International Journal of Food Science and Biotechnology
2022; 7(4): 100-110
http://www.sciencepublishinggroup.com/j/ijfsb
doi: 10.11648/j.ijfsb.20220704.13
ISSN: 2578-9635 (Print); ISSN: 2578-9643 (Online)

Role of Prebiotics & Immuno-Nutrients in Protecting Toddlerhood for Healthy Growth and Development

Uttam Kumar Saha[1, *], Bijoy Kumar Saha[2], S. Ahsan Ahmed[3], Magibur Rahman[1], Md. Bellal Hossain[4], Mohammad Abdul Hye[5], Md. Shamsur Rahman[6], Firoz Ahmed[7]

[1]Department of Pediatrics, Sher-E-Bangla Medical College & Hospital, Barisal, Bangladesh

[2]Diabetic Association and Medical College Hospital, Faridpur, Bangladesh

[3]Department of Pediatrics, Kid Care Center, Khulna, Bangladesh

[4]Department of Pediatrics, Ad-din Akij Medical College Hospital, Khulna, Bangladesh

[5]Department of Pediatrics, Magura Medical College & Hospital, Magura, Bangladesh

[6]Department of Pediatrics, Satkhira Medical College & Hospital, Magura, Bangladesh

[7]Department of Pediatrics, Kushtia Medical College, Kushtia, Bangladesh

Email address:

sahauk1996@gmail.com (Uttam Kumar Saha), bijoysahadr@gmail.com (Bijoy Kumar Saha), dr.ahsan1971@gmail.com (S. Ahsan Ahmed), drmajib6@gmail.com (Magibur Rahman), belalcmc39@gmail.com (Md. Bellal Hossain), dr.mahye@yahoo.com (Mohammad Abdul Hye), shamsurdrsb27@yahoo.com (Md. Shamsur Rahman), firoz72ahmed@gmail.com (Firoz Ahmed)

[*]Corresponding author

To cite this article:

Uttam Kumar Saha, Bijoy Kumar Saha, S. Ahsan Ahmed, Magibur Rahman, Md. Bellal Hossain, Mohammad Abdul Hye, Md. Shamsur Rahman, Firoz Ahmed. Role of Prebiotics & Immuno-Nutrients in Protecting Toddlerhood for Healthy Growth and Development. *International Journal of Food Science and Biotechnology*. Vol. 7, No. 4, 2022, pp. 100-110. doi: 10.11648/j.ijfsb.20220704.13

Received: September 1, 2022; **Accepted**: September 28, 2022; **Published**: December 29, 2022

Abstract: Infant immune system development is influenced by the nutritional state of the mother during pregnancy as well as the nutrients that the baby is exposed to through breastmilk and other meals. The development of the immune system during the newborn era is significantly influenced by micronutrients including iron, zinc, and vitamins A, C, D, and E as well as Prebiotics which act like fertilizers that stimulate the growth of healthy bacteria in the gut. The growing immune system is impacted by micronutrient deficiencies (MNDs), hence a gathering of experts was called to discuss prevention and mitigation measures. Malnutrition is the primary global cause of immunodeficiency and nutrition plays a crucial role in determining immunological responses. A serious reduction of cell-mediated immunity, phagocyte function, complement system, secretory immunoglobulin a antibody concentration, and cytokine production is linked to protein-energy deficiency. Even when the deficient condition is quite minor, deficiencies of specific nutrients lead to altered immunological responses. Micronutrients including zinc, selenium, iron, copper, vitamins A, C, E, and B-6, as well as folic acid, have a significant impact on immunological responses. Obesity and overnutrition also lower immunity. Infants with low birth weight have persistent impairments in their cell-mediated immunity, which can be partially reversed by supplementing their diets with additional zinc. In addition to Immuno-nutrients, Prebiotics are nondigestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon. The government, development partners, non-governmental organizations, and academia must collaborate to increase the availability of basic and effective nutrition interventions, such as exclusive breastfeeding, appropriate complementary feeding, supplementing micronutrients for children, adolescent girls, pregnant women, and lactating women, managing severe acute malnutrition and deworming, and hygiene interventions, along with those that address more stifling issues. To overcome the barriers that are present at the policy, governance, and service delivery levels, as well as to generate demand for the services at the household level, the entire healthcare system has to be reinvigorated. Managing nutrition in the wake of natural catastrophes and stabilizing food prices should also be given top priority.

Keywords: Immunity, Micronutrients, Macronutrients, Prebiotics, Nutritional Problems, Maternal Nutrition, Child Nutrition

1. Introduction

Innate and adaptive immunity are parts of the immune system. [1, 2] As the immune system develops during embryogenesis, the first hematopoietic cells start to form in the yolk sac. The development of the thymus, a key component of the immune system, starts during the seventh week of pregnancy, whereas the formation of the bone marrow starts by the twentieth. [3, 4] While B lymphocytes, monocytes, granulocytes, and certain DCs grow in the bone marrow, T lymphocytes, natural killer (NK) cells, and different dendritic cells (DCs) develop in the thymus. Even while the lymphoid system is created at birth, it is still not fully functioning. [3]Neonatals are more susceptible to infections and have less capacity for an adequate response since their immune systems are still developing and not completely functional. But newborns are shielded against infections by passive immunity, which is provided by IgG and IgA antibodies that are passed from the mother through the placenta during the last trimester of pregnancy and through breastmilk during nursing, respectively. During the prenatal stage, the fetal immune system is vulnerable to any inflammatory, viral, environmental, or dietary alterations. [4] Major exposure to or injury from any of these during pregnancy may have a significant impact on the programming of the thymus' function and/or structure, which may result in a permanent change in the population of certain immune cells, leading in immunological deficiencies. [5] Micronutrient deficiencies (MNDs) have been linked to adverse effects on thymus size and function, lymphocyte function, and B lymphocyte size in studies using animal models. As a result, dietary insults during pregnancy cause adverse changes in immunological programming that raise the risk of infection during infancy and inflammatory disorders later in life. [5] These findings emphasize the significance of enough and optimal diet for the development of the immune system and a sufficient immunological response throughout pregnancy and the early years of life.

