Amerta Nutrition
e-ISSN: 2580-1163 (Online)
p-ISSN: 2580-9776 (Print)
Pelangi et al. | Amerta Nutrition Vol. 9 Issue 4 (December 2025). 722-734

LITERATURE REVIEW
English Version
OPEN ACCESS

Breastfeeding as Protective Nutrition: The Immunological Foundation for Infants

Pemberian ASI Sebagai Gizi Pelindung: Aspek Imunologi Bayi

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ARTICLE INFO

Received: *20-12-2024*
Accepted: *04-08-2025*
Published online: *21-11-2025*

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DOI:
10.20473/amnt.v9i4.2025.722-734

Available online at:
https://e-journal.unair.ac.id/AMNT

Keywords:
Breastfeeding, Immunological foundation, Protective nutrition, Infant health, Maternal health

ABSTRACT

Background: Breastfeeding, a crucial foundation for infant health, provides essential protective nutrition and a complex array of immune-protective factors. Breastfeeding as a natural, protective, and ethical practice is very important to support the health of infants and, by extension, the health of future generations.
Objectives: The author emphasizes the biological components of breast milk as physiological protection for infant immunity and highlights the importance of breastfeeding promotion and protection within ideological and cultural contexts.
Methods: A comprehensive literature review was performed using online database from Google Scholar to explore the immunological foundation of breastfeeding from original research articles published in recent 5 years.
Discussions: Maternal health and maternal immunity are transferred to the infant through breast milk, providing a temporary but significant shield against pathogens. Ethical and philosophical dimensions of breastfeeding as an intrinsic maternal practice that extends beyond nutrition to embody intergenerational health protection.
Conclusions: The role of breastfeeding as a natural, protective, and ethical practice is very important to support the health of infants and, by extension, the health of future generations. Philosophically and theoretically grounded strategies are effective in enhancing exclusive breastfeeding rates, particularly in treatments focused on breastfeeding education, empowerment, and counselling. Assistance in the initial days and weeks following delivery is crucial, as this timeframe is critical for the effective establishment of lactation.

INTRODUCTION

The neonatus comparatively fully equipped to establish early immune defences against pathogens and prevent overshooting immune responses from the initial colonisation of commensal microbiota. However, the immune defences of neonates are delicate during the early stages of life, rendering them susceptible to infections. This poses a substantial threat to their future health and survival[1]. In neonatal biology and medicine, the prevailing concept that healthy neonates are inherently susceptible to infection-causing microorganisms is deeply ingrained. The highest incidence of infections observed early in life is typically attributed to immature immune responses during the postnatal transition period. As the gestational age at birth decreases in preterm neonates, the risk of infection is elevated as a result of the reduced barrier defences and the elevated levels of immune immaturity[2]. The placenta has a significant impact on foetal growth and development by vertically transferring growth factors, nutrients, oxygen, pathogen-specific antibodies, and immune cells through the maternal circulation to the foetus to support early life immunity[1]. For the infant's development, breast milk supplies an assortment of immunomodulatory components and adaptive nutritional requirements[3]. Research has demonstrated that the consumption of breastmilk provides a variety of benefits. This study investigates the mechanism by which maternal immunity is transmitted to the neonate through breast milk, thereby establishing a temporary but substantial barrier against pathogens. This process involves the transfer of various immune components, including immunoglobulins, cell-free DNA, and other bioactive molecules, which collectively enhance the neonate's immune defenses. These components not only protect against infections but also play a crucial role in shaping the neonatal immune system and microbiota[4]. Breastfeeding provides a configuration advantage for women's health, enhancing infant development, sustainable environmental practices, and national productivity[5]. Additionally, breastfeeding is associated with a decreased risk of infections, infant mortality,

How to cite: *Pelangi, B., Wasito, E., Sitorus, N., & Shella, S. (2025). Breastfeeding as Protective Nutrition: The Immunological Foundation for Infants: Pemberian ASI Sebagai Gizi Pelindung: Aspek Imunologi Bayi. Amerta Nutrition, 9(4), 722–734.*

sudden infant death syndrome, dental malocclusion, obesity in adulthood, increased intelligence, and a reduction in primary malnutrition, particularly in regions impacted by poverty, unhealthy conditions, and food insecurity. The mechanisms underlying these benefits are complex and multifaceted, involving nutritional, immunological, and developmental factors[4]. Variety factors may influence the effectiveness of lactation, such as social and cultural influences[6]. This manuscript offers a thorough examination of the specific immunological advantages of breastfeeding, emphasising the biological aspects that contribute to infant immunity and portraying breastfeeding as a philosophical and physiological act of protection.This study aims to emphasizes the biological components of breast milk as physiological protection for infant immunity and highlights the importance of breastfeeding promotion and protection within ideological and cultural contexts.

METHODS

The literature search was conducted in November 2024. The research process commences with the establishment of research questions and objectives, the review of the available literature, the application of inclusion and exclusion criteria, the extraction of data, and data analysis. The following keywords were utilized to conduct a literature search on Google Scholar: (Breastfeeding) OR (Breast Milk), (Immunity) OR (Antibody), (Protective Nutrition), (Maternal Health) OR (Mother Health), (Infant Health) OR (Newborn Health), and (Immunological Foundation).

Using the following inclusion criteria, titles and abstracts were screened: (1) studies that involved mothers and children; (2) studies that assessed the immunity aspects of breastfeeding; (3) studies that employed big data analytics; (4) original research articles such as cohort/longitudinal, cross sectional, and case-control study; (5) articles that were accessible for review; and (6) articles published between 2020 and 2024. Articles published prior to 2020 and those published in a language other than English were excluded from the titles. In order to offer a thorough summary of the research findings, the selected articles were reviewed in a non-systematic, textual manner using manual reading and thoroughly review to ensure they provided data relevant to the objectives of this analysis. This review method has the potential to incorporate a variety of perspectives from the articles that were obtained, thereby reducing the likelihood of overlooking significant insights. The lack of a systematic process may also increase the risk of bias, as it's easier to unintentionally emphasize certain studies over others or overlook relevant sources. We already balancing inclusivity of perspectives with rigorous evaluation to ensure that this review remains credible and insightful.

