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Pioneering Health Innovation in Society 5.0: The Vital Role of Gut Microbiota in Immune Balance

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Abstract: Microbiota, particularly gut microbiota, plays a crucial role in maintaining human health and influencing disease pathogenesis. Microbiota consists of a collection of microorganisms living in the human body, with essential functions in metabolic processes, nutrient breakdown, and metabolite production that contribute to homeostasis and immune balance. Microbiota imbalance (dysbiosis) can lead to health disorders such as infections and autoimmune diseases. This article evaluates various related studies to understand how gut microbiota interacts with the immune system and maintains human health using the Systematic Literature Review (SLR) method and Meta-Analysis of journals on gut microbiota published in Sinta 3 and 4 reputable journals from 2022 to 2024. This research emphasizes the importance of microbiota in disease prevention and maintaining immune system balance while providing insights into future research directions in this field. Gut microbiota not only functions within the gastrointestinal tract but also has extra-intestinal impacts, such as on the immune system, metabolism, and neurology. Dysbiosis can lead to health issues like metabolic syndrome, inflammatory bowel disease, and autoimmune disorders. Factors influencing microbiota composition include diet, antibiotic use, and environmental factors. Microbiota also affects the immune system by modulating T cells and cytokine production, which are vital for maintaining immune balance and preventing excessive inflammatory responses. Recent studies highlight the role of microbiota in preventing allergies, supporting immune system development, and influencing conditions such as asthma and food allergies. The use of probiotics and prebiotics, along with other dietary interventions, has been shown to help maintain microbiota balance and support overall body health. This article aims to enhance knowledge about microbiota and its benefits for health, including aspects like digestion, immunity, mental health, and well-being.

Keywords: 1; Microbiota 2; Immunity 3; Innovation 4; Health 5; Homeostasis

Introduction

In modern healthcare, the focus has expanded from merely treating diseases to also emphasizing prevention, understanding, and maintaining health. A key area of interest is the study of microbiota, a term introduced in the 20th century during research on the microorganisms, such as bacteria, fungi, and viruses, that live in various parts of the human body, including the gut, skin, lungs, and mouth. "Microbiota" refers to the specific microorganisms in particular environments, like the gut or mouth, while "microbiome" includes not only these microorganisms but also their genetic material, metabolites, and the surrounding environment. The gut microbiota, which includes bacteria, archaea, and eukaryotes in the digestive tract, plays an important role in maintaining immune balance and overall health. (N. Laudy Putri, 2024).

Microbiota refers to the diverse collection of microorganisms, including viruses, bacteria, archaea, and single-celled eukaryotes, that reside within a host. The majority of these microbes, particularly the gut microbiota, inhabit the human gastrointestinal system. In fact, the human body harbors over 100 trillion microbiota cells, representing thousands of different species. These

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microorganisms play a crucial role in protecting the body from harmful pathogens and are integral to metabolic processes and nutrient synthesis, both of which are vital for maintaining human health. Consequently, preserving a balanced microbiota is essential for sustaining the body's homeostasis and overall well-being (Toor, 2019)- (Fetarayani, 2021). The microbiota plays a critical role in regulating various physiological and biological processes within the body. Disruptions in its balance can contribute to the development of diseases and non-communicable conditions (NCDs), often linked to immune system dysfunction and improper inflammatory responses. Moreover, an imbalance in the microbiota can heighten the risk of infections (Rodney Dietert, 2015).

The gut microbiota, which refers to the collection of microorganisms living in the human digestive tract, is increasingly seen as a key player in both health and disease. It helps break down complex carbohydrates, ferment fiber, and metabolize certain nutrients, while also producing important compounds like short-chain fatty acids (SCFAs). These processes not only aid in energy extraction from food but also influence nutrient absorption and help maintain balance in the body, playing an essential role in overall health (Valentina Tremaroli, 2012). Furthermore, the gut microbiota plays a significant role in modulating the immune system. It assists in educating and regulating immune responses, ensuring the proper development and functioning of immune defenses. When the balance of the gut microbiota is disrupted, it can contribute to the onset of immune-related conditions, including autoimmune disorders and allergies (Jian Shen, 2013).

