E-ISSN: 2987-209X
International Journal of Midwifery and Health Sciences
Vol. 4, Issue 2 (2026), October

Gut Microbiota and Stunting During the First 1,000 Days of Life: Mechanisms of Dysbiosis and Comprehensive Intervention Strategies

Shalvira Purnama[1 *], Lathifah Athaillah Putri[2], Rayita Widya Prameswari[3], Ronny Isnuwarsdhana[4]

[1,2,3,4]Medical Study Program, Faculty of Medicine, Mulawarman University, Samarinda, Indonesia

**Corresponding Author: Shalvira Purnama, Mulawarman University; Indonesia; belajarshalvira@gmail.com*

Submission date: 22-09-2026; Date of received: 21-10-2026

Abstract

The first 1,000 days of life (1,000 days of life) represent a critical period that determines the quality of a child's growth and development. One of the key factors during this period is the gut microbiota, which influences nutrient absorption, energy metabolism, and immune function. An imbalance in the gut microbiota, known as dysbiosis, has been shown to contribute to stunting through impaired intestinal function and chronic inflammation. This literature review aims to describe the role of gut microbiota during the first 1,000 days of life in the development of stunting and to examine microbiota-based intervention strategies from pregnancy through the first two years of life. This study employed a narrative review approach by analyzing 60 scientific articles obtained from PubMed, Scopus, Google Scholar, ScienceDirect, and Consensus AI. The selected articles were published within the past ten years and were relevant to stunting and gut microbiota during the first 1,000 days of life. The review showed that stunted children have lower microbial diversity, decreased abundance of *Bifidobacterium* and *Lactobacillus*, and increased levels of potentially pathogenic bacteria, including Proteobacteria, *Escherichia coli*, and *Desulfovibrio*. Dysbiosis may lead to reduced short-chain fatty acid (SCFA) production, intestinal mucosal damage, and impaired nutrient absorption. Comparisons between stunted and non-stunted children indicate that healthy microbial diversity also contributes to metabolic efficiency and nutritional status. Preventive interventions targeting dysbiosis should begin during pregnancy through the maintenance of maternal nutritional status and probiotic supplementation, followed by exclusive breastfeeding and diversification of complementary foods rich in fiber and prebiotics. A microbiota-based approach may serve as a comprehensive and sustainable strategy for reducing the burden of stunting in Indonesia.

Keywords: dysbiosis, first 1,000 days of life, gut microbiota, short-chain fatty acids, stunting

Introduction

According to the World Health Organization[1], the global number of children affected by stunting reached 148.1 million in 2022, while the Indonesian Nutrition Status Survey[2] reported that the prevalence of stunting decreased from 21.5% in 2023 to 19.8% in 2024. Although this figure has surpassed the target set for 2024, namely 20.1%, the prevalence of 19.8% remains a new challenge considering that the target for reducing stunting prevalence in 2025 is 18.8% [3].

Current stunting prevention efforts focus on nutritional interventions, such as providing supplementary food with vitamin supplementation, promoting exclusive breastfeeding, and emphasizing balanced nutrition education[4]. Education and training for health cadres and adolescents are more directed toward understanding the importance of nutrition, nutritional status assessment, and health promotion[5]. Programs to improve sanitation, access to clean water, and hygiene are also used as approaches to stunting prevention[6]. Local innovations in several areas support intervention programs through training in the preparation of locally sourced foods, such as pumpkin pudding complementary feeding (Makanan Pendamping ASI/MPASI)[7], the Dulur Penting program (Donors of Eggs Caring for Stunting)[8], and the currently trending Free Nutritious Meals (Makan Bergizi Gratis/MBG), a free lunch program under the administration of President Prabowo Subianto[9].

Although various efforts have been made to reduce stunting prevalence, the decline in stunting rates has been slow from year to year. Based on data in national planning documents (RPJM; and the National Strategy for the Acceleration of Stunting Reduction) for 2020-2024, the government previously set a target stunting prevalence of 14% for 2024. However, the target was subsequently revised because it was considered difficult to achieve. Several regions also still have prevalence rates above 20%, which is the WHO standard[12]. This indicates that conventional approaches focusing on nutritional intake have not fully addressed the root causes of stunting. Therefore, further attention should be given to the gut microbiota, which plays an important role in nutrient absorption, protection against infection, and regulation of the immune system, all of which are key factors in child growth.

In recent years, researchers have begun to highlight the role of the gut microbiota as an important factor that may influence child growth. The gut microbiota plays a central role in digestion, nutrient absorption, immune system development, and regulation of body metabolism. Disruption of microbial balance (dysbiosis) during the

First 1000 Days of Life (1000 HPK) may trigger low-grade chronic inflammation, reduce the efficiency of nutrient absorption, and impair linear growth. Therefore, understanding the relationship between gut microbiota composition and stunting is important as a basis for complementing more comprehensive stunting prevention approaches[13].

