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Gut Microbiota and Human Health: The Nutrition Connection-A Systematic Review

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Abstract

A well-balanced intestinal microbial ecosystem is fundamental to human health, influencing digestion, metabolism, immunity, and neurological processes. Growing evidence demonstrates that diet plays a central role in shaping microbial composition and functionality. This systematic review examined the influence of dietary patterns on the human gut microbiota and their consequent effects on health. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. Thirty studies were screened for eligibility, of which thirteen met the inclusion criteria. Relevant literature was sourced from PubMed, Google Scholar, Science Direct, and African Journals Online. Data were extracted on dietary interventions and patterns that modulate gut microbiota composition and function, with key outcomes including microbial diversity, metabolic resilience, inflammation, and long-term health effects associated with diet-induced microbial changes. Findings from randomized controlled trials indicate that fiber-rich, Mediterranean, and plant-based diets promote microbial diversity, enhance metabolic resilience, and reduce inflammation. Observational studies further suggest long-term associations between these dietary patterns and reduced risks of metabolic disorders, gastrointestinal diseases, and adverse mental health outcomes. In contrast, diets high in fat, sugar, and processed foods were consistently linked to dysbiosis and increased disease risk. However, uncertainties remain regarding the long-term efficacy of probiotic supplementation and the impact of artificial food additives on microbial integrity. Future research should prioritize mechanistic studies on diet-induced microbial changes and the development of targeted dietary guidelines informed by microbiome profiling. Additionally, long-term clinical trials are needed to validate personalized nutrition and microbiome-based interventions for sustainable gut health.

Keywords: Dietary patterns, diet-induced microbial changes. Dysbiosis, gut health, gut microbiota, probiotics

Introduction

The gut microbiota is highly adaptable and contains a varied community of microorganisms present within the gastrointestinal tract, such as bacteria, viruses, fungi, and archaea. These microbes interact with the host and play an essential role in body functions, for example, metabolic processing of nutrients, regulating host immunity, and maintaining the gut barrier integrity. The variation in the composition and function of the gut microbiota has been associated with numerous chronic and acute health conditions. (Roychoudhuri et al., 2024)

The diet serves as a major regulator of gut microbiota population and function. The food we eat provides nutrients that support the growth of both beneficial and harmful microorganisms. A diet high in fiber, probiotics, and prebiotics is known to enhance gut microbiota diversity and improve metabolic functions, while overconsumption of ultra-processed foods, saturated fats, and simple sugars promotes dysbiosis (microbial imbalance) and associated health issues (Zhang, 2022)

Objective

The review examined the influence of dietary patterns on human gut microbiota composition and functionality, and their consequent effects on health.

Literature Review

How Nutrition Shapes the Gut Microbiota

Nutrients influence the profile and functionality of the intestinal microbiota, with dietary carbohydrates, proteins, fats, minerals, vitamins, and polyphenols exerting distinct effects. Complex carbohydrates serve as nutrients for probiotics such as Bifidobacterium and Lactobacillus. (Zheng et al., 2020a), whereas refined sugars reduce microbial diversity. Protein source and quantity influence gut microbial balance, with plant-based proteins being more favorable than animal sources (He et al., 2022).In addition, diets high in unhealthy fat, such as saturated and Trans fats, promote dysbiosis, whereas unsaturated fats, particularly omega-3s, promote a healthier gut microbiota.

Although evidence underscores the significant influence of diet in regulating gut microbiota and health outcomes, the evidence base remains fragmented(M et al., 2025). Variations in study design, population demographics, dietary assessment methods, and microbiome analysis techniques limit comparability across studies(Y et al., 2022). Many investigations are short-term, making it difficult to establish causality or assess sustained dietary effects. Furthermore, inconsistencies in reporting outcomes such as microbial diversity indices, metabolite production, and clinical endpoints create challenges in synthesizing results. Findings from a systematic review analyzing both randomized controlled trials and observational studies indicate a lack of consistent evidence that diet alters gut microbiota composition or metabolism (Kimble et al., 2022). Dietary studies for human gut microbiota research often use varying assessment methods or summary indices, complicating the interpretation of associations with microbiota outcomes (Diacova et al., 2025). Emerging issues, including the effect of artificial food additives, the gut-brain axis, and personalized nutrition strategies, are often explored in isolation without integration into broader dietary frameworks(Berding et al., 2021). In summary, the variation in study designs and inconsistencies in reporting outcomes underscore the need for a systematic review. The review included observational studies and randomized controlled trials, which applied inclusion and exclusion criteria. The reviewed evidence across diverse populations documented both the strengths and limitations of the study findings.

