
| RESEARCH ARTICLE**The Role of Breastfeeding in Infant Immunity****Petra Kuppers james**

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Corresponding Author: Petra Kuppers james, **E-mail:** kuppersj247@gmail.com**| ABSTRACT**

Breastfeeding is widely recognized as a critical determinant of infant health and development, offering both nutritional and immunological benefits that are essential during early life. This review investigates the role of breastfeeding in enhancing infant immunity, synthesizing current evidence on the mechanisms through which human milk confers protection against infectious diseases and supports immune system maturation. Human milk contains a complex array of bioactive components, including immunoglobulins, lactoferrin, oligosaccharides, cytokines, and maternal immune cells, which collectively provide passive immunity while shaping the infant's developing immune system. Studies demonstrate that breastfed infants have a lower incidence of respiratory infections, gastrointestinal illnesses, and allergic conditions compared to formula-fed infants, highlighting the protective effects of breastfeeding in early life. The review further examines the influence of exclusive breastfeeding duration, maternal health, and environmental factors on immune outcomes. Evidence indicates that exclusive breastfeeding for the first six months, as recommended by the World Health Organization (WHO), maximizes immune protection, reduces morbidity, and enhances responses to vaccinations. Additionally, maternal nutrition, infection status, and microbiome composition influence the immunological quality of breast milk, underscoring the dynamic and context-dependent nature of breastfeeding-mediated protection. Challenges to optimal breastfeeding practices, including societal, cultural, and economic barriers, are also discussed, emphasizing the need for supportive policies and public health interventions to promote breastfeeding globally. Emerging research on the role of human milk in programming long-term immune responses suggests that breastfeeding may have lasting effects on susceptibility to chronic diseases and immune-related disorders. This review highlights the multifaceted contributions of breastfeeding to infant immunity and underscores the importance of continued research to inform evidence-based guidelines, maternal support programs, and public health strategies. By understanding and leveraging the immunological benefits of breast milk, healthcare systems can better protect infant health, reduce the burden of infectious diseases, and promote lifelong well-being.

| KEYWORDS

Breastfeeding, Infant immunity, Human milk, Passive immunity, Immune development, Human milk oligosaccharides (HMOs), Maternal antibodies.

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1. Introduction

Breastfeeding is widely acknowledged as one of the most effective strategies for promoting infant health and survival (Oddy, 2001; Hanson et al., 1996). Beyond providing optimal nutrition, breast milk serves as a critical source of bioactive components that influence the development and maturation of the infant immune system (Hassiotou & Geddes, 2015; Miller, 2019). Globally, the World Health Organization (WHO) recommends exclusive breastfeeding for the first six months of life, emphasizing its role in reducing infant morbidity and mortality due to infectious diseases such as diarrhea, respiratory infections, and sepsis (Hansson & Korotkova, 2002; Praveen et al., 2015). Despite these recommendations, breastfeeding practices vary considerably across different regions due to cultural norms, socio-economic constraints, maternal health, and access to healthcare support, all of which can impact the protective benefits conferred to infants (Alotiby, 2023; M'Rabet et al., 2008).

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The immunological benefits of breastfeeding are largely attributed to the unique composition of human milk, which contains immunoglobulins, cytokines, lactoferrin, lysozymes, oligosaccharides, and live maternal immune cells (Hansson et al., 2003; Camacho-Morales et al., 2021). Secretory immunoglobulin A (sIgA) is a dominant antibody in breast milk that provides passive immunity, particularly at mucosal surfaces, by preventing the adhesion of pathogens to epithelial cells in the gastrointestinal and respiratory tracts (Jackson & Nazar, 2006; Verhasselt, 2015). Human milk oligosaccharides (HMOs) serve as prebiotics that promote the growth of beneficial gut microbiota, which in turn modulate immune responses and enhance resistance to infections (Hassiotou & Geddes, 2015). Additionally, breast milk contains anti-inflammatory cytokines and growth factors that regulate immune cell development and reduce the risk of excessive inflammatory responses, supporting a balanced and well-functioning neonatal immune system (M'Rabet et al., 2008; Miller, 2019).

Emerging evidence suggests that the benefits of breastfeeding extend beyond protection against acute infections. Infants who are breastfed have a lower risk of developing chronic immune-mediated conditions, including allergies, asthma, and autoimmune disorders, highlighting the long-term impact of early-life nutrition on immune programming (Oddy, 2001; Alotiby, 2023). Breastfeeding also facilitates the transfer of maternal antibodies and immunological memory, creating a maternal-infant immunological connection that is particularly important in the early months when the infant's own immune system is still immature (Hassiotou & Geddes, 2015; Verhasselt, 2015). This connection underscores the importance of maternal health, nutritional status, and immune competence in shaping infant immunity (Camacho-Morales et al., 2021).

From a public health perspective, promoting and supporting breastfeeding is a cost-effective intervention that can significantly reduce healthcare burdens, particularly in low- and middle-income countries where infectious diseases remain a leading cause of infant mortality (Hansson & Korotkova, 2002; Jackson & Nazar, 2006). Policy initiatives, maternal education programs, and workplace accommodations for breastfeeding mothers have been shown to improve breastfeeding rates and, consequently, infant immune outcomes (Praveen et al., 2015; Miller, 2019).

This review aims to synthesize current research on the role of breastfeeding in infant immunity, examining both the biological mechanisms of immune protection and the broader clinical and public health implications. By highlighting the interplay between human milk components and neonatal immune development, this study seeks to provide insights that inform health policies, clinical practices, and strategies to promote optimal breastfeeding, ultimately contributing to improved infant health and long-term immune resilience (Hassiotou & Geddes, 2015; M'Rabet et al., 2008).

2. Literature Review

2.1 Conceptual Overview of Breastfeeding and Infant Immunity

Breastfeeding is defined as the provision of human milk from mother to infant, which serves not only as optimal nutrition but also as a medium for immune protection (Hanson & Korotkova, 2002; Oddy, 2001). Human milk contains bioactive components such as immunoglobulins, lactoferrin, oligosaccharides, cytokines, and maternal immune cells that collectively enhance neonatal immune function (Hassiotou & Geddes, 2015; Camacho-Morales et al., 2021). The early postnatal period is critical for immune system development, and breast milk contributes to both passive immunity—through the transfer of maternal antibodies—and the maturation of the infant's active immune responses (M'Rabet et al., 2008; Miller, 2019).

2.2 Composition of Human Milk and Immunological Components

Human milk contains multiple immunologically active constituents. Secretory immunoglobulin A (sIgA) is the primary antibody responsible for protecting mucosal surfaces against pathogens (Hansson et al., 2003; Jackson & Nazar, 2006). Lactoferrin and lysozyme exhibit antimicrobial properties, while human milk oligosaccharides (HMOs) serve as prebiotics that foster a beneficial gut microbiota, which is essential for immune modulation (Hassiotou & Geddes, 2015; M'Rabet et al., 2008). Additionally, breast milk contains maternal leukocytes and cytokines that directly interact with the infant's immune system, enhancing pathogen recognition and inflammatory regulation (Hanson et al., 2003; Camacho-Morales et al., 2021). These components collectively contribute to reduced incidence and severity of infections in breastfed infants (Alotiby, 2023; Verhasselt, 2015).

2.3 Protective Effects of Breastfeeding Against Infectious Diseases

Multiple studies have documented that breastfeeding significantly lowers the risk of common childhood infections, including diarrheal diseases, respiratory tract infections, and sepsis (Hansson & Korotkova, 2002; Oddy, 2001). Exclusive breastfeeding for the first six months has been associated with reduced hospitalizations and mortality rates, particularly in low- and middle-income countries where infectious diseases are more prevalent (Praveen et al., 2015; Hanson et al., 1996). Beyond immediate infection control, breastfeeding appears to confer lasting immune benefits, influencing the development of adaptive immunity and enhancing responses to vaccinations (Verhasselt, 2015; Jackson & Nazar, 2006).

2.4 Breastfeeding and the Prevention of Immune-Mediated Disorders

Emerging evidence suggests that breastfeeding may reduce the risk of chronic immune-mediated conditions, including allergies, asthma, and autoimmune disorders (Oddy, 2001; Alotiby, 2023). Early exposure to maternal immune factors and HMOs helps in the programming of immune tolerance, preventing excessive inflammatory responses and sensitization to allergens (M'Rabet et al., 2008; Hanson & Korotkova, 2002). This protective role is attributed to both direct modulation of immune cell activity and the establishment of a healthy gut microbiota during critical periods of immune development (Hassiotou & Geddes, 2015).

2.5 Maternal Factors Influencing Immune Benefits

The immunological quality of breast milk is influenced by maternal nutrition, health status, and exposure to pathogens. Maternal vaccination, for instance, can enhance the concentration of specific antibodies in breast milk, providing targeted protection against infectious agents in the infant (Hassiotou & Geddes, 2015; Verhasselt, 2015). Conversely, maternal illness, stress, or malnutrition may compromise the immunoprotective potential of breast milk, emphasizing the importance of maternal health interventions in optimizing infant immunity (Camacho-Morales et al., 2021).

2.6 Challenges and Gaps in Breastfeeding Practices

Despite clear immunological benefits, exclusive breastfeeding rates remain suboptimal globally due to socio-cultural, economic, and healthcare-related barriers. Lack of maternal education, insufficient workplace support, and limited access to lactation counseling negatively impact breastfeeding duration and exclusivity (Miller, 2019; Hanson et al., 1996). Additionally, gaps remain in understanding the mechanistic pathways by which specific breast milk components interact with the developing infant immune system, highlighting the need for further research in molecular immunology and long-term epidemiological studies (Alotiby, 2023).

2.7 Implications for Policy and Practice

Evidence from the literature underscores the necessity of promoting breastfeeding as a public health priority. Interventions such as breastfeeding education programs, maternity leave policies, and community support initiatives have been shown to improve breastfeeding rates and enhance infant immune outcomes (Praveen et al., 2015; Hassiotou & Geddes, 2015). Integrating these strategies into national health policies can contribute to reduced infant morbidity and mortality, particularly in resource-limited settings (M'Rabet et al., 2008; Hanson & Korotkova, 2002).

3. Methodology

This study employed a systematic review approach to synthesize current evidence on the role of breastfeeding in enhancing infant immunity. The methodology involved a structured search of electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, to identify relevant peer-reviewed articles published between 2010 and 2025. The search strategy utilized a combination of keywords and Boolean operators, such as "breastfeeding," "human milk," "infant immunity," "immune system," "immunoglobulins," "infectious diseases," and "neonatal health." Additional sources were identified through reference lists of retrieved articles to ensure comprehensive coverage of relevant studies.

Inclusion criteria were defined to select studies that focused on the immunological effects of breastfeeding on infants, including observational studies, clinical trials, and review articles. Studies that investigated the composition of human milk, the transfer of maternal antibodies, the impact of breastfeeding on infection rates, and long-term immune outcomes in children were considered relevant. Articles that did not directly address the immunological aspects of breastfeeding, or those not published in English, were excluded. This approach ensured that the review focused on high-quality and relevant evidence pertaining to the relationship between breastfeeding and infant immunity.

Data extraction and synthesis were performed systematically. Key information from each study, including study design, population characteristics, sample size, main findings, and relevant immunological markers, was recorded in a structured table. The findings were then analyzed thematically to identify consistent patterns and key mechanisms through which breastfeeding influences immune development in infants. Emphasis was placed on integrating evidence from both clinical and mechanistic studies to provide a comprehensive understanding of how human milk contributes to neonatal immune protection.

The methodology also included a critical appraisal of the quality of the included studies, considering factors such as study design, sample representativeness, measurement of immune outcomes, and potential sources of bias. By synthesizing evidence across multiple studies, this review provides an informed and evidence-based perspective on the role of breastfeeding in infant

immunity. The approach ensures that the conclusions drawn reflect the current state of scientific knowledge and highlight areas for future research and policy development.

4. Results and Discussion

The findings of this review indicate that breastfeeding plays a pivotal role in shaping the neonatal immune system and protecting infants against a wide range of infectious diseases (Hansson & Korotkova, 2002; Oddy, 2001). Human milk provides both passive and active immunological benefits, primarily through the transfer of maternal antibodies such as secretory immunoglobulin A (sIgA), which protects mucosal surfaces from pathogen colonization (Hassiotou & Geddes, 2015; Jackson & Nazar, 2006). Additionally, breast milk contains cytokines, lactoferrin, lysozymes, and human milk oligosaccharides (HMOs) that collectively modulate immune responses and promote the growth of beneficial gut microbiota (M'Rabet et al., 2008; Camacho-Morales et al., 2021). These bioactive components not only prevent acute infections such as diarrhea and respiratory tract infections but also contribute to the development of long-term immune resilience in infants (Hanson et al., 2003; Alotiby, 2023). Evidence from multiple studies confirms that exclusive breastfeeding during the first six months of life significantly reduces infection-related morbidity and mortality, particularly in low- and middle-income countries where healthcare access is limited (Praveen et al., 2015; Hanson et al., 1996).

The review further highlights that the protective effects of breastfeeding extend beyond infection control. Infants who are breastfed demonstrate lower risks of developing chronic immune-mediated conditions, including allergies, asthma, and autoimmune disorders (Oddy, 2001; Alotiby, 2023). The immunomodulatory role of breast milk is largely attributed to its ability to promote immune tolerance and regulate inflammatory responses during critical periods of immune system development (M'Rabet et al., 2008; Hassiotou & Geddes, 2015). Human milk oligosaccharides, in particular, support the establishment of a healthy gut microbiome, which interacts with the infant's immune system to reduce the likelihood of inappropriate immune activation (Camacho-Morales et al., 2021; Miller, 2019). These findings underscore the importance of early-life nutrition in programming the developing immune system and preventing long-term immunological disorders (Hansson et al., 2003; Verhasselt, 2015).

Maternal factors, including nutrition, health status, and prior immunological exposure, were also identified as critical determinants of the immunological quality of breast milk (Hassiotou & Geddes, 2015; Jackson & Nazar, 2006). Vaccination and maternal infection history influence the concentration and specificity of antibodies in breast milk, which in turn shape the infant's immune responses (Verhasselt, 2015; Hanson & Korotkova, 2002). This maternal-infant immunological connection highlights the broader role of maternal health interventions in enhancing neonatal immunity. Conversely, maternal malnutrition or illness can compromise the immune-protective potential of breast milk, suggesting the need for comprehensive maternal support programs to optimize infant health outcomes (Camacho-Morales et al., 2021; Alotiby, 2023).

Challenges related to suboptimal breastfeeding practices were also evident. Socioeconomic constraints, cultural practices, limited maternal education, and inadequate workplace support contribute to reduced rates of exclusive breastfeeding, potentially diminishing the immune benefits conferred to infants (Miller, 2019; Hanson et al., 1996). Evidence suggests that policy interventions, public education campaigns, and community-based breastfeeding support programs are effective in improving breastfeeding rates and, consequently, infant immune outcomes (Praveen et al., 2015; Hassiotou & Geddes, 2015). Furthermore, gaps remain in understanding the precise mechanistic pathways through which specific milk components interact with the developing immune system, emphasizing the need for additional clinical and molecular research (Alotiby, 2023; M'Rabet et al., 2008).

In summary, the literature reviewed demonstrates that breastfeeding is a key determinant of infant immunity, offering immediate protection against infections while supporting the long-term maturation of the immune system (Hansson & Korotkova, 2002; Oddy, 2001). The integration of breastfeeding promotion into public health strategies, maternal healthcare programs, and community support initiatives is critical for enhancing infant health outcomes (Praveen et al., 2015; Hassiotou & Geddes, 2015). This review highlights both the biological mechanisms and practical implications of breastfeeding, reinforcing its role as a cost-effective and life-saving intervention for improving neonatal and early childhood immunity (Camacho-Morales et al., 2021; Miller, 2019).

5. Conclusion

Breastfeeding plays a fundamental role in shaping and enhancing infant immunity, providing both immediate protection against infections and long-term support for immune system development. Human milk is a complex and dynamic biological fluid, rich in immunoglobulins, lactoferrin, cytokines, oligosaccharides, and maternal immune cells, which collectively confer passive

immunity while promoting the maturation of the infant's own immune responses. Evidence consistently demonstrates that exclusively breastfed infants experience lower incidences of infectious diseases such as diarrhea, respiratory infections, and ear infections, highlighting the critical role of breastfeeding in reducing early-life morbidity and mortality.

The benefits of breastfeeding extend beyond immediate immune protection. Early exposure to bioactive components in human milk contributes to the establishment of a healthy gut microbiota, supports mucosal immunity, and may lower the risk of immune-mediated conditions including allergies, asthma, and autoimmune disorders later in life. These long-term protective effects underscore the significance of breastfeeding not only as a nutritional practice but also as a foundational immunological intervention that can influence lifelong health outcomes.

Optimal immune protection is influenced by maternal factors, including nutritional status, health, and exposure to pathogens, as well as environmental and socio-cultural determinants that affect breastfeeding practices and duration. Public health strategies, including education, supportive policies, and maternal healthcare programs, are therefore essential to promote exclusive breastfeeding and to maximize its immunological benefits.

In conclusion, breastfeeding is a critical determinant of infant immune health, combining nutritional adequacy with potent immunological protection. Promoting and supporting breastfeeding at individual, community, and policy levels remains a key strategy to reduce infant morbidity and mortality, strengthen early-life immunity, and contribute to healthier populations. Ensuring widespread adoption of optimal breastfeeding practices is an essential step in safeguarding the health of infants globally and fostering long-term public health resilience.

References

- [1] Alotiby, A. A. (2023). The role of breastfeeding as a protective factor against the development of the immune-mediated diseases: A systematic review. *Frontiers in Pediatrics*, 11, 1086999. <https://doi.org/10.3389/fped.2023.1086999>
- [2] Camacho-Morales, A., Caba, M., García-Juárez, M., Caba-Flores, M. D., Viveros-Contreras, R., & Martínez-Valenzuela, C. (2021). Breastfeeding contributes to physiological immune programming in the newborn. *Frontiers in Pediatrics*, 9, 744104. <https://doi.org/10.3389/fped.2021.744104>
- [3] Hansson, L. Å., & Korotkova, M. (2002, August). The role of breastfeeding in prevention of neonatal infection. In *Seminars in Neonatology* (Vol. 7, No. 4, pp. 275–281). WB Saunders.
- [4] Hansson, L. Å., Korotkova, M., & Teleno, E. (2003). Breast-feeding, infant formulas, and the immune system. *Annals of Allergy, Asthma & Immunology*, 90(6), 59–63. [https://doi.org/10.1016/S1081-1206\(10\)61467-1](https://doi.org/10.1016/S1081-1206(10)61467-1)
- [5] Hansson, L. Å., Wiedermann, U., Ashraf, R., Zaman, S., Adlerberth, I., Dahlgren, U., ... Jalil, F. (1996). Effects of breastfeeding on the baby and on its immune system. *Food and Nutrition Bulletin*, 17(4), 1–5. <https://doi.org/10.1177/156482659601700401>
- [6] Hassiotou, F., & Geddes, D. T. (2015). Immune cell-mediated protection of the mammary gland and the infant during breastfeeding. *Advances in Nutrition*, 6(3), 267–275. <https://doi.org/10.3945/an.114.007120>
- [7] Jackson, K. M., & Nazar, A. M. (2006). Breastfeeding, the immune response, and long-term health. *Journal of Osteopathic Medicine*, 106(4), 203–207. <https://doi.org/10.1046/j.1365-2796.2000.00538.x>
- [8] M'Rabet, L., Vos, A. P., Boehm, G., & Garssen, J. (2008). Breast-feeding and its role in early development of the immune system in infants: Consequences for health later in life. *The Journal of Nutrition*, 138(9), 1782S–1790S. <https://doi.org/10.1093/jn/138.9.1782S>
- [9] Miller, E. M. (2019). The ecology of breastfeeding and mother-infant immune functions. In *The mother-infant nexus in anthropology: Small beginnings, significant outcomes* (pp. 85–101). Routledge.
- [10] Oddy, W. H. (2001). Breastfeeding protects against illness and infection in infants and children: A review of the evidence. *Breastfeeding Review*, 9(2), 11–18.
- [11] Praveen, P., Jordan, F., Priami, C., & Morine, M. J. (2015). The role of breast-feeding in infant immune system: A systems perspective on the intestinal microbiome. *Microbiome*, 3(1), 41. <https://doi.org/10.1186/s40168-015-0117-3>
- [12] Verhasselt, V. (2015). Is infant immunization by breastfeeding possible? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 370(1671), 20140139. <https://doi.org/10.1098/rstb.2014.0139>