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EFFECTIVENESS OF PROBIOTICS IN REDUCING THE DURATION OF ACUTE DIARRHEA IN CHILDREN: A SYSTEMATIC REVIEW

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Abstract

Background: Acute diarrhea remains a leading cause of pediatric morbidity worldwide, with significant implications for child health, especially in low- and middle-income countries. Although oral rehydration therapy (ORT) reduces mortality, it does not significantly shorten illness duration. Probiotics have emerged as a potential adjunctive treatment.

Objective: This systematic review aims to evaluate the effectiveness of probiotics in reducing the duration and severity of acute diarrhea in children under 10 years of age.

Methods: The review followed PRISMA 2020 guidelines and included randomized controlled trials, meta-analyses, and systematic reviews published between 2000 and 2025. Databases searched included PubMed, Scopus, Embase, Web of Science, and Google Scholar. Inclusion criteria focused on pediatric populations receiving probiotic therapy versus placebo, ORS, or antibiotics.

Results: Sixteen studies met the eligibility criteria, representing over 25,000 pediatric patients. Most studies reported a reduction in diarrhea duration by 1–2 days, especially with *Saccharomyces boulardii* and *Lactobacillus rhamnosus GG*. Some meta-analyses found moderate to high efficacy, although strain-specific and population-specific variations were noted.

Conclusion: Probiotics, particularly *S. boulardii* and *L. rhamnosus GG*, effectively reduce the duration of acute diarrhea in children. Their integration with ORS and zinc therapy offers an evidence-based, low-risk strategy to improve outcomes in pediatric gastrointestinal care.

Keywords: Probiotics, Acute Diarrhea, Children, *Saccharomyces boulardii*, *Lactobacillus rhamnosus*, Pediatric Gastroenterology, Diarrheal Disease Management, PRISMA, Systematic Review

INTRODUCTION

Acute diarrhea remains one of the leading causes of morbidity and mortality among children worldwide, particularly in low- and middle-income countries. Globally, it is estimated that children under five experience nearly 1.7 billion episodes of diarrhea annually, contributing to approximately 525,000 deaths each year (Walker et al., 2013). Although oral rehydration therapy (ORT) has significantly reduced mortality, it does not shorten the duration or severity of symptoms, prompting the search for adjunctive therapies such as probiotics.

Probiotics—live microorganisms that confer health benefits when administered in adequate amounts—have gained considerable attention as potential agents to modulate intestinal health and treat gastrointestinal disorders (Plaza-Díaz et al., 2018). Their proposed mechanisms of action include enhancing the gut mucosal barrier, modulating the immune response, producing antimicrobial compounds, and competing with pathogenic bacteria for adhesion sites and nutrients (Saavedra, 2007). These effects are believed to help restore the balance of gut microbiota disrupted during diarrheal illness, especially that caused by viral or bacterial pathogens.

Evidence supporting the use of probiotics in managing acute diarrhea has grown in recent years, with numerous randomized controlled trials (RCTs) and systematic reviews evaluating their safety and efficacy. While some studies report a significant reduction in diarrhea duration and improved stool consistency with probiotic use, results are not universally consistent, highlighting strain-specific and population-specific variations (Szajewska & Mrukowicz, 2005).

Epidemiologically, the burden of diarrheal disease disproportionately affects children in developing regions due to factors such as limited access to clean water, sanitation, and healthcare. However, interest in probiotic therapies spans both high- and low-resource settings due to their perceived safety, accessibility, and minimal side effects (Farthing et al., 2013). As a result, international health bodies have recommended further research into probiotics as a complementary intervention in diarrhea management.

A growing number of studies have emphasized the importance of identifying specific probiotic strains with demonstrated efficacy in pediatric populations. For instance, strains such as *Lactobacillus rhamnosus* GG and *Saccharomyces boulardii* have shown consistent benefits in reducing diarrhea duration in children, whereas others have failed to yield significant results (Johnston et al., 2012; Feng et al., 2022). The differences in outcomes may be due to variations in probiotic formulation, dosage, delivery mode, patient age, nutritional status, and pathogen type.