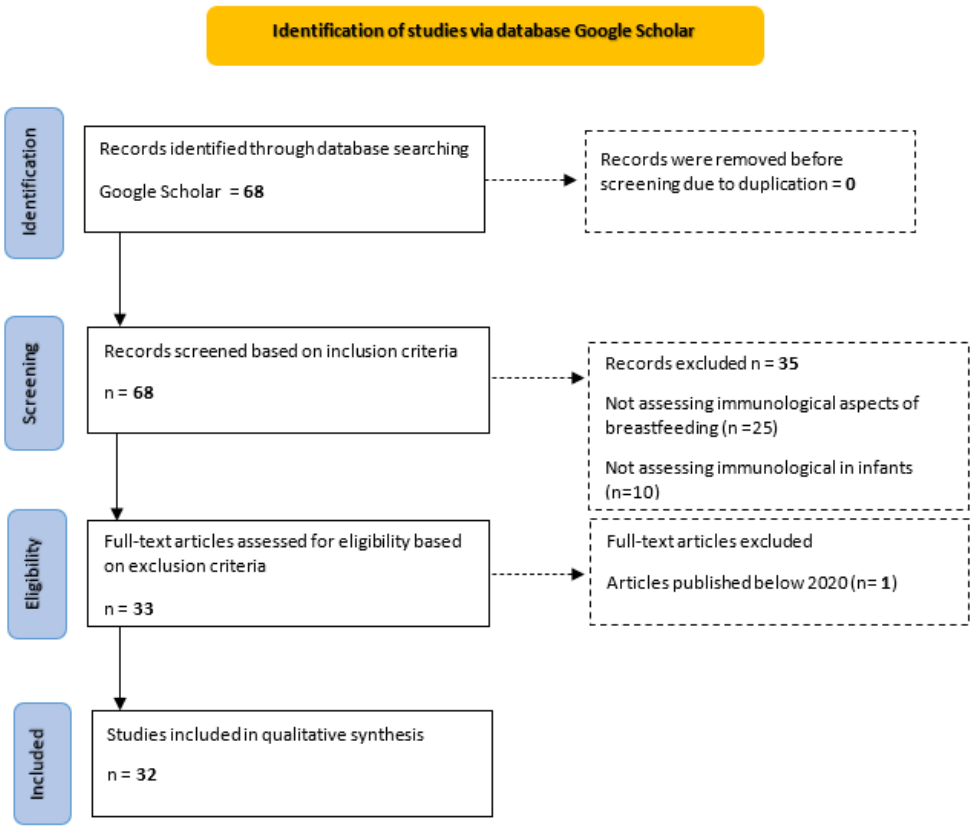

Figure 1. Flow chart of study selection

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DISCUSSIONS

Immunology Concept of Breastfeeding

Breast milk plays a critical role in supporting the infant during the postnatal maturation of the immune system by promoting its development and delivering a range of antimicrobial and anti-inflammatory constituents. A diverse array of bioactive components present in breast milk—such as enzymes, hormones, growth factors, lactoferrin, cytokines, immune cells, and various immunomodulatory molecules—actively contributes to the stimulation and regulation of the neonate's immune defenses[7].

Immunological Components of Breast Milk

Antibodies

Breast milk serves not only as a vital nutritional source but also significantly contributes to the maturation of the infant's immune system, owing to its rich composition of immunological constituents. These include various immune cells—such as macrophages, neutrophils, T lymphocytes, stem cells, and other lymphocytes—as well as a range of immune-related proteins, including lysozymes, specialized antimicrobial agents, diverse cytokines, and multiple classes of immunoglobulins (Ig), such as IgM, IgG, secretory IgG, and secretory IgA (sIgA), all of which play crucial roles in establishing neonatal immune protection[7]. The establishment of the infant's immune defenses during the early months of life is supported by both prenatal and postnatal maternal antibody transfer. During gestation, antibodies are conveyed to the fetus via the placenta, while after birth, additional immunological protection is provided through breast milk. Secretory immunoglobulin A (sIgA), the predominant antibody in breast milk, functions by neutralizing enteric pathogens, thereby contributing to the maintenance of a balanced gut microbiota and enhancing mucosal immunity within the intestinal tract[8]. Secretory IgA and lactoferrin play a protective role by inhibiting the adhesion of pathogens to the intestinal epithelium, whereas lysozyme exerts its antimicrobial effect through the direct lysis of bacterial cell walls[7].

Cytokines

Cytokines, small soluble glycoproteins that function by adhering to specific cellular receptors, are one of the mature immune components, in addition to lysozyme and antibodies. They regulate the development and function of the immune system. TGF-β (Transforming growth factor-β) is a cytokine that is present in human milk and has the potential to contribute to the maturation and development of the mucosal immune system of the neonate[7]. Cytokines are crucial during embryonic development due to their ability to both initiate and suppress inflammatory responses. Cytokines play a crucial role in disease pathogenesis, facilitating cell interactions, altering cognitive functioning, mediating senescence, responding to infectious and inflammatory stimuli, eliciting specific immune responses to antigens and viruses, and guiding stem cell differentiation. They are mostly generated by immune system cells, including monocytes, macrophages, lymphocytes, neutrophils, B cells, and T cells[9]. Research indicates that TGF-β may be a critical immunoregulatory component in the establishment of this immune response, as it facilitates the induction of oral tolerance and promotes the production of IgA. The infant's immune system initially relies on the innate immune defences of the intestines, which are further bolstered by the bioactive components found in breast milk, as it progressively matures[7].

