

Supporting mothers, protecting babies for long-term health: establishing a pasteurised human milk bank

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ABSTRACT

It is now very clear that early feeding practices have lifelong implications for an individual's health as well as economic and public health consequences. This article summarises some of the important reasons to prioritise breast milk feeding and introduces the Christchurch Neonatal Intensive Care Human Milk Bank. This Milk Bank was opened in 2014 to support babies and their families with the provision of pasteurised donor milk. The primary goals were to support mothers while they established their own milk supply, reduce exposure to parenteral nutrition and formula and reduce the risk of necrotising enterocolitis in this vulnerable population.

The importance of infant feeding practices to an adult's long-term health are of relevance to all health professionals, not just those involved with the care of the newborn infant and young child.¹⁻³ This article will briefly examine the evidence for the use of human milk, including pasteurised donor milk (PDM), before discussing the establishment of the first New Zealand Pasteurised Human Milk Bank at Christchurch Neonatal Unit.

Feeding the newborn

International and local recommendations

International recommendations are that breastfeeding and human milk should be considered the normative standards for infant feeding.⁴ In New Zealand, the Ministry of Health upholds the position of the American Academy of Nutrition and Dietetics which is that mothers exclusively breastfeed their infants for the first six months of life to achieve optimal growth,

development and health.⁵ Despite this, the prevalence of breastfeeding or feeding with human milk has decreased in many societies, which includes New Zealand.⁶ The Plunket Annual Breastfeeding statistics of 2017 suggest that 52% of babies were exclusively breastfed at six weeks, 48% at three months and 21% at six months.⁷ This has been influenced by a myriad of societal and maternal factors, including the availability of maternity leave, financial stability, psychosocial belief systems (such as the sexualisation of breasts), family expectations and the availability of support systems (both within the family and local community).^{8,9} An additional influencing factor is that of increasing maternal morbidities, such as obesity and diabetes, affecting the physiology of milk production.¹⁰ The term 'breast is best' had been used to try and reverse this trend and encourage breastfeeding but this terminology may have discouraged some families, and 'normal' is now considered a more appropriate terminology.^{11,12}

Species-specific milk

Human milk provides immunological protection for the vulnerable newborn infant (containing immunoglobulins, lactoferrin and human milk oligosaccharides (HMOs) which act as probiotics) as well as species-specific nutrition that has not yet been matched by breast milk substitutes.⁴ This should be considered a public health issue that has significant economic repercussions.^{6,13} It is hoped that the availability of pasteurised donor milk (PDM) may have a part to play in enabling this.

Colostrum/first milk

Where possible, an infant should be given their own mother's first milk, known as colostrum, prior to being fed with other milk, including PDM. It is likely that exposure to colostrum facilitates the adaptive processes of the gastrointestinal system following birth, and this may have benefits that are independent of whether the infant will be ultimately breast or formula fed.¹⁴⁻¹⁶

Short and long-term benefits

The short and long-term benefits of breast milk for both term and preterm infants have been extensively summarised.¹⁷⁻¹⁹ Examples of these benefits include:

- An optimal nutritional diet that is metabolised efficiently with faster gut transition and improved stool frequency.^{20,21}
- Provision of passive immunity mediated by immune factors such as lactoferrin and maternal IgA.²²
- As a prebiotic in establishing a healthy gastrointestinal microbiome.^{22,23}
- Reduction in the risk of necrotising enterocolitis (NEC).^{14,19,24}
 - This is a specific complication seen in the preterm infant (increased incidence with increased prematurity) which has a significant mortality as well as morbidity.
- Reduction in the risk of Crohn's disease and ulcerative colitis.²⁵
- Reduction in the risk of obesity and diabetes.^{26,27}
- Possible reduction in asthma.^{28,29}

The health benefits of breast milk appear to be dose dependent and it is important to

positively reinforce the benefits of breastfeeding or feeding with breast milk even when exclusive breastfeeding will not be possible.^{24,27,30} A potential limitation of an exclusively breast milk diet in preterm babies is that breast milk may not contain adequate protein, mineral and vitamins to provide optimal nutrition in this vulnerable group. This may require fortification, although the exact criteria for supplementation continues to be debated and there are no clear international guidelines for neonatal intensive care units (NICUs).^{19,21,31} Additional benefits of breastfeeding or bottle feeding with expressed breast milk for a family with a newborn infant include reduced cost and improved accessibility.