In recent decades, our understanding of microbiota has evolved dramatically. While it was once thought that microbiota primarily had negative effects on the body, it is now recognized that these microorganisms can play a beneficial role in human health (Baohong Wang, 2017). In this era of technological advancement, growing evidence highlights the significant role of commensal microbiota in maintaining gut homeostasis for several key reasons. First, microbiota provide essential trophic and mechanical signals that support critical metabolic functions such as nutrient breakdown, vitamin synthesis, and strengthening of the epithelial barrier. Second, they inhibit the colonization of harmful opportunistic pathogens. Third, microbiota actively engage the immune system by enhancing the body's defense mechanisms against infections and promoting immune tolerance to potential antigens present in the gut lumen (Sarkis K Mazmanian, 2008). This review seeks to provide an in-depth analysis of the role of microbiota in both health and disease, while also exploring future research directions that focus on the interactions between the gut microbiota and the immune system.

What is particularly intriguing is whether the gut microbiota can serve as a breakthrough in health innovation within the framework of Society 5.0, a vision that integrates advanced technology to develop sustainable solutions. In the current era, health solutions extend beyond pharmaceuticals, embracing a holistic approach to optimize human well-being. Therefore, it is essential to understand how the gut microbiota interacts with the immune system, which plays a pivotal role in health maintenance and disease prevention. This paper aims to explore the role of the gut microbiota in sustaining immune homeostasis, examine the factors that can disrupt this balance, and analyze the subsequent impacts on human health. Through this critical approach, we hope to identify new pathways for health innovations that offer significant promise. Now is the time to delve deeper into the vital role of the gut microbiota in maintaining immune balance as a foundation for future health advancements.

Materials and Methods

Study area

This article employs a Systematic Literature Review (SLR) method aimed at evaluating research that may be relevant to answer a specific question (Evi Triandini, 2019). A Systematic Review is a secondary study, which differs from primary studies (individual studies). This qualitative research describes the roles of the researcher, subjects, informants, and data collection methods and assesses the reliability or quality of the data. The advantage of a Systematic Literature Review lies in its ability to summarize research findings into a concrete, comprehensive, and balanced fact.

Procedures

This article applies the Systematic Literature Review (SLR) method, aimed at evaluating and synthesizing research that may be relevant to addressing a specific research question (Evi Triandini, 2019). Unlike primary studies, which produce original data, a systematic review is a secondary study that compiles findings from existing research. This qualitative method details the role of the researcher, subjects, informants, and data collection techniques, while assessing the reliability and quality of the data. The key advantage of the SLR approach is its ability to summarize multiple research studies into a comprehensive, balanced, and concrete overview. By drawing upon pre-existing evidence, it offers a holistic perspective on the topic under study. The SLR process involves several steps: formulating the research question, conducting a literature search, defining inclusion and exclusion criteria, selecting relevant studies, presenting and processing data, and formulating conclusions. The following section elaborates on the Systematic Literature Review method.

1. The research question formulated for this study is: "Does the gut microbiota contribute to immunity and promote balance within the human body?" The literature review was conducted by analyzing data sourced from journals indexed in Sinta, Scopus, and Google Scholar. The search utilized the keyword "The Role of Gut Microbiota in Human Health and Disease", and was carried out between August 15, 2024, and September 15, 2024, to ensure the validity and relevance of the data.
2. The inclusion criteria for this study were as follows: (a) studies published in Sinta-indexed scientific journals that are relevant to the topic under discussion, and (b) prioritization of journals published within the time span of 2022-2024. These criteria were used to ensure the relevance and timeliness of the research material.
3. The literature is meticulously selected based on the established criteria. Journals that meet these criteria undergo further analysis, where the researchers closely review and examine the data. The obtained data is then compared across different studies to identify similarities and differences. This process allows the researchers to draw well-founded conclusions by thoroughly analyzing and contrasting the findings from various sources.
4. Data extraction is performed from journals that have undergone qualitative synthesis. This synthesis process is aimed at addressing the research question. The findings are presented in the form of a narrative report, offering valuable insights for both the community and future researchers, providing a clearer understanding of the topic and guiding further research efforts.