Research findings indicate that nutrients are a key determinant in influencing the profile and functionality of the intestinal microbial community. Dietary carbohydrates, especially complex carbohydrates, act as substrates for probiotic strains like Lactobacillus and Bifidobacterium. (Zheng et al., 2020b). However, a high intake of food with refined sugars has been shown to reduce microbial diversity. Moreover, the consumption of plant-based proteins supported a healthier microbial balance as compared to the consumption of red meat. (He et al., 2022). High intake of trans fats and saturated fats is associated with dysbiosis, whereas unsaturated fats, for example, omega-3 fatty acids, have been shown to promote microbial diversity. (Wu et al., 2021). Finally, vitamins, minerals, and polyphenols were found to promote gut health by influencing microbial populations and reducing inflammation. (Janis & Sharma, 2025).

Influence of Gut Microbial Composition on Health Outcomes

A balanced gut microbial community supports metabolic functions through the production of short-chain fatty acids (SCFAs), important for maintaining insulin sensitivity and energy homeostasis. Microbial dysbacteriosis in the gut has been linked to obesity, type 2 diabetes, and other metabolic disorders (Winiarek et al., 2024). While a disruption in gut microbes' balance has been associated with inflammatory disorders like inflammatory bowel disease (IBD) and irritable bowel syndrome (IBS), this is often as a result of increased gut permeability and chronic inflammation(Basak et al., 2022). Furthermore, disruptions in the gut-brain axis caused by dysbiosis contribute to mental health disorders such as depression and anxiety. However, causality remains under investigation, with several studies suggesting a significant correlation between altered microbiota and adverse neurological outcomes(Petrut et al., 2025).

Beneficial and Harmful Dietary Patterns that Influence Gut Microbial Diversity and Functionality

Polyphenols, unsaturated fat, and fiber-rich diets, such as Mediterranean and plant-based diets, positively influence gut microbial diversity and promote good health. It lowers inflammation and improve metabolic outcomes(Jafarnezhad et al., 2025). Conversely, the Western diet, characterized by dietary patterns rich in processed foods, unhealthy fat, and simple carbohydrates, is associated with dysbiosis, metabolic disorders, gastrointestinal disease, and severe mental health outcomes. (Zheng et al., 2020b).

Methodology

Research Design

The study adopted a systematic literature review approach, reviewing existing literature regarding the association between nutrition, human health, and gut microbiota. Scientifically reviewed journal articles, books, and reports were reviewed to collect data on dietary influences, microbiota composition, and health effects.

Data Collection

Data collection for this review was guided by clearly defined inclusion and exclusion criteria. The review focused on studies involving healthy adult participants. It included randomized controlled trials, clinical trials, and observational studies that examined the relationship between diet and gut microbiota composition and function. Eligible studies were required to evaluate health outcomes associated with microbiome alterations and to provide relevant information on dietary interventions, including whole diets, specific foods, probiotics, and prebiotics.

Studies were excluded if they primarily focused on animal models without clear human relevance, lacked empirical data or were not peer-reviewed, or fell outside the scope of nutrition-related microbiome research. Relevant literature was identified through established academic databases, including Google Scholar, PubMed, and Science Direct. The search strategy incorporated key terms such as "gut microbiota and nutrition," "dietary impact on gut microbiome," "probiotics and prebiotics," and "gut health and disease" to ensure comprehensive coverage of the topic.

The selection process was limited to studies published between 2020 and 2025 to ensure the inclusion of recent and relevant evidence. These eligibility criteria were applied systematically to identify studies that were most appropriate for addressing the objectives of the review.

Eligibility criteria

Criteria	Inclusion Criteria	Exclusion Criteria
Population	• Healthy adult participants	• Adults with chronic or acute illnesses • Studies on animals or in vitro models • populations not clearly described
Intervention	• Food- or diet-based interventions, including whole diets, specific foods, prebiotics, probiotics, or symbiotic	• Interventions limited to nutrition supplements only; studies not clearly describing dietary components
Comparators	Placebo, standard diet, or alternative dietary interventions	• Comparisons involving only supplements without a dietary context
Outcomes	Gut microbiota composition (α- and β-diversity, taxa abundance), microbial functionality (metabolites, SCFAs), health outcomes related to microbiota alterations (e.g., inflammation, gastrointestinal symptoms, metabolic markers)	• Outcomes unrelated to gut microbiota or diet (e.g., unrelated clinical outcomes, data not extractable, duplicate or overlapping data)

Study Type	Randomized Controlled Trials (RCTs) and observational studies (cohort, case-control, cross-sectional)	• Abstract-onlypapers, editorials, commentaries, author responses, theses and books, articles without full text, case reports/series, systematic reviews, studies in languages other than English, protocols, or conference proceedings
Publication Period	Studies published between 2020 and 2025	Studies published outside this period
Language	English	Non-English publications

Data Analysis

The selected papers were thematically examined, with findings divided into three categories: nutrition-microbiota interactions, health implications of microbiota changes, and successful diet interventions. Data trends and patterns were combined to draw meaningful conclusions.

