



# Human Milk Banks in India: Innovations, Digitalization, and the Road Ahead

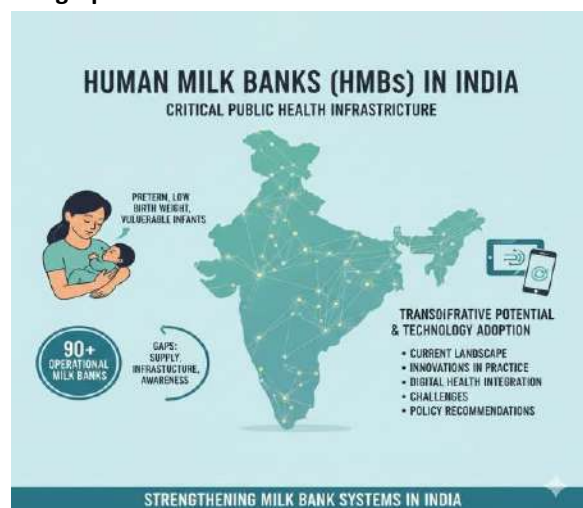
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## Abstract

Human milk banks (HMBs) in India have emerged as a cornerstone of public health infrastructure, providing essential nutrition to preterm, low birth weight (LBW), and medically vulnerable infants. Although India has seen a rapid expansion to over 90 operational units (often integrated as Comprehensive Lactation Management Centres), significant geographic disparities and supply-demand gaps persist. This paper evaluates the current landscape, highlighting a shift toward innovation and digitalization to ensure safety and scalability. Key advancements include the adoption of IoT-enabled cold chains, cloud-based inventory tracking, and barcoding for end-to-end traceability. Despite these strides, the sector faces systemic challenges, including inadequate recurring funding, staffing shortages, and low community awareness. We provide actionable policy recommendations, advocating for the integration of HMBs into national neonatal health strategies, standardized digital frameworks, and enhanced public-private partnerships. Ultimately, strengthening the milk bank ecosystem is vital for India to achieve its Sustainable Development Goals (SDG 3.2) for neonatal mortality.

**Keywords:** Human Milk Banks, Donor Human Milk, Digital Health Innovation, Neonatal Nutrition, India Healthcare System.

## Infographic Abstract



## Articalinfo

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## Research Highlights

- **Impact on Neonatal Survival:**

Establishment of HMBs in tertiary care units in India has been linked to a significant reduction in neonatal mortality (up to 53%) and morbidity (up to 49%), primarily by preventing Necrotizing Enterocolitis (NEC) and sepsis.

- **Expansion of Infrastructure:**

India has scaled to 90+ operational milk banks, transitioning from standalone units to integrated Comprehensive Lactation Management Centres (CLMCs), though significant regional clusters (e.g., Maharashtra and Rajasthan) highlight a need for equitable national distribution.

- **Digitalization as a Game-Changer:**

Adoption of IoT-enabled cold chain monitoring

and cloud-based inventory systems (supported by organizations like PATH) has minimized milk wastage and ensured 100% traceability from donor to recipient.

- **Socio-Cultural Barriers:**

While 73% of mothers in clinical settings express a willingness to donate, only about 47% are willing to accept donor milk for their own infants due to "milk kinship" myths and safety concerns.

- **Policy Imperatives:**

Critical gaps remain in recurring funding and specialized human resources. The study recommends integrating HMB services into the National Health Mission (NHM) to ensure financial sustainability and standardized quality assurance.

## 1. Introduction

Human milk provides unparalleled immunological and nutritional benefits for newborns and is especially crucial where maternal breastfeeding is constrained by health conditions, Quigley et al., 2024. When mothers' milk is unavailable, donor human milk from milk banks offers the next best alternative. Human milk banking in India is commonly implemented under Comprehensive Lactation Management Centres (CLMCs) supported by health institutions and national networks such as the Human Milk Banking Association of India (HMB-AI) that promotes evidence-based practices and awareness.

India accounts for the highest global burden of preterm births. Donor Human Milk (DHM) is the "gold standard" alternative when biological maternal milk is unavailable, reducing the incidence of Necrotizing Enterocolitis (NEC) by up to 79%.

- Evolution: From the first bank in 1989 (Sion Hospital, Mumbai) to the National Guidelines of 2017.
- Current Framework: The 3-tier system:
  1. CLMC: High-volume hubs (processing, screening, and storage).
  2. Lactation Management Units (LMU): Smaller units for collection and storage.
  3. Lactation Support Centres: Grassroots-level counselling.