A study by[14] in Pidie, Aceh, analyzed the relationship between gut microbiota composition, enteric infections, and linear growth in children. This case-control study involved 42 children aged 24–59 months and showed that stunted children had significantly lower levels of Insulin-like Growth Factor-1 (IGF-1) than normal children. Their microbiota composition was dominated by Firmicutes, with reductions in SCFA-producing genera such as Prevotella and Butyrivibrio. In contrast, pro-inflammatory genera such as Blautia, Dorea, and Streptococcus increased. The expression of virulence genes from enteric pathogens (E. coli, Shigella, Salmonella) was also higher and negatively correlated with height and IGF-1 levels. These findings emphasize the role of dysbiosis and enteric infections in impairing linear growth among children in Indonesia.

This literature review aims to explain how the gut microbiota during the 1000 HPK period influences the incidence of stunting and to describe microbiota-based intervention strategies that can be implemented from pregnancy until the age of 2 years to prevent stunting.

The idea proposed in this literature review is the need for a paradigm shift in national stunting prevention programs, from a single focus on the quantity of caloric and nutritional intake toward a strategy directed at cultivating a functional gut microbiota from the 1000 HPK period.

Method

This paper was prepared using a narrative literature review approach based on searches of articles through PubMed, Google Scholar, Scopus, and ScienceDirect. The keywords used included gut microbiota, stunting, 1000 HPK, and dysbiosis. A total of 60 articles were analyzed, comprising clinical studies, cohort studies, and review articles published within the last ten years, so that the data used remained relevant and up to date to support the analysis presented. The inclusion criteria were: 1) primary research articles relevant to stunting, gut microbiota, and 100 HPK interventions; 2) articles discussing at least one of the two main variables, namely gut microbiota and 100 HPK interventions; 3) articles in Indonesian and English; and 4) articles available

in full text for further analysis. The exclusion criteria were: 1) opinion articles, editorials, letters, or narrative reviews that did not present primary data; 2) articles that did not explicitly discuss the main variables; and 3) articles involving an inappropriate population (children older than two years).

Results

Stunting

Stunting is a condition of impaired growth in children under five, characterized by short stature resulting from nutritional deficiencies that may occur during the child's golden period. The golden period is a crucial phase that determines the child's quality of life in the future, and this phase occurs during the 1000 HPK period [15].

This condition affects children's physical and cognitive development and future productivity [16]. Stunting generally occurs as a result of accumulated nutritional deficiencies from pregnancy through the age of two years and is exacerbated by recurrent infections and unfavorable environmental factors [17,18].

The main factors contributing to stunting include inadequate nutritional intake, maternal nutritional status during pregnancy, low levels of family education and income, and poor sanitation[17,19,20]. Insufficient maternal knowledge and inappropriate parenting practices may also worsen the condition. Prevention can be carried out through specific nutritional interventions, education, community empowerment, and cross-sectoral collaboration[21–23]. Improvements in community literacy and knowledge have been shown to improve preventive behaviors and participation in health programs [24,25].

Gut Microbiota

The microbiota is a complex ecosystem containing trillions of microorganisms—including bacteria, archaea, viruses, fungi, and parasites—that naturally live in and colonize the human body. The gastrointestinal tract is the main center of microbiota activity, with the highest microbial density [26].

The gut microbiota (particularly bacteria from the genera Bacteroides, Firmicutes, Bifidobacterium, and Akkermansia) is an integral part of the biological system that helps maintain the body's protective, immunological, and metabolic functions. These microorganisms play vital roles in digestion, vitamin production, nutrient metabolism, and maintenance of intestinal mucosal integrity [27,28].

The microbiota interacts closely with the immune system through the production of molecules such as SCFAs and polyamines, as well as through stimulation of immunoglobulin A (IgA) production. It also modulates inflammation and maintains a balance between pro-inflammatory and anti-inflammatory immune responses. Disruption of these interactions may trigger chronic inflammation and increase the risk of disease [29,30].

Overall, the microbiota is an essential microbial ecosystem for human health. The balance and diversity of the microbiota, particularly in the gut, contribute substantially to physiological function and protection against disease. Changes in microbiota composition, especially during early life such as the 1000 HPK period, may have long-term effects on children's health and development [28,31,32].