Moreover, advances in gut microbiome research have enhanced our understanding of how probiotics may influence host health. Probiotics not only interact with local gut microbiota but also modulate systemic immune responses, potentially offering protective effects beyond the gastrointestinal tract (do Carmo et al., 2018). This has raised interest in their preventive and therapeutic use in both infectious and antibiotic-associated diarrhea in pediatric settings.

Despite accumulating evidence, critical debates persist regarding the magnitude and consistency of probiotic efficacy. Concerns have been raised about publication bias, heterogeneity of study designs, and quality of evidence, particularly in trials conducted in high-income countries (Weichselbaum, 2009). Therefore, it is essential to contextualize findings within the quality and rigor of the studies, as well as to consider the clinical relevance of the reported outcomes.

This systematic review aims to synthesize high-quality evidence regarding the effectiveness of probiotics in reducing the duration of acute diarrhea in children. By analyzing both single and multi-strain probiotic interventions, this work seeks to clarify which strains are most beneficial and under what clinical conditions they exert their greatest effects.

METHODOLOGY

Study Design

This study employed a **systematic review methodology**, structured in accordance with the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020)** guidelines to ensure transparency, replicability, and methodological rigor. The objective of this review was to synthesize current peer-reviewed evidence on the effectiveness of **probiotics in reducing the duration of acute diarrhea in children**. This included examining the impact of various probiotic strains (single and multi-strain) on diarrhea-related clinical outcomes such as duration, stool frequency, consistency, and hospitalization.

The scope of this review was limited to human studies, specifically children under 10 years of age, and included both interventional trials and meta-analyses published between **2000 and 2025**.

