do not present an unacceptable clinical risk to the intended recipient population. To ensure that this principle is achieved, a milk bank could apply a modified HACCP methodology. Considering the first 3 preliminary steps of a HACCP, a milk bank could assemble a multidisciplinary team, including a milk bank medical director, microbiologist, and a milk bank quality manager who would then identify the product (donor milk), the producer (the donor population), any intended or existing control methods (donor screening, pasteurization), and the intended use (define the clinical acuity of the intended recipient population). Next, the milk bank could undertake a formal risk assessment on the potential risks in donated milk. Considering the first part of our quality principle, milk banks could prepare a list of potential infectious agents, including viruses (enveloped and nonenveloped, known and unknown), bacteria (pathogenic), prions, vaccines (live attenuated virus).

The milk bank HACCP team could then prepare a list of all hazards that may be expected to occur in donated human milk from the point of production to the point of consumption. For example, the viral risks of transmission in donor milk may be summarized as shown in **Table 3**.[5,6,36,39–45] The next step would be to conduct a formal risk assessment using specifically developed consequence and likelihood tables for each identified hazard to quantify (rank) them, identify any that are not appropriately controlled, and document the milk bank's management of these risks. The milk bank HACCP team would be responsible for a consensus decision regarding consequences and likelihood descriptors. The judgment should be made bearing in mind the existing or proposed control measures and their effectiveness. For each hazard, a numerical Consequence Severity Level and the Likelihood Level is applied

Table 3
Potential viral hazards in human milk

Hazard	Identified in Breast Milk	Cause of Illness in Infant	Comment	References
HIV-1 and 2	Yes (HIV1)	Yes	Serologic screening available, Holder and HTST pasteurization inactivate HIV-1	5,39–41
HTLV-I and II	Yes (HTLV-I)	Yes (HTLV-I) Inconclusive (HTLV-II)	Serologic screening available Holder pasteurization inactivates HTLV-I[a]	39,42
Hepatitis B and C	Yes (HBsAg)	Unlikely	Serologic screening available No evidence that Holder pasteurization inactivates HBV or HCV	39,40,43
Cytomegalovirus	Yes	Yes	Serologic screening available Holder and HTST pasteurization inactivate the virus	6,39
Rubella (wild type and vaccine)	Yes (both)	No evidence	—	40,43
Herpes simplex virus	Yes (with active breast lesions)	Unlikely	—	43
Varicella zoster virus (VZV) and vaccine	Yes (VZV DNA) Unknown (vaccine)	Unlikely	—	43
Yellow fever virus and vaccine	Not confirmed	Yes (vaccine)	—	44
Other nonenveloped viruses[b]	Unknown	Unknown	Transmitted by respiratory droplets or fecal–oral route. Could be transmitted by contaminated pump equipment Survive low pH, drying, and thermal disinfection	45
Other enveloped viruses[b]	Unknown	Unknown	Require an intact lipid envelope for infectivity and most are labile in response to acids, detergent, and heat.	45

[a] Experiments not conducted with human milk.
[b] Milk banks may choose to consider generic risks as a way to manage the potential transmission of currently unknown or emergent viral risks—a comparison would be the emergence of HIV in the 1980s, which resulted in the closure of many milk banks.

to provide a Level of Risk, which corresponds to a Risk Score and defines a management response to this risk.

The process described earlier should be undertaken for each identified potential hazard in donor human milk (eg, each viral hazard described in **Table 3**). Any risks rated "unacceptable" should be clearly identified and require additional control measures to ensure patient safety. If this method is applied in conjunction with a traditional HACCP assessment of hazards during the actual processing of product, the milk bank will have a sound and transparent assessment of the potential risks of their product to recipients. This procedure will give clinicians more confidence in the safety of the product, ensure that appropriate precautions have been taken to protect recipients, and give regulators confidence that the milk bank has delivered these outcomes.

Future Developments in Donor Milk Banking

The major process step related to quality and safety of donor milk is clearly thermal pasteurization (Holder or HTST). The negative effect of heat on product quality is unavoidable at temperatures and exposure times required to kill common bacteria, and researchers are examining alternative pasteurization technologies used by the food industry for microbiological control. Most alternative methods either directly or indirectly result in thermal damage of protein. However, short-wave ultraviolet light (UVC), particularly that in the narrow wavelength of 250 to 260 nm, is lethal to most microorganisms, including bacteria, viruses, protozoa, mycelial fungi, and yeasts, at ambient temperatures.[46] The UVC damage directly alters microbial DNA such that the microorganism can no longer reproduce and the risk of disease is eliminated.[46] A barrier to its use in human milk is the lack of penetration through opaque fluids; however, research is ongoing to examine the use of turbulent flows to combat this issue.[46]

If and when future research demonstrates that an alternate method of processing is effective at bacterial and viral inactivation and that there are no detrimental effects of the method itself, there will be a challenge to milk banks to introduce an alternative to the established thermal processing methods. The previously described risk assessment methodology can be applied to any new technology. A milk bank will have a thorough risk assessment of its current processing method and a quantitative score for this process. Should a similar risk assessment with the alternative technology in place be conducted and it resulted in an equivalent or lower level of risk score (using the modified HACCP approach), it should be reasonable for the milk bank to introduce this new technology. The formalization of this process ensures transparency in this decision for the recipients of donor milk and the clinicians ordering the milk.

SUMMARY

This response to clinical perspectives and concerns in donor milk banking has focused on examining the potential for standardization of management practices. In taking this risk assessment approach, it is relevant to consider the risk of not providing donor human milk when a mother's own milk is not available. Where the potential risks of donor milk banking are well managed, the risk of formula feeding is quantifiably greater than that of donor milk feeding. The potential to further increase product quality with the introduction of new technology may provide an even greater benefit to recipients where mother's own milk is unavailable. This response should also illustrate the significant difference between donor milk banking and informal milk sharing. Individuals engaging in informal milk sharing must understand and accept the potential risks involved with this process. However, where a donor milk bank operates, it is the responsibility of the bank to appropriately manage these issues for their recipient population.

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