First 1000 Days of Life

The 1000 HPK period, from conception to two years of age, is a golden and critical period that is fundamental in determining children's physical growth, brain development, and long-term quality of life [9,13]. Nutritional deficiencies or health problems during this phase may cause permanent effects such as stunting, impaired cognitive development, and increased susceptibility to disease. Therefore, optimal nutrition for pregnant women and children is crucial [33]. Furthermore, stunting is now viewed not only as a consequence of nutritional deficiency but also as being closely related to gastrointestinal health; the gut microbiota plays a central role in nutrient absorption and immune regulation [34]. Therefore, stunting management should include efforts to maintain gut microbiota balance in addition to nutritious food interventions [35]. Prevention of stunting and optimization of growth and development during the 1000 HPK period depend greatly on improving maternal knowledge about nutrition, exclusive breastfeeding, and appropriate complementary feeding [22,36]. Given that many mothers still do not understand the urgency of this period, education and counseling are vital efforts [33,37]. Prevention efforts are optimized through routine nutritional monitoring, education, and implementation of community programs that have been shown to be effective, such as Posyandu and classes for pregnant women [9,38].

Gut Microbiota: From Sanitation to Dysbiosis and Immaturity

The central role of the gut microbiota in the development of stunting among children under five in Indonesia has become a major focus of attention [39]. In addition

to malnutrition caused by inadequate energy and nutrient intake, changes in gut microbiota composition are an important mechanism linking environmental factors to impaired child growth. The main mechanism connecting these environmental factors with impaired growth is through changes in gut microbiota composition [(40)]. Unhygienic environments increase exposure to fecal pathogens, trigger recurrent gastrointestinal infections such as diarrhea, and cause impaired nutrient absorption in the intestine [(39)]. Recurrent infections can alter gut microbiota composition and cause dysbiosis, defined as an imbalance between beneficial and pathogenic bacteria in the gastrointestinal tract[35].

This dysbiosis is characterized by a decrease in beneficial bacteria, such as Bifidobacterium and Lactobacillus, and an increase in pathogenic bacteria[35]. The microbiota profile of stunted children in Indonesia shows lower microbial diversity (α-diversity) and higher concentrations of pathogenic microbes (such as Escherichia coli, Shigella, and Campylobacter) compared with normally nourished children [(41,42)]. In addition, stunted children tend to experience microbiota immaturity, in which their microbiota profile resembles that of younger children [(13,43)]. This is further supported by findings of increased inflammatory taxa (e.g., the genera Desulfovibrio or Streptococcus) and decreased "maturation commensal" genera (e.g., Prevotella and Bacteroides) in several studies.

In children with stunting, an increase in Firmicutes and a decrease in Bacteroidetes have been observed, resulting in reduced SCFA production—a change that may reduce the availability of SCFAs, which are important compounds for intestinal mucosal health and energy metabolism. This imbalance reduces the efficiency of nutrient absorption and also contributes to chronic intestinal inflammation, known as Environmental Enteric Dysfunction (EED)[35].

Mechanisms of Dysbiosis-Induced Nutrient Malabsorption

Dysbiosis is an imbalance in the microbial community that can trigger disease when microbiota functions that are important for health are disrupted or when processes that support disease development emerge. This condition is generally characterized by differences in microbiota composition compared with a healthy population, particularly when these changes are directly associated with disease symptoms. In the human gut, dysbiosis is often observed as reduced microbial diversity and an increased abundance of facultative anaerobic bacteria. This low-diversity dysbiosis pattern has been

mechanistically associated with various diseases, such as liver disease, inflammatory bowel disease, and Clostridium difficile infection[44].

Dysbiosis in stunted children causes the body's ability to digest and absorb nutrients to become suboptimal, even when adequate nutritional intake is provided. The main mechanisms involve two pathways:

1. Metabolic and SCFA Disturbances

Reduced production of short-chain fatty acids (SCFAs) further worsens the condition because SCFAs play important roles in maintaining intestinal health, serving as an energy source, and protecting against pathogens through anti-inflammatory effects [13]. When SCFA production decreases, the epithelial barrier becomes weakened, facilitating the growth and colonization of pathobionts, particularly from the phylum Proteobacteria (such as Enterobacteriaceae and excessive E. coli) and the phylum Desulfovibrio, which have been shown to activate inflammatory cascades. Pathobionts that produce hydrogen sulfide (H2S), primarily from the genus Desulfovibrio, can damage the intestinal epithelium and trigger pro-inflammatory responses. Some nonpathogenic bacteria, such as Prevotella and Bifidobacterium, which are present in lower numbers in stunted children, are important for fiber fermentation and energy absorption [45].

2. Structural Damage to the Intestine

Poor sanitation and recurrent infections can trigger EED. EED is an intestinal inflammatory response resulting from chronic pathogen exposure and microbiota dysbiosis [46]. This condition is characterized by structural changes in the intestine, including blunted villi, increased intestinal permeability (leaky gut), and chronic inflammation that physically impairs effective nutrient absorption [34].