The nutritional state of the mother from the time of conception till lactation has a significant impact on how the child's developing organ systems and homeostatic pathways are programmed. The immune system and associated organs grow and proliferate quickly throughout the first trimester of pregnancy. Consequently, during the first few years of life, the immune system continues to grow and develop. [5] By influencing placentation and the subsequent transfer of immune components through the placenta and breastfeeding, maternal malnutrition or a decrease in food intake can also have a direct impact on the development of the fetus's immune system. Organogenesis, growth, and fetal programming are all effected by a fetus's nutritional state being disturbed. [6] Early childhood immune development is greatly influenced by the postnatal environmental shocks that children are exposed to as well as the nutrition they receive from breast milk, breast milk substitutes, and supplementary meals. [6, 7] Postnatally, foods have an impact on immune cell development and innate immunological signal transduction pathways, which affect early allergen sensitivity, foster tolerance for developing gut microbiota and ingested antigens, and establish patterns of host defense against infections.

Table 1. *Innate vs. adaptive immunity.*

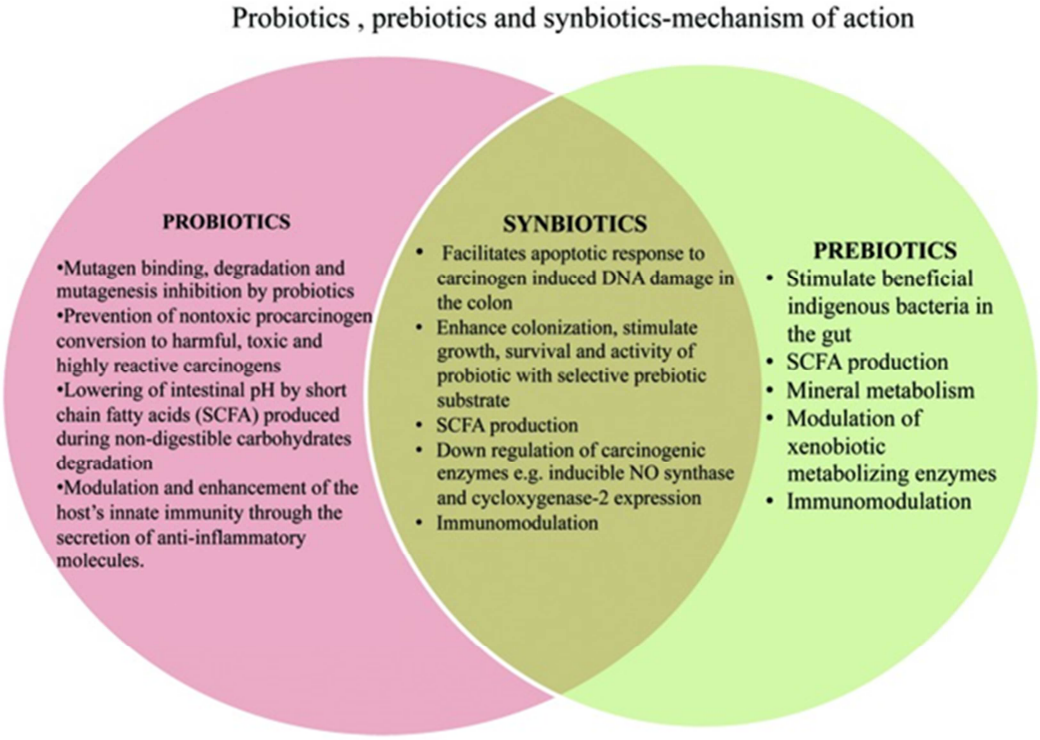
Innate immunity	Adaptive immunity
Provides first line of defense	Serves as second line of defense
Activated as soon as an antigen is encountered	Triggered for secondary elimination of infectious agents
Comprises neutrophils, macrophages, monocytes, and dendritic cells	Comprises T cells and B cells
Has no immunologic memory	Has immunologic memory

Impaired immunity is linked to malnutrition or undernutrition, which increases vulnerability to infections and cytokine activation. [8] Immuno-nutrient deficiencies can influence the immune system at the cellular level, e.g., by influencing cell function, the mucosal barrier, etc., which might impede immunological response. According to studies, severe malnutrition can impact how the thymus develops, which in turn affects immunity. On the other hand, malnutrition is also a result of infection. A variety of immune system inflammatory cascades are triggered by infection, further taxing the developing immune system. As a result, the host's nutritional state has a role in how an infection turns out.

2. Prebiotics

Probiotics have been demonstrated to lower the risk of illnesses such as infectious diarrhea as well as the frequency and length of upper respiratory tract infections. [9] As they have been found to enhance the absorption of several minerals (calcium, zinc, and vitamin B12) and lower the risk of anemia, [9, 10] probiotics may promote infant growth by preventing infections and micronutrient deficiencies. In many parts of the world, fermentation is widely used and tolerated, especially in Asia and Africa, where fermented foods make up a sizable element of the diets of rural populations. [11] Fermented foods are crucial for baby and child nutrition since the fermentation technique is widely employed in many African nations to make supplementary meals. [12] The Food and Agriculture Organization (FAO) and World Health Organization (WHO) together convened a workshop in 1995 to discuss the possible use of fermented food to enhance newborn and early child nutrition, [13] Fermentation is a cost-effective procedure. [14] So, it is possible to boost children's growth at a cheap cost and on a wide scale to reach the target population by using locally produced/culturally accepted probiotic products. [14] Despite this

acknowledgment, the effects of probiotics on weight gain have only been studied in two systematic studies. [15, 16] The reviews by Steenhout et al. in 2009 evaluated the effects of bifidobacteriumlactis in infants under six months of age, [17] and Million et al. evaluated the effects of lactobacillus species on weight gain in healthy humans and animals. Both reviews, however, were focused on specific probiotic strains in target populations. By promoting the growth and metabolism of protective commensal microorganisms in the baby gut, prebiotics, or non-digestible oligosaccharides, can reduce the risk of allergy disorders in young children. Live bacteria known as probiotics interact with the gut microbiota to produce positive effects when given in sufficient doses. They strengthen the barrier function of the stomach and control the immune system. Additionally, probiotics influence immune system cells, particularly dendritic cells, and enhance the functionality of regulatory T cells.



Source: Article - Potential of probiotics, prebiotics and synbiotics for management of colorectal cancer.