Results and Discussion

Result

In this study, ten selected data sources were further analyzed and rigorously reviewed using the Systematic Literature Review method for comprehensive insights.

Table 1. Research Journal Studies to Microbiota

No.	Identity	Author	Methods	Conclusion
1.	Human gut microbiota in healt and disease: unveiling the relationship	Muhammad Afzaal	Qualitative methods with literature review	The mechanisms that lead to disease development have a significant correlation with gut microbiota, metabolic products, and the host immune response in humans
2.	Designing an Illustrated storybook on the Role of microbiota in the Human body	Dimas Agung Pangestu	Qualitative methods with literature review yield descriptive data	Illustrated storybook design can enhance microbiology knowledge and foster children's interest in reading, particularly regarding the role of microbiota in the body
3.	Role of The gut microbiota in human health	Aleksandra Chalupnik	Using standard qualitative criteria as a research	Abnormal gut microflora not only accelerates the development of metabolic

			method	syndrome but also contributes to other diseases
4.	Mikrobioma usus yang sehat untuk menua dengan sehat	Teresa Liliana Wargasetia	Using traditional literature review as refrence	The role of the microbiome in aging and disease, as well as healthy lifestyle (diet) and medical interventions for the presence of microbes.
5.	Exploring the role of gut microbiota in human health	Amarachukwu Bernaldine Isiaka	Qualitative methods with literature review	Understanding can enhance knowledge about the role of gut microbiota in health, suggesting future research and interventions
6.	Relationship between gut microbiota and allegies in children: A Literature Review	Alexandru Cosmin Pantazi	Qualitative methods with literature review	The complexity of gut microbiota is influenced by host genotype, mode of delivery, breastfeeding, diet, antibiotic use, and environmental factors. The relationship between gut microbiota and atopic sensitization, the immune system, body growth, and diseases such as atopic dermatitis, asthma, and necrotizing enterocolitis indicates the importance of a balanced gut microbiome.
7.	The importance of the gut microbiome in the development of allergic diseases	Emilia Januszkiewicz	Qualitative methods with literature review	Microbiota can lead to various allergic diseases, resulting in patient discomfort and potentially life-threatening conditions.
8.	Mivrobiome and Allergy : New Insights and perspective	Zubeldia-Varela E	Qualitative methods with literature review	Microbiota significantly impacts fundamental aspects of human physiology and health, and it is influenced by factors such as diet, antibiotic use, and lifestyle.
9.	Defining the relationship of gut Microbiota, Immunity, and Cognition in Early Life A Narrative Review	Melissa Stephanie Kartjito	Qualitative literature analysis	Gut microbiota and its implications for human health, particularly the gastrointestinal, immune, and nervous systems. Gut microbiota, the immune system, and the central nervous system are interconnected through the "gut-brain axis."
10.	Role of gut microbiota in infectious and inflammatory diseases	Mirian Ferrao Maciel-Fiuza	Qualitative methods with literature review	The cytokine realtionship between microbiota and the host is a dynamic and complex process tha significantly affects inflammation

Recent advances in human microbiome research have significantly expanded our understanding of normal microbial communities, particularly those residing within the human body. Studies on microbiota have shown that microbial-host interactions are not confined to a single organ but extend across multiple organs.

Discussion

The Role of Microbiota

Most microorganisms residing on body surfaces are closely linked to the immune system and can present a pathogenic threat to the host. The immune system's role is to maintain the homeostasis of the body's microbiota, ensuring a mutualistic relationship between the host and these microorganisms (Fitri Elizabrth Br Hasibuan, 2017). According to Muhammad Afzaal (2022), the microbiota acts as a key mediator of body homeostasis, influencing various physiological activities such as metabolism, barrier integrity, inflammation, and hematopoiesis. More recently, the gut microbiota has been described as a “vital organ” due to its associations with other organs via neural, endocrine, humoral, immunological, and metabolic pathways (Muhammad Afzaal, 2022).