Risk of Bias Assessment

This review did not conduct a formal risk-of-bias assessment using standardized tools, such as the Cochrane Risk of Bias tool (RoB 2) for randomized controlled trials or the Newcastle-Ottawa Scale (NOS) for observational studies. The included studies were heterogeneous in design, population demographics, dietary assessment methods, and microbiome analysis techniques, which limited the applicability of a single tool. Nevertheless, potential sources of bias were noted during data extraction, including small sample sizes, short intervention durations, reliance on self-reported dietary intake, and inconsistencies in reporting microbiota outcomes. These methodological limitations were considered in the interpretation of findings.

Results and Discussion

Figure 1 PRISMA 2020 Flow Diagram for Study Selection in the Systematic Review on Gut Microbiota and Human Health

The PRISMA 2020 flow diagram Figure 1 illustrates the systematic process of study selection in the review on gut microbiota and human health. Out of 629 records initially identified from databases, duplicates were removed, leaving 369 records. Of these, 250 were screened, and 210 were excluded based on titles and abstracts. The remaining 25 full-text articles were assessed for eligibility, but 17 were excluded. Ultimately, 8 studies met all criteria and were included in the qualitative synthesis, showing how the review narrowed down from a broad search to a focused set of relevant studies.

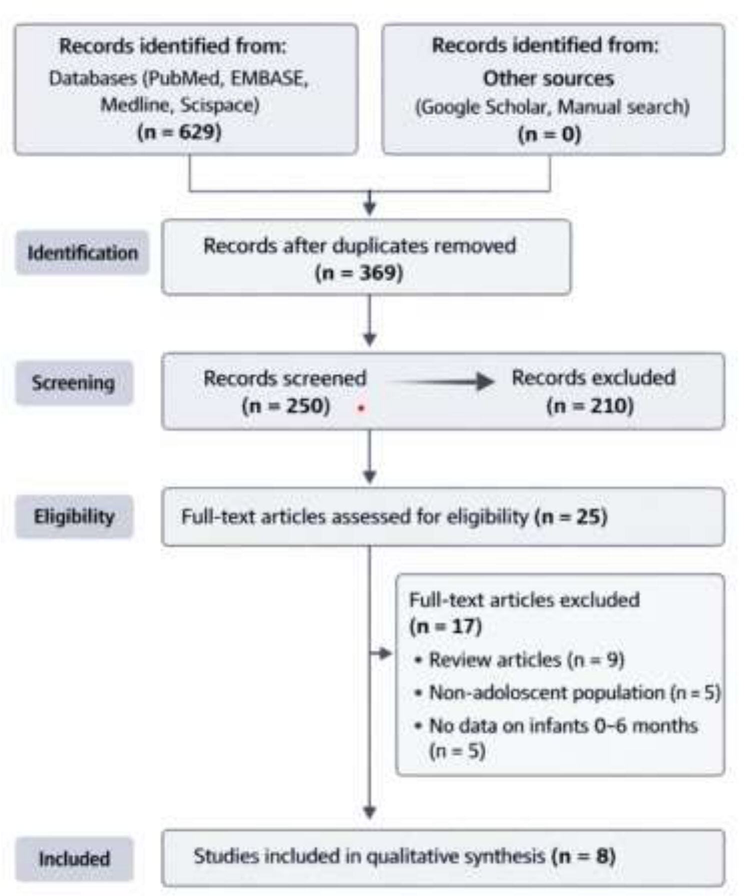

Table 2: The evidence from Recent Studies on Dietary Interventions, Gut Microbiota Modulation, and Associated Health Outcomes

Study/Author (Year)	Design & Population	Dietary Pattern / Intervention	Key Effects on Gut Microbiota	Health Outcomes
Zhang (2022)	RCT, healthy adults	High-fiber diet (prebiotics: inulin, FOS)	↑ Bifidobacterium, ↑ Lactobacillus	Improved microbial diversity, reduced inflammation
Basak et al. (2022)	Observational	High-fat, high-sugar diet	↓ microbial diversity, ↑ pathogenic microbes	Linked to dysbiosis, metabolic dysfunction
He et al. (2022)	Review of IBD patients	Plant-based vs. animal protein	Plant proteins supported a healthier microbial balance	Reduced inflammatory markers