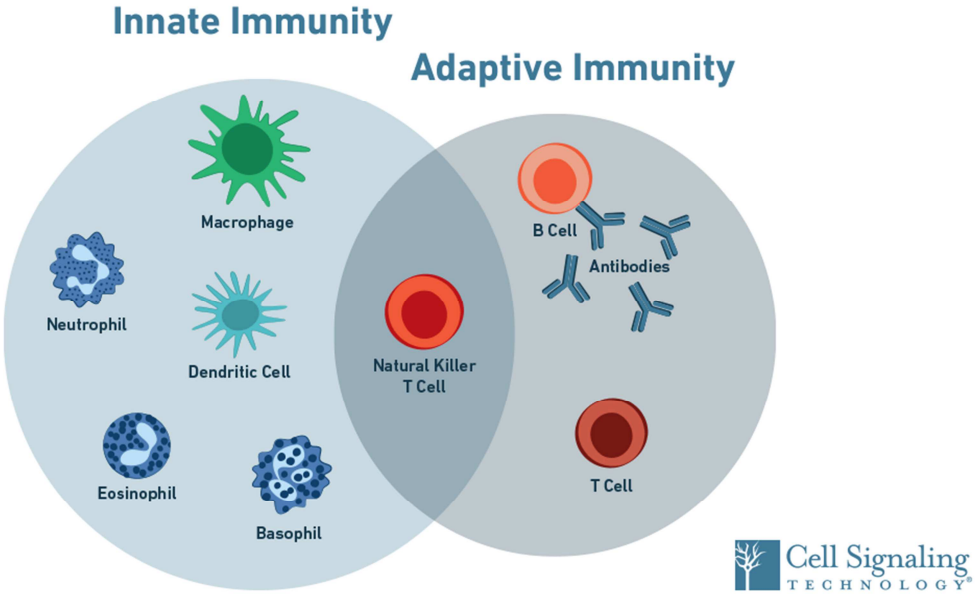
Figure 1. *Probiotics Activity.*

For a source to be categorized as a prebiotic, it must be demonstrated that it benefits the host. [15] Fermentable sugars made from xylans and fructans are one well-known kind of prebiotic. [16] Since 4-10% of the starch in mixed meals has been demonstrated to enter the large intestine, resistant starch from starchy foods is also a well-documented prebiotic and has historically been the biggest source of prebiotics in the diet. [17] According to one study, people eating a traditional diet in Africa took in 38 grams of resistant starch per day. [18] When the prebiotic idea was initially proposed in 1995, Bifidobacteria and Lactobacillus were primarily the focus of attention. [15, 16, 17] The current prebiotic targets have increased to include a larger variety of microorganisms thanks to better mechanistic methodologies in recent years, including Roseburia spp., Eubacterium spp., Akkermansia spp., Christensenella spp., Propionibacterium spp., and Faecalibacterium spp. [18] As they may have various positive impacts on the host in terms of digestion (including but not limited to boosting mineral absorption) [18] and the efficiency and inherent strength of the immune system, these bacteria have been identified as essential probiotics and beneficial gut bacteria. [19] It has been demonstrated that prebiotic specificity varies between Bifidobacteria and Lactobacillus, and that both may preferentially digest prebiotic fiber dependent on the enzymes present in the bacterial community. [18] In this way, while Bifidobacteria show selectivity for inulin, fructooligosaccharides, xylooligosaccharides, and galactooligosaccharides, Lactobacilli prefer inulin and fructooligosaccharides. [19] Studies have also demonstrated that prebiotics can limit the growth of harmful and possibly pathogenic microorganisms in the gut, such as clostridia, in addition to promoting the growth of beneficial gut bacteria. [20].

3. The Immune System

The mucous membranes of the skin and other mucous tissues, phagocytic cells, mucus, cilia, lysozyme, interferon, and other humoral components are examples of nonspecific defenses. These intrinsic mechanisms are inherent and unaffected by earlier exposure to the infectious pathogen.

They serve as the initial line of defense and prevent overt infection from developing. The B cell system for producing antibodies and the T cell system for cell-mediated immunity are examples of antigen-specific systems. These mechanisms are adaptable and required because they are particular responses brought on by earlier contact with the bacterium and its antigenic determinants. They are efficient at stopping the infection's progress and getting rid of the invader. The specialized immune responses serve as the foundation for preventative vaccination against widespread infectious diseases including measles, respiratory illnesses brought on by Hemophilus influenza, and systemic illnesses brought on by Salmonella. Nonspecific and antigen-specific defenses cooperate in the body. A striking symptom of protein-energy deficiency is lymphoid atrophy (PEM). The thymus shrinks in size and weight. Histologically, there is a lack of corticomedullary differentiation, a reduction in lymphoid cells, and enlargement, degeneration, and rarely calcification of the Hassall bodies. These alterations may easily be distinguished from those found in primary immune deficiencies such DiGeorge syndrome. [20, 21] In PEM, there is also a loss of lymphoid cells in the spleen's paracortical regions, which are dependent on the thymus for production of lymphocytes. Most host defensive systems are compromised in PEM. Both memory and fresh antigen-induced delayed-hypersensitivity cutaneous reactions are significantly suppressed. Complete energy to a battery of several antigens is not unusual. Additionally, mild impairments show these alterations. After receiving the proper nutritional therapy for a few weeks or months, the skin responses are restored. Additionally, there is a decrease in mature, completely differentiated T cells, which is partly attributed to a decrease in serum thymic factor activity. Leukocytes' deoxy-nucleotidyltransferase activity is also elevated.



Source: Used with permission from Macmillan Publishers Ltd: Nature Reviews Cancer, 4, 11-22, copyright 2004.