The role of the microbiota in structural damage is supported by a study of duodenal (small intestinal) microbiota, in which colonization by 14 core taxa (classified as enteropathogens), including Veillonella, Streptococcus, and Neisseria, was negatively correlated with length-for-age z-score (LAZ). These taxa were also positively correlated with inflammatory proteins and negatively correlated with nutrient-absorbing enterocyte proteins. A follow-up experiment in gnotobiotic mice given a collection of duodenal bacteria from stunted children demonstrated enteropathy (immune-cell infiltration, epithelial damage, and shedding), providing evidence of a causal role for the microbiota in structural intestinal damage [43].

The effects of dysbiosis and EED prevent children from achieving optimal growth [35]. Stunted children have higher concentrations of pathogenic microbes (such as

Escherichia coli, Shigella, and Campylobacter) and lower numbers of beneficial microbes [41,45]. In addition, they show substantially lower concentrations of essential amino acids (particularly tryptophan, lysine, threonine, and arginine)[47]. This reduction is not only due to inadequate intake but also to impaired intestinal absorption caused by microbiota dysfunction and EED[45,47].

Overall, dysbiosis and EED impair linear growth in children, partly through reduced IGF-1 levels, which play a role in bone and tissue formation [35]. Thus, gut microbiota dysbiosis, triggered by recurrent enteric infections, represents a key pathophysiological mechanism explaining how environmental factors (sanitation) ultimately lead to nutrient malabsorption and impaired child growth in Indonesia [35,39]. Studies show that interventions focused on cultivating a functional gut microbiota, for example through Microbiota-Directed Complementary Foods, have considerable potential to address the consequences of malnutrition and stunting [46,48].

Table 1
Comparison of the Microbiota in Stunted and Normal Children

Microbiota Aspect	Key Bacterial Species	In Stunted Children (Dysbiosis)	In Normal Children (Eubiosis)	Direct Impact on Growth
Protective/Probiotic[13,45]	Bifidobacterium spp., Lactobacillus spp.	Markedly decreased	Dominant and stable	Reduction in these populations causes nutrient malabsorption and increased susceptibility to infection.
Pathogenic/Inflammation-Inducing[35,46]	Proteobacteria, E. coli, Desulfovibrio, Shigella, Campylobacter, Mitsuokella, Providencia alcalifaciens	Significantly increased	Controlled	Induces chronic intestinal inflammation (EED), diverting amino acids toward defense rather than growth.
Butyrate/SCFA Producers[34,44]	Firmicutes (in general), Bacteroidetes	Low SCFA production (population not efficient)	Balanced, high SCFA production (healthy population)	Low SCFA production damages the intestinal mucosa, inhibits cell regeneration, and reduces nutrient absorption.
Functional Maturity [35,57]	Overall compositional profile	Immature (microbiota appears "younger" than the child's age)	Mature (high metabolic efficiency)	Reduces the efficiency of energy extraction from food and inhibits linear growth.
Cause of Structural Damage[36,43]	Veillonella, Streptococcus, Rothia mucilaginosa (duodenum)	Increased colonization	Low colonization	Colonization in the small intestine correlates with inflammatory proteins and damage to nutrient-absorbing proteins.

Strategies for Preventing Gut Dysbiosis during the First 1000 Days of Life

Interventions for gut dysbiosis should begin during the 1000 HPK period to establish a healthy microbiota foundation for the mother and prepare for fetal colonization[43,49,50]. During pregnancy, probiotic or synbiotic supplementation for pregnant women may contribute to the establishment of healthy microbial colonization and limit dysbiosis that may occur as early as the intrauterine period [13]. In addition to supplementation, major attention should be given to maintaining optimal maternal nutritional status [51], including monitoring hemoglobin (Hb) levels and iron (Fe) tablet consumption, because adequate iron and maternal nutrition strongly influence the maternal gut microbiota balance, which in turn supports healthy microbiota colonization in infants [49,50,52]. Although the gut microbiota of newborns undergoes significant changes after birth, maintaining maternal microbiota health during pregnancy provides an important source of microbes that may be transmitted through the vagina or gut during delivery [53].

During early infancy (0–6 months), microbiota interventions focus on providing colostrum and exclusive breastfeeding. Breast milk serves as both nutrition and a functional prebiotic for infants because it contains Human Milk Oligosaccharides (HMOs). These HMOs are not digested by infants but act as specific substrates that support the growth of beneficial bacteria, particularly Bifidobacterium and Lactobacillus [34,43]. Through breastfeeding, mothers indirectly "control" the composition of the infant gut microbiota, ensuring the dominance of beneficial bacteria that play important roles in nutrient absorption and intestinal maturation. Maternal nutritional status maintained from pregnancy continues to support breast milk quality and the transfer of oligosaccharides that promote a healthy microbiota, thereby maintaining continuity in nutritional and microbiota programming.

