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Research Article

NICU preterm mothers can become the main population of human milk donors-report from a newly established human milk bank in China

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Article Info

Received: June 02, 2026
Accepted: June 19, 2026
Published: June 22, 2026

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Citation: Zhang X, Honga F, Wanga Y.. (2026) "NICU preterm mothers can become the main population of human milk donors-report from a newly established human milk bank in China'', Pediatrics and Child Health Issues. 6(1); DOI: 10.61148/2836-2802/JPCHI /075.

Abstract

Background After mother's own milk (MOM), donor human milk (DHM) is the optimal nutritional choice for preterm infants. To meet this clinical demand, the Xiamen Humanity Human Milk Bank (XMHHMB) was established in October 2018 and maintained continuous operation throughout the COVID-19 pandemic. This study sought to investigate the characteristics of human milk donors and elucidate the operational advantages of XMHHMB, aiming to provide valuable insights for the development and management of Human Milk Banks (HMBs).

Materials and Methods We retrospectively analyzed the demographic and clinical characteristics of human milk donors of the XMHHMB, affiliated with Xiamen Humanity Women and Children's Hospital (XMHWCH) between October 2018 and July 2023.

Results A total of 231 donors were enrolled in this study. The donors were aged between 17 and 43 years, with an average of 29.83±4.05 years. Among the donors, 60.61% (140/231) were primiparous, while 63.20% (146/231) delivered via cesarean section (C-section). The vast majority of donors (99.13%, 229/231) held a bachelor's degree or higher. Furthermore, approximately three-quarters (177/231, 76.62%) of the donors gave birth at XMHWCH, contributing 75.6% (836210/1105730 mL) of the total volume of collected milk. More than half of the donors (127/231, 54.98%) had infants admitted to the neonatal intensive care unit (NICU) of XMHWCH. These NICU mothers contributed 60.8% (672070/1105730 mL) of the total donated milk volume. Regarding gestational age and donation volume, mothers of premature infants delivered at <32 gestational week donated a significantly higher volume of milk (median: 5000ml [IQR: 3100, 9875mL]) than those in the other groups (32–36 weeks: median 2200ml [IQR: 1000, 4850 mL]; ≥37 weeks: median 3000ml [IQR: 1840, 5650ml]; P <0.05).

Conclusion NICU mothers and mothers of preterm infants can produce abundant breast milk and represent an excellent, highly viable donor pool. However, providing targeted, comprehensive lactation support for NICU preterm mothers is essential to encourage and facilitate their engagement in breast milk donation.

Keywords: Human milk donor, human milk bank, population characteristics, NICU mothers, preterm delivery

Introduction

Breast milk is universally recognized as the ideal nutrition for preterm newborns, whether orally or enterally. When a mother's own milk (MOM) is insufficient or unavailable, pasteurized nor human milk (DHM) from human milk banks (HMBs) is recommended by major international health organizations, including the World Health Organization (WHO), the American Academy of Pediatrics (AAP), and the European Society for Pediatric Gastroenterology Hepatology and Nutrition (ESPGHAN)**Error! Reference source not found.Error! Reference source not found.Error! Reference source not found.**. The utilization of DHM offers numerous clinical advantages, notably reducing neonatal necrotizing enterocolitis (NEC), promoting better feeding tolerance, and mitigating long-term cardiovascular risk factors in adolescence**Error! Reference source not found.Error! Reference source not found.**. A recent Cochrane systemic review further confirmed that, compared with formula feeding, DHM significantly decreases the risk of NEC and improves short-term feeding outcomes in preterm and low-birth-weight infants**Error! Reference source not found.**.

Globally, the establishment of HMBs has expanded rapidly over recent decades. A study from 2020 reported that 572 HMBs were operating across more than 37 countries, providing DHM to approximately 800,000 infants annually**Error! Reference source not found.Error! Reference source not found.**. According to the 2023 WHO global preterm birth report, an estimated 13.4 million infants are born preterm each year worldwide, with China continuing to rank second globally in the absolute number of preterm births **Error! Reference source not found.**. Despite the high clinical demand for DHM, the establishment and sustainable operation of HMBs in China face persistent hurdles. Although approximately 35 human milk banks have been established across mainland China by 2025, most still struggle with limited donor recruitment and unstable operational models**Error! Reference source not found.**. A recent study evaluating Chinese mutual-aid milk banks highlighted that fluctuating donor pools and constrained funding remain the primary bottlenecks restricting overall service capacity**Error! Reference source not found.**.