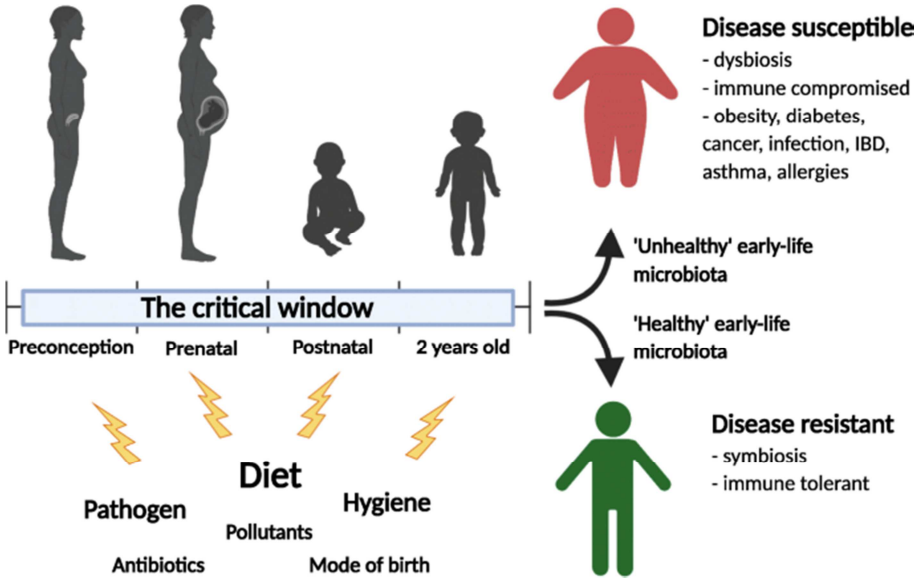
Figure 2. *The Immunity System.*

Nutritional Condition Throughout Pregnancy and Afterward: Effects on the Immune System of the Newborn

The nutritional state of the mother from the time of conception till lactation has a significant impact on how the child's developing organ systems and homeostatic pathways are programmed. The immune system and associated organs grow and proliferate quickly throughout the first trimester of pregnancy. Consequently, during the first few years of life, the immune system continues to grow and develop. [22] By influencing placentation and the subsequent transfer of immune components through the placenta and breastfeeding, maternal malnutrition or a decrease in food intake can also have a direct impact on the development of the fetus's immune system. Organogenesis, growth, and fetal programming are all effected by a fetus's nutritional state being disturbed. [23] Early childhood immune development is greatly influenced by the postnatal environmental shocks that children are exposed to as well as the nutrition they receive from breast milk, breast milk substitutes, and supplementary meals. [23, 24] Postnatally, foods have an impact on immune cell development and innate immunological signal transduction pathways, which affect early allergen sensitivity, foster tolerance for developing gut microbiota and ingested antigens, and establish patterns of host defense against infections.

Breast milk is acrucial component in the development of the immune system. As the first meal to which newborns are exposed, breast milk is a crucial conduit for the transmission of the mother's immunological memory to the child. [23] It contains a number of physiologically active antimicrobial peptides (AMPs), including as defensins and cathelicidin, as well as immune-modulating substances that boost active and

passive immunity during the developing years of life. [23-25] The neutrophil granules contain cathelicidin (an AMP), which produces cathelin following neutrophil degranulation, in inactive proform. Cathelicidin's function as a mediator between innate and adaptive immunity is revealed by a number of actions including endotoxin neutralization, angiogenic, chemotactic, and wound healing. [25] Probiotics and oligosaccharides found in breast milk contribute to the infant's growing gut microbiota, which is essential for the development of the immune system. Evidence suggests that genetic factors passed from mother to kid through breast milk composition affect the immunological response in the youngster.

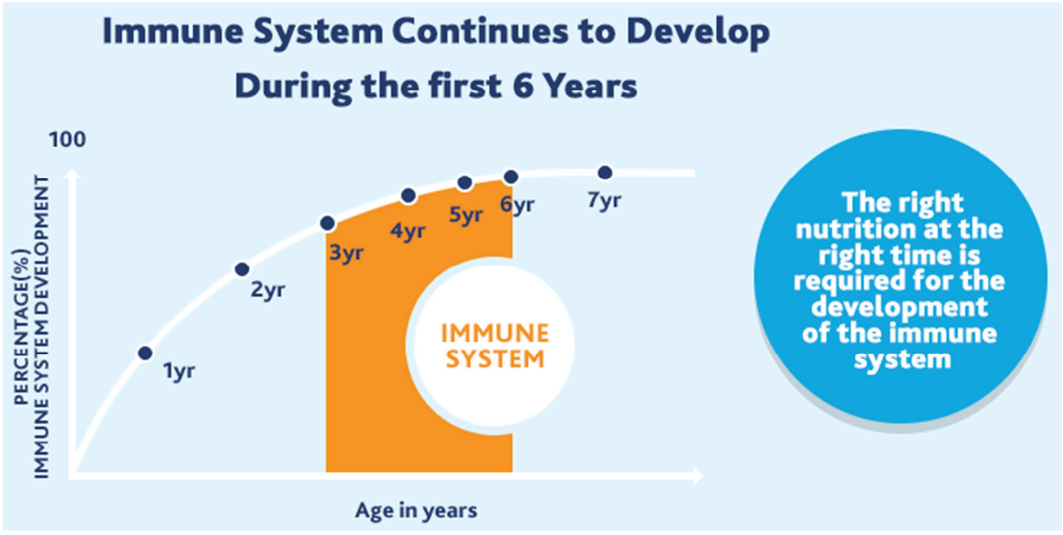


Source: Article - Impact of maternal and early life malnutrition on health: a diet -microbe perspective | BMC Medicine