Wu et al. (2021)	Cohort study	Omega-3 unsaturated fats	↑ anti-inflammatory microbial populations	Improved metabolic outcomes
Ezenabor et al. (2024)	RCT	SCFA production from a fiber-rich diet	↑ SCFA-producing bacteria	Better insulin sensitivity, metabolic homeostasis
Almonajjed et al. (2025)	Narrative review	Western diet (processed foods, unhealthy fats)	Dysbiosis, ↑ gut permeability	Associated with IBD, IBS
Petrut et al. (2025)	Observational	Gut-brain axis focus	Dysbiosis linked to altered microbial signaling	Correlated with depression, anxiety
Clemente-Suárez et al. (2023)	Narrative review	Mediterranean diet (polyphenols, fiber, healthy fats)	↑ microbial diversity, resilience	Reduced inflammation, improved metabolic health
Jafarnezhad et al. (2025)	Review	Vegan/plant-based diets	↑ microbial diversity	Lower risk of metabolic syndrome
Janis & Sharma (2025)	Conference paper	Anti-inflammatory foods, polyphenols	↑ beneficial microbial populations	Reduced inflammation

Table 2 above shows the results suggesting that diet influences gut microbiota and health. Moreover, fiber-rich and plant-based diets increased beneficial bacteria, boosting microbial diversity, and reduced inflammation, while Mediterranean and omega-3 diets promoted resilience and anti-inflammatory microbes, improving metabolic outcomes. In contrast, Western-style, high-fat, and high-sugar diets reduced diversity, increased gut permeability, and were linked to IBD, IBS, and metabolic dysfunction. Other findings highlighted the gut-brain axis, with dysbiosis contributing to depression and anxiety, while polyphenols and anti-inflammatory foods supported healthier microbial populations. Overall, fiber and plant-rich diets foster gut health, whereas processed diets drive disease risk.

Table 3. Summary of Dietary Patterns, Gut Microbiota Effects, and Health Implications

Factor / Diet Pattern	Effect on Microbiota	Health Implications
Fiber & Prebiotics	↑ Beneficial bacteria (*Bifidobacterium, Lactobacillus*)	Improved metabolism, reduced inflammation
High-fat / High-sugar diet	↓ Diversity, ↑ pathogenic bacteria	Dysbiosis, obesity, diabetes
Mediterranean diet	↑ Diversity, balanced microbiome	Lower risk of chronic disease
Probiotics (fermented foods)	↑ Beneficial bacteria	Enhanced gut integrity, metabolic resilience
Western diet (high protein/fat)	Dysbiosis, ↓ diversity	Adverse metabolic outcomes

Table 3 above summarizes how different dietary patterns shape gut microbiota and influence health. Fiber and prebiotics increase beneficial bacteria like *Bifidobacterium* and *Lactobacillus*, improving metabolism and reducing inflammation, while high-fat and high-sugar diets lower beneficial bacteria diversity and promote pathogenic microbes, leading to dysbiosis, obesity, and diabetes. The Mediterranean diet supports a balanced, diverse microbiome that lowers chronic disease risk, and probiotics from fermented foods enhance gut integrity and metabolic resilience. In contrast, Western diets high in protein and fat disrupt microbial balance and diversity, resulting in adverse metabolic outcomes. Overall, the table highlights diet as a key determinant of gut health and disease risk.

Effects of Nutrition on Gut Microbiota

The reviewed studies presented in Table 3 consistently demonstrated that diet significantly influences gut microbiota composition. Diets rich in fiber, especially those that are rich in prebiotics like inulin and fructooligosaccharides, favor the growth of good bacteria, namely *Bifidobacterium and Lactobacillus*(Zhang, 2022). On the contrary, diets high in fat and sugar are linked to decreased microbial variety and an increase in pathogenic microbes(Basak et al., 2022)

Effects of Microbiota Community on Human Health

An impaired gut microbial ecosystem, as shown in Table 3, has been associated with metabolic disorders like diabetes and obesity. Studies indicate that gut microbiota regulate host metabolism, facilitating SCFA production, which regulates glucose and metabolic homeostasis(Ezenabor et al., 2024). Moreover, changes in gut microbial communities are associated with inflammatory disorders(Mhd Bashir Almonajjed et al., 2025).