Current literature has delineated the general sociodemographic profiles of human milk donors, such as age, education, parity, and delivery mode—and has explored factors influencing donation volumes**Error! Reference source not found.Error! Reference source not found.**. However, most existing studies have focused on healthy, term postpartum women as the primary donor pool, while in-depth investigations into mothers of preterm infants hospitalized in the neonatal intensive care unit (NICU) remain scare. Although recent pilot studies suggest that NICU mothers may represent a highly committed and reliable donor, to verify their actual contributions, donation capacities, and key driving factors, demographic, large-sample, long-term observational data are still required**Error! Reference source not found.Error! Reference source not found.Error! Reference source not found.**. Furthermore, integrated HMB-NICU operational models have rarely been documented in China, and their advantages in ensuring donor stability, optimizing cost savings, and enhancing service sustainability have not been fully validated.

The Xiamen Humanity Human Milk Bank (XMHHMB), affiliated with Xiamen Humanity Women and Children's Hospital, was established in October 2018. It stands as the only HMB in Fujian Province to maintain continuous operations over the past five years, sustained by institutional financial support from the hospital. Notably, this milk bank remained fully functional during the challenges of the COVID-19 pandemic. A key feature of our facility is that the NICU is staffed by a full-time, certified lactation consultant who provides specialized, proactive breastfeeding and milk expression support to mothers of hospitalized infants. This infrastructure establishes an integrated HMB–NICU management model.

Against this background, this study retrospectively analyzed the characteristics and donation data of 231 human milk donors at the XMHHMB between October 2018 and July 2023. We aimed to characterize this donor population and elucidate the relationships between donor attributes and milk donation volumes, thereby providing empirical data to guide the establishment, management, and long-term sustainability of other HMBs and NICUs.

Study Methodology

Data Collection and Consent

Donor data were extracted retrospectively from the electronic medical and donation records of the XMHHMB. Informed consent was confirmed and verified via telephone communication with all participants. All donors enrolled in this study provided explicit consent for their data to be used for research purposes.

Eligibility and Variables

Medical records of mothers who donated human milk to the XMHHMB between October 20, 2018, and July 24, 2023, were screened for eligibility. To evaluate the correlations between donor characteristics and donation volumes, comprehensive demographic and clinical data were collected. These variables included donor name, age, contact information, education level, parity history, delivery mode, NICU admission status of the newborn, gestational age at delivery, infant birth weight, volume per individual donation. For mothers of twins, the birth weight of the lighter twin was utilized for analysis, as this parameter more critically influences the length of NICU stay and subsequent maternal donation patterns.

Early Lactation Support

At Xiamen Humanity Women and Children's Hospital, all mothers whose infants were admitted to the NICU, including those who subsequently became milk donors, received standardized, comprehensive lactation support from certified lactation consultants as part of a routine, center-specific protocol. This intervention package included:

•Assessing maternal breastfeeding intentions and educating mothers on the immunological and nutritional importance of breast milk for preterm infants.

• Provide one-on-one breastfeeding counseling within 24 hours postpartum.

• Perform regular follow-up to assess milk production.

• Offer individualized guidance on milk expression.

Calculation of Donation Volume

The total individual donation volume for each mother was calculated as the cumulative sum of all milk volumes recorded across all separate donation sessions throughout her active donor period. The cohort's overall total donation volume was defined as

the sum of these individual cumulative volumes across all 231 donors.

Statistical Analysis

Statistical analysis was performed using SPSS version 25.0 software. Categorical data are expressed as frequencies and percentages (%). For continuously distributed data, conforming to a normal distribution, dada are presented as mean±standard deviation (x±s), and comparisons were performed using independent-samples t-tests or one-way analysis of variance (ANOVA) for intergroup and intragroup differences. For non-normally distributed continuous data, variables are expressed as median and interquartile range (M (P25, P75)). Group comparisons for these variables were executed using the Mann-Whitney U test (for two groups) or the Kruskal-Wallis H test (for multiple groups). Statistical significance was defined at $P < 0.05$.