Figure 3. *Impact of Early Life Nutrition on Children's Immune System.*

4. Importance of Good Nutrition for Toddlers

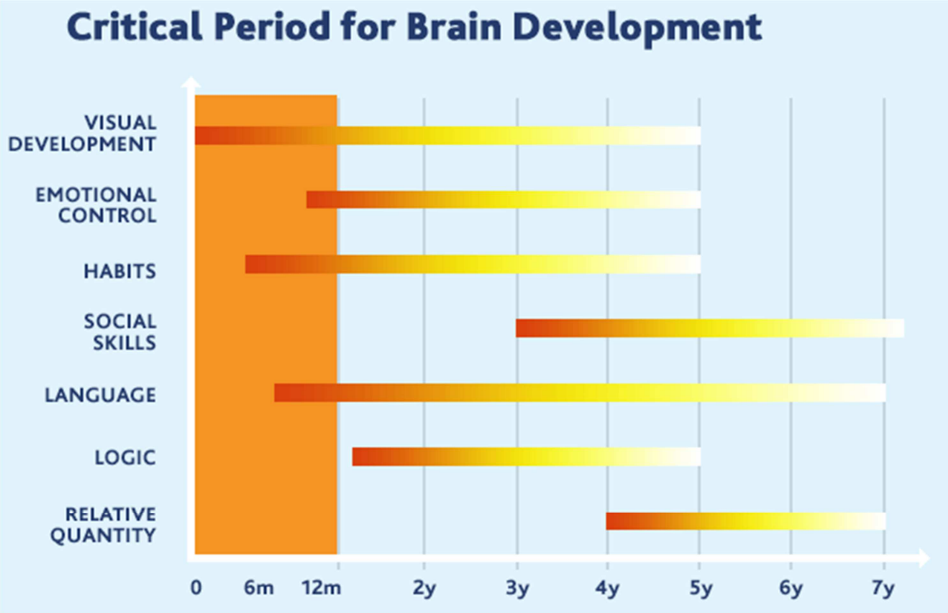
A toddler's growth advances at a highly astounding rate from birth to age 6 and requires an adjusted dietary intake. A healthy diet throughout a child's first six years of life, according to studies, can significantly affect the child's future health. Early nutrition has an impact on development of the immune system, the brain, and the eyes. At this time of life, your child's immunity is developing quickly, so it's critical to give him the best start with the appropriate nutritional assistance.



Source: Article- Importance of Good Nutrition for Toddlers

Figure 4. *Immune System During First 6 Years.*

It is also a key period for brain development thus the need to provide the child with essential nutrients to support the brain development mainly LCPs that are not found in adult's milk.



Source: Article - Importance of Good Nutrition for Toddlers

Figure 5: *Critical Period for Brain Development.*

5. Role of Different Nutrients in Immune Response and the Consequences of Their Deficiencies

5.1. Macronutrients

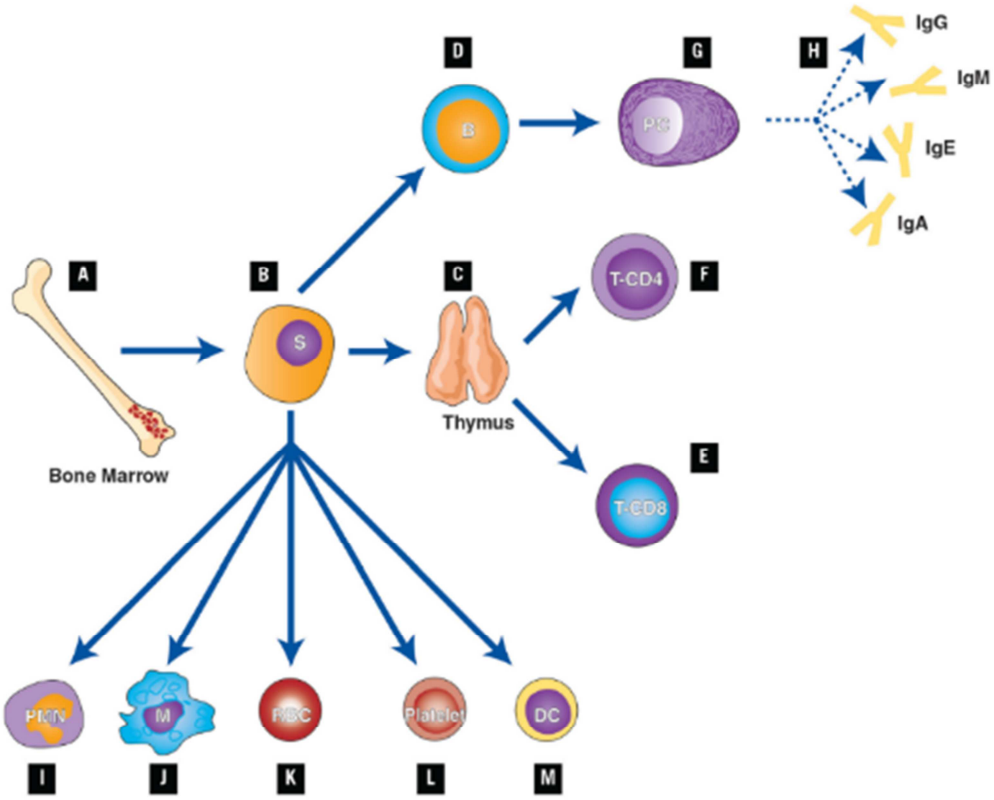
Since they control the synthesis of cytokines and antibodies, the activation of T lymphocytes, B lymphocytes, macrophages, and NK cells, lymphocyte proliferation, and gene expression, amino acids are essential for the immune system. [24] Increasing the synthesis of interlukin-1 b and decreasing neutrophil apoptosis are two ways that studies show carnosine, a bioactive peptide present in meats and fish, might affect an individual's immune system. [25] Since they help maintain the fluidity of cell membranes, regulate gene expression and signal transmission, and provide the building blocks for the creation of chemical mediators, LC-PUFAs are crucial for immune cell responses. [26] Due to the high metabolic demands of lymphocytes, macrophages, neutrophils, and other immune cells, carbohydrates are essential for a proper immunological response. [27] Out of all the carbohydrates, galactose-involving interactions are crucial to host defenses. Immune systems, including innate and adaptive immunity, include any structure containing galactose.

5.2. Micronutrients

Micronutrients control humoral antibody response, cell-mediated and innate immunity, cytokine production, and play a key role in the differentiation and growth of Th1 and Th2 lymphocyte subsets. [27] Studies have shown that micronutrients including folic acid, iron, zinc, selenium, vitamin A, C, D, and E are crucial for the proper operation of the immune system. [28] In addition to these, copper and chromium are crucial micronutrients for immunomodulation. According to animal studies, copper shortage decreases T cell multiplication, which in turn lowers humoral, cell-mediated, and non-specific immunological responses, pointing to its function in immune competence maintenance. [25-28] Chromium, on the other hand, modifies immunostimulatory or immunosuppressive processes, influencing the immunological response that results in hypersensitive responses. It also affects the generation of cytokines, macrophages, and T and B cells.