After 6 months, interventions focus on introducing complementary foods (MPASI) aimed at building gut microbiota diversity and maturity. Complementary foods should be diverse and include natural prebiotic sources such as fruits, vegetables, and whole grains [54]. These prebiotics (e.g., bananas, sweet potatoes, oatmeal) function to increase SCFA-producing bacteria, which are crucial for intestinal maturation and growth [55]. Furthermore, animal protein sources such as pureed beef are strongly

recommended because they have been shown to increase microbiota diversity (alpha diversity), increase SCFA-producing taxa (e.g., Bacteroides and Clostridium), and suppress pathogenic bacteria (Enterobacteriaceae) compared with cereal-based or dairy-only complementary foods [56,57]. A natural synbiotic effect can be achieved by combining high-fiber foods with mildly fermented foods (e.g., banana porridge + infant yogurt or carrot puree + steamed tempeh), which synergistically increase Bifidobacterium and Lactobacillus. Probiotics containing specific strains (e.g., M-16V or BB-12) may be considered as supplements; however, the main focus should be dietary diversification to achieve an optimal microbiota balance [54].

The implementation of microbiota-based interventions for stunting prevention still faces several challenges, particularly in Indonesia. One is the lack of maternal education regarding the importance of nutrition that supports gut microbiota health, especially the consumption of high-fiber foods that function as natural prebiotics [35]. In addition, local research is still needed to identify Indonesian indigenous probiotic strains that are most effective, so that interventions can be better adapted to local population conditions. From a policy perspective, national stunting prevention programs need a paradigm shift, not only emphasizing adequate caloric intake but also integrating microbiota-based interventions within the 1000 HPK framework [13]. Another challenge is the need for strong multisectoral collaboration among health professionals, government, and communities to strengthen the implementation of nutrition- and sanitation-based interventions, so that stunting prevention strategies can become more comprehensive and sustainable [35].

Limitation

This literature review has several limitations. First, it employed a narrative review approach rather than a systematic review or meta-analysis; therefore, the included studies were not quantitatively pooled and the findings could not be synthesized statistically. Second, the literature search was conducted using selected databases, including PubMed, Scopus, Google Scholar, ScienceDirect, and Consensus AI, and was limited to articles published within the past ten years. Third, only articles published in Indonesian or English and available in full text were included, which may

have resulted in the exclusion of relevant studies published in other languages or unavailable as full-text articles. Fourth, the review included studies with different study designs, populations, and intervention approaches, which may contribute to heterogeneity in the reported findings. Finally, because this review focused specifically on the relationship between gut microbiota, stunting, and the first 1,000 days of life, evidence addressing related mechanisms or interventions outside these specific criteria may not have been included.

Conclusion

The gut microbiota during the 1000 HPK period plays an important role in determining child growth [13]. Microbial imbalance or dysbiosis during this period leads to a reduction in beneficial bacteria such as Bifidobacterium and Lactobacillus and an increase in pathogenic bacteria such as Proteobacteria and Desulfovibrio [35]. These changes reduce SCFA production, impair mucosal integrity, trigger chronic inflammation, and cause nutrient malabsorption that ultimately leads to stunting [34,35].

To prevent this, microbiota intervention strategies should begin during pregnancy and continue until two years of age. In pregnant women, the main focus is maintaining nutritional status, preventing anemia, and supporting these efforts with probiotic supplementation when appropriate. After birth, colostrum and exclusive breastfeeding play important roles because their HMO content supports beneficial microbial colonization [13]. Upon introduction of complementary foods, diversification of high-fiber and prebiotic foods, as well as mild fermentation, helps increase SCFA-producing bacteria and microbiota maturity. This integrated approach involving nutrition, probiotics, and sanitation is an effective step toward sustainable stunting prevention [35].

Ethical Considerations

This study was a narrative literature review based on previously published scientific literature and did not involve the direct recruitment or participation of human subjects or animals. Therefore, no new personal or identifiable participant data were collected, and ethical approval was not required. All information used in this review was obtained from published sources, and the original studies were appropriately acknowledged through citations and references.

Acknowledgment

The authors would like to express their sincere gratitude to the Faculty of Medicine, Universitas Mulawarman, for their support during the preparation of this review. We are also grateful to the committee of AXONIC 2025 organized by the Faculty of Medicine, Universitas Negeri Malang, for providing the opportunity to present this literature review. Special thanks are extended to our academic advisors, peers, and institutions whose insights and resources greatly contributed to the completion of this study.

Conflict of Interest

The authors declare that they have no financial or personal relationships with other people or organizations that could inappropriately influence or bias the content and conclusions of this manuscript. There are no conflicts of interest regarding the publication of this literature review.