Lactoferrin (LF)

Lactoferrin is a glycoprotein that binds iron, thereby diminishing its accessibility to pathogens and inhibiting their adhesion to the gut membrane[7]. Colostrum includes seven times more lactoferrin, an iron-binding protein that facilitates the management of iron levels in the body, as indicated by its nomenclature (lacto + ferrin = milk + iron). Excessive iron can be harmful, as it transfers electrons to oxygen, leading to the generation of reactive oxygen species (ROS) such as hydroxyl radicals and superoxide anions[10]. Lactoferrin is an antimicrobial agent that demonstrates bactericidal properties against numerous pathogens and bacteriostatic effects against iron-dependent bacteria. This results from its strong affinity for iron. Lactoferrin also influences the generation and expression of many cytokines that affect the immune system[11]. Lactoferrin predominantly enters the colon as peptide fragments, exerting localised effects on the intestinal microbiota and the immune system of the mucosal layer. This promotes intestinal health, enhances food absorption, fortifies the immunological defence of all mucosal surfaces in the body, and regulates lipid metabolism. This not only enhances the regulation of satiety pathways but also mitigates the accumulation of fat tissue. LF is acknowledged for its capacity to enhance bone formation, maintain bone health, impede bone resorption, facilitate normal foetal tissue development, including ossification, ensure sufficient iron availability and absorption, protect against infection and inflammation, and confer advantages to both the mother and foetus[10].

Human Milk Oligosaccharides (HMO)

Human milk oligosaccharides (HMO) exist in over 150 distinct forms and are indigestible by the infant's underdeveloped intestines. Upon reaching the intestines, HMOs function locally by promoting the maturation of intestinal epithelial cells, safeguarding the lumen against pathogenic infections by enhancing the permeability of the intestinal barrier, and playing a crucial role in the intestinal microbiota by augmenting the diversity and viability of beneficial commensal bacteria. The most recognized effect of HMOs is their prebiotic influence on the infant's gut microbiota, which is initially formed at birth and is contingent upon the method of delivery[8]. The function of HMOs is to act as soluble decoy receptors that prevent pathogens such as viruses, bacteria, or protozoan parasites from binding to epithelial cell surface receptors. This helps to reduce the risk of infectious diseases happening. HMOs function as antimicrobials, serving as either bacteriostatic or bactericidal agents, and augment epithelial and host immune cell responses in newborns[12].

White Blood Cells

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A diverse array of immune cells derived from the mother's haematopoietic system is present in fresh breast milk. Myeloid cells are the most abundant, accounting for over 80% of the total leukocyte population, according to Laouar (2020). Lymphocytes, which make up less than 20% of the leukocyte population, and T cells, which make up approximately 80% of lymphocytes, follow in that order. Natural killer (NK) cells, NKT cells, and innate lymphoid cells (ILCs) immature granulocytes, regulatory T cells (Treg), and myeloid precursors are among the other categories of immune cells that are present in breast milk[13].

Mechanisms of Immune Transfer

Due to the ongoing development of their immune systems, infants are susceptible to viral infections due to their limited capacity to generate an effective antibody response[14]. Maternal antibodies (MatAbs) are important during the first year of life, as they are passively transmitted across the placenta and into breast milk, where they protect against infectious diseases and promote immune development[15]. The infant initially receives partial protection from maternal antibodies that are transmitted through the placenta. This is followed by protection from maternal secretory immunoglobulin A (IgA), secretory immunoglobulin M (IgM), and immunoglobulin G (IgG) that are transferred through lactation[14]. The placenta is the primary conduit through which the mother's immunoglobulin G (IgG) is transferred to human infants, with the transfer commencing in the 13th to 34th week of pregnancy. IgG levels in the foetal circulation are relatively modest from weeks 17 to 22 (5–10% of maternal levels), but they typically surpass the maternal plasma IgG levels at birth by week 32, reaching 50%. IgG is exclusively transferred through the consumption of IgG-rich colostrum after delivery and is absorbed into the body's circulation through the "open" intestine within the first few days of life[16]. The volume of secretory IgA in human milk is the highest, but the IgG in human milk is also believed to support antimicrobial defense processes during early infant development[14].

Breast milk and colostrum are significant sources of immunomodulators, such as chemokines, cytokines, and growth factors, that assist the infant's mucosal immune system in establishing appropriate reactivity. By influencing immune cell function and supporting mucosal barrier development, these elements are crucial during early life when microbial exposure is particularly high. and high antigenic and mitogenic stimuli[17]. There is a wide range of structural and molecular weight differences among the components of cytokines, which include chemokines, adipokines, interferons, interleukins, transforming growth factors, and tumour necrosis factors. The molecular weight of these components ranges from around 6 to 70 kilodaltons. In addition to their role as chemoattractant, chemokines play a role in the development of organogenesis, embryogenesis, and angiogenesis. They have the ability to cause inflammation and are thought to play a role in the development of diseases such as autoimmune responses, infections, and the growth of tumours[9]. The mammary gland epithelium and leukocytes release cytokines into colostrum or milk, with a small amount originating from the mother's bloodstream. TGF-β, one of the first cytokines to be identified in human colostrum, regulates the early development and regression of the mammary gland during weaning by modulating apoptosis in epithelial cells. The concentration of TGF-β2 in lacteal secretions decreases after birth, despite the fact that the overall amount remains elevated due to the increased volume of lacteal secretion. TGF-β2 forms the majority of TGF-β in lacteal secretions[17]. Colostrum contains the highest concentrations of TGF-β, which decrease considerably between 4-6 weeks of age. TGF-β2, which is one of the three TGF-β isoforms, is the most prevalent. TGF-β exhibits a broad spectrum of immunomodulatory functions. It promotes intestinal development and immune defense by inducing immunoglobulin class switching from IgM to IgA in B lymphocytes, enhances immunoglobulin synthesis within the mammary glands and infant gastrointestinal tract, supports the regeneration of intestinal mucosa, and fosters oral tolerance. Moreover, TGF-β modulates inflammatory responses by downregulating the expression of pro-inflammatory cytokines[18]. It plays a direct role in maintaining intestinal immune homeostasis by preventing hyperreactivity to commensal microbiota and accelerating intestinal barrier maturation through the differentiation and antigenic unresponsiveness of epithelial cells. Premature infants may experience additional advantages from oral TGF-β supplementation, despite the fact that TGF-β-induced intestinal barrier maturation is indispensable for all neonates. Nevertheless, TGF-β serves a dual function by inducing the local B cells to transition to secretory IgA production, a crucial step in safeguarding the infant from infection[17].