Lymphoid atrophy is linked to both acquired and hereditary zinc deficiency. reduced cutane-0115 responses with delayed hypersensitivity, reduced thymicliornione activity and postponed homograft rejection Acrodermatitisenteropathica patients have a compromised lymphocyte response to phytohernagglutinin. Reduced delayed-hypersensitivity cutaneous responses and lowered thymulin activity. These results may be confirmed in experimental animals, and one can also demonstrate a decreased number of antibody-forming cells in the spleen and diminished T killer cell activation. Reduced consumption. Decreased phagocytosis, too. Through its function as a cofactor for phospho-lipase A2 or phospholipase C, zinc is most likely involved in the activation of NADPH oxidase. Arachidonic acid may be stabilized by zinc against oxidation by iron complexes. Oxygen and zinc complexes may interact. Producing items with significant pathogen toxicity. Zinc deficiency impairs the healing of wounds. Animals exposed to different species experience increased norhidity and mortality when zinc levels are low. Although spontaneous Otis cure is unaffected, zinc deficiency promotes the development of neniatodes and changes the characteristics of

their ejection from the gut.



Source: The Immune System and Primary Immunodeficiency from Immune Deficiency Foundation

Figure 6: *Role of Micronutrients.*

6. Approaches for Preventing and Treating a Lack of Micronutrients

6.1. Dietary Diversification

In order to maintain a balance of nutrients in the diet, dietary diversification or modification mostly entails increasing the consumption of a range of foods from various food categories. As making food calorie rich promotes the bioavailability of nutrients in the body, babies' diets should be both nutrition and energy dense. Although changing one's diet is the most effective and ideal way to avoid MNDs, impoverished nations may struggle to get or consume foods high in micronutrients due to a lack of resources. Additionally, certain cultural or religious views can prevent people from eating items with animal sources, which would limit their intake of nutrients.

6.2. Fortification

Food fortification offers the dual benefit of providing nutrients to large segments of the population without necessitating any changes in food consumption patterns, which is a factorlimiting the adoption of appropriate diverse dietary habits given that universal access to adequate food is a major factor limiting this. [29] In comparison to alternative approaches, food fortification is also more affordable, and frequent intake of fortified foods helps to maintain consistent body reserves of the micronutrients. [30] The effectiveness of fortification efforts in reducing malnutrition in poor nations is coming under increased scrutiny. The 10th, 11th, and 12th Five-Year Plans from the Government of India suggested food titration as a means of enhancing nutritional status through already in place government nutritional programs. [31] To improve iron status and reduce the occurrence of iron deficiency anemia in communities where anemia prevalence in children aged 2–5 years is 20%, the World Health Organization advises adding iron to complete diets or fortifying them with iron-containing micronutrient powders. A study by Detzel has demonstrated that in India, the current consumption fortified infant foods (e.g. fortified cereals) has already reduced theannual iron deficiency anemia burden, representing a 50%reduction in the health burden (in terms of disability-adjustedlife years) and a 36% reduction in economic losses.

6.3. Supplementation

Micronutrient supplementation is used as a treatment technique to provide children and pregnant women relatively significant doses of micronutrients that are essential for growth and development in the form of syrups or tablets.

Research shows that the percentage of children aged 6-59 months who benefitted was just 13.8%. From the supplementation with iron and folic acid. Additionally, it is a population with widespread deficits. With a clinically documented acute micronutrient deficiency calls for remedial action and should only be employed as a short-term strategy. [32] Insufficient supplies and poor compliance are the main obstacles to dietary supplement programs. [33] There is proof that dietary diversity and food Supplements are less effective than fortification.

7. Nutrition and Immunity: Current Developments and Future Prospects

Nutrition affects the immune system among other things. It is a physically complex and functionally diversified organ system. Both the qualitative and the quantitative components of an immune response affect an individual's immunity. Genetic predisposition, maternal stress, nutritional status, exposure to pollutants in the environment, infant's nutritional adequacy (quantitative levels of macro & micronutrients), etc. can all have an impact on the growing fetal and neonatal immune system.

Despite the fact that the newborn immune system is susceptible to insults throughout the crucial window of development and contains a wide range of biomarkers and proteomic indicators, there is no one test that can accurately predict an infant's immunological state. The persistence, severity, and frequency of infections in children may be signs of a weakened immune system, which may be brought on by undernutrition, micronutrient deficiencies, and other related causes. In order to assist a newborn reach their full growth and development potential, it is important to treat hidden hunger at an early age. In order to identify a deficient status, it may be helpful to assess the levels of important immune-supporting elements such iron, zinc, vitamin B12, and vitamin D. Because of the crucial function it plays in the immune system, hematopoietic system, growth, and cognitive development of newborns and toddlers, iron, once considered a micronutrient, is now considered to be a macronutrient. Hemoglobin levels may be used as a marker to identify iron deficiency anemia, and serum ferritin levels may be assessed to establish the requirement for iron supplementation.

Since there is no collection of consistent symptoms to measure immune system impairment, clinical prediction of it is difficult. One of the clinically available markers for determining macronutrient deficiency may be close monitoring of a child's growth chart. Except in cases of extreme malnutrition, a growth chart may not be useful for identifying micronutrient deficiencies. In general, it may be a good sign that a child's diet contains enough macronutrients if they are marching along a growth chart in the correct percentile. A balanced diet with the necessary amounts of macro- and micronutrients should be given to infants as soon as supplemental feeding is started in order to ensure their general health and wellbeing.

The expert group came to the conclusion that parents and other caregivers need to be greatly educated on the importance of nutrition throughout an infant's first 1000 days. Nutrition has a function in immune system programming in addition to influencing an infant's growth and development. Any dietary deficiency or damage now might have long-term effects on the immune system, cognition, susceptibility to infections, and even a reduction of 5 to 10 IQ points in adulthood. The expert group suggests that parents, guardians, and caregivers become more generally aware of nutrition. Offering age-specific, real-world problem-solving education and nutritional counseling on child feeding techniques should be the medical fraternity's strategy. The medical profession can assist in achieving this goal by focusing on different touch points, such as vaccination visits, regular check-up visits, or other visits, to maximize the opportunities to emphasize the benefits of nutrition through counseling in order to improve dietary adequacy, growth, and health of an infant and help them to reach their full potential for growth and development.