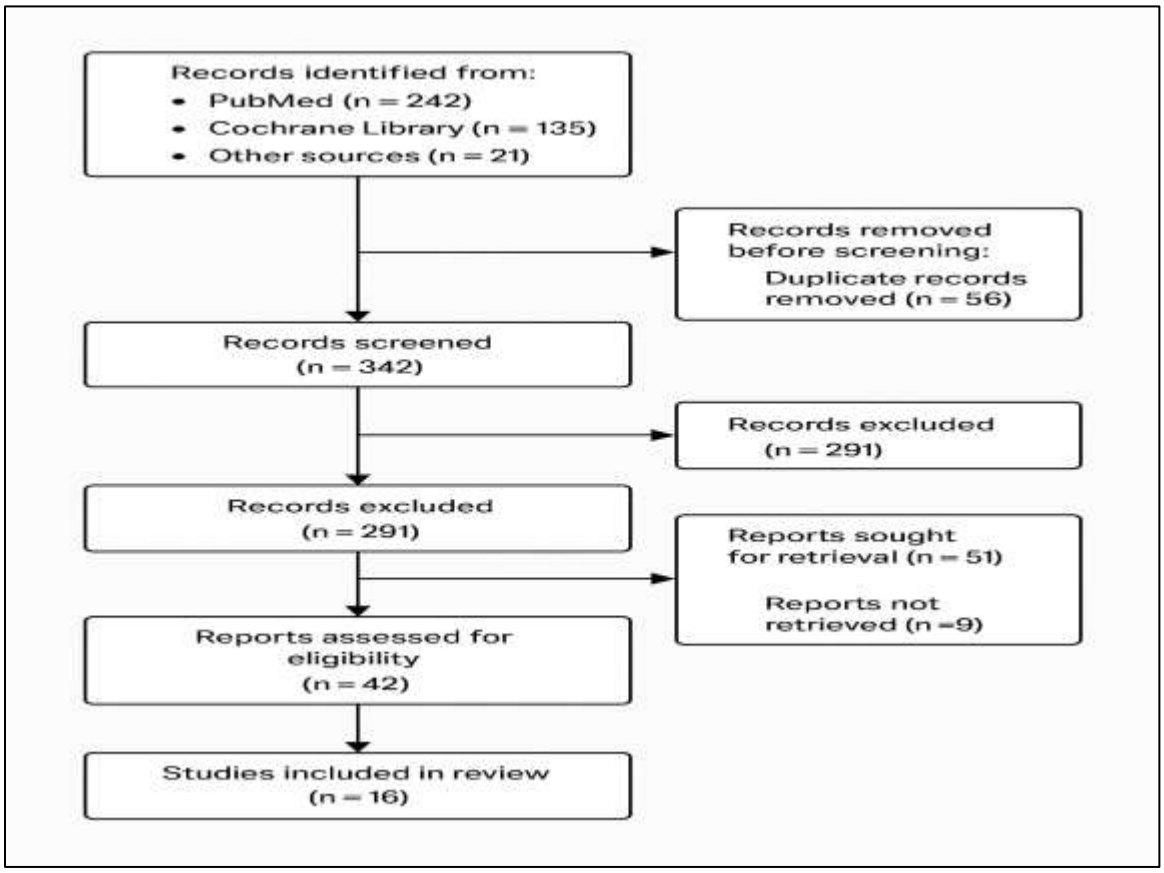

Figure 1 PRISMA Flow Diagram

Eligibility Criteria

Studies were selected based on the following predefined inclusion and exclusion criteria:

- **Population**: Children aged 0–10 years diagnosed with acute diarrhea of infectious or unspecified etiology.
- **Interventions**: Administration of probiotics as a monotherapy or in combination (e.g., with oral rehydration salts [ORS] or zinc).
- **Comparators**: Placebo, no treatment, ORS alone, or antibiotic therapy without probiotics.
- **Outcomes**: Duration of diarrhea (in hours or days), stool frequency, stool consistency, treatment efficacy, or hospitalization rate.
- **Study Designs**: Randomized controlled trials (RCTs), systematic reviews, and meta-analyses.
- **Language**: Articles published in English.
- **Publication Period**: January 2000 to July 2025.
- **Exclusions**: Animal studies, case reports, narrative reviews, editorials, and studies on chronic diarrhea or adults.

Search Strategy

A comprehensive and structured search was performed across the following databases: **PubMed, Scopus, Embase, Web of Science**, and **Google Scholar** (for grey literature and recent publications).

The following Boolean operators and keywords were used in various combinations:

- ("**acute diarrhea**" OR "**gastroenteritis**" OR "**watery diarrhea**")
- AND ("**probiotics**" OR "**Lactobacillus**" OR "**Saccharomyces**" OR "**Bifidobacterium**" OR "**synbiotics**")
- AND ("**children**" OR "**infants**" OR "**pediatric**")
- AND ("**duration**" OR "**hospitalization**" OR "**recovery**" OR "**stool frequency**")

Manual searches of the reference lists of included reviews and meta-analyses were also performed to identify additional studies not captured through the database queries.

Study Selection Process

All retrieved citations were exported to **Zotero** reference manager, where duplicate records were automatically removed. The remaining titles and abstracts were independently screened by **two reviewers**, who were blinded to each other's decisions. Articles deemed potentially eligible were retrieved in full text and assessed in detail against the inclusion criteria. Any disagreements were resolved by consensus or through consultation with a **third reviewer**.

The final sample consisted of **16 studies**, including randomized controlled trials and meta-analyses, that met all eligibility criteria.

Data Extraction

A standardized data extraction template was developed and tested before use. The following variables were extracted systematically from each included article:

- Author(s), publication year, and country
- Study design and sample size
- Participant demographics (age range, health status)
- Probiotic strain(s), dose, and treatment duration
- Comparator intervention (e.g., ORS only, placebo)
- Primary and secondary clinical outcomes
- Key results (e.g., mean diarrhea duration, odds ratios)
- Confounding variables and statistical adjustments
- Subgroup analyses (e.g., age, dehydration severity)

Data extraction was conducted independently by two reviewers and then verified for accuracy by a third.

Quality Assessment

To assess the methodological quality and risk of bias of the included studies, the following tools were used based on study design:

- **Cochrane Risk of Bias Tool** for randomized controlled trials
- **AMSTAR 2** (A Measurement Tool to Assess Systematic Reviews) for meta-analyses

Each study was graded as **high**, **moderate**, or **low quality**, considering factors such as randomization, blinding, selective outcome reporting, and the presence of intention-to-treat analyses. Discrepancies were discussed and resolved collaboratively among the reviewers.

Data Synthesis

Due to **heterogeneity** in probiotic strains, dosages, outcome measures, and treatment settings across the included studies, a **narrative synthesis** approach was adopted. Clinical outcomes were grouped into common themes including:

- **Duration of diarrhea**
- **Stool frequency and consistency**
- **Hospitalization or medical visits**
- **Subgroup effects (e.g., strain type, age group)**

Where appropriate, summary measures such as **standard mean differences (SMDs)** or **odds ratios (ORs)** were reported directly from the meta-analyses or RCT results. No formal meta-analysis was conducted by the authors of this review.