Role of Specific Diets, Nutrients, and Interventions

The results summarized in Table 3 show that consumption of a Mediterranean diet high in polyphenols and plant-based fiber and beneficial fats has been shown to enhance microbial diversity and gut health. Regular consumption of foods rich in probiotics, such as yogurt and kimchi, confers health benefits, while those high-protein, high-fat Western diets contribute to dysbiosis (Clemente-Suárez et al., 2023).

Dietary Influences on the Microbial Community and Their Consequences on Health

The findings of this review reaffirm that nutrition plays a critical role in regulating the makeup and functional capabilities of the gut microbiota. Diets rich in fiber, especially those containing prebiotics, consistently promote good bacterial populations, including *Bifidobacterium* and *Lactobacillus* (Zhang, 2022). These results are in line with previous studies that demonstrated the capacity of dietary fibers to increase microbial diversity and promote biosynthesis of SCFA. This is necessary for maintaining metabolic balance and suppressing inflammatory response (Ezenabor et al., 2024). On the other hand, diets containing atherogenic fats and refined carbohydrates were associated with less diverse gut bacteria and increased abundance of pathogenic bacteria. These findings align with Basak et al. (2022), who reported that high-fat and high-sugar dietary patterns contribute to microbial imbalance and energy-related dysfunction.

The connection between gut microbiota and human health was further underscored by evidence linking microbial imbalances to energy regulation and various health conditions like obesity and type 2 diabetes. SCFAs produced by gut microbes contribute significantly to regulating insulin sensitivity and energy homeostasis, and their reduction in dysbiotic states has been implicated in metabolic disease progression (Ezenabor et al., 2024). These findings are similar to those of Mhd Bashir Almonajjed et al. (2025), who observed that dysbiosis contributes to disorders of the gastrointestinal conditions, such as IBD and IBS, through increased gut permeability and chronic inflammation. Emerging research also highlights the microbial brain axis, with Petrut et al. (2025) reporting correlations between dysbiosis and mental health disorders such as depression and anxiety. While our review supports these associations, causality remains uncertain, echoing the conclusions of Clemente-Suárez et al. (2023), who emphasized the need for mechanistic studies to clarify these pathways.

Specific dietary patterns and interventions further illustrate the potential for modulating gut health. High consumption of fiber, polyphenols, and healthy fats has consistently been attributed to enhanced microbial variety and resilience (Clemente-Suárez et al., 2023). This finding is in agreement with Wu et al. (2021), who demonstrated that unsaturated fats, particularly fatty acids with omega-3, promote the growth of anti-inflammatory microbial populations. Similarly, probiotics derived from fermented foods were shown to support beneficial bacterial populations, though the long-term efficacy of supplementation remains debated (Zheng et al., 2020). In contrast, Western-style diets high in protein and fat were linked to dysbiosis and adverse metabolic outcomes, reinforcing the importance of dietary quality in maintaining microbial integrity (He et al., 2022).

Despite these convergences, notable gaps remain. Much of the current evidence is derived from short-term interventions, limiting understanding of sustained dietary impacts. Furthermore, the role of artificial additives and food processing methods in shaping microbial diversity is poorly understood, a gap highlighted by Janis and Sharma (2025). Additionally, most studies are concentrated in Western populations, raising questions about the generalizability of findings to diverse global contexts. These limitations underscore the need for systematic reviews and meta-analyses that apply rigorous inclusion criteria, synthesize findings across populations, and evaluate both strengths and weaknesses of current evidence. Such reviews would not only consolidate knowledge but also identify research priorities, guide the development of standardized dietary guidelines, and provide an evidence base for clinical and public health interventions targeting gut health.

Conclusion

The review underscores the significance of nutrition in influencing the gut microbiota and promoting human health. A high-fiber diet, probiotics, and prebiotics promote microbial diversity and have health benefits. Dysbiosis has been associated with metabolic illness, gastrointestinal ailments, and neurological conditions. Therefore, emphasizing the need for dietary interventions in maintaining gut health.

Recommendations

Future research should focus on microbiome-personalized diets to create tailored nutritional therapies based on individual microbiota profiles. Experimental dietary studies are required to investigate how dietary changes affect microbiota composition and overall health. Moreover, innovative probiotic and prebiotic-based therapies for disease prevention and therapy should be investigated further.

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Conflict of Interest Statement

The authors declare no conflict of interest.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Authorship Statement

We, the authors, declare that each author contributed significantly to the conception, research, writing, and preparation of the final work.

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