For one to achieve good health, a high quality of life, and national productivity, adequate nutrition is a requirement. Concerns about the nation's food security and nutrition situation, as well as the likelihood of meeting the MDG 1 nutrition target, are raised by the current low rate of undernutrition decline and the sharp increase in prices of rice and other necessities over the past couple of years. Bangladesh is predicted to face a significant risk due to an increase in food prices because it is ranked in the bottom 25% of the Global Hunger Index ranking. [10] According to the Household Food Security and Nutrition Survey, which examined how the price hike shock during 2007-2008 affected food security and nutrition, 22% of families cut back on health spending in order to cope with the high cost of food, which is likely to have had an adverse effect on health. [31] However, the retail price of rice during the first half of 2011 was 3% higher than its peak in the year of the food price shock, 2008, which suggests that children and women face a greater risk than in that year [32].

Framework for nutrition policy: Nutrition interventions are now given very seldom. The National Nutrition Programme (NNP), which was run by the government and local NGOs, was the biggest single source of comprehensive nutrition interventions aimed at adolescent girls, women, and children. The program's effectiveness has been questioned because it only covered roughly 30% of the population while having a solid design that was customized to local circumstances. [33] The program's recipients were not properly targeted, and the food supplements given to mothers and children were of poor nutritional quality. The program's accountability was subpar, and its monitoring and assessment systems were inadequate. Children with SAM were not taken care of by the program, and none of the cities with sizable slum populations were included. Due to these flaws, the government chose to terminate the NNP and integrate nutrition services into the healthcare system in the new Health, Population and

Nutrition Sector Development Programme (HPNSDP, 2011-2016).

The existing knowledge and lessons from the NNP must be included, and changes to the strategy where necessary, in order to mainstream nutrition services within the health system. The modification should emphasize better complementary feeding, more effective behavior change communication, better micronutrient status through dietary intake and micronutrient supplementation, etc. Food supplementation shouldn't be used routinely and should only be used as a safety net for vulnerable persons living in areas of the nation where there is a high rate of malnutrition and food insecurity. Additionally, the supplement's quality and the amount should be reviewed in order to make it nutritionally adequate by including micronutrients and any meals derived from animals, such as milk, which are essential for the development of undernourished children. The government wants to build community clinics nationwide, one for every 6,000 residents, to deliver basic nutrition treatments at the community level. A doctor working in the sub-district health complex may be designated as the nutrition manager for this model, who would oversee the program at the sub-district level with help from field supervisors and community health workers. However, it is crucial that the community clinic staff at least one person who is solely responsible for dietary treatments. There is a chance that nutrition might fall behind other competing health concerns. It will be obvious that extra, qualified employees must be mobilized. In order to combat the enormous issue of undernutrition, coordinated inter-ministerial efforts are crucial. Only a powerful body in the Prime Minister's Office can ensure coordination between numerous ministries that play significant roles in health, nutrition, and food security as well as with NGOs, the private sector, and international initiatives on nutrition issues (Scaling up Nutrition, REACH, and Feed the Future).

8. Increasing the Scope of Successful Nutrition Interventions

8.1. During Pregnancy and Lactation

1) Effective counseling for increased rest and food intake during pregnancy and counseling on appropriate infant-feeding practices during the second half of pregnancy;
2) Regular consumption of iodized salt;
3) Supplementation of a dose of vitamin A (200,000 units) to mothers within six weeks of delivery are all examples of measures that can be taken to prevent anemia during pregnancy and lactation.

8.2. 0 to 5 Months

1) Promoting breastfeeding awareness through a variety of means, including classroom discussions for adolescent girls, counseling during pregnancy, feeding support, troubleshooting during the first few hours and days after childbirth, and media coverage.
2) Encouraging exclusive breastfeeding during the early years of infancy.

8.3. 1-63 Months

1) Promotion of continued breastfeeding Counseling of women regarding supplemental feeding utilizing nutrient-dense local foods comprised of cereals, vegetables, oil, lentils, and, where available, animal protein (fish, eggs, or meat) Six-monthly vitamin A supplementation.
2) Zinc treatment and ORT during diarrhea.
3) Hygiene measures, such as hand-washing; multiple vitamin powder for food fortification at home.
4) Deworming in accordance with WHO standards.
5) Treatment for SAM at the facility and community levels using ready-to-use therapeutic meals derived from local ingredients.

8.4. Teenage Girls and Recently Wed Ladies

1) Supplementation of iron-folic acid tablets
2) Nutrition and health education
3) Deworming

Food security is crucial to enhancing nutrition since over 40% of the population cannot afford to consume the recommended quantity of calories each day. For interventions that indirectly affect food security and nutrition, a multi-sectoral strategy should promote pro-poor livelihood opportunities, such as direct cash transfers or transfers of productive assets, women's empowerment, girls' education, safe water, improvement in a community's infrastructure, and so on.

9. Conclusion

Putting nutrition high on the list of priorities, implementing cost-effective and sustainable interventions at scale using appropriate strategies, improving access to the services for those who are truly in need, making evidence-based decisions, and increasing operational capacity are the main challenges for promoting programs to prevent undernutrition at the national level in Bangladesh. Economic and social policies targeting poverty, trade, and agriculture should be put into place in addition to health and nutrition initiatives since they have been linked to quick gains in nutritional status. However, robust governance is necessary for any nutrition and health intervention to be cost-effective. Unsuccessful attempts would arise from inadequate accountability at all stages of developing, implementing, and evaluating, failing to address the needs of the population and failing to deliver the correct services to the right individuals. Strong governance is necessary for treatment and health interventions to be cost-effective. Unsuccessful attempts would arise from inadequate accountability at all stages of developing, implementing and evaluating, failing to address the needs of the population and failing to deliver the correct

services to the right individuals.

References

[1] Black RE, Allen LH, Bhutta ZA, Caulfield LE, de OnisM, Ezzati M et al. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 2008; 371: 243-60 1.

[2] Bryce J, Coitinho D, Darnton-Hill I, Pelletier D, Pinstrup-Andersen P; Maternal and Child Under-Nutrition Study Group. Maternal and child under-nutrition: effective action at national level. Lancet 2008; 371: 510-26. 2.

