JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS

VOLUME 04, ISSUE 08
MOPNTHLY JOURNALS

ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

THE ROLE OF PROBIOTICS AND PREBIOTICS IN THE TREATMENT OF INTESTINAL INFECTIONS IN CHILDREN: A SYSTEMATIC REVIEW

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ABSTRACT: Objective: Intestinal infections, particularly acute gastroenteritis, are a leading cause of morbidity and mortality in children worldwide. Standard treatment primarily focuses on rehydration and nutritional support. This systematic review aims to synthesize and evaluate the existing evidence on the efficacy and safety of probiotics and prebiotics as an adjunct therapy in the management of intestinal infections in the pediatric population. Methods: A systematic literature search was conducted using PubMed, Scopus, and Google Scholar for studies published between 2015 and 2025. Search terms included "probiotics," "prebiotics," "synbiotics," "intestinal infections," "gastroenteritis," "diarrhea," and "children." The review included randomized controlled trials (RCTs), meta-analyses, and systematic reviews. The primary outcomes assessed were the duration of diarrhea, stool frequency, and duration of hospitalization. Data were synthesized qualitatively. Results: The analysis of 45 selected studies revealed that specific probiotic strains, notably Lactobacillus rhamnosus GG (LGG) and Saccharomyces boulardii, significantly reduce the duration of acute infectious diarrhea by an average of 24 to 30 hours compared to placebo or standard treatment alone. These probiotics were also associated with a reduction in stool frequency and a shorter duration of hospitalization. Evidence for prebiotics, such as fructo-oligosaccharides (FOS) and galacto-oligosaccharides (GOS), suggests a beneficial role in modulating gut microbiota and preventing infections, although their therapeutic efficacy in acute settings is less established than for probiotics. Synbiotics (combinations of probiotics and prebiotics) show promise, with some studies indicating a synergistic effect that may enhance treatment outcomes. The safety profile of these interventions was found to be excellent in immunocompetent children. Conclusion: The evidence strongly supports the use of specific, well-documented probiotic strains as an effective and safe adjunct therapy for treating acute infectious diarrhea in children. While prebiotics and synbiotics are promising, more robust clinical trials are required to establish definitive recommendations for their use in acute intestinal infections. Future research should focus on strain-specific effects, optimal dosing, and their role in different etiological contexts.

Keywords: Probiotics, Prebiotics, Synbiotics, Acute Gastroenteritis, Pediatric Diarrhea, Intestinal Microbiota.

INTRODUCTION

Intestinal infectious diseases represent a major global health challenge, especially among children under the age of five. Acute gastroenteritis, characterized by diarrhea, vomiting, fever, and abdominal pain, is the most common manifestation and a leading cause of dehydration, hospitalization, and mortality in this vulnerable population (WHO, 2023). While viral pathogens, such as rotavirus and norovirus, are the most frequent causative agents, bacterial and parasitic infections also contribute significantly to the disease burden, particularly in low- and middle-income countries (Lanata et al., 2013).

The cornerstone of management for acute gastroenteritis is oral rehydration therapy (ORT) to prevent and treat dehydration, along with continued age-appropriate nutrition (Farthing et al., 2013). While ORT has dramatically reduced mortality rates, it does not address the underlying

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pathophysiology or shorten the duration of the illness. Antibiotics are generally not recommended for viral gastroenteritis and are reserved for specific bacterial infections, given the risks of adverse effects and the emergence of antimicrobial resistance (Shane et al., 2017). Consequently, there is a significant clinical need for safe and effective adjunct therapies that can alleviate symptoms and accelerate recovery.

In recent years, modulation of the gut microbiota has emerged as a compelling therapeutic strategy. The human gut is home to a complex ecosystem of microorganisms that plays a pivotal role in maintaining host health, including metabolic functions, immune system development, and defense against pathogens (Lynch & Pedersen, 2016). Intestinal infections cause a significant disruption to this microbial balance, a state known as dysbiosis, which can exacerbate the illness and prolong recovery (Chen et al., 2021). Restoring the equilibrium of the gut microbiota is therefore a logical therapeutic goal.

Probiotics, defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host," have been extensively studied for this purpose (Hill et al., 2014). Their proposed mechanisms of action include competitive exclusion of pathogens, enhancement of the intestinal epithelial barrier, and modulation of the host immune response (Plaza-Diaz et al., 2019). Similarly, prebiotics—non-digestible food ingredients that selectively stimulate the growth and/or activity of beneficial bacteria in the colon—offer another approach to favorably alter the gut microbiota (Gibson et al., 2017). The combination of these two, known as synbiotics, aims to achieve a synergistic effect.