In the landscape of 21st-century neonatal care, the "Digital Postmortem Machine" has revolutionized forensic pathology; similarly, the nutrition sector is witnessing a high-tech metamorphosis through the rise of Human Milk Banking (HMB). As India grapples with the highest global burden of preterm births—approximately 3.5 million annually—

the establishment of robust, digitally-integrated milk banks has shifted from a clinical luxury to a public health imperative, Ramanathan et al., 2025.

### The Foundation: From Ancient Concepts to Modern Necessity

While the concept of "wet-nursing" is deeply embedded in Indian mythology (e.g., the tales of Yashoda and Krishna), the formalization of this practice began in 1989 at Sion Hospital, Mumbai, the first HMB in Asia. Today, the sector has evolved into a sophisticated network under the National Guidelines on Lactation Management Centers (2017). These centers, categorized into Comprehensive Lactation Management Centres (CLMCs) and Lactation Management Units (LMUs), serve as the primary defence against neonatal mortality, specifically targeting Necrotizing Enterocolitis

(NEC) and sepsis in vulnerable infants, Belekar, A. (2025).

### The Digital Pivot: Innovations in the 2020s

The current era (2024–2026) marks the "Digitalization Phase" of Indian milk banking. Innovation is no longer restricted to just the pasteurization process but extends across the entire supply chain:

- **IoT and Smart Cold Chains:** Implementation of Internet of Things (IoT) sensors in transport bags and storage freezers allows for real-time temperature monitoring, ensuring that the "liquid gold" never exceeds the critical -20°C threshold.
- **Traceability through AI and Barcoding:** Modern CLMCs utilize specialized software to track a single donation from the donor's ID and nutritional

analysis to the specific recipient in the NICU, minimizing human error and ensuring accountability.

- **Cloud-Based Donor Registries:** Integrated platforms now facilitate seamless donor screening and longitudinal tracking, allowing hospitals to manage demand-supply mismatches more effectively across regional networks.

#### The Road Ahead: Challenges and Scale

Despite the technological leap, the road ahead is defined by a significant "availability gap." India currently operates approximately 100 milk banks, yet estimates suggest a need for over 1,300 fully functional centers to achieve universal coverage. The future of HMB in India lies in, Jain, S., Bansal, A., & Chawla, D. (2023,2025):

1. **Technological Democratization:** Moving beyond expensive

hospital-grade pumps to affordable, locally-manufactured "Smart Pasteurizers" like the *FoneAstra* system.

2. **Nutritional Precision:** Utilizing Infrared Spectroscopy to analyze the macronutrient content of donor milk, allowing clinicians to provide "targeted fortification" for extremely low-birth-weight (ELBW) infants.
3. **Societal Digital Advocacy:** Using digital health platforms (like the *Abha* ID ecosystem) to normalize milk donation and dispel cultural myths regarding "milk kinship" and safety.

#### 2. Current Landscape in India

Human milk banking in India has expanded steadily, Singh, et al. (2025):

- As of recent estimates, nearly 90 milk banks are operational across the country.
- The first milk bank in Asia was established in Sion Hospital, Mumbai and has supported thousands of infants through donated milk.
- Regional initiatives, such as Payodhi at AIIMS Delhi, provide processed donor milk to critically ill preterm babies, highlighting both clinical integration and lactation support services.
- In states like Gujarat, over 5,500 mothers donated more than 5,000 litres of milk in a year,

benefitting nearly 8,000 babies.

Despite these advances, demand often outstrips supply, and many banks lack resources for sustainable scaling, Varghese, S., et al. (2025).

#### Innovations in Processing and Quality Control

Traditional milk banking relied on manual temperature logs and basic pasteurization, Mathias, et al. (2023/2025). Modern Indian banks are adopting:

- Lacto-engineering: Using Infrared Spectroscopy to analyze macronutrients (fat, protein, lactose). This allows "targeted fortification," where milk is tailored to the specific caloric needs of a 26-week-old vs. a 32-week-old infant.

- Advanced Pasteurization: Moving beyond the standard Holder Method (62.5\text{°C} for 30 mins) to explore Flash Pasteurization, which better preserves immunological components like Immunoglobulin A (IgA) and Lactoferrin.

### 3. Core Functions and Best Practices

HMBs collect, screen, process (including pasteurization and microbiological testing), store, and dispense donated milk. Standard operational practices are guided by safety protocols aligned with WHO and national policy frameworks.

Past evaluations found that many existing banks face resource constraints—such as limited dedicated staff (e.g., technicians and lactation counsellors), manual

processing, and supply-demand mismatches.

#### Digitalization: The New Frontier

Digitalization is the bridge between "collecting milk" and "ensuring safety."

##### A. IoT and Real-time Cold Chain

Newer installations use IoT sensors in deep freezers and transport bags.

These sensors provide:

- Real-time temperature alerts to central dashboards via GPRS.
- GPS tracking for "Home Donor" collection models, ensuring the cold chain isn't broken during transit.

##### B. Data Management Systems

The shift from paper registers to cloud-based Milk Bank Management Systems (MBMS) has streamlined:

- Traceability: Using 2D barcodes to link a single bottle of milk back to the specific donor's health screening and the batch pasteurization data.
- Inventory Optimization: Algorithms that predict demand based on NICU occupancy, reducing milk wastage (current spoilage rates in digitalized banks have dropped by an estimated 15-20%).

#### 4. Innovations Transforming Human Milk Banking

##### 4.1 Technological Innovations

Technological advancements are emerging globally and have relevance for India:

- Advanced screening tools for faster pathogen detection

enhance safety profiles.

- Blockchain and AI enable secure traceability and better inventory oversight, ensuring donor milk is tracked from collection to use.
- AI-driven inventory systems can forecast supply-demand trends, streamline stock levels, and reduce waste.
- Chatbots and virtual assistants can expand donor engagement and education.

The Road Ahead: 2026 and Beyond

To universalize access to DHM, the following steps are critical:

1. Integration with "Bharat Pashudhan": Leveraging the digital architecture of India's dairy sector (like the

- Automatic Milk Collection System) to include human milk tracking.
2. Public-Private Partnerships (PPP): Utilizing private logistics companies for "last-mile" delivery of DHM to smaller private NICUs.
  3. National Registry: A centralized digital registry to monitor donor health and prevent "over-donation" by a single individual across different banks.
- Online donor registration and electronic record-keeping improve data accuracy and reduce manual log errors.
  - Digital dashboards and mobile apps can connect donors with supply needs in real time and support better allocation of resources.
  - Integrating milk bank data with broader maternal–child health information systems strengthens continuity of care and monitoring outcomes.

These innovations enhance efficiency, safety, and transparency—building credibility among stakeholders.

## 5. Digitalization and Data Ecosystems

Digital platforms offer several benefits for milk banks:

Evidence from international contexts indicates that milk bank professionals overwhelmingly desire greater digital support but face implementation barriers including cost and IT infrastructure gaps.

## 6. Challenges and Barriers

Despite progress, several challenges remain:

Despite technological gains, systemic hurdles remain:

- **The Demand-Supply Gap:** India needs over 600-800 banks to cover its neonatal population; current numbers are less than 15% of the target.
- **Electricity Inconsistency:** In rural regions, maintaining a stable  $-20\text{°C}$  environment is difficult without expensive solar-hybrid backups.
- **Commercialisation Risks:** The rise of private "for-profit" milk companies poses an ethical threat to the altruistic "voluntary donation" model established by the government.

### 6.1 Awareness and Social Barriers

Awareness about milk donation and milk bank services is limited in many regions. Studies show high willingness to donate among mothers when informed, yet only a small fraction know about nearby banks.

### 6.2 Supply-Demand Mismatch

Evaluations have highlighted ongoing deficits between available donor milk and neonatal needs, with HMBs often unable to serve beyond their host hospitals.

### 6.3 Infrastructure and Workforce Constraints

Many facilities lack adequate automated pasteurization equipment, trained technicians, and consistent staffing levels, resulting in operational bottlenecks.

### 6.4 Regulatory and Quality Assurance Needs

Standardized national frameworks that ensure consistent quality, equitable access, and ethical donor practices are still evolving.

## 7. The Road Ahead: Policy and Practice Recommendations

### 7.1 Scaling Infrastructure

Investment in hub-and-spoke models can enable regional pooling of resources, shared quality laboratories, and expanded reach for remote facilities.

### 7.2 Prioritizing Digital Integration

Government and healthcare partners should support digital transformation through:

- Subsidies for digital platforms and AI tools

- Integration with national health information systems (mHealth and hospital EMRs)
- Standardized electronic protocols for donor screening and traceability

### 7.3 Awareness and Community Engagement

National campaigns and local health worker training can reduce stigma, increase donor pools, and reinforce the value of human milk over substitutes.

### 7.4 Research and Evaluation

Ongoing research into outcomes (e.g., reductions in neonatal infections or length of stay) and implementation science will inform best practices and funding priorities.

Table 1. Current Status of Human Milk Banks in India.

Parameter	Details
Total operational milk banks (2025–26)	~90 across India
First milk bank established	Sion Hospital, Mumbai (1989)
Main coordinating body	Human Milk Banking Association of India (HMB-AI)
Key beneficiaries	Preterm infants, LBW babies, critically ill newborns
States with high activity	Maharashtra, Gujarat, Delhi, Karnataka
Annual donor participation example	Gujarat: 5,500+ donors, 5,000+ L milk/year

Table 2. Core Operational Workflow of Human Milk Banks.

Stage	Key Activities	Tools/Technology Used
Donor Recruitment	Counseling, eligibility screening	Apps, online forms
Milk Collection	Expression, safe storage	Sterile containers, QR labelling

Pasteurization	Holder method (62.5°C for 30 min)	Automated pasteurizers
Microbiological Testing	Pre- and post-pasteurization analysis	Culture tests, rapid detection kits
Storage	Freezing at -20°C to -40°C	Medical-grade deep freezers
Distribution	Priority-based dispensing	Digital inventory systems

Table 3. Innovations in Human Milk Banking.

Innovation Type		Description	Benefits
Digital Registration	Donor	Mobile apps, digital consent forms	Saves time, reduces errors
AI-based Forecasting	Inventory	Predict demand & optimize supply	Reduces wastage
Blockchain Traceability		Secure tracking of milk batches	Enhances safety & transparency
Automated Pasteurization Units		Fully controlled heating/cooling	Quality consistency
Electronic Systems	Record	Centralized digital logs	Better audit & reporting

Table 4. Challenges Facing Human Milk Banks in India.

Challenge	Description	Impact
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Low Awareness	Many mothers unaware of donation options	Low supply
Workforce Shortages	Few trained lactation counsellors & technicians	Operational delays
Infrastructure Gaps	Lack of modern equipment in many districts	Safety & scalability issues
Regulatory Variation	Non-uniform adoption of standards	Variable quality
Limited Digitalization	Manual logs, paper-based systems	Errors, poor monitoring

Table 5. Roadmap Recommendations for Strengthening Milk Banks.

Focus Area	Strategies	Expected Outcome
Infrastructure	Hub-and-spoke model, govt. funding	Increased access
Digitalization	AI, apps, EMR integration	Real-time data use
Awareness	National campaigns, ASHA worker training	More donors
Research	Outcome tracking, policy evaluation	Evidence-based improvements
Quality Assurance	National guidelines, audits	Safe & uniform services

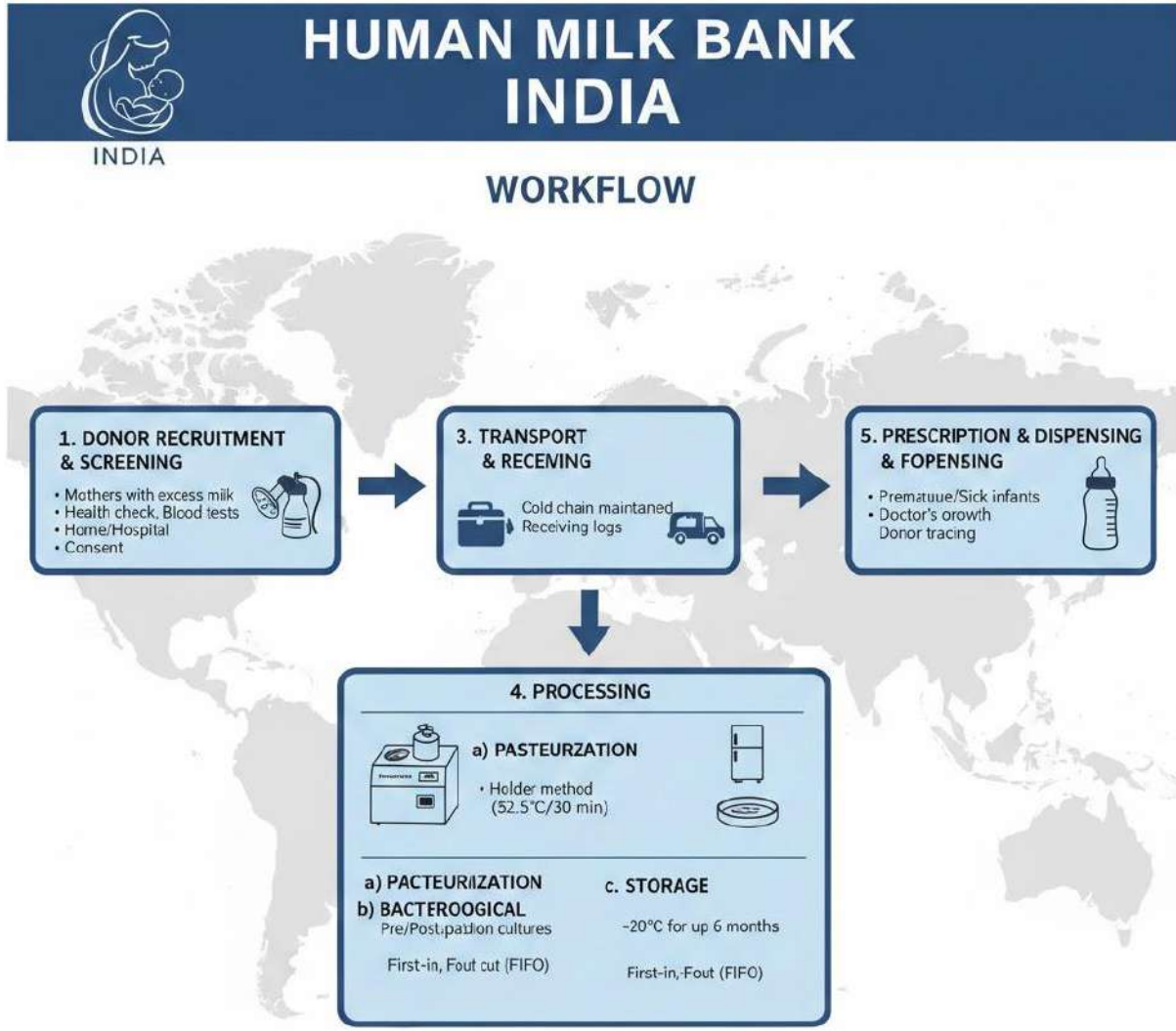


Fig 1: Schematic Workflow of a Human Milk Bank in India.

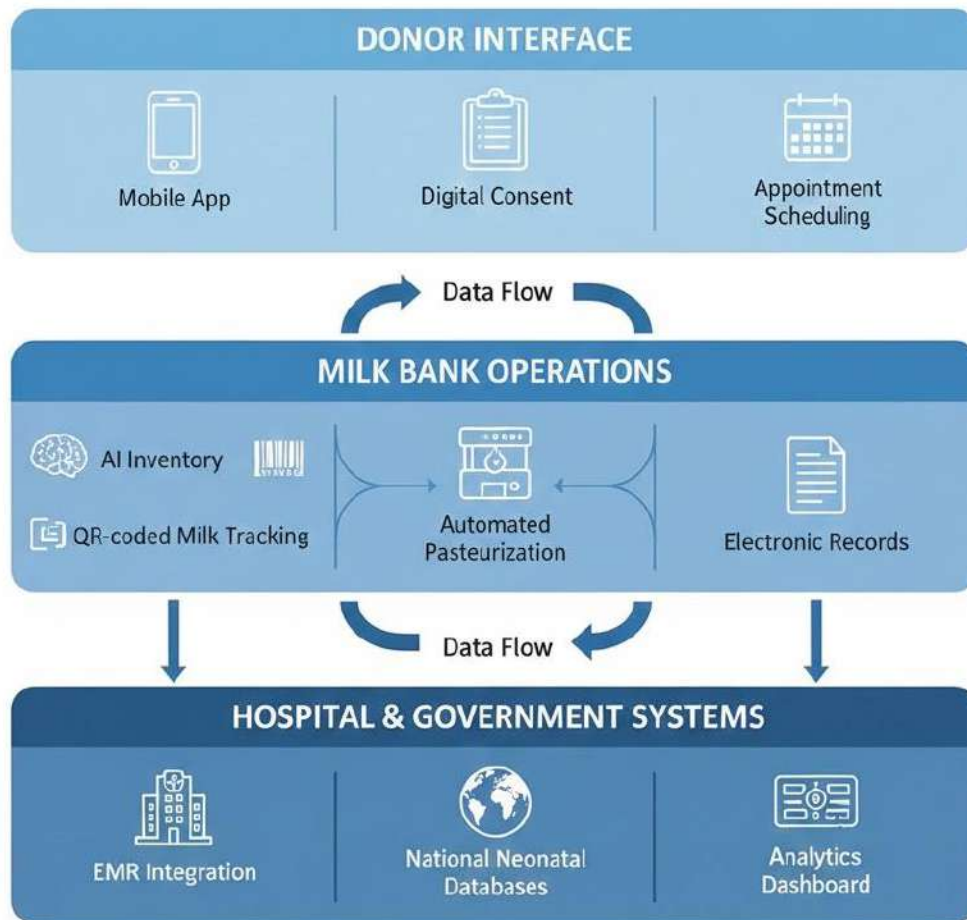
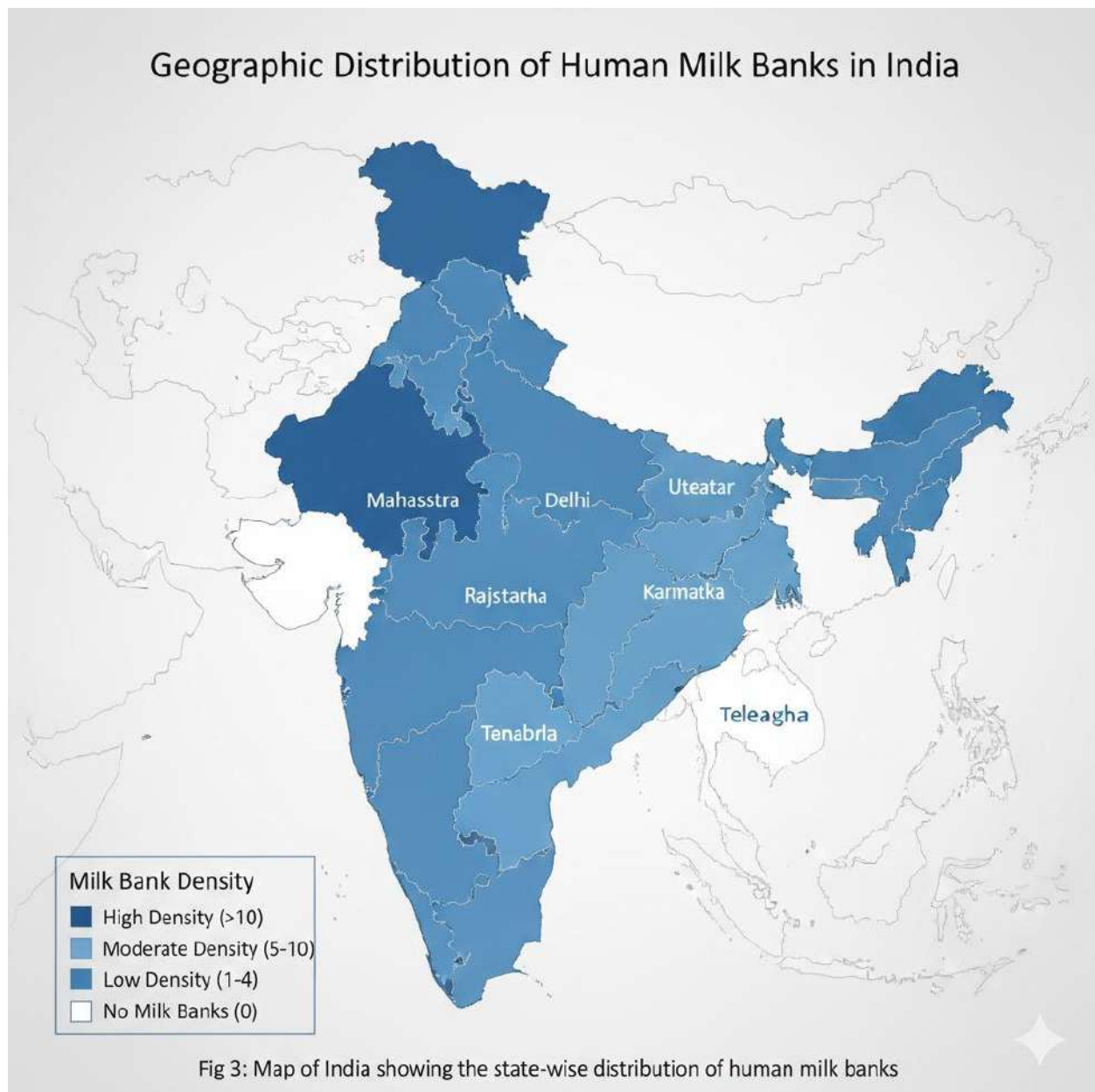


Figure 2. Digital Human Milk Bank Ecosystem



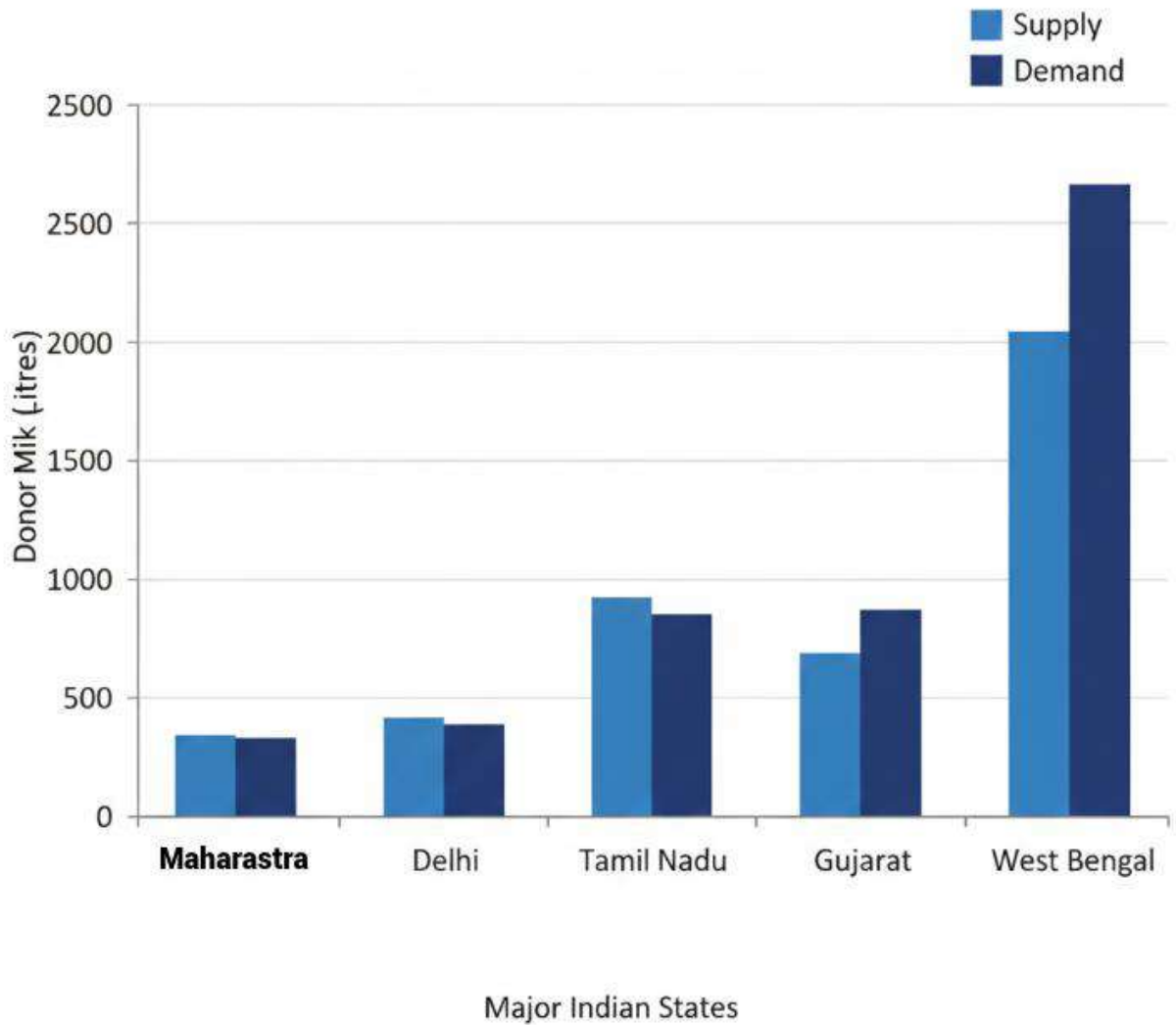


Figure 4. Supply vs. Demand Gap in Human Milk Banks



Figure 5. Future Roadmap for Milk Bank Digitalization

1. Clinical Imperative: Reducing Neonatal Mortality

Current literature (Singh et al., 2025; Quigley et al., 2024) reinforces that Donor Human Milk (DHM) is the "biological gold standard" when Mother’s Own Milk (MOM) is unavailable.

- Necrotizing Enterocolitis (NEC): A 2024 Cochrane review and Indian retrospective studies highlight that DHM reduces the risk of NEC by over 50% compared to formula.
- Sepsis and Hospital Stay: Recent data from Indian tertiary care centers (2025) indicate that infants receiving DHM have a significant reduction in late-onset sepsis and a median

reduction in hospital stay by 4.2 days.

2. Structural Evolution: The CLMC Model

The Ministry of Health and Family Welfare (MoHFW) guidelines (2017) and their recent 2024/2025 operational updates have standardized the hierarchy of milk banking in India:

Literature Note: Research by *Sachdeva et al. (2025)* notes that while CLMCs are increasing, the focus is shifting toward "Lactation Support" to ensure the milk bank does not replace direct breastfeeding, but rather supports it.

Table-2: Structural Evolution: The CLMC Model

Facility Type	Scope of Services	Primary Function
CLMC	Tertiary Care/Medical Colleges	Screening, Pasteurization, Storage, and Regional Distribution.
LMC/LMU	District Hospitals	Collection and storage of Mother’s Own Milk (MOM) for her own baby.

LSU	Sub-district/FRUs	Skilled lactation counseling and early initiation support.
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### 3. Digitalization and Technological Innovations

The most recent scholarship (2024–2026) focuses on the "Digitalization of the Cold Chain":

- IoT-Enabled Logistics: Studies on the *REAMIT* project and local Indian startups show that IoT sensors in transport bags now provide real-time GPS and temperature tracking ( $\pm 20^{\circ}\text{C}$ ), sending automated alerts to milk bank managers to prevent batch wastage (Ramanathan et al., 2025).
- Nutritional Precision: Literature (2024) highlights the use of Infrared Spectroscopy (Milk Analyzers). This allows for "Targeted Fortification," where the protein and caloric content of donor milk is matched specifically to the needs of Extremely Low Birth Weight (ELBW) infants.
- AI in Screening: New pilot programs (2025) are exploring

Machine Learning to predict donor behavior and identify potential high-volume "super-donors" based on demographic and clinical data.

### 4. Sociocultural Barriers and Awareness

Despite technological gains, literature (Varghese et al., 2025; Shodh Forensic, 2025) identifies persistent "soft" barriers:

- The "Milk Kinship" Concept: In some communities, concerns regarding religious and social kinship through shared milk remain a barrier to acceptance.
- Awareness Gaps: A 2025 cross-sectional study in Tamil Nadu found that while 79% of women were aware of milk donation, only 5% knew the location of the nearest bank, indicating a need for better digital mapping and public health communication.

### 5. The Road Ahead: 2026 and Beyond

The current research frontier focuses on Sustainability and Quality Assurance:

- National Quality Assurance Standards (NQAS): New literature (2025) discusses the implementation of NQAS specifically for CLMCs, moving toward a "zero-infection" protocol through automated pasteurization cycles.
- Scale-up Models: Scholars advocate for a "Hub and Spoke" model where one CLMC (Hub) supports multiple NICUs (Spokes) via digital inventory management systems.

## 8. Conclusion

Human milk banks in India represent a cornerstone of neonatal nutrition and child survival strategies. While the current network has demonstrated impact, realizing its full potential requires strategic innovation and digital transformation. By investing in technology, workforce capacities, policy frameworks, and community outreach, India can strengthen milk banking as a sustainable, efficient, and

equitable system—benefiting thousands of vulnerable infants annually. The future of Human Milk Banks in India lies in the synergy between empathy and engineering. While digitalization ensures safety and scalability, the core remains the voluntary donor. Strengthening the digital infrastructure will not only save lives but also establish India as a global leader in high-tech, low-cost neonatal care.

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