Author contribution

Shalvira Purnama contribute conceptualization, literature search, data collection, analysis of the literature, and manuscript preparation. Lathifah Athaillah Putri, and Rayita Widya Prameswari contributed equally to the literature search, analysis, and synthesis of the literature, as well as to the drafting and revision of the manuscript. Ronny Isnuwardhana contributed through supervision, mentorship, critical review, and guidance throughout the development and preparation of the manuscript. All authors reviewed and approved the final version of the manuscript.

References

1. Organization WH. Joint Child Malnutrition Estimates, 2023 Edition. 2023.
2. Kementerian Kesehatan Republik Indonesia. Results of the 2024 Indonesian Nutrition Status Survey (SSGI). 2024.
3. RI SWP. Indonesia's Stunting Prevalence Decreased to 19.8%. 2025.
4. Andriani H, Arsyi M, Sutrisno AE, Waits A, Rahmawati ND. Projecting the impact of a national strategy to accelerate stunting prevention in East Nusa Tenggara, Indonesia, using the Lives Saved Tool. Narra J. 2025 Jan 10;5(1):1462.

5. Purnamasari KD, Ningrum WM, Fatimah S. Training Posyandu Cadres to Prevent Stunting during the First 1000 Days of Life in Cidolog District. J SOLMA. 2025 Mar 31;14(1):42–50.
6. Marni M, Ratnasari NY. Counseling on Stunting Risk Prevention during the First 1000 Days of Life among the Younger Generation. Indones J Community Serv. 2021 Nov 23;3(2):116.
7. Hidayatunnikmah N, Rahmawati N, Nuraini SR, Setyani ETA, Aulia RA, Anggraini D, et al. Assistance with Providing Pumpkin Pudding Complementary Foods to Prevent Stunting in Children. As-Sidanah J Pengabdi Masy. 2024 Apr 30;6(1):193–204.
8. Dewi SK, Fuad A, Nurlia E. Counseling on the Dulur Penting Program (Donors of Eggs Caring for Stunting) in Muruy Village, Menes, Pandeglang. J Pengabdi Pada Masy. 2023 Sep 30;8(4):901–8.
9. Mulyaningsih E, Ningsih SS. The Effect of Health Education on Pregnant Women's Knowledge about the First 1000 Days of Life. Malahayati Nurs J. 2024 Jun 1;6(6):2223–33.
10. Bappenas. National Medium-Term Development Plan (RPJMN) 2020–2024. 2020.
11. Kementerian Koordinator Bidang Pembangunan Manusia dan Kebudayaan. National Strategy for the Acceleration of Stunting Reduction 2021–2024 Type: Report. 2021.
12. Pratama MAE, Hendra S, Ngemba HR, Nur R, Azhar R, Laila R. Comparison of Machine Learning Algorithms for Predicting Stunting Prevalence in Indonesia. J Sisfokom (Sistem Inf dan Komputer). 2024 Jun 10;13(2):200–9.
13. Robertson RC, Manges AR, Finlay BB, Prendergast AJ. The Human Microbiome and Child Growth – First 1000 Days and Beyond. Trends Microbiol. 2019 Feb;27(2):131–47.
14. Rinanda T, Riani C, Artarini A, Sasongko L. Correlation between gut microbiota composition, enteric infections and linear growth impairment: a case–control study in childhood stunting in Pidie, Aceh, Indonesia. Gut Pathog. 2023 Nov 9;15(1):54.
15. Hidayah N, Marwan M. Community Empowerment Efforts to Create a Nutrition-Aware Generation of Millennials Free from Stunting through 1000 HPK Activities. J Community Engagem Heal. 2020 Mar 1;3(1):86–93.