Dimas Agung further elaborates on the functions of microbiota in relation to immune system regulation, human development, and nutrition. The microbiome plays a pivotal role in aiding digestion, modulating immune responses, and providing protection against pathogenic bacteria. Microbiomes located in the skin, digestive system, respiratory tract, and urogenital tract interact directly with external factors such as air, food, and medications (Dimas Agung Pangestu, 2021). Within the intestinal tract, the role of microbiota in maintaining a balanced microbial state is referred to as eubiosis, while dysbiosis describes a condition of microbial imbalance in the digestive tract, leading to dysfunction in the gastrointestinal microflora and subsequent health issues (Dimas Agung Pangestu, 2021).

Aleksandra Chaÿupnik (2019) explains that gut microorganisms contribute to the immune system by influencing the maturation of immune cells. However, an abnormal composition of gut microflora can lead to conditions such as metabolic syndrome and other diseases. Factors such as diet, lifestyle, and antibiotic therapy can disrupt the balance of microbiota (Aleksandra Chałupnik, 2020).

Alexandru Cosmin Pantazi's research (2023), which focuses on children, shows that the formation of human gut microbiota begins during fetal development, with bacterial DNA detected in the placenta, amniotic fluid, and meconium of newborns (Alexandru Cosmin Pantazi, 2023).

Furthermore, Emilia Januszkiewicz's (2023) study highlights that the gut microbiome is highly diverse and dynamic, comprising bacteria, viruses, fungi, and parasites (Emilia Januszkiewicz, 2023). In adults, the makeup of the intestinal microflora is influenced by past infections, antibiotic use, stress, and diet, which can contribute to the development of autoimmune disorders, cancer, infectious diseases, and allergies.

Researcher Melissa Stephanie Kartjito (2023) describes the gut microbiota as being involved in key processes such as metabolism, protection, and trophic functions, including nutrient breakdown, pathogen prevention, and maintaining immune system homeostasis. Various factors, such as mode of birth, antibiotic use, and diet, influence the composition and function of the microbiome (Melissa Stephanie Kartjito, 2023).

Miriãn Ferrão Maciel-Fiuza (2023) further elaborates on the multiple functions of the gut microbiota, including its role in protecting against pathogens by colonizing mucosal surfaces and producing antimicrobial substances, assisting with digestion and metabolism, regulating epithelial cell proliferation and differentiation, modulating insulin resistance and secretion, and influencing brain-gut communication, thereby affecting the host's neurological functions (Miriãn Ferrão Maciel-Fiuza, 2023).

Microbiota Diversity

Research by Teresa (2023) explains that aging is associated with significant changes in the gut microbiome, particularly in the composition of bacterial populations. Older adults exhibit an increased abundance of bacteria from the genera Enterococcaceae, Enterobacteriaceae, Lactobacillaceae, and Bacteroides, some of which, like *E. coli*, are linked to conditions such as diarrhea and urinary tract infections. Additionally, bacterial diversity diminishes with age, with a more noticeable decline occurring after the age of 80 (Liliana, 2023).

Amarachukwu's research (2024) further describes the gut microbiota as being composed of bacteria from the phyla Firmicutes, Bacteroidetes, Actinobacteria, Verrucomicrobia, and Proteobacteria. The variation in species between individuals is influenced by factors such as age, diet, geography, and host genetics. Additionally, the human colon contains primary pathogens, including species like *Campylobacter jejuni*, *Vibrio cholerae*, *Salmonella enterica*, *Escherichia coli*, and *Bacteroides fragilis* (Amarachukwu Bernaldine Isiaka, 2024).

The development of the microbiome is greatly influenced by the method of delivery, as noted by Alexandru Cosmin Pantazi (2023). Vaginal and perianal births promote the growth of specific bacteria like *Lactobacillus*, *Prevotella*, and *Sneathia* spp. Breastfeeding also plays a significant role in shaping the *microbiome*, as human breast milk contains important prebiotic substances such as human milk oligosaccharides, which support the growth of beneficial bacteria, particularly *Bifidobacterium* and *Lactobacillus*. In contrast, formula-fed infants typically develop microbiomes with different bacterial populations, including *Roseburia*, *Clostridium*, and *Anaerostipes*. Additionally, dietary factors can have a major impact on the *microbiome*. For example, high-fiber foods and the use of antibiotics during infancy and early childhood can significantly change microbial composition (Aleksandra Chałupnik, 2020).