Donor human milk

Throughout history there has been sharing of breast milk (unpasteurised or raw) between mothers and this continues, both in local communities and now more widely, facilitated by social media.³² In considering the sharing of unpasteurised milk, the aim is that this practice should be conducted in a way that mitigates unrecognised harm to vulnerable newborn infants.³³ This requires at least some knowledge of both the risk of transmission of viral and bacterial infections^{34,35} and medications through breast milk.³⁶ There are few absolute contraindications to breastfeeding your own child while on medications, and the benefits of feeding with human milk must be balanced against the effects of the medication.^{33,37} The exposure of a more vulnerable infant who is preterm or unwell may require a higher standard of medication surveillance.

Unpasteurised donor milk

In the 1980s, human immunodeficiency virus (HIV) received a lot of publicity and was one of the reasons that milk banks globally went out of favour. It is now known that the HIV virus is rapidly denatured with pasteurisation.^{38,39} There is a low prevalence of HIV in New Zealand, but it is increasing and despite antenatal testing it remains possible that a mother may have asymptomatic HIV, which could be transferred through the sharing of unpasteurised breast milk. The risk of HIV transmission from a mother to her own baby is significantly reduced with maternal and infant retroviral treatment.^{40,41} One of the other concerns in

developed countries is the risk of cytomegalovirus (CMV) infection, and CMV exposure is especially of concern in the preterm population.^{42,43} Women are unlikely to recognise whether they have CMV without specific testing. There are also other less well-known viral infections, such as human T-cell leukaemia virus (HTLV), which have been implicated in the long-term risk of cancer (HTLV).⁴⁴ The collection, storage and transportation of unpasteurised donor milk all increase the risk of microbiological (bacterial) contamination, but bacteriological contamination is also known to be a risk with formula milk, for similar reasons.³³

Pasteurised donor milk

The aim of pasteurising donated milk is to denature possible viral and bacterial pathogens. A recognised standard is that women who donate breast milk complete a health questionnaire and are screened for infections such as hepatitis, HIV and HTLV prior to being accepted as potential donors.⁴⁵ The freezing and standard pasteurising process (Holder technique) does partially destroy some of the beneficial properties but has little effect on oligosaccharides (HMOs).⁴⁶ Alternative methods of pasteurisation are also being studied.^{47,48} Human milk banks have been established to recruit and screen donors as above, collect milk, pasteurise and perform further bacteriological screens before storing and packaging the milk for distribution.

The medical evidence for using pasteurised donated milk (PDM) instead of formula is accumulating.^{15,49} Donated human milk is increasingly cited as preferential to infant formula in promoting the health of the newborn, particularly the preterm newborn admitted to the neonatal unit.^{14,50,51} PDM may not be nutritionally individualised for the baby in the way that a mother's own milk is, and may require supplementation, but the immune protection it provides is still significant.^{15,52,53}

The other consideration is that of an informed choice for the family. It is hoped that the availability of pasteurised donated breast milk, as an alternative to formula, may further encourage staff and families to persist with breastfeeding where a lactation consultant assessment has verified that at least partial breastfeeding is possible with support.

Formula

It is not the intent of this article to discuss formula in detail but it must be recognised that there are risks which are especially significant in preterm infants.^{54,55} Formula milk is currently not constructed of the quantity, quality and type of nutrients (carbohydrate, protein, fat, minerals and vitamins) or the immune factors that the newborn requires for optimal short-term and long-term health. Follow-up studies of ex-preterm babies have also shown an abnormal pattern of fat deposition compared to term controls.⁵⁶ While these results have not been proven to relate to early nutrition, the contributing factors continue to be investigated.

It must also be remembered that formula requires the multiple steps of preparation in a factory and reconstitution under clean conditions in the home and there have been a variety of bacterial infection outbreaks worldwide.^{33,57} The significant economic advantages of breastfeeding rather than feeding with formula have also been well studied.^{2,3,58,59}

Neonatal unit context

Preterm admissions

Preterm is the term used to describe deliveries before 37 completed weeks of gestation, and preterm deliveries make up 7.4% of births in New Zealand. The nutritional management of the different categories of a preterm infant can be summarised below:

- Extreme preterm (<28 completed weeks): total parenteral nutrition (TPN) usually with central line access and slow grading up with breast milk until TPN can be ceased.
- Very preterm (28–32 completed weeks): as above.
- Moderately preterm (32–34 completed weeks): in the moderately preterm infant, the balance of risks between using TPN or formula must be carefully considered.
- Later preterm (34–37 completed weeks): this most commonly involves supplementing the mother's breast milk with formula.