The combined activity of numerous cytokines (e.g., TNF-α, IL-17A, IL-1β, IL-6, IFN-γ, and CCL18) and chemokines (e.g., IL-8 and MCP-1) may aid in the establishment of a protective immune response in the mucosa, preventing tissue damage that is associated with uncontrolled inflammation. This is achieved by maintaining a balance between pro- and anti-inflammatory factors, which serves to reduce inflammation and safeguard the mammary glands from infection. The benefits of breastfeeding may be extended beyond weaning, the establishment of gut-associated lymphoid tissue and critical aspects of mucosal and systemic immunity is markedly enhanced by breast milk. This, in turn, enhances humoral and cellular immune responses in the breastfed child[17]. A well-balanced gut microbiome plays a critical role in the health of humans by manufacturing essential vitamins and amino acids, digesting food and fibre, and competing with pathobionts, thereby preventing potential infections. The composition of the infant's intestinal microbiome is also linked to a variety of subsequent outcomes, such as obesity, asthma, and coeliac disease[19]. Kartjito et al (2023) conducted a review that demonstrated the gut microbiota's significant influence on the development and homeostasis of barrier components, as well as the production of secreted mucin that is modulated by the gut microbiota. Mucin glycosylation processes, which are crucial for cellular communication and physiological protection, such as signal transduction and intercellular adhesion, can be disrupted by the presence of pathogenic

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microbes and a poor diet[20]. HMOs are classified as prebiotics due to their inability to be digested by neonates. Consequently, they are able to enter the intestines in their entirety and foster the proliferation of potentially advantageous bacteria, including Bifidobacterium spp. and the Bacteroides genus[20]. HMOs safeguard the infant's gut by promoting the colonisation of beneficial bacteria and acting as anti-adhesive antimicrobials by coating pathogens, preventing their attachment to epithelial surfaces, thereby reducing the risk of infection. Their similarity to the cell surface glycans used by *E. coli* and *Campylobacter jejuni* allows them to function as decoy receptors during the infection process[19].

Protective Benefits of Breastfeeding in Infant Immunity

IgA and IgG, which are passed down from mother to child through breast milk, have the ability to bind to pathogens such as bacteria, viruses, and toxins, thereby preventing the pathogens from attaching themselves to cells. Through its ability to engage on mucosal surfaces and neutralise germs, immunoglobulin A (IgA) provides protection against respiratory infections and diarrhoea. Lactoferrin, which is a glycoprotein that binds iron and may be found in breast milk, exhibits antimicrobial qualities. These properties include the ability to break the integrity of bacterial cell membranes, impede the growth of bacteria, and reduce the adhesion of pathogens. These chemicals protect neonates from common pathogens, notably those that cause respiratory infections and diarrhoea, by transferring passive immunity from the mother to the infant from the mother to the infant[21].

According to the findings of a study that was carried out by Branger and colleagues (2023), it was established that breastfeeding a baby exclusively is a preventive factor against respiratory infections, gastroenteritis, and otitis. Children who were breastfed for more than six months, either whole or in part, were found to have the most protective benefits associated with breastfeeding. On the other hand, the research did not give a substantial level of protection against infectious diseases in children who had been breastfed for less than six months or who had begun weaning themselves early. A primary level of protection against gastroenteritis was offered to children who were three months old or older, and a secondary level of protection against bronchiolitis was supplied after that. This suggests that breastfeeding is an effort to protect newborns from respiratory infections, otitis, and gastroenteritis, despite the fact that the experiment did not uncover any protective effects on a wider variety of infections when it was conducted. There are, however, a number of other factors that may potentially contribute to the incidence of infectious diseases. These factors include the occupation of the parents, group parenting, and the use of dummies[22].

Research has demonstrated that breastfeeding not only safeguards against infections but also against diabetes, obesity, asthma, eczema, and early dental decay, as well as has long-term effects on cognitive development[22]. The TEDDY study demonstrated that exclusive breastfeeding for more than three months and breastfeeding duration of more than six months were not associated with protection from the development of autoimmunity associated with type 1 diabetes and coeliac disease. Hummel et al. (2021) hypothesised that the protective effect of breast milk was limited to the early development of autoimmunity. This was due to the fact that the TEDDY study demonstrated that the protective effect of breast milk was limited to the early stages of it. When children are first exposed to environmental influences, breast milk is one of the first things they are exposed to. Shorter periods of exclusive breastfeeding were associated with an increased risk of seasonal allergy rhinitis, but not with the risk of food allergies, according to the findings of Hummel et al. (2021), who investigated the relationship between breastfeeding and allergic disorders. There is a possibility that the relationship between breastfeeding and the likelihood of allergic reactions is dependent on the kind of allergy[23].