According to Zubeldia-Varela E (2022) (According to Zubeldia-Varela E, 2022), the gut microbiome is the most complex and diverse microbial ecosystem in the body, with the highest concentrations found in the oral cavity and digestive tract. The number of bacteria in areas between the colon and appendix can range from 10^9 to 10^{11} per gram, with the total number of bacterial genera varying between 1,000 and 3,000. A single gram of human feces may contain between 10 million and 100 billion bacteria. The overall makeup of the gut microbiota is shaped by various factors, including age, diet, antibiotic use, smoking, lifestyle, and environmental influences.

Melissa Stephanie Kartjito (2023) describes how advancements in sequencing technology allow for the identification of microbial species within the gut, categorizing them as "good" or "bad" based on their effects on health or disease. Examples of beneficial bacteria include *Bifidobacterium* spp. and *Lactobacillus* spp., while harmful bacteria encompass *Enterococcus faecalis*, *Clostridium difficile*, and *Campylobacter* spp. (Melissa Stephanie Kartjito, 2023).

Similarly, Miriãn Ferrão Maciel-Fiuza (2023) elaborates that the human gut microbiota comprises a diverse array of microorganisms, including viruses, bacteria, archaea, fungi, and protozoa. This complex ecosystem features over 1,500 species, establishing symbiotic or mutualistic relationships with both epithelial and lymphoid tissues. The predominant components of the gut microbiota are bacteria, particularly those belonging to the phyla *Firmicutes*, *Bacteroidetes*, *Actinobacteria*, and *Proteobacteria* (Miriãn Ferrão Maciel-Fiuza, 2023).

The Influence Of Gut Microbiota On Immunity

Muhammad Afzaal (2022) explains how early development of the gut microbiota is important for preventing autoimmune disorders and supporting immune function. The gut microbiome is vital for the maturation of the immune system, encompassing both adaptive and innate immune responses. Innate immunity involves physical barriers provided by the epithelium, specialized immune cells, and various chemical factors. The gastrointestinal (GI) microbiota modulate neutrophil activity and influence the differentiation of T cell populations into distinct types, including T helper (Th) cells such as Th1, Th2, and Th17, as well as regulatory T cells. Th17 cells, a subset of TCD4+ cells, secrete several cytokines that are pivotal in maintaining immune homeostasis and regulating inflammation. Proper maturation of the immune system necessitates a balanced diet and dietary supplements that can alter the composition of gut microbes, helping to prevent abnormal immune responses that can lead to inflammation and chronic diseases (Muhammad Afzaal, 2022).

Meanwhile, Dimas notes that the influence of gut microbiota extends from birth into adulthood, shaped by environmental and nutritional factors. The gut microbiota significantly affects immunity, and dysbiosis can adversely impact this system. Immunoglobulin A (IgA) is particularly important for mucosal immunity, as it protects the surfaces of organs by preventing the adhesion of viruses and bacteria. Dimas highlights that a decrease in IgA-producing cells in the colon, particularly when challenged by pathogenic bacteria, correlates with reduced levels of IgA in feces. This finding underscores the involvement of IgA secretory cells in maintaining intestinal microbial populations and fostering the establishment of normal microbial communities (Dimas Agung Pangestu, 2021).