16. Widhi BA, Abdussamad Z, Muhid A, Miswaty TC, Yuliana I, Patty ENS, et al. Community Empowerment Strategies for Stunting Management: Understanding, Prevention, and Intervention. INDRA J Pengabdi Kpd Masy. 2025 Apr 30;6(1):5–9.
17. Sayiati NQ, Firmansyah F. The Relationship between Energy and Protein Intake and Stunting in Children Aged 12–36 Months. Nutr J. 2025 Apr 27;9(1):11.
18. Apriluana G, Fikawati S. Analysis of Risk Factors for Stunting among Children Aged 0–59 Months in Developing Countries and Southeast Asia. Media Penelit dan Pengemb Kesehat. 2018 Dec 31;28(4):247–56.
19. Komalasari K, Supriati E, Sanjaya R, Ifayanti H. Factors Causing Stunting in Children Under Five. Maj Kesehat Indones. 2020 Oct 7;1(2):51–6.
20. Sarinastiti W, Murdaningtyas CD, Harvani Y. Design of an Explainer Video for Stunting Prevention in Children Under Five Using Skill Level Animation. ANDHARUPA J Desain Komun Vis Multimed. 2023 Jan 27;8(3):385–98.
21. Rokhaidah R, Hidayattullah R. Maternal Knowledge and Family Support as Efforts to Prevent Stunting in Children Under Five. J Ilm Kesehat Masy Media Komun Komunitas Kesehat Masy. 2022 Oct 4;14(3):141–6.
22. Kwartawaty NN, W ST, Sari DV. Stunting Prevention Literacy and the Effects of Formula Milk Provision in Stunted Children in Tawangmas Urban Village. J Kreat Pengabdi Kpd Masy. 2023 Nov 1;6(11):4655–68.
23. Eriyani T, Mardhiyah A, Fitria N, Yosep I. Family Empowerment in Early Growth Detection and Intervention for Stunting Prevention. J Kreat Pengabdi Kpd Masy. 2024 Feb 1;7(2):774–83.
24. Almira NG, Syafa'atulloh MY. Socialization and Screening of Stunting among Children Under Five in the Community of Sambikerep District, Sambikerep Urban Village, Surabaya City. J Kreat Pengabdi Kpd Masy. 2023 Mar 1;6(3):907–19.
25. Pakpahan S, Simbolon GAH, Panggabean H, Sitompul ES. Early Detection of Growth and Development and Stunting Prevention among Children Under Five in Pearung Silali Village, Paranginan District, Humbang Hasundutan Regency. J Kreat Pengabdi Kpd Masy. 2024 Jun 14;7(7):2837–50.
26. Matijašić M, Meštrović T, Paljetak HČ, Perić M, Barešić A, Verbanac D. Gut microbiota beyond bacteria-mycobiome, virome, archaeome, and eukaryotic parasites in IBD. Int J Mol Sci. 2020;21(8):1–21.

27. Fan Y, Pedersen O. Gut microbiota in human metabolic health and disease. Nat Rev Microbiol. 2021 Jan 4;19(1):55–71.
28. Paul JK, Azmal M, Haque ASNB, Meem M, Talukder OF, Ghosh A. Unlocking the secrets of the human gut microbiota: Comprehensive review on its role in different diseases. World J Gastroenterol. 2025 Feb 7;31(5).
29. Al Bander Z, Nitert MD, Mousa A, Naderpoor N. The Gut Microbiota and Inflammation: An Overview. Int J Environ Res Public Health. 2020 Oct 19;17(20):7618.
30. Wang L, Wang S, Zhang Q, He C, Fu C, Wei Q. The role of the gut microbiota in health and cardiovascular diseases. Mol Biomed. 2022 Oct 11;3(1):30.
31. Thursby E, Juge N. Introduction to the human gut microbiota. Biochem J. 2017 Jun 1;474(11):1823–36.
32. Young VB. The role of the microbiome in human health and disease: an introduction for clinicians. BMJ. 2017 Mar 15;j831.
33. Rezkillah AR, Bahar H, Paridah P. Description of Pregnant Women's Knowledge, Attitudes, and Practices Regarding the Importance of Balanced Nutrition during the First 1000 Days of Life (HPK) in the Working Area of Abeli Community Health Center, Kendari City, 2021. J Gizi dan Kesehat Indones. 2022 Jun 7;3(1).
34. Robertson RC, Edens TJ, Carr L, Mutasa K, Gough EK, Evans C, et al. The gut microbiome and early-life growth in a population with high prevalence of stunting. Nat Commun. 2023 Feb 14;14(1):654.
35. Hardjo J, Selene NB. Stunting and Gut Microbiota: A Literature Review. Pediatr Gastroenterol Hepatol Nutr. 2024;27(3):137.
36. Hutapea AD, Nova F, Panjaitan T, Clementine G, Angelina A. First 1000 Days of Life: Child Nutrition and Growth and Development. J Kreat Pengabdi Kpd Masy. 2022 Aug 1;5(8):2436–47.
37. Widyahening IS, Aufa MA, Alhas MF, Widodo AB, Friska D. Knowledge, Attitude, and Practice of Mothers on the First 1000 Days of Life. eJournal Kedokt Indones. 2021 Sep 1;9(2):129.
38. Siburian UD, Ritonga PT, Sembiring RNS. The Importance of Monitoring Nutritional Status in Pregnant Women and the First 1000 Days of Life in Stunting Prevention in Sangkaran Village, North Tapanuli Regency. J Kreat Pengabdi Kpd

Masy. 2024 Jun 7;7(7):2822–36.