The majority of these deaths occur in low and middle-income countries (LMICs), where the incidence of around 525,000 deaths each year and diarrhoea is the most common infection. According to North K. et al. (2022), previous research estimated that nearly 100% compliance with the main recommendations for breastfeeding could save over 820,000 children's lives per year and over $300 billion annually. Optimal breastfeeding can reduce the mortality rate from infections by 88% in the first six months of an infant's life, according to a meta-analysis of data from LMICs. This is in contrast to infants who do not breastfeed[21]. Breast milk serves as a significant reservoir of bacterial species and plays a crucial role in shaping the composition of the infant's intestinal microbiota. The establishment of a beneficial bacterial population in the neonatal gut is primarily facilitated through breastfeeding. This process promotes the development of a dynamic gut microbiome that produces antimicrobial compounds, enhances intestinal mucin secretion, and inhibits the adhesion of pathogenic microorganisms, thereby reducing the risk of various infectious diseases in infants[4]. North K. et al. (2022) have reported on a variety of meta-analyses that indicate infants who are exclusively breastfed have a 56% lower mortality rate from diarrhoea and a 56% lower incidence of diarrhoea than infants who are exclusive breastfed. Additionally, breastfeeding has been discovered to have a protective effect against diarrhoeal disease in more recent individual studies conducted in low- and middle-income countries (LMICs)[21]. Not only does breast milk contain immunoglobulins, primarily secretory IgA, but it also contains specific pathogens that have the ability to prevent the translocation of pathogens in the digestive tract, neutralise toxins and other infectious agents, and bioactive factors called cytokines, chemokines, growth factors, hormones, and lactoferrin.

These bioactive factors have the ability to inhibit inflammation, increase the production of specific antibodies, facilitate the inflammatory process, differentiate and grow B lymphocytes, and ultimately lead to improved recognition of microorganisms. Additionally, oligosaccharides in breast milk serve as a defensive mechanism for the immunological system. Oligosaccharides are soluble complex carbohydrates that provide prebiotics. Through their contribution to the

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formation of particular beneficial bacterial strains in the digestive tract of the infant, such as *Bifidobacterium infantis*, they protect the infant from the development of bacteria that are harmful to the infant's health[22]. Respiratory tract infections are one of the primary causes of death among infants under the age of five in developing countries. Compared to infants who are not breastfed, exclusively breastfed infants aged <5 years are 67% less likely to be hospitalised due to pneumonia, according to a meta-analysis of 18 studies from LMICs conducted by North K. et al. (2022). Concurrently, infants under the age of five who receive any breast milk are 70% less likely to succumb to respiratory tract infections than those who do not receive breast milk[21]. Malnutrition is a significant issue in Indonesia, a developing country. It is not only a contributing factor to the prevalence of infectious diseases, including AIDS, tuberculosis, and parasitic infections, but also a predisposing factor for a weakened immune response, rendering children more susceptible to infection. The immune system, infectious disease, and inadequate nutrition are interdependent and constitute a straightforward cycle[24]. It is crucial to address the issues of optimal growth and development of children in the context of antenatal care and birth prepared practices, as they are related to healthy digestion, nutrition, and parenting patterns. This is particularly essential when managing children's nutritional conditions. The nutritional status of children is contingent upon their food intake and the ability to absorb all the nutrients from the food they consume. Additionally, sound digestion is necessary[25].

Components in Promoting A Balanced and Effective Immune Response

The immune system commences to develop during pregnancy and continues to develop after birth as a result of exposure to microorganisms. By changing cell proliferation, differentiation, and apoptosis, as well as cell signalling pathways and cell surface glycosylation, human milk oligosaccharide (HMO) has an effect on the development of the immune system that is responsible for the digestive tract. A consequence of this is that it influences the operation of the immune system[26]. HMOs, a family of complex unconjugated glycans, are structurally unique to breast milk and the third most prevalent solid component in breast milk, following lactose and lipids. Their concentration ranges from 9 to 24 g/L, which typically surpasses the total protein content. A composition of five monosaccharides, including glucose (Glc), galactose (Gal), N-acetylglucosamine (GlcNAc), fucose (Fuc), and sialic acid (N-acetylneuraminic acid (Neu5Ac), is the source of HMOs[19]. HMOs directly interact with infant intestinal epithelial barrier cells, thereby modulating growth, differentiation, and apoptosis, as well as influencing gene expression, cell cycle, and cell surface glycosylation. The formation of the infant gut microbiota, which is characterised by its metabolic activity, is a critical mechanism of HMOs that affects the immune system's development by mediating immune cell interactions and performing a systemic immunomodulatory role[26].

In order to generate a more balanced TH1/TH2 response, HMOs inhibit cell proliferation, promote differentiation, apoptosis, and maturation of cells, enhance barrier function, and promote the production of cytokines by lymphocytes. Galectins are immune system receptors that are regulated by HMOs, which are responsible for intracellular signalling, cell communication, proliferation, and survival[26]. Breast milk contains a variety of cytokines and chemokines that are produced by the mammary glands. These include IL-1β, IL-2, IL-4, IL-5, IL-6, IL-8, IL-10, IL-12, IL-13, TNFα, TGF-β, IFN-γ, granulocyte colony-stimulating factor (G-CSF), and monocyte chemotactic protein 1 (MCP-1). The development and maturation of immune cells in neonates are influenced by the cytokines derived from breast milk. For instance, TGF-β, IL-6, and IL-10 induce the differentiation and development of IgA-producing cells[27]. HMOs have a dual effect on mucosa-associated lymphoid cells, influencing dendritic cells and increasing levels of IL-10, IL-27, and IL-6. However, they do not affect IL-12p70 and TNF-α. The production of interferon-gamma and IL-10 by 2'-FL enhances Th1 responses, whereas 3'-SL in mesenteric lymph node dendritic cells increases Th1 and Th17 immune cells[26].

In their study, Meek et al. (2022) highlighted the fact that children who were not breastfed as infants were more likely to suffer from a variety of disorders. These disorders included otitis media, diarrhoea, lower respiratory disease, sudden infant death syndrome (SIDS), inflammatory bowel disease, childhood leukaemia, diabetes mellitus, obesity, asthma, and atopic dermatitis. Because of the biological composition of breast milk, which includes anti-infective and anti-inflammatory factors, growth factors, microRNAs that play a crucial role in modulating epigenetic regulators, cells such as neutrophils, leukocytes, and stem cells, and bacteria (bifidobacteria and lactobacilli), this is the reason why breast milk is beneficial to infants. According to the findings of this study, breastfeeding is an essential activity for infants throughout the "early critical window" of the first year of their lives[28].