Results

Relationship between donor characteristics and volume of milk donated

A total of 231 donors were evaluated. The mean age of the cohort was 29.83±4.05 years (range: 17 - 43 years). Parity history and maternal education level did not correlate significantly with total volume of milk donated ($P > 0.05$). Interestingly, our analysis revealed that mothers who underwent a C-section demonstrated significantly higher donation volumes compared to those who delivered vaginally (median 3,850 mL vs. 2,800 mL, $P = 0.011$; Table 1). While this finding appears to diverge from some previous literatures[Error! Reference source not found.], we hypothesize that it reflects the universal, proactive lactation support provided by our full-time certified lactation consultants, who deliver standardized, early counseling and hands-on guidance within 24 hours postpartum regardless of delivery mode. These findings provide preliminary evidence that mothers delivering via C-section can serve as highly productive milk donors when given adequate support.

Table 1: Relationship between human milk donor characteristics and the volume of milk donations.

Characteristics	Total N (%)	Volume of milk donation (mL) Median (IQR)	*P*
	231	3000 (1500, 6000)	
Age (year)			0.328
≤24	12 (5.19%)	5200 (2625, 7150)	
25–29	95 (41.13%)	3000 (2000, 7000)	
30–34	97 (41.99%)	3000 (1500, 5035)	
≥35	27 (11.69%)	3000 (1000, 5200)	
Parity			0.185
1	140 (60.61%)	3500 (2000, 6000)	
2	85 (36.80%)	2500 (1000, 6000)	
3	6 (2.60%)	3500 (1800, 4125)	
Childbirth Mode			0.011
Delivery via C-section	146 (63.20%)	3850 (2000, 7500)	
Vaginal delivery	85 (36.80%)	2800 (1400, 5000)	
Education Level			0.247
High School and below	2 (0.86%)	8500 (6000, NA)	
College and undergraduate	213 (92.21%)	3000 (1500, 6000)	
Master and above	16 (6.93%)	4000 (2000, 5000)	

Relationship between neonatal characteristics and the volume of milk donations

A total of 231 maternal-infant pairs were evaluated. For the two donors who delivered twins, only the lighter infant was indexed for clinical tracking. All newborns survived to discharge, and 127 (54.98%) were admitted to the NICU (Table 2).

No significant difference was observed between the milk volume donated by mothers whose infants required NICU admission and those whose infants were not hospitalized ($P = 0.929$). However, statistically significant differences were observed across

gestational age categories (P = 0.001): mothers who delivered extremely preterm infants (<32 gestational weeks) donated significantly more milk (median 5,000 mL) than those who delivered at later gestational ages.

When stratifying donors by newborn birth weight, a parallel and statistically significant trend emerged (P = 0.043). Mothers of extremely low-birth-weight infants (<1,500 g) donated substantially higher volumes of milk (median 8,000 mL) compared to the higher birth weight cohorts.

Table 2: Relationship between neonatal characteristics and the volume of milk donated.

Characteristics	Total N (%)	Volume of milk donation (mL) Median (IQR)	*P*
	231	3000 (1500, 6000)	
Newborn status			0.929
NICU admitted	127 (54.98%)	3000 (1500, 6500)	
Not hospitalized	104 (45.02%)	3000 (2000, 5375)	
Gestational age (weeks)			0.001
<32	28 (12.12%)	5000 (3100, 9875)	
32–36	62 (26.84%)	2200 (1000, 4850)	
≥37	141 (61.04%)	3000 (1840, 5650)	
Birth weight (g)			0.043
<1500	17 (7.36%)	8000 (2000, 11150)	
1500–2499	62 (26.84%)	3000 (1800, 5017)	
≥2500	152 (65.80%)	3000 (1500, 5500)	

Overall, 76.62% (177/231) of the donors delivered at our hospital (XMHWCH). Although there was no statistically significant difference in median donation volumes between the NICU and non-NICU groups, the 127 NICU mothers collectively contributed 60.8% (672,070/1,105,730 mL) of the milk bank's total volume. In total, 90 mothers had preterm deliveries, accounting for 42.21% of all donors. This proportion is significantly higher than the 9.4% previously reported in China [13], though lower than the 65.5% reported in India [14]. Because prematurity is the primary reason for NICU admission at our facility, our findings indicate that mothers facing the highest clinical severity—those with the most premature and lowest-birth-weight infants—ultimately donated the largest volumes of surplus breast milk.

Discussion

The findings of this study offer encouraging perspectives on optimizing donor pools. Securing breast milk donations from mothers of premature infants provides several clear operational and clinical advantages.

First, our observations demonstrate that when structured, proactive lactation support is provided, mothers of preterm infants can produce milk volumes that far exceed their own infants' needs, yielding a substantial surplus for donation.

Second, because these mothers are thoroughly educated on the critical role of human milk in preterm outcomes—and since their own infants often receive DHM during the immediate postpartum period—they exhibit high altruistic motivation to return the favor and support other vulnerable neonates.