[3] National Institute of Population Research and Training. Bangladesh demographic and health survey 2007. Dhaka: National Institute of Population Research and Training, 2009. 346 p. 3.

[4] Balarajan Y, Villamor E. Nationally representative surveys show recent increases in the prevalence of overweight and obesity among women of reproductive age in Bangladesh, Nepal, and India. J Nutr2009; 139: 2139-44 4.

[5] National Institute of Population Research and Training. Bangladesh demographic and health survey 1996-97. Dhaka: National Institute of Population Research and Training, 1997. 252 p. 5.

[6] National Institute of Population Research and Training. Bangladesh demographic and health survey 1999-2000. Dhaka: National Institute of Population Research and Training, 2001. 211 p. 6 6.

[7] de Onis M. Measuring nutritional status in relation to mortality. Bull World Health Organ 2000; 78: 1271-4 7.

[8] United Nations Administrative Committee on Coordination Sub-Committee on Nutrition. 4th report on the world nutrition situation: nutrition throughout the life cycle. Geneva: Administrative Committee on Coordination Standing Committee on Nutrition, United Nations System, 2000. 138 8.

[9] Nahar S. Impact of food supplementation on pregnancy weight gain and birth weight in rural Bangladesh. Cambridge: University of Cambridge, 2004: 50-70. (PhD dissertation). 9.

[10] World Food Programme. Bangladesh household food security and nutrition assessment report 2009. Dhaka: World Food Programme, 2009. 176 p 10.

[11] United Nations Children's Fund and World Health Organization. Low birth weight: country, regional and global estimates. New York, NY: United Nations Children's Fund, 2004. 27 p 11.

[12] Ahmed T, Roy SK, Alam N, Ahmed AS, Ara G, Bhuiya AU et al. Baseline survey 2004: National Nutrition Programme. Dhaka: International Centre for Diarrhoeal Disease Research, Bangladesh, 2005. 319 p 12.

[13] Helen Keller International. Vitamin A status through-out the lifecycle in rural Bangladesh: national vitamin A survey, 1997-98. Dhaka: Helen Keller International, 1999. 38 p 14.

[14] de Benoist B, McLean E, Egli I, Cogswell M, editors. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. Geneva: World Health Organization, 2008. 40 p 15.

[15] Jahan K, Hossain M. Nature and extent of malnutrition in Bangladesh: Bangladesh national nutrition survey 1995-96. Dhaka: Institute of Nutrition and Food Sciences, University of Dhaka, 1998. 33 p 17.

[16] Kumar D, Goel NK, Mittal PC, Misra P. Influence of infant-feeding practices on nutritional status of un-der-five children. Indian J Pediatr 2006; 73: 417-21. 18.

[17] United Nations Children's Fund. Strategies for improving nutrition of children and women in devel-oping countries. New York, NY: United Nations Children's Fund, 1990. 34 p. 19.

[18] Haddad L, Alderman H, Appleton S, Song L, Yohannes Y. Reducing child malnutrition: how far does income growth take us? World Bank Econ Rev 2003; 17: 107-31 20.

[19] Moore SE, Fulford AJC, Wagatsuma Y, Persson LÅ, Arifeen SE, Prentice AM. Thymus development and infant and child mortality in rural Bangladesh. IntJEpidemiol. 2014; 43: 216-223. 21.

[20] Nauta AJ, Ben Amor K, Knol J, Garssen J, van der Beek EM. Relevance of pre- andpostnatal nutrition to development and interplay between the microbiotaanmetabolic and immune systems. Am J ClinNutr. 2013; 98: 586S-593S. 23.

[21] Marques AH, O'Connor TG, Roth C, Susser E, Bjørke-Monsen AL. The influence of maternal prenatal and early childhood nutrition and maternal prenatalstress on offspring immune system development and neurodevelopmentaldisorders. Front Neurosci. 2013; 7: 120. 22.

[22] Tan KM, CandlishCarnosine JK. Anserine as modulators of neutrophil function. Clin Lab Haematol. 1998; 20: 239-244. 24.

[23] Brockhausen I. The Role of Galactosyltransferases in Cell Surface Functions and in the Immune System. Drug News Perspect. 2006; 19: 401-409 25.

[24] Micronutrients. UNICEF; 2017. Available at: Accessed on June 2, 2017. https:// www.unicef.org/nutrition/index_iodine.html. 26

[25] Ministry of women and child development government of india. rapid survey on children. 2013-2014. India fact sheet: 2. Available at: Accessed on: 06 June 2017. http://wcd.nic.in/issnip/National_Fact%20sheet_RSOC%20_02-07-2015. Pd 27

[26] Simon AK, Hollander GA, McMichael A. Evolution of the immune system in humans from infancy to old age. Proc R Soc B. 2017; 82: 20143085 28.

[27] Beisel WR. Single nutrients and immunity. Am J Cliii Nutr I982: 35: 4 I 7-68. 29.

[28] Roitt IM. Brostoff J. Immunology. London: Gower. 1991 30.

[29] Schwarzenberg SJ, Georgieff MK. Advocacy for improving nutrition in the first 1000 days to support childhood development and adult health. Pediatrics (2018) 141: e20173716. doi: 10.1542/peds.2017-3716 32

[30] García-Mantrana I, Bertua B, Martínez-Costa C, Collado MC. Perinatal nutrition: How to take care of the gut microbiota? Clin Nutr Exp (2016) 6: 3-16. doi: 10.1016/j.yclnex.2016.02.002 33

[31] Moore SE. Nutrition, immunity and the fetal and infant origins of disease hypothesis in developing countries. ProcNutrSoc (1998) 57: 241-7. doi: 10.1079/pns19980038 34

[32] Food and Agricultural Organisation-World Health Organisation. Evaluation of Health and Nutritional Properties of Probiotics in food including Powder Milk with Live Lactic Acid Bacteria. In: Joint FAO/WHO Expert Consultation. 2001. 35.

[33] Sazawal S, Dhingra U, Hiremath G, Sarkar A, Dhingra P, Dutta A, et al. Effects of Bifidobacteriumlactis HN019 and prebiotic oligosaccharide added to milk on iron status, anemia, and growth among children 1 to 4 years old. J Pediatr Gastroenterol Nutr. 2010; 51 (3): 341-6. 37.