Other Nutrient Content in Breastmilk and the Collaboration

Breastfeeding is regarded as the most effective method for supplying the essential nutrients that enhance the immune system development and promote the growth of neonates. In addition to providing nutrition, breast milk is abundant in microbiota, immune and non-immune components, all of which are crucial for the neonate's protection from a variety of maladies and the development of their immune defences[27]. There are a number of physiological functions that HMOs perform, including the formation of a balanced microbiota in the infant's gut, the prevention of infection, the strengthening of the gastrointestinal barrier, the potential support of the immune system, brain, and cognitive development, and the weakening, prevention, and diverting of pathogens from bonding with their cognate cell surface ligands. In order to replicate, infiltrate, and cause disease, infectious agents, such as viruses (influenza virus, respiratory syncytial virus, rotavirus, HIV, coronavirus, and norovirus), bacteria (including Streptococcus pneumoniae, Haemophilus influenza, Group B streptococci (GBS), and protozoan

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parasites), and protozoan parasites, necessitate adhesion to epithelial cell surfaces. On the other hand, HMOs perform the role of soluble decoy receptors, which inhibit certain viral, bacterial, or protozoan parasite pathogens from attaching themselves to the surface of epithelial cells[26].

Breastfeeding Viewed from an Ideological and Cultural Prospective

Philosophical and Ethical Dimensions of Breastfeeding

Breastfeeding is the recommended method of feeding infants, with the notion that "breast is best" and breast milk is known as "liquid gold". The WHO's breastfeeding promotion campaign emphasises the belief that nursing is the morally and ethically proper choice for new moms to ensure their infants' survival and the important nutritional benefits of breast milk[29]. Family and peer support, as well as proper access to health promotion resources and information, play a vital role in the breastfeeding process, assisting mothers in developing a good attitude towards nursing.According to the American Academy of Paediatrics (AAP) and World Health Organisation (WHO), infants should be exclusively breastfed for the first six months before transitioning to solid complementary foods[29]. In 2012, Indonesia established a Government Regulation on Exclusive Breastfeeding, which compels all citizens, including the business community, to support the success of exclusive breastfeeding and to preserve working moms' right to breastfeed and pump milk at work. Every employer is required to provide a designated lactation room with standardised facilities.Breastfeeding should begin within an hour of birth, be exclusive for the first six months, and continue for at least two years. Safe complementary foods should be introduced at six months to support optimal breastfeeding practices. This work is critical in reaching the Sustainable Development Goals by 2030[5].

Breastfeeding in Cultural Context

A link was found between socio-cultural factors and the success of exclusive breastfeeding. Socio-culture refers to the values, habits, beliefs, and traditions that exist within a society. Moreover, traditional elements have an important influence in achieving effective exclusive breastfeeding[6]. Tradition is a culture that is passed down from generation to generation through enculturation and socialisation, becoming deeply ingrained in a person's life and having a significant impact on their behavioural acts. Cultural awareness of breastfeeding is one aspect that can influence whether infants receive adequate nutrition, but it is frequently constrained by religious beliefs, parents, in-laws, and traditions about what is thought suitable or not[31]. Sociocultural factors, like as habits and misconceptions, influence the success of exclusive breastfeeding and are intimately associated to exclusive breastfeeding behaviour. Pratiwi et al. (2021) cited this in their review of a study article[6]. The mother's nursing behaviour is influenced by societal and cultural norms, which can impact her motivation and desire to offer exclusive breastfeeding. Social attitudes and cultural practices are influenced by what society sees and knows, thus moms who live in a supportive socio-cultural context are more likely to succeed in giving exclusive breastfeeding[32]. Once a belief is developed, it serves as the foundation for a person's understanding of what to expect from a certain thing[6]. Knowledge, or cognition, is a critical domain for shaping a person's behaviour[31].

Mothers who believe in the benefits of exclusive breastfeeding are more knowledgeable and likely to believe the facts. In contrast, women who lack trust are more inclined to rely on the opinions of those closest to them without consulting acceptable sources of information. Family support is essential for encouraging moms to breastfeed exclusively because it makes them feel cared for and motivated.A mother's willingness to exclusively breastfeed her kid is influenced by cultural conventions, traditions, and beliefs surrounding nursing[32]. In some households, the social culture does not promote exclusive breastfeeding since infants are given food or beverages at a young age while they wait for breast milk to develop[32]. The position of someone who is appreciated and respected is also important in creating situations that encourage positive behaviour. This influence is based on persuasive communication, which involves the recipient's attention, understanding, memory, and behavioural changes. This communication will establish and maintain a relationship that will facilitate favourable outcomes and encourage beneficial activities[31]. Personal experience, information from others, and emotional needs all contribute to the development of trust. However, trust is not always accurate; it can be established as a result of a lack of correct information about the object in question[32].

Breastfeeding's Challenges and Barriers

Patil et al. (2020) conducted a systematic review that emphasised the numerous challenges that mothers worldwide face when attempting to exclusively breastfeed (EBF). The absence of support, guidance, and knowledge from elder family members or healthcare providers is a significant factor contributing to the discontinuation of EBF among teenage mothers. Studies have demonstrated that interventions such as education and support during pregnancy and the postpartum period can increase the rate of EBF[33]. Developing a more profound comprehension of the attitudes and behaviours of mothers towards lactation is crucial for improving the duration, exclusivity, and initiation of breastfeeding[5]. Patil et al. (2020) also found that mothers who resumed work or school after childbirth were unable to provide exclusive breastfeeding to their babies due to a brief maternity leave and an unsupportive work environment. A review of 16 studies revealed that, despite the existence of maternity leave policies, their implementation is insufficient, resulting in a high number of women in the informal sector returning to work promptly after giving birth. This practice contributes to the low rate of exclusive breastfeeding[33].

The lack of privacy in public spaces during breastfeeding was reported by mothers, who felt uncomfortable being observed by others. This led many to prefer bottle-feeding their infants in public, as supported by strong methodological evidence. Although

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there are initiatives that advocate for breastfeeding-friendly public spaces, their implementation has been impeded by infrastructure and behavioural obstacles. The resolution of these obstacles requires a strong political commitment and a concentration on behavioural change communication[33]. Basrowi et al. (2019) conducted a study that revealed that white-collar workers possess a higher level of knowledge regarding breastfeeding than blue-collar workers, which is evidenced by their more favourable attitudes towards breastfeeding. This disparity may be attributed to the white-collar workers' higher educational attainment[30]. Interventions that are specifically designed to educate and empower working mothers about lactation and health have been shown to be effective in enhancing breastfeeding behaviours and attitudes[34]. The rate of Exclusive Breastfeeding (EB) among women employed in professional sectors remained low between 2002 and 2017, according to research conducted by Saputri et al. (2020). This is consistent with research conducted in Indonesia, which suggests that the likelihood of women practicing exclusive breastfeeding was reduced among those employed in both private and public sectors[35].

Before returning to work, breastfeeding mothers must make numerous preparations, with the father's robust support being particularly important. They must coordinate logistics, establish a practical pumping schedule, and take into account factors such as the frequency of lactation, break times, work hours, and potential obstacles to breastfeeding or pumping at work[34]. Indonesia has not yet implemented the International Labour Organization's Maternity Protection Recommendation (R191), which recommends a minimum of 18 weeks of maternity leave. Women with paid leave frequently continue to work during the majority of their exclusive breastfeeding period (6 months, as recommended by the WHO) as a result of employer inflexibility regarding the scheduling of paid maternity leave and the generally brief 6-week postpartum leave[35]. Basrowi et al. (2019) conducted a study that demonstrated that working mothers encounter frequent conflicts in their daily lives as a consequence of their difficulty in managing their dual responsibilities as employee and breastfeeding mothers. In numerous cases, these mothers prioritise their professional objectives or employment obligations over breastfeeding, which has a detrimental impact on the health of both the mother and the baby[30]. In Indonesia, a substantial number of working women lack adequate facilities for expressing and storing breastmilk, including private chambers and refrigerators. Although employers are legally mandated to provide lactation chambers and breastfeeding breaks, research suggests that these regulations are not consistently enforced, resulting in a significant number of women being unable to access appropriate lactation spaces[35].

The World Health Organisation has established an objective of 50% of mothers worldwide exclusively breastfeeding their newborns by 2025[36]. Paid maternity leave and workday pauses for breast milk extraction or breastfeeding are two critical components of breastfeeding support. Maternity leave that is paid has been linked to improved breastfeeding outcomes and reduced neonatal mortality rates[5]. Basrowi et al. (2018) found that the rate of exclusive breastfeeding among working women in Indonesia was a mere 19%, which is substantially low. Compared to mothers who remain at home, those who are employed are at a greater risk of discontinuing breastfeeding earlier[37]. Although the majority of countries provide some form of paid maternity leave, only a small number adhere to the World Health Organization's recommendation to provide at least six months of paid leave to support exclusive lactation. The International Labour Organisation (ILO) has established global maternity leave standards of 14 to 18 weeks, which is considerably shorter than the 26 weeks recommended by the World Health Organisation (WHO). This gap can be partially attributed to this[5]. It is imperative to establish a supportive environment in both the home and workplace in order to comply with the World Health Organization's recommendation for six months of exclusive lactation. Nevertheless, the effective lactation of mothers is frequently impeded by the absence of adequate support when they return to work. This is due to the fact that full-time employment significantly reduces the duration of breastfeeding. The situation is further complicated by workplace challenges, including the absence of adjacent childcare, concerns about lower productivity with infants present, and limited time and space for expressing breast milk[34].

The ILO's maternity protection convention recommends that parental leave be taken in conjunction with maternity leave, a recommendation that has been consistently linked to enhanced breastfeeding outcomes. Additional evidence-based maternity protection policies that are supportive of breastfeeding include family-friendly workplace practices for returning employees, such as lactation rooms for milk expression, workday breaks, flexible working hours, and accessible, affordable, high-quality childcare services in close proximity to the workplace[5]. In their 2018 study, Basrowi et al. elucidated that specialists consider maternity leave that exceeds three months to be a critical factor in promoting breastfeeding among working mothers. They also recommend that workplace regulations be implemented to permit breastfeeding employees to take breaks every three hours, provide part-time options or an earlier return for mothers with children under six months, and provide dedicated lactation rooms with the requisite amenities, including cold storage, chairs, sinks, and breast milk pumps[37].

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Table 1. Summary of study included in the analysis

Authors (Year)	Objectives	Study Design	Methods	Key Findings
Nuzzi et al. (2021)	Reviewing Breastfeeding & allergy risk	Review	Synthesis of epidemiologic & mechanistic studies	Breastfeeding reduces early wheeze/asthma; immunological factors contribute
Di Benedetto et al. (2020)	Explain maternal psychopathology in producing breastmilk	Review	Integrative biological & psychological evidence	Stress alters milk hormones/cytokines affecting infant development
Kiełbasa et al. (2021)	Identify Cytokines in breast milk	Review	Molecular & analytical literature review	Milk cytokines regulate immune maturation & inflammatory responses
Kowalczyk et al. (2022)	Assess lactoferrin properties	Review	Clinical & molecular evidence review	Lactoferrin shows antimicrobial, antiviral & immunomodulatory activity
Yi & Kim (2021)	Explain composition & function of breast milk	Review	Nutritional, immune, microbiome evidence review	Components synergistically support immunity & microbiome maturation
Hegar et al. (2019)	Describe the role of 2'FL & LNnT	Review	Clinical & mechanistic studies synthesis	HMOs enhance gut microbiota, immunity & reduce infections
Laouar (2020)	Explain maternal leukocyte transfer	Review	Immunological & mechanistic evidence review	Milk leukocytes influence infant immune programming
Grobben et al. (2022)	Investigate passive immunity to respiratory viruses	Observational	Quantify and analyze antibody in dyads	Passive viral immunity varies by pathogen
Langel et al. (2020)	Summarize maternal antibody Fc traits	Review	Synthesis Fc receptor & glycosylation evidence	Fc features influence efficiency of passive immune transfer
Pierzynowska et al. (2020)	Assess maternal immunoglobulins	Review	Immune & developmental literature review	Milk Igs shape immunity, microbiota & long-term susceptibility
Tlaskalová-Hogenová et al. (2020)	Identify immunomodulators in colostrum	Review	Immunology evidence review	Colostrum contains high immunoregulatory factors
Thai & Gregory (2020)	Explain how bioactive reducing intestinal inflammation	Review	Mechanistic & clinical data synthesis	HMOs, cytokines & growth factors decrease gut inflammation
Masi & Stewart (2022)	Assess HMOs & microbiome	Review	Microbiome studies synthesis	HMOs promote Bifidobacterium, influencing immune & metabolic pathways
Kartjito et al. (2023)	Explain the role of microbiota–immunity–cognition	Review	Multidisciplinary synthesis	Breastfeeding supports microbiome & cognitive development
North et al. (2021)	Summarize global breastfeeding context	Review	Global epidemiological data review	Breastfeeding lowers morbidity/mortality; disparities persist
Branger et al. (2023)	Investigate breastfeeding & infections	Observational	Analyze pediatric emergency data	Breastfed infants have fewer respiratory, GI & ear infections
Hummel et al. (2021)	Investigate breastfeeding & autoimmunity	Cohort (TEDDY)	Analysis of multi country longitudinal data	Reduced allergy/overweight; minimal effect on autoimmunity
Prasadajudio et al. (2023)	Explain malnutrition in chronic disease	Review	Pediatric data review	Breastfeeding enhances nutritional resilience
Wrottesley et al. (2023)	Explore nutrition in LMICs	Scoping review	Multi-regional synthesis	Stunting & deficiencies persist; early nutrition crucial

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Authors (Year)	Objectives	Study Design	Methods	Key Findings
Dinleyici et al. (2023)	Assess functional effects of HMOs	Review	Mechanistic & clinical evidence review	HMOs support immunity, gut barrier & brain-gut axis
Lokossou et al. (2022)	Review breast milk as immune system	Review	Immunology data synthesis	Milk acts as active immune organ supporting disease protection
Meek et al. (2022)	Identify breastfeeding guidelines	Technical report	Clinical & public health evidence review	Breastfeeding improves outcomes; systemic support needed
Perez (2020)	Summarize emotional meaning of breastmilk	Qualitative	Interviews	Breastmilk tied to identity, bonding & motherhood meaning
Basrowi et al. (2019)	Analyze breastfeeding in worker groups	Cross-sectional	Surveys	Workplace support strongly impacts breastfeeding practice
Ardhani et al. (2020)	Investigate early feeding & diarrhea	Cross-sectional	Surveys	Poor knowledge & cultural practices ↑ diarrhea risk
Rahayu & Atmojo (2022)	Review culture & exclusive breastfeeding	Review	Indonesian literature review	Cultural norms strongly shape feeding behavior
Patil et al. (2024)	Analyze barriers to exclusive breastfeeding	Mixed-methods systematic review	Quant + qualitative synthesis	Barriers: workplace limits, culture, low support, perceived milk insufficiency
Basrowi et al. (2024)	Evaluate workplace breastfeeding strategies	Expert opinion	Delphi consensus	Recommends lactation rooms & flexible work policies
Saputri et al. (2020)	Explain breastfeeding disparities in Indonesia	Trend analysis	National survey data	Disparities improving, but SES & education gaps remain
Basrowi et al. (2023)	Asses breastfeeding during COVID-19	Cross-sectional	Online surveys	Breastfeeding stable; challenges include misinformation
Basrowi et al. (2018)	Develop lactation promotion model	Delphi	Expert rounds	Comprehensive Indonesian workplace model developed
Modak et al. (2023)	Describe psychological benefits of breastfeeding	Review	Mental health literature review	Breastfeeding reduces stress, supports bonding & development
Amoo et al. (2022)	Analyze philosophic approach to EBF	Scoping review	Ethical & cultural frameworks	Values-aligned communication improves breastfeeding uptake

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CONCLUSIONS

Human milk is considered the optimal source of sustenance for infants in the initial months of life, provide the vital nutrients necessary for maximum growth and survival, with a unique composition tailored to meet the biological and psychological requirements of the neonate. Philosophical strategies and ideas effectively enhance exclusive breastfeeding rates, particularly in campaigns centred on empowerment, education, and counselling related to breastfeeding. Theories of planned behaviour and self-efficacy are essential in the design and implementation of these treatments. Research underscores the significance of breastfeeding counselling during the prenatal, perinatal, and early postpartum periods, highlighting the necessity for specific support in the earliest days and weeks following birth. Support from family, workplace, and society is crucial for the effective breastfeeding of women.

ACKNOWLEDGEMENT

The authors sincerely thank all contributors for their valuable insights and support in advancing the research on breastfeeding and infant health.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

No conflict of interests. We received no specific grant from any institution.

AUTHOR CONTRIBUTIONS

B.P., E.W., and N.S. involved in conceptualization, B.P., N.S., and S. writing the original draft preparation, B.P., E.W., N.S., and S. writing review and editing manuscript. All authors have read and agreed to published version of manuscript.

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