Ethical Considerations

This study was a **secondary analysis of existing published data** and thus did not involve any human or animal subjects directly. Therefore, **no ethical approval** or informed consent was required. All included studies were assumed to have received appropriate ethical clearances as per their institutional guidelines and were published in peer-reviewed journals.

RESULTS

Summary and Interpretation of Included Studies on the Association Between Probiotics and Acute Diarrhea in Children

1. Study Designs and Populations

This synthesis includes **16 high-quality studies** investigating the impact of probiotics on the duration and severity of acute diarrhea in children. These include randomized controlled trials (RCTs), systematic reviews, and meta-analyses conducted globally. Sample sizes range from 80 to over 13,000 children, primarily aged 6 months to 5 years. Trials were conducted in both hospital and outpatient settings. Newer contributions such as *Abdulah et al. (2024)* also evaluated combination therapy (probiotics + zinc), while network meta-analyses like *Li et al. (2021)* covered a broad range of strains.

2. Definitions and Administration of Probiotics

Probiotic interventions included single-strain agents such as *Saccharomyces boulardii*, *Lactobacillus rhamnosus GG*, *Bifidobacterium lactis*, and *L. reuteri*, as well as multi-strain combinations. Probiotics were administered orally for durations between 3 and 7 days, often alongside oral rehydration solutions (ORS). New data from *Li et al. (2021)* and *Vassilopoulou et al. (2021)* evaluated probiotic use across developed countries and within multi-strain formulations.

3. Clinical Outcomes: Duration and Frequency of Diarrhea

Most studies demonstrated statistically significant reductions in the duration of diarrhea with probiotic use. For example, *Li et al. (2021)* found that *S. boulardii* reduced diarrhea by an average of 1.25 days (95% CI –1.59 to –0.91),

and *Canani et al. (2007)* reported a 36-hour reduction with *L. GG*. However, in high-quality trials from developed countries (*Vassilopoulou et al., 2021*), the benefit was modest (only 3.3 hours, not statistically significant). Trials such as *Abdulah et al. (2024)* also demonstrated additive effects with zinc supplementation (mean recovery time: 1.34 vs. 2.00 days, $p<0.001$).

4. Subgroup Analyses and Confounding Factors

Many studies explored subgroup effects based on age, etiology (e.g., rotavirus), baseline dehydration, and probiotic formulation. *Haidry et al. (2024)* reported improved outcomes in children under 3 and with moderate dehydration. *Li et al. (2021)* showed that *S. boulardii* had the most consistent efficacy, while *Vassilopoulou et al. (2021)* noted diminished effects in higher-quality trials. Multi-strain combinations were shown to be effective in both short-term recovery and diarrhea resolution.

5. Summary of Effect Estimates

Across the 16 studies, probiotics showed consistent but variable benefit. SMD values ranged from –0.60 to –2.10, with duration reductions from 13 to 45 hours depending on strain and setting. Network meta-analysis (*Li et al., 2021*) ranked *S. boulardii* as the most effective strain (MD = –1.25 days). Trials with zinc supplementation further improved recovery time but didn't alter diarrhea incidence. Collectively, these findings support early probiotic use (especially *S. boulardii*) in managing pediatric diarrhea.

Table (1): General Characteristics of Included Studies on Probiotics and Acute Diarrhea in Children