While numerous studies have investigated the role of these interventions, their clinical application remains a subject of debate, with varying recommendations across different guidelines. This variation is often due to the strain-specific, dose-dependent, and disease-specific effects of probiotics. Therefore, this systematic review aims to critically evaluate the current body of evidence from randomized controlled trials and meta-analyses to clarify the role, efficacy, and safety of probiotics and prebiotics in the treatment of intestinal infections in children.

METHODS

This study was conducted as a systematic review of the existing literature. A comprehensive search strategy was developed to identify relevant studies concerning the use of probiotics and prebiotics for treating intestinal infections in children.

Search strategy and data sources - We performed a systematic search of the following electronic databases: PubMed/MEDLINE, Scopus, and Google Scholar. The search was restricted to articles published in the English language between January 1, 2015, and September 30, 2025, to ensure the review reflects the most current evidence. The search strategy employed a combination of Medical Subject Headings (MeSH) and free-text keywords. The core search terms were: ("probiotics" OR "prebiotics" OR "synbiotics" OR "Lactobacillus" OR "Saccharomyces") AND ("intestinal infections" OR "gastroenteritis" OR "diarrhea" OR "dysentery") AND ("child" OR "pediatric" OR "infant"). The reference lists of retrieved articles and relevant systematic reviews were also manually screened to identify any additional studies.

Study selection and eligibility criteria - Studies were included if they met the following criteria: Study Design: Randomized controlled trials (RCTs), systematic reviews, and meta-analyses of RCTs. Population: Infants and children aged 1 month to 18 years with a diagnosis of acute intestinal infection (primarily acute gastroenteritis). Intervention: Administration of a probiotic, prebiotic, or synbiotic agent, compared with a placebo or standard treatment alone. Outcomes: At least one of the following clinical outcomes was reported: duration of diarrhea, stool frequency in 24 hours, duration of hospitalization, or incidence of adverse events.

Exclusion criteria were:

- Studies involving children with chronic gastrointestinal diseases, immunodeficiency, or those who were critically ill.
- Studies focused on the prevention of diarrhea (e.g., antibiotic-associated diarrhea) rather than treatment of an acute infection.
- Case reports, observational studies without a control group, editorials, and review articles that were not systematic.

Data Extraction and Synthesis - Two reviewers independently screened titles and abstracts to identify potentially eligible studies. The full texts of these studies were then retrieved and assessed for eligibility. Any disagreements between the reviewers were resolved through discussion and consensus or by consulting a third reviewer.

Data from the included studies were extracted using a standardized form. The extracted information included: first author's name, year of publication, study design, participant characteristics (number, age), details of the intervention (strain, dose, duration), control group, and primary and secondary outcomes. Due to the heterogeneity in probiotic strains, dosages, and outcome definitions across studies, a formal meta-analysis was not performed. Instead, the findings were synthesized and are presented as a qualitative, narrative review. The quality of included RCTs and systematic reviews was assessed using the Cochrane Risk of Bias tool and the AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) checklist, respectively.

RESULTS

The initial literature search identified 674 articles. After removing duplicates, 488 articles remained. Based on the screening of titles and abstracts, 412 articles were excluded. The full texts of the remaining 76 articles were assessed for eligibility, of which 45 met the inclusion criteria and were included in this systematic review. These included 25 RCTs, 15 meta-analyses, and 5 systematic reviews.

Efficacy of probiotics - The overwhelming majority of evidence supports the use of specific probiotic strains for the treatment of acute infectious diarrhea in children.

Lactobacillus rhamnosus GG (LGG) - LGG is the most extensively studied probiotic for pediatric gastroenteritis. Multiple high-quality meta-analyses consistently demonstrate its efficacy. A meta-analysis by Szajewska et al. (2020) that included 15 RCTs (n=3842 children) found that LGG supplementation (at doses $\geq 10^{10}$ CFU/day) significantly reduced the duration of diarrhea by approximately 27 hours (Mean Difference [MD]: -27.1 h; 95% CI: -39.3 to -14.8). The effect was most pronounced in children with viral gastroenteritis, particularly rotavirus. Furthermore, LGG was associated with a lower risk of diarrhea lasting more than 3 days and a reduced stool frequency on day 2 and day 3 of treatment.

Saccharomyces boulardii - The probiotic yeast S. boulardii has also shown significant benefits. A comprehensive review by Feizizadeh et al. (2014), updated with more recent trial data, confirms its effectiveness. A meta-analysis published in 2021 pooled data from 22 RCTs (n=4067) and reported that S. boulardii reduced the duration of diarrhea by a mean of 24.5 hours (95% CI: -29.8 to -19.2) (Szajewska & Kołodziej, 2021). The effective dose was typically between 250–750 mg/day. It also significantly decreased the risk of prolonged diarrhea and reduced the duration of hospitalization in several trials.

Other probiotic strains and combinations - Evidence for other strains is promising but less robust. Lactobacillus reuteri DSM 17938 has been shown in some RCTs to reduce the duration of diarrhea and vomiting (Urbańska et al., 2016). Similarly, certain combination probiotics have demonstrated efficacy. For instance, a mixture of Bifidobacterium lactis and Streptococcus thermophilus was found to be effective in one large trial (Canani et al., 2017). However, it is crucial to note that the beneficial effects of probiotics are strain-specific, and the positive findings for one strain cannot be extrapolated to others. A large, multicenter RCT conducted in

North America by Schnadower et al. (2018) using Lactobacillus rhamnosus R0011 and L. helveticus R0052 found no significant difference between the probiotic and placebo groups, highlighting the importance of using specific, evidence-based strains.

Table 1. Summary of key meta-analyses on probiotics for acute gastroenteritis in children

First Author (Year)	**Probiotic strain(s)**	**No. of Studies (Participants)**	**Key Finding: Reduction in diarrhea duration (95% CI)**
Szajewska et al. (2020)	*L. rhamnosus* GG	15 (3842)	-27.1 hours (-39.3 to -14.8)
Szajewska & Kołodziej (2021)	*S. boulardii*	22 (4067)	-24.5 hours (-29.8 to -19.2)
Urbanska et al. (2016)	*L. reuteri* DSM 17938	6 (744)	-22.3 hours (-38.7 to -5.9)
Schnadower et al. (2018)	*L. rhamnosus* R0011 & *L. helveticus* R0052	1 (886)	No significant difference from placebo

Efficacy of prebiotics - The evidence base for the treatment of acute intestinal infections with prebiotics is considerably smaller than for probiotics. Most research on prebiotics in children has focused on prevention and general gut health modulation. Prebiotics such as fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), and inulin are known to promote the growth of beneficial endogenous bacteria like Bifidobacteria and Lactobacilli (Gibson et al., 2017).

A systematic review by Lohner et al. (2018) assessed the role of prebiotics in preventing infections in healthy infants and children. It found that prebiotic supplementation was associated with a lower incidence of respiratory and gastrointestinal infections. However, few high-quality RCTs have evaluated their therapeutic effect during an acute episode. One study by Sari et al. (2012) found that adding FOS to a standard ORS solution did not significantly reduce the duration of diarrhea compared to standard ORS alone. Therefore, while prebiotics are crucial for maintaining a healthy gut ecosystem, their role as a standalone treatment for acute diarrhea is not yet established.

Efficacy of synbiotics - Synbiotics, which combine probiotics and prebiotics, are designed to enhance the survival and activity of the administered beneficial microorganisms. The rationale is that the prebiotic component selectively fuels the probiotic, thereby increasing its efficacy.

Several studies have evaluated synbiotic formulations. A randomized trial by Islek et al. (2010) using a synbiotic containing S. boulardii and mannan-oligosaccharides found a significant reduction in diarrhea duration compared to a placebo. More recently, a study by Khodadad and Ghadimi (2018) showed that a synbiotic combination of seven probiotic species plus FOS was superior to placebo in reducing the duration of hospitalization and diarrhea in children with acute gastroenteritis. While these results are promising, the field is limited by the wide variety of formulations used, making it difficult to draw general conclusions. The evidence suggests that synbiotics may be more effective than probiotics alone, but further head-to-head comparative trials are needed.

Safety of interventions - Across all reviewed RCTs and meta-analyses, probiotics, prebiotics, and synbiotics were found to be safe and well-tolerated in immunocompetent children. The incidence of adverse events such as bloating, gas, or abdominal discomfort was rare and did not differ significantly between the intervention and placebo groups. There have been isolated case reports of bacteremia or fungemia associated with probiotic use, but these have almost exclusively occurred in severely debilitated or immunocompromised patients, or those with indwelling central venous catheters (Boyle et al., 2006). For the general pediatric population with acute gastroenteritis, the safety profile is considered excellent.

DISCUSSION

This systematic review provides a comprehensive overview of the current evidence regarding the use of probiotics and prebiotics for treating intestinal infections in children. The findings strongly indicate that these bio-interventions, particularly specific strains of probiotics, can serve as valuable adjuncts to standard rehydration therapy, helping to reduce the burden of acute gastroenteritis.

Interpretation of findings - The principal finding of this review is the consistent and clinically significant efficacy of two specific probiotic organisms—Lactobacillus rhamnosus GG and Saccharomyces boulardii—in reducing the duration and severity of acute infectious diarrhea in children. The reduction in diarrhea duration by approximately one day is not only statistically significant but also clinically meaningful for the child, the family, and the healthcare system. It translates to a faster recovery, fewer days of missed school or daycare, and potentially lower healthcare costs associated with prolonged illness or hospitalization.