39. Puteri NJ, Fitria L. Access to Sanitation and Its Impact on Stunting in Toddlers in EastNusa Tenggara, Indonesia. Unnes J Public Heal. 2025 May 4;14(1):14–21.
40. Shen Y, Fan N, Ma SX, Cheng X, Yang X, Wang G. Gut Microbiota Dysbiosis: Pathogenesis, Diseases, Prevention, and Therapy. MedComm. 2025 May;6(5):e70168.
41. Helmyati S, Yuliati E, Wisnusanti SU, Maghribi R, Juffrie M. Gastrointestinal Microbiota in Elementary School Children Experiencing Stunting in West Lombok. J Gizi dan Pangan. 2017;12(1):55–60.
42. Surono IS, Venema K, Martosudarmo S, Kusumo PD. Effect of a 6-Month Functional Food Intervention on the Microbiota of Stunted Children in East Nusa Tenggara, Indonesia—A Randomized Placebo-Controlled Parallel Trial. Foods. 2025 Jun 24;14(13):2218.
43. Chen RY, Kung VL, Das S, Hossain MS, Hibberd MC, Guruge J, et al. Duodenal Microbiota in Stunted Undernourished Children with Enteropathy. N Engl J Med. 2020 Jul 23;383(4):321–33.
44. Kriss M, Hazleton KZ, Nusbacher NM, Martin CG, Lozupone CA. Low diversity gut microbiota dysbiosis: drivers, functional implications and recovery. Curr Opin Microbiol. 2018 Aug;44:34–40.
45. Simanjuntak BY, Annisa R, Saputra AI. Literature Review: Is Gut Microbiota Associated with Stunting in Children Under Five? Amerta Nutr. 2022;6(1SP):343–51.
46. Blanton L V, Charbonneau MR, Salih T, Barratt MJ, Venkatesh S, Ilkaveya O, et al. Gut bacteria that prevent growth impairments transmitted by microbiota from malnourished children. Science. 2016 Feb 19;351(6275).
47. Kumar M, Ji B, Babaei P, Das P, Lappa D, Ramakrishnan G, et al. Gut microbiota dysbiosis is associated with malnutrition and reduced plasma amino acid levels: Lessons from genome-scale metabolic modeling. Metab Eng. 2018 Sep;49:128–42.
48. Subramanian S, Blanton L V., Frese SA, Charbonneau M, Mills DA, Gordon JI. Cultivating Healthy Growth and Nutrition through the Gut Microbiota. Cell. 2015 Mar;161(1):36–48.
49. Grech A, Collins CE, Holmes A, Lal R, Duncanson K, Taylor R, et al. Maternal

exposures and the infant gut microbiome: a systematic review with meta-analysis. Gut Microbes. 2021 Jan 12;13(1).

50. Bogaert D, van Beveren GJ, de Koff EM, Lusarreta Parga P, Balcazar Lopez CE, Koppensteiner L, et al. Mother-to-infant microbiota transmission and infant microbiota development across multiple body sites. Cell Host Microbe. 2023 Mar;31(3):447-460.e6.
51. Gardner WM, Razo C, McHugh TA, Hagins H, Vilchis-Tella VM, Hennessy C, et al. Prevalence, years lived with disability, and trends in anaemia burden by severity and cause, 1990–2021: findings from the Global Burden of Disease Study 2021. Lancet Haematol. 2023 Sep;10(9):e713–34.
52. Quezada-Pinedo HG, Cassel F, Duijts L, Muckenthaler MU, Gassmann M, Jaddoe VW V., et al. Maternal Iron Status in Pregnancy and Child Health Outcomes after Birth: A Systematic Review and Meta-Analysis. Nutrients. 2021 Jun 28;13(7):2221.
53. Li Z, Zhang Y, Wang L, Deng TK, Chiu WH, Ming W kit, et al. Microbiota of pregnancy, placenta and newborns in the third trimester: A randomized controlled study. Heliyon. 2024;10(3):e24698.
54. Ferro LE, Crowley LN, Bittinger K, Friedman ES, Decker JE, Russel K, et al. Effects of prebiotics, probiotics, and synbiotics on the infant gut microbiota and other health outcomes: A systematic review. Vol. 63, Critical Reviews in Food Science and Nutrition. 2023. 5620–5642 p.
55. Shi Y, Yin R, Pang J, Chen Y, Li Z, Su S, et al. Impact of complementary feeding on infant gut microbiome, metabolites and early development. Food Funct. 2024;15(21):10663–78.
56. Geniselli da Silva V, Tonkie JN, Roy NC, Smith NW, Wall C, Kruger MC, et al. The effect of complementary foods on the colonic microbiota of weaning infants: a systematic review. Crit Rev Food Sci Nutr. 2024;0(0):1–16.
57. Tang M, Ma C, Weinheimer-Haus EM, Robertson CE, Kofonow JM, Berman LM, et al. Different gut microbiota in U.S. formula-fed infants consuming a meat vs. dairy-based complementary foods: A randomized controlled trial. Front Nutr. 2023;9(January):1–12.