Third, during crises such as the COVID-19 pandemic, when community donor recruitment was severely restricted, hospitalized preterm mothers remained a highly stable and resilient donor population because they were already required to express and transport milk to the facility for their infants.

Fourth, given that Chinese HMBs operate under considerable financial pressure (funded almost exclusively by hospitals or charitable grants without charging recipient families), cost containment is vital for long-term sustainability. Because mothers of hospitalized preterm infants already undergo rigorous infectious disease screening at admission for their own infants' safety, no additional laboratory screening costs are incurred by the milk bank, significantly lowering the economic threshold for donation.

Fifth, preterm milk is biologically tailored; it contains higher concentrations of energy, protein, and bioactive immunoglobulins (which are partially preserved during pasteurization) compared to mature milk, making it clinically superior for preterm recipients[15].

Furthermore, our data highlight how differences in institutional framework can impact HMB performance. In many countries, HMB operations are independent of NICU clinical management, meaning there is no direct structural link between preterm mothers and the milk bank. In contrast, the XMHHMB utilizes a unified model where the same neonatology team oversees both the NICU and the milk bank. This integrated administration significantly streamlines the recruitment of donors from the NICU. A similar integrated model implemented in India yielded comparable success[14].

The mean age of donors in this study (29.83±4.05 years) aligns closely with the early-thirties demographic typical of donors in developed regions, as identified in a recent global scoping review[6], but is notably higher than the mean age of 21.6±2.7 years reported from India**Error! Reference source not found.**. Additionally, 99.13% of our donors held an undergraduate degree or higher. This profile reflects both the rising educational attainment among Chinese women and a shifting demographic toward delayed childbearing

age, mirroring trends in high-income countries rather than those in traditional developing regions like Brazil[6].

In China, despite declining overall birth rates in the post-pandemic era, advanced neonatological care has led to increasing survival rates for extremely premature infants. Consequently, the clinical demand for HMBs is accelerating. However, HMB expansion across China remains slow, primarily due to the lack of dedicated financial frameworks. While processing donor milk costs approximately $3–$5 per 30 mL in the United States[16], Chinese HMBs operate on zero-tariff models for recipient families, creating immense operational deficits[17]. Daili et al. evaluated costs in China and calculated that a typical HMB requires an annual budget of $50,000–$170,000, translating to roughly $168 per liter of processed milk[17]. While a precise formal cost-benefit analysis was not performed in our study, the fact that 54.98% of our donors were internal NICU mothers suggests substantial savings in screening and recruitment expenses.

Our experience suggests that targeting NICU mothers offers a practical strategy to address both donor shortages and financial constraints. Although preterm birth has traditionally been viewed as a physiological barrier to lactation initiation, our cohort demonstrates that these mothers possess high donor potential; our earliest-recruited donor delivered at 33 weeks, and the lowest gestational age recorded among donors was 26 weeks. This aligns with findings from Spain, where mothers of infants delivered at <37 weeks consistently donated significantly larger volumes than mothers of term infants[11]. These outcomes underline the imperative that NICU staff and dedicated lactation consultants provide timely, intensive, and continuous milk production support to this specific population.

Limitations

This study has certain limitations. As a single-center retrospective study conducted at the XMHHMB, our sample size was relatively small (231 donors), which may limit the generalizability of our findings to regions with different socio-economic backgrounds or alternative HMB configurations. Furthermore, the exceptionally high education rate (99.13% with a bachelor's degree or higher) exceeds that of the general population, meaning our findings may not fully apply to cohorts with lower educational attainment. To improve external validity, future multi-center studies encompassing diverse geographic areas and operational models are warranted.

Declarations

Ethical approval: This study was approved by the Ethics Committee of Xiamen Humanity Hospital (No. HAXM-MEC-20210809-008-01). Telephone informed consent was obtained from all participants. The study was conducted in strict compliance with the principles of the Declaration of Helsinki.

Author contributions: ZXL designed the study, supervised the project, and provided overall research direction. HFP and WY performed data processing and statistical analysis. ZXL and WY drafted the manuscript. ZXL provided critical intellectual feedback and revised the final manuscript. All authors have read and approved the final version of the manuscript for submission.

Conflicts of interest statement: The authors declare that they have no conflicts of interest.

Data availability statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Research funding: This work was supported by a grant from 2021 Xiamen Medical and Health Guidance Project (No.3502Z20214ZD109).

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