Teresa's research (2023) aligns with previous findings, indicating that gut microbiota can aid in restoring immune and cognitive functions affected by aging. She notes that administering probiotics enhances antioxidant activity, improves immune balance, suppresses chronic inflammation, regulates fat storage and metabolism, and helps prevent insulin resistance (Liliana, 2023). Similarly, Amarachukwu (2024) explains that one of the primary functions of the gut microbiota is the fermentation of dietary fibers and complex carbohydrates that evade digestion by host enzymes in the upper gastrointestinal tract. This process involves colonic organisms such as *Bacteroides*, *Roseburia*, *Bifidobacterium*, *Faecalibacterium*, and *Enterobacteria*. The fermentation yields short-chain fatty acids (SCFAs) like acetate, propionate, and butyrate, which serve as energy sources for colonic epithelial cells. SCFAs also act as immunomodulators, influencing the differentiation and functionality of immune cells within the gut. The gut microbiota significantly shapes the development and function of the immune system, particularly in the maturation of gut-associated lymphoid tissue (GALT) and the differentiation of immune cells, such as regulatory T cells, which maintain immune tolerance and prevent inappropriate immune responses. Through interactions with intestinal epithelial cells and immune cells like dendritic cells, macrophages, and T cells, the gut microbiota contributes to immune homeostasis, tolerance to commensal microbes, and the enhancement of immune responses. Furthermore, the gut microbiota enables the immune system to differentiate between harmful pathogens and beneficial commensal microorganisms. Disruption of this balance can lead to immune-mediated conditions, including inflammatory bowel disease (IBD) and allergies (Amarachukwu Bernaldine Isiaka, 2024).

According to Alexandru Cosmin Pantazi (2023), gut microbiota populations aid physiological processes such as digestion, metabolism, and immune system regulation. Dysbiosis is an important factor in the increasing prevalence of allergies. Further research explains that certain bacterial species, including *Bifidobacteria* and *Lactobacilli*, play a significant role in maintaining immune homeostasis; specifically, the stimulation of regulatory T cells can reduce allergic responses, along with the promotion of anti-inflammatory cytokines such as IL-10. Many instances of dysbiosis result in a decrease in gut microbiota, disrupting immune balance and making individuals susceptible to allergic reactions. Additionally, a reduction in the diversity of gut microbiota influences dysbiosis, leading to decreased resistance to pathogenic microorganisms and weakened immunity. Probiotics, when consumed in sufficient amounts, provide numerous benefits by competing with harmful bacteria for adhesion sites on the intestinal epithelial surface, thereby limiting the proliferation of pathogenic bacteria. They also improve intestinal barrier function, reducing the translocation of pathogens and harmful bacterial toxins, which helps decrease inflammation. Probiotics modulate immune responses by increasing anti-inflammatory cytokines (e.g., IL-10, TGF-β) and reducing the release of pro-inflammatory cytokines (e.g., TNF-α, IL-6), thus enhancing gut immune responses. Research noted by Alexandru indicates that the gut microbiome can influence respiratory diseases, such as asthma (the "gut-lung axis" phenomenon), and that microbial changes can increase the risk of developing food allergies (Alexandru Cosmin Pantazi, 2023).

According to Emilia Januszkiewicz (2023), gut microbiota significantly influence several diseases, including food allergies, asthma, and eczema. The pathogenesis of food allergies is primarily associated with immunoglobulin E (IgE)-mediated reactions, where symptoms can manifest within minutes and may include rash, fever, redness, diarrhea, vomiting, and swelling. In severe cases, food allergies can lead to life-threatening anaphylaxis. The symptoms of food allergies are a result of degranulation of basophils and mast cells, triggered by IgE binding to the high-affinity IgE receptor (FceRI). The production of IgE depends on Th2 lymphocytes, which release IL-4; this interleukin is necessary for B cells to produce IgE isotypes. In the context of asthma, various studies have noted differences in the gut microbiota of asthmatic versus non-asthmatic individuals. For instance, individuals with allergic asthma tend to have higher levels of *Lactobacillales*, while non-allergic patients exhibit a lower abundance of the *Clostridia* genus. Additionally, asthma patients have been found to possess higher levels of *Lachnoclostridium*, *Parabacteroides*, and *Faecalitalea* compared to their non-asthmatic counterparts. Regarding eczema, a clear association exists between gut microbiota and the development of atopic eczema, with notable differences in the abundance of bacterial species, particularly within the Gram-negative *Enterobacteriaceae* family and the Gram-positive *Ruminococcaceae* (Emilia Januszkiewicz, 2023).