In each of these cases, nutritional supplementation is important to ensure optimal nutrition for the preterm infant during the

first few days and weeks. During this time, a mother needs to establish a regular routine of expressing her breast milk using a milk pump to mimic the feeding pattern of a preterm infant and the supply of a baby at term. The goal is to develop her supply so that it becomes sufficient for her new baby by 7–10 days.

Term babies admitted to neonatal intensive care unit (NICU)

Although preterm babies are responsible for most admissions to NICUs, term babies are also commonly admitted with a variety of morbidities which include:

- Breathing difficulties (secondary to transition to ex utero life, infection and meconium aspiration).
- Low sugar levels (most commonly secondary to maternal diabetes or in small babies with poor reserves).
- Infections (eg, Group B Streptococcal infection).
- Congenital abnormalities which include chromosomal disorders such as Trisomy 21, congenital heart defects and gastrointestinal surgical abnormalities (eg, gastroschisis).
- Birth asphyxia and/or seizures.

Most families are unaware that it is not unusual for a term infant to spend some time in a NICU or special care baby unit (mean admission rate approximately 10%, although there is wide variation between units).^{60,61} The emotional load of this situation may influence maternal milk supply and the infant's nutritional needs are also likely to be more than those required by a well term baby, further exacerbating the fragile relationship between an infant's needs and a mother's breast milk supply.

Breast milk production in our NICU mothers

The production of breast milk is regulated by maternal hormones which are influenced by the frequency and effectiveness of the newborn's suckling pattern. There are several complications of this 'supply and demand' feature in both the preterm and term infant admitted to NICU:

- The maternal condition that resulted in an early delivery and the complications of pregnancy may contribute to primary milk insufficiency.⁶²

- The infant may have been born by caesarean section and the maternal hormone response to labour and delivery may be delayed due to physiological factors.^{6–65}
- The infant is not effectively suckling to stimulate and maintain milk production until near to discharge or not at all.^{66,67}
- The rise in maternal BMI and deterioration of maternal health is associated with additional challenges in lactation.^{64,68}

The physiological stresses and the physical separation that characterise an admission of the newborn baby to the neonatal unit also have their own impact on the hormonal influences required to stimulate and maintain a milk supply.

A milk bank in Christchurch (New Zealand)

It should now be clear that feeding both preterm and term infants admitted to NICU exclusively with breast milk is a specific challenge. The Christchurch Human Milk Bank Project was established primarily to support mothers who wished to breast feed with a secondary aim to provide the best nutritional start to a vulnerable group of babies at high risk of gastrointestinal complications due to being preterm. The project was supported by NICU nursing and medical leadership as well as colleagues and families on the NICU who were engaged in the milk bank's development. One of the reasons for the project's success, both in the development of the NICU service and current expansion of the service, was the development of a committed multidisciplinary steering group (2010–2014) which later developed into the Milk Bank Executive (2014–current). This multidisciplinary group not only supported an experienced neonatal nurse, recruited as the Milk Bank Manager, but led the consultation processes with questionnaires and audits, a literature review, detailed mapping processes and economic calculations to ensure that the business case was robust.

Prior to the establishment of the human milk bank, an audit of the use of formula milk was conducted on the Christchurch Neonatal Unit. The audit concluded that an average of four litres of formula each

day was required to support the feeding of NICU admissions and that the late preterm population (not requiring intravenous cannulation) were the main consumers. This population were therefore likely to be the largest group of consumers of PDM and the mothers of this preterm population would need time and support to establish their own milk supply, which was estimated at one week, during which time PDM should be available. This has been borne out by data collected following the opening of the Milk Bank. This data is shown in the figure below (Figure 1) and confirms that the moderately and late preterm (32 to 36+6 weeks) as well as term (>37 weeks) populations tend to require PDM support for seven days, validating the hypothesis that their own mother's supply would become sufficient by seven days. One of the conditions of supplying PDM to these populations is that the human milk bank supplies are sufficient to guarantee a supply of PDM to each family consented for PDM for one week. Although the numbers of extreme and very preterm infants (<32 weeks) are small, it can also be seen in Figure 1 that these infants may require support with PDM for longer. The milk bank aims to provide PDM until *at least 34 weeks* corrected in this population. This aligns with the vision that ranks donated human milk (fresh or pasteurised) as the

next best feeding option when mother's own milk is not available or unable to be supplied in quantities supporting optimal infant nutrition.