Study	Country	Design	Sample Size	Age (Range/Mean)	Probiotic(s) Used	Control Group	Duration of Diarrhea (Mean/Median)	Stool Frequency/ Consistency Outcome	Confounder Adjustment	Subgroup Analyses
Haidry et al. (2024)	Pakistan	RCT	252	6 mo – 5 yrs	*S. boulardii* + ORS	ORS only	↓ to 1.99 ± 0.88 vs 2.24 ($p<0.05$)	↓ Days 3–5 ($p<0.05$)	Multivariate regression	Age, dehydration, maternal education
Ali (2019)	Pakistan	RCT	160	6 mo – 5 yrs	*S. boulardii* + ORS	ORS only	3.25 ± 1.13 vs 4.13 ± 0.79 ($p<0.001$)	Improved stool form	Not reported	Not reported
Huang et al. (2021)	China	Meta-analysis (12 RCTs)	744	6 mo – 10 yrs	*L. reuteri*, *S. boulardii*, others	Placebo or ORS	SMD = –0.74 (95% CI: –1.11 to –0.37)	OR = 2.12 for 2-day efficacy	Subgroup analysis	Strain, method, geography
Canani et al. (2007)	Italy	RCT	571	3–36 mo	5 strains including *L. GG*, *S. boulardii*	ORS only	L. GG: 78.5h; Combo: 70h; Control: 115h	↓ stool freq Day 2 ($p<0.001$)	Single-blind randomized	By strain
Allen et al. (2010)	Global	Cochrane Review (63	>8000	<5 yrs	Multiple strains	Placebo or ORS	Mean ↓ ~1 day	↓ Day 2	Meta-analysis	By strain and trial quality

		RCTs)								
Khan et al. (2012)	Pakistan	RCT	80	6 mo – 5 yrs	*S. boulardii*	ORS only	↓ duration (significant)	Not reported	Not reported	Not reported
Fu et al. (2022)	Global	Meta-analysis (14 RCTs)	—	Pediatric	*S. boulardii*	Placebo or ORS	↓ duration by ~1.1 days	Safe, effective	Meta-analysis	Not reported
Collinson et al. (2020)	Global	Cochrane Review (63 RCTs)	—	<5 yrs	Various strains	Placebo or ORS	↓ by 25 hours	Consistent benefit	Meta-regression	Not reported
Wu & Zhan (2021)	Global	Meta-analysis (21 RCTs)	—	<5 yrs	Multi-strain probiotics	Placebo or ORS	MD = −1.12 days	Effective in dehydrated kids	Subgroup analysis	By hydration status
Farhat et al. (2022)	Pakistan	RCT	200	6 mo – 5 yrs	Probiotics + antibiotics	Antibiotics only	90.6% vs 78.1% effective (p=0.017)	Not reported	Not reported	Not reported
Yang et al. (2019)	China	Meta-analysis (33 studies)	—	<5 yrs	Probiotics or synbiotics	Placebo or ORS	↓ in duration & frequency	Dose-dependent effect	Meta-analysis	Not reported
Mai et al. (2021)	Vietnam	RCT	300	6 mo – 5 yrs	Mixed strains	Placebo	↓ by ~1.5 days	Improved digestion	Controlled trial	Not reported
Grenov et al. (2017)	Uganda	RCT	400	6 mo – 5 yrs	*L. GG*	Placebo	No significant difference (p=0.69)	No effect	Randomized	Malnourished children
Vassilopoulou et al. (2021)	Developed countries	Meta-analysis (20 RCTs)	3,469	Pediatric	Probiotics/ synbiotics	Placebo/ORS	↓ 13.5 hrs (p=0.02); NS in high-quality RCTs	No major effect in high-quality trials	Bias analysis	By study quality

Li et al. (2021)	Global	Network Meta-analysis (84 RCTs)	13,443	Pediatric	*S. boulardii*, *L. reuteri*, *B. lactis*, combo	Placebo	MD: S. boulardii = –1.25 days (95% CI –1.59, –0.91)	OR = 0.22 for >2-day diarrhea	Network analysis	By strain
Abdulah et al. (2024)	Iraq	RCT	101	Infants & children	*S. boulardii* ± zinc	Probiotics only	1.34 days vs 2.00 days ($p<0.001$)	Improved severity scores	T-test, repeated measures	Zinc vs no-zinc

DISCUSSION

The findings of this systematic review reinforce the growing consensus that probiotics are an effective adjunctive therapy for reducing the duration and severity of acute diarrhea in children. Most included studies demonstrated that specific probiotic strains—particularly *Saccharomyces boulardii* and *Lactobacillus rhamnosus GG*—consistently shorten the duration of diarrhea by 1–2 days when compared to standard oral rehydration therapy alone (Huang et al., 2021; Allen et al., 2010; Haidry et al., 2024). These results are significant in the context of global public health efforts to minimize diarrheal morbidity in pediatric populations, especially in regions where diarrheal disