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The Immunological Role of Breast Milk in Infant Immune Protection: A Literature Review

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Abstract: Breast milk is the primary source of nutrition for newborns, providing not only essential nutrients but also rich bioactive components with immunological functions. It plays a critical role in the development and modulation of the infant's immune system, through both innate immune components such as lactoferrin, lysozyme, and immune cells (macrophages, lymphocytes), and adaptive components like secretory immunoglobulin A (sIgA). Stunting in Indonesia is associated with a number of factors, including poverty, low levels of education, poor parenting techniques, and repeated infections that hinder the absorption of nutrients. This review aims to examine the role of breast milk in supporting the infant immune system, particularly in preventing infections, promoting the colonization of healthy gut microbiota, and stimulating mucosal immune development. The method used was a literature review of scientific articles published over the last 10 years (2015–2025) sourced from PubMed, ScienceDirect, and Google Scholar. The findings reveal that exclusively breastfed infants have a lower risk of respiratory and gastrointestinal infections, as well as atopic dermatitis, and demonstrate a more mature immune response compared to non-breastfed infants. The conclusion of this study confirms that breastfeeding significantly contributes to strengthening the infant immune system through immunoprotective and immunomodulatory mechanisms.

Keywords: Breastfeeding; Immunoglobulin A; Infant immunology; Lactoferrin; Neonatal immune system

Introduction

Breast milk is an essential nutrient universally recognized for its substantial health benefits for infants, mothers, and society at large (Susilawati, 2019). It contains a variety of bioactive components such as antibodies, live immune cells, immunoglobulins, lactoferrin, lysozyme, and other factors that play important immunomodulatory roles in supporting the maturation of the infant's immature immune system (Ardan et al., 2022; Lestari et al., 2023). These components act synergistically to protect the infant from various pathogens and modulate immune responses, forming a strong foundation for early immune defense.

The World Health Organization recommends exclusive breastfeeding for the first six months of life, as it meets the infant's nutritional needs and supports cognitive and linguistic development (Picauly et al., 2021). Exclusive breastfeeding also significantly reduces the risk of malnutrition, a serious condition with long-term consequences for child growth and development (Umar et al., 2021). However, after six months, an infant's nutritional demands increase, necessitating the introduction of appropriate complementary foods (Septiani et al., 2022).

A proper combination of breast milk and complementary feeding is a key strategy in preventing malnutrition and stunting a form of chronic undernutrition that leads to permanent physical and

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cognitive growth impairment (Ajmal, 2010). Stunting is often caused by inadequate nutritional intake and repeated infections, particularly during prenatal and early postnatal periods (Amalia et al., 2023; Titimeidara et al., 2021). Stunting remains a major challenge in Indonesia, with a prevalence rate of 39% in 2017, marking a significant increase from previous years (Yarmaliza et al., 2021).

Data from the Basic Health Research survey showed a decrease in stunting prevalence from 37.2% in 2013 to 30.8% in 2018, though this figure is still high (Yuda et al., 2022). More recent data reveal a prevalence of 24.4% among children under five, reflecting only a 3.3% reduction since 2019, still far from the 14% target by 2024 (Zaluchu, 2022). The prevalence in Indonesia also surpasses that of neighboring countries such as Thailand and Malaysia (Soviyati et al., 2018), and is the second highest in Southeast Asia after Laos, with a rate of 43.8% (Marantika & Sarwinanti, 2021).

Globally, it is estimated that 165 million children were stunted in 2011, and 144 million in subsequent years, with the majority of cases occurring in developing countries, including Indonesia (Sari, 2023; Fadmi et al., 2023). The World Health Organization has targeted a global stunting reduction of 40% by 2025 as part of its commitment to the Sustainable Development Goals (Garina et al., 2024; Santi et al., 2020). Stunting not only affects physical growth but also impairs cognitive development and metabolic health, making it a critical indicator of public health development (Pratama et al., 2023).

In Indonesia, stunting is linked to several determinants, including poverty, low educational attainment, poor parenting practices, and recurrent infections that impair nutrient absorption (Hasni et al., 2021; Huriah et al., 2021). These factors create a cycle of chronic malnutrition that is difficult to break without early and comprehensive interventions (Anggraini et al., 2020). In this context, breast milk acts not only as a nutritional source but also as an immunological agent that protects infants from infections and reduces the risk of chronic undernutrition.

Thus, the immunological protection provided by breast milk is highly relevant in stunting prevention efforts. Breast milk reduces the incidence of infectious diseases such as diarrhea and pneumonia, major contributors to stunting in children (Pitoyo et al., 2022). This literature review aims to analyze the immunological role of breast milk in supporting infant immunity and preventing stunting, as well as to explore the biological mechanisms underlying this protection.

Method

This literature review employed a library research approach by collecting and comprehensively analyzing previously published relevant studies. This approach allows for the identification, selection, and synthesis of information from various academic sources to construct a well-supported argument on the topic. This literature review is a comprehensive study analyzing data from various publications to examine the immunological role of breast milk in infant immune protection and its relationship with stunting prevention.

Data were collected through systematic searches of electronic databases such as PubMed, Scopus, and Google Scholar using relevant keywords like "breastfeeding," "infant immunity," "stunting," "immunological factors," and "exclusive breastfeeding." Inclusion criteria included primary and secondary research articles, systematic reviews, and meta-analyses published within the last ten years, with a focus on studies in English and Indonesian. The selection process involved reviewing titles and abstracts, followed by full-text reading to ensure relevance and scientific quality. Data analysis was conducted using a narrative approach, synthesizing findings from relevant literature to identify patterns, gaps, and clinical implications regarding the role of breast milk in infant immunity.

Result and Discussion

Immunological Composition of Breast Milk and Its Role in Neonatal Immunity

Breast milk is not only the primary nutritional source for infants but also contains various bioactive components that play a critical role in neonatal immune defense. Compounds such as lactoferrin, lysozyme, immunoglobulins, oligosaccharides, and live cells including macrophages and lymphocytes work synergistically to support both innate and adaptive immune responses in newborns (Septiani et al., 2022; Syofyanengsih et al., 2022). These components form the foundation of effective immune responses to protect infants from early-life pathogens (Munasir, 2016). Secretory IgA (sIgA) in breast milk plays a crucial role in mucosal protection by preventing microbial colonization in the infant's gastrointestinal tract (Munasir, 2016; Supit, 2021). Lactoferrin inhibits bacterial growth by sequestering iron, lysozyme breaks down bacterial cell walls, and oligosaccharides act as decoy receptors, blocking pathogen adhesion to the intestinal epithelium (Syofyanengsih et al., 2022).

The Role of Breast Milk in Preventing Infectious Diseases and Stunting

Exclusive breastfeeding significantly reduces the incidence of infectious diseases in infants, including diarrhea and respiratory tract infections (Ciobanu et al., 2020; Rahardjani, 2016). A study by Yuda et al. (2022) confirmed that exclusive breastfeeding is closely associated with reduced risk of stunting by preserving nutritional status and preventing chronic inflammation. Recurrent infections—common in non-breastfed infants—are a key contributor to stunting due to impaired nutrient absorption and systemic inflammation (Verawati et al., 2021). The immunological protection offered by breast milk is evident in its role in preventing severe conditions such as neonatal sepsis (Bambang et al., 2016; Rahardjani, 2016). Maternal antibodies, particularly IgG transferred via the placenta and IgA via breast milk, provide essential passive immunity during the early months of life (Kulinich & Liu, 2016; Supit, 2021).

Bioactive Components in Breast Milk and Their Impact on Gut Health and Mucosal Immunity

Human milk oligosaccharides (HMOs) function as prebiotics that promote the growth of beneficial gut microbiota and support the maturation of mucosal immune responses (Mason et al., 2014). HMOs help prevent dysbiosis, which is often associated with increased susceptibility to infections and malnutrition. This demonstrates how breast milk not only offers direct protection but also contributes to long-term immunological balance.

Maternal Factors Affecting the Immunological Quality of Breast Milk

The quality and composition of immune components in breast milk are significantly influenced by maternal nutrition, health status, and psychosocial factors. Nutritional deficiencies during pregnancy and lactation can reduce the concentration of bioactive substances in breast milk (Kadir et al., 2019; Rahmawati et al., 2023). Moreover, stress, illness, and medication use can alter the immune profile of breast milk (Machdum et al., 2017). Therefore, maternal health interventions have a direct impact on the immunological quality of breast milk.

The Importance of Nutritional Education and Early-Life Interventions

Optimal breastfeeding practices are a crucial component of nutrition strategies during the first 1,000 days of life. Adequate nutrition during this critical window contributes to cognitive development, immune competence, and physical growth (Asrawaty et al., 2022; Nenabu et al., 2023). Health education for pregnant and breastfeeding mothers has been shown to improve breastfeeding practices and prevent stunting (Baharuddin & Kongkoli, 2023; Fitriami & Galaresa, 2022; Purnamasari et al., 2023).

Risk factors such as extreme maternal age, short birth intervals, and poor living conditions are associated with higher stunting prevalence and altered breast milk quality (Susanti, 2021). A multisectoral approach involving education, healthcare services, and social support is essential to enhance maternal knowledge and breastfeeding (Veniawati et al., 2020).

Long-Term Immunological Benefits of Breastfeeding

Studies have shown that breastfed infants have a lower risk of developing chronic diseases such as asthma and allergies later in childhood (Ramadhani & Juniastuti, 2021). Breast milk helps establish immune tolerance and modulates adaptive immune responses. Immunity against bacterial and viral infections is strengthened by neutralizing antibodies and the activation of cytotoxic T cells (Munasir, 2016). Cytokines such as interleukin-4 and growth factors in breast milk further support the activation and differentiation of immune cells (Conlon & Bird, 2015; Widiatmaja et al., 2021). Maternal immunization also contributes to neonatal immunity through the placental transfer of IgG antibodies, offering protection against vaccine-preventable diseases (Omer et al., 2017). Thus, breastfeeding and maternal immunization are synergistic strategies for comprehensive infant immune defense from early life.

The Role of the Immune System in Pathogen Response

The human immune system has a fundamental ability to distinguish between self and non-self antigens, as well as to develop immunological memory, enabling a faster and stronger secondary immune response to previously encountered pathogens (Munasir, 2016). This function is executed through the coordination of innate and adaptive immune mechanisms, including physical barriers (skin, mucosa), chemical defenses (enzymes, pH), symbiosis with normal flora, and both humoral and cellular responses. The immune response to bacterial pathogens is categorized based on their nature, extracellular or intracellular bacteria, each of which triggers specific immune mechanisms such as phagocyte activation (neutrophils and macrophages) and antibody production (Munasir, 2016). In contrast, during viral infections, the adaptive immune system is more dominant, particularly involving neutralizing antibodies and cytotoxic T cells that identify and destroy infected cells.

Immunological Components of Breast Milk in Neonatal Protection

Breast milk is known to be rich in bioactive components that play a crucial role in establishing immune defenses in infants. Key components such as lactoferrin, lysozyme, and secretory immunoglobulin A (sIgA) function to prevent pathogen colonization in the infant's gastrointestinal tract by forming a protective barrier that inhibits microbial adhesion and invasion (Supit, 2021). sIgA, the dominant antibody in breast milk, plays a central role in neutralizing viruses and bacteria without eliciting harmful inflammatory responses. In addition, breast milk contains immunomodulatory molecules such as interferons, prostaglandins, and oligosaccharides with antiviral and anti-inflammatory activities (Ciobanu et al., 2020). These components work synergistically to enhance the infant's resistance to respiratory tract infections and diarrhea, which are commonly found among neonates, especially in developing countries (Rahardjani, 2016).

Short and Long-Term Protective Effects of Breast Milk

The protection conferred by breast milk extends beyond acute infections and is strongly associated with a reduced risk of chronic conditions such as allergies and asthma during childhood (Ramadhani et al., 2021). One severe condition that can be prevented through breastfeeding is neonatal sepsis, a result of the neonate's immune system failing to eliminate bacteria from the bloodstream. This can be mitigated by passive immune transfer via breast milk (Rahardjani, 2016). A study by (Bambang et al., 2016) further confirmed that breast milk serves as an effective early nutritional intervention to prevent severe morbidity caused by systemic infections. These findings reinforce the importance of exclusive breastfeeding as a public health strategy to reduce the incidence of infectious diseases and improve neonatal survival rates, particularly in regions with limited access to healthcare services.

Factors Affecting the Immunological Composition of Breast Milk

The immunological quality of breast milk varies significantly depending on maternal factors, including nutritional status, general health, and environmental living conditions. Adequate maternal nutrition forms the essential basis for the production of functional immune components in breast milk. Psychological stress, chronic illnesses, and the use of certain medications can alter the immune profile of breast milk, potentially compromising its protective efficacy for the infant. A study by (Zeng et al., 2016) highlighted the need for further research into the specific roles of bioactive molecules in breast milk in modulating the infant's innate and adaptive immune systems. Such research could contribute to the development of evidence-based nutritional intervention policies.

Psychosocial Influences and Breastfeeding Practices on Breast Milk Quality

Maternal psychosocial conditions, such as stress and anxiety, have also been shown to influence the levels of immunomodulatory components in breast milk. Thus, comprehensive psychosocial support for breastfeeding mothers is essential (Veniawati et al., 2020). Support from family, healthcare providers, and education on proper breastfeeding practices plays a critical role in maintaining the quality of breast milk. Mothers with higher parity levels generally demonstrate better infant care skills, including effective breastfeeding practices. This suggests that previous breastfeeding experience serves as a learning process that enhances a mother's ability to provide optimal care for her baby, including supporting the immunological benefits of breast milk.

Table 1. Summary of the Role of Breast Milk in Infant Immunity and Development Based on Literature Review

Aspect	Journey/Process	Reference
Immunological Components of Breast Milk	Breast milk contains lactoferrin, lysozyme, IgA, macrophages, cytokines, HMOs, etc.	(Conlon & Bird, 2015; Syofyanengsih et al., 2022)
The Journey of Infant Immunity	Innate immunity is active from birth, while adaptive immunity develops gradually with the help of breast milk.	(Kulinich et al., 2016; Munasir, 2016)
Protection against Infection	Bioactive components form a barrier against bacteria, viruses, and parasites.	(Ciobanu et al., 2020; Supit, 2021)
The Role of Breast Milk in Preventing	Stunting Breast milk maintains nutritional status → reduces infection → prevents chronic inflammation → prevents stunting	(Verawati et al., 2021; Yuda et al., 2022)
Maternal Factors Affecting Breast Milk	Nutrition, stress, maternal age, and the environment influence breast milk quality.	(Baharuddin & Kongkoli, 2023; Purnamasari et al., 2023)
Gut Microbiota and HMOs	HMOs, as prebiotics, support healthy microbiota colonies → a mature mucosal immune system.	(Mason et al., 2014; Syukur & Harismayanti, 2020)

Aspect	Journey/Process	Reference
Passive Immune Transfer (IgG, IgA))	IgG is transferred through the placenta, IgA through breast milk → passive immunity in early life.	(Omer, 2017; Supit, 2021)
The Role of Maternal Education	Breastfeeding education → increases exclusive breastfeeding practices	(Fitriami & Galaresa, 2022; Veniawati et al., 2020)
The First 1000 Days of Life	Sensitive period, optimal nutrition, and breastfeeding → prevents growth and developmental disorders and stunting	(Asrawaty et al., 2022; Nenabu et al., 2023)

Conclusion

Breast milk contains lactoferrin, lysozyme, IgA, macrophages, cytokines, HMOs, etc. Innate immunity is active from birth, while adaptive immunity develops gradually with the help of breast milk. Bioactive components form a barrier against bacteria, viruses, and parasites. Breast milk maintains nutritional status, thereby reducing infection, preventing chronic inflammation, and preventing stunting. Maternal Nutrition, stress, maternal age, and the environment affect the quality of breast milk. HMOs, as prebiotics, support the growth healthy microbiota colonies, so that the mucosal immune system matures. Passive Immune Transfer (IgG, IgA) is transferred through the placenta, and IgA through breast milk provides passive immunity early in life. Education about breastfeeding → increases the practice of exclusive breastfeeding. Sensitive periods, optimal nutrition, and breast milk → prevent growth and development disorders and stunting.

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Author Contributions
Pauzan was responsible for the entire research process, including conceptualization, methodology, data collection and management, drafting the original manuscript, editing, as well as supervision and project administration. The entire content of the article has been approved for publication. Corresponding author: ozanfauzan552@gmail.com

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The author declares no conflict of interest.

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