The financial cost of establishing the human milk bank has not been insignificant. This consisted of the capital costs associated with the purchasing of equipment and room alteration and the operational staffing costs. The capital costs were met predominantly by the Canterbury Neonatal Unit Trust Fund (CNUF) and Canterbury District Health Board (CDHB) supported the staffing costs. The business case proposed that savings would occur in the use of total parenteral nutrition and that the prevention of only one case of NEC per year in the preterm population would also be of economic value. A recent audit comparing nutritional parameters of moderately and late preterm infants born in 2013 to matched infants born in 2016 or 2017 showed a trend towards a reduction in TPN usage in these populations from eight infants (11%) in the 2013 cohort to three infants (4%) in the 2016/17 cohort following the opening of the milk bank.⁶⁹ The number of preterm infants diagnosed with NEC in Christchurch is small, making it difficult to prove any relationship with the opening of the milk bank but the fact that PDM is protective has been confirmed by others.⁷⁻⁷²

Figure 1: This figure shows the average number of days of pasteurised donated milk (PDM) use per infant of a specific gestation in each year between 2014–2017. PDM is ceased once the mother's own expressed breast milk (EBM) meets her own infant's requirements.

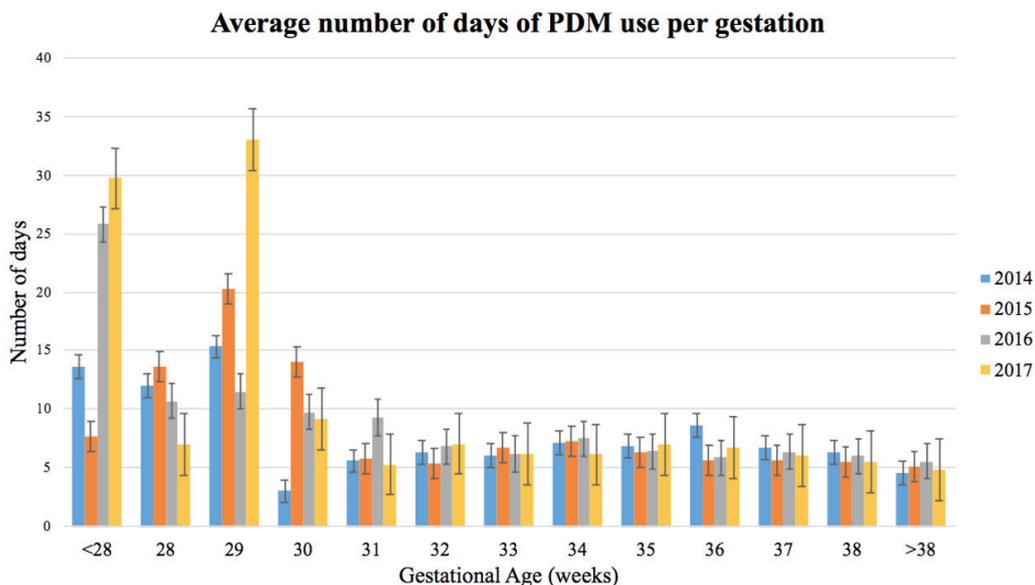


Table 1: The number of milk bank donors and newborn pasteurised donated milk (PDM) recipients together with the amount of donor milk pasteurised and dispensed.

	2014	2015	2016	2017
Donors	63	57	73	81
Recipients	154	258	234	365
Amount milk pasteurised in L	308	398	448	580
Amount of PDM dispensed in L	251	379	386	549

A culture of PDM

The milk bank is now fully embedded within the NICU culture with the number of milk bank donors and PDM recipients continuing to increase (Table 1) such that it has recently expanded to provide PDM to high-risk babies within maternity wards.

Conclusion

Although the human milk bank has become successfully embedded within NICU culture, a considerable amount of work continues behind the scenes to ensure that the original aims continue to be met and these are summarised below:

1. Practically support mothers wishing to breastfeed by providing an alternative to formula milk in the first week after birth when their breast milk supply is developing.

2. Positively role model the value that the neonatal unit places on breast milk and reinforce feeding with breast milk as the 'norm'.
3. Reduce the use of TPN and formula milk.
4. Reduce the risk of neonatal complication such as necrotising enterocolitis.
5. Contribute to a reduction in the long-term financial cost associated with poor nutritional health.

Evaluating the long-term financial cost will require evidence that the milk bank has helped support women to maintain breast-feeding or feeding with breast milk. This work is ongoing and if this is the case, the economic benefits to the DHB can be calculated based on established mathematical modelling techniques.

Competing interests:

Nil.

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