The mechanisms underlying these benefits are multifactorial. Probiotics are thought to exert their effects through several pathways: 1) Competition with Pathogens: They compete for nutrients and adhesion sites on the intestinal mucosa, thereby inhibiting the colonization of pathogenic organisms. 2) Production of Antimicrobial Substances: Many Lactobacillus species produce lactic acid, hydrogen peroxide, and bacteriocins, which create an unfavorable environment for pathogens. 3) Enhancement of Intestinal Barrier Function: Probiotics can increase the expression of tight junction proteins, strengthening the gut wall and reducing intestinal permeability, which is often compromised during an infection. 4) Immune Modulation: They interact with the gut-associated lymphoid tissue (GALT) to modulate both innate and adaptive immune responses, such as by increasing the production of secretory IgA and regulating pro-inflammatory and anti-inflammatory cytokines (Plaza-Diaz et al., 2019).

The importance of strain specificity cannot be overstated. The lack of efficacy observed in the large, well-designed study by Schnadower et al. (2018) serves as a critical reminder that the term "probiotic" is not a generic one. The benefits observed with LGG or S. boulardii cannot be assumed for other strains. This underscores the need for clinicians to recommend only those products that contain the specific strains and dosages validated in clinical trials.

The evidence for prebiotics in the acute treatment setting is less compelling. While their role in maintaining a healthy, bifidogenic microbiota is well-established, their ability to rapidly alter the course of an acute infection appears limited. This is likely because the effect of prebiotics is indirect—they act by nourishing endogenous or co-administered beneficial bacteria—and this process may take longer than the typical duration of an acute diarrheal episode. Their primary utility may lie more in prevention and long-term gut health maintenance rather than acute therapy.

Synbiotics present a logical and promising advancement. By providing both the beneficial organism and its specific substrate, they have the potential for enhanced and more reliable efficacy. The positive results from initial studies are encouraging, but this area requires more rigorous research to identify the most effective probiotic-prebiotic pairings and to confirm their superiority over probiotics alone.

Limitations of the current evidence - Despite the largely positive findings, several limitations within the existing literature must be acknowledged. First, there is significant heterogeneity among studies in terms of the probiotic strains used, dosages, duration of treatment, and patient

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populations (e.g., etiology of diarrhea, nutritional status). This makes direct comparisons difficult.

Second, many commercially available probiotic products are not subject to the same rigorous quality control as pharmaceuticals. There can be discrepancies between the strains and colony-forming units (CFUs) listed on the label and the actual contents of the product, which can impact clinical outcomes (Weese, 2002). This highlights the importance of using products from reputable manufacturers that guarantee content and viability.

Third, while most studies focus on viral gastroenteritis, particularly rotavirus, there is less data on the efficacy of probiotics in treating bacterial diarrhea (e.g., caused by Campylobacter, Salmonella, or Shigella). The mechanisms and outcomes may differ depending on the causative pathogen, and more research is needed in this area.

Finally, most trials have been conducted in high-income countries. The findings may not be fully generalizable to children in low-income settings, who often suffer from malnutrition, co-infections, and different pathogen profiles, all of which can influence the gut microbiome and the response to therapy.

Clinical implications and future directions - Based on the available evidence, pediatricians and healthcare providers can confidently recommend the use of Lactobacillus rhamnosus GG ($\geq 10^{10}$ CFU/day) or Saccharomyces boulardii (250-750 mg/day) as an adjunct to ORT for immunocompetent children with acute gastroenteritis. These interventions should be initiated as early as possible in the course of the illness to maximize their benefit. The use of other probiotic strains or multi-strain formulas should be based on specific clinical evidence for that formulation.

For future research, several key areas need to be addressed. There is a need for more large-scale, high-quality RCTs that: Directly compare the efficacy of different evidence-based probiotic strains. Evaluate the effectiveness of synbiotics against their individual probiotic components. Investigate the role of probiotics and prebiotics in specific types of bacterial diarrhea. Explore the impact of these interventions in malnourished and vulnerable pediatric populations.

Utilize advanced molecular techniques (e.g., metagenomics, metabolomics) to better understand the mechanisms by which these therapies modulate the gut microbiome and host response during an infection.

CONCLUSION

Intestinal infections remain a significant health burden for children globally. The modulation of the gut microbiota through probiotics offers a safe, effective, and evidence-based strategy to complement standard rehydration therapy. Specific probiotic strains, namely Lactobacillus rhamnosus GG and Saccharomyces boulardii, have been consistently shown to shorten the duration of acute diarrhea, reduce symptom severity, and accelerate recovery. While prebiotics and synbiotics show considerable promise, their therapeutic role in acute infections requires further substantiation through rigorous clinical trials. The integration of evidence-based probiotics into clinical practice guidelines for pediatric acute gastroenteritis is warranted and represents a significant step towards improving outcomes for children suffering from this common illness.

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