Zubeldia-Varela E (2022) explained that microbial imbalance is linked to immune system modulation, which affects the gastrointestinal tract. Microbes promote the differentiation of regulatory T cells (Tregs) by activating dendritic cells located on the surface of the intestinal mucosa through the recognition of Toll-like receptors. These activated cells produce interleukins that stimulate TH0 lymphocytes to differentiate into specific T lymphocyte subtypes, including TH1, TH2, TH17, and Tregs. In a healthy individual, there is a dynamic balance between TH lymphocytes and Tregs. However, in individuals with illnesses such as rhinitis, atopic eczema, asthma, and allergies to foods like peanuts, eggs, or cow's milk, both gut microbiota and Treg levels are diminished. Probiotics function as immunomodulators by promoting the establishment of a diverse microbiota and providing protective effects through competition with pathogenic bacteria, maintaining the integrity of the intestinal barrier, and preventing antigenic sensitization. The most commonly used probiotics include *Lactobacillus rhamnosus* and various species of *Bifidobacteria*. Prebiotics, which also confer health benefits, consist of carbohydrate oligosaccharides such as fructans (including inulin and fructooligosaccharides [FOS]), galacto-oligosaccharides (GOS), and lactulose (According to Zubeldia-Varela E, 2022).

Melissa Stephanie Kartjito (2023) emphasizes dietary interventions such as prebiotics, synbiotics, probiotics, and polyunsaturated fatty acids (PUFAs) that are beneficial in reducing the impact of disturbances in the gut microbiota early in life. Probiotics can help establish a healthy gut microbiota, improve gut integrity, and enhance immune function. PUFAs, especially omega-3 fatty acids, have anti-inflammatory properties and have been shown to influence the gut microbiota, thereby improving gut health and immune function (Melissa Stephanie Kartjito, 2023).

In a study by Miriãn Ferrão Maciel-Fiuza (2023), the gut microbiota is important for food degradation, fermentation, and defense against pathogens. In the absence of gut microbiota, the gut mucosal immune system cannot develop properly; for example, the number of functional regulatory CD4+ CD25+ T cells is reduced, resulting in diminished capacity to fight pathogenic bacteria. The balance between effector T helper cells (Th17), which produce pro-inflammatory interleukin (IL)-17, and regulatory T cells (Tregs) expressing Forkhead box P3 (Foxp3+) in the gut requires signaling from gut bacteria. Gut microbiota dysbiosis is associated with the body's immunity, affecting the regulation of the human immune system. For instance, molecular mimicry can impact intestinal mucosal permeability and disease initiation and progression. Certain microbiota can prevent autoimmunity in genetically susceptible individuals, potentially triggering autoimmune processes (Melissa Stephanie Kartjito, 2023).

Conclusions

Based on the results and discussion presented, it can be concluded that the analysis of 10 articles through the Systematic Literature Review method indicates that gut microbiota plays a significant role in human health, particularly within the gastrointestinal tract. The gut microbiota is essential for maintaining metabolism, nutrition, and immunity, influencing various physiological processes. It assists the body in defending against pathogens and interacts with the immune system to maintain balance. When an imbalance occurs, referred to as dysbiosis, it can lead to numerous health issues, including metabolic syndrome, autoimmune diseases, and disorders related to the digestive, circulatory, nervous, or immune systems, as well as other organ-related diseases. The composition of the microbiota can be affected by multiple factors, including diet, lifestyle, age, environmental influences, and antibiotic therapies. The use of antibiotics, in particular, can impact microbiota diversity and composition. However, the analyzed journals did not provide a detailed examination of the gut microbiota's role in mental health. According to Baiq Annisa Pratiwi in her journal, the microbiota can influence the nervous system through the “gut-brain axis,” potentially contributing to conditions such as stroke (Baiq Annisa Pratiwi, 2022). To address these issues, increasing the consumption of probiotics and prebiotics is recommended, as these can enhance immune function and restore microbiota balance. This is particularly beneficial for managing allergic diseases, asthma, and eczema, suggesting that the microbiota has a substantial impact on various health conditions. This article aims to emphasize the importance of maintaining immune balance, paving the way for the development of innovative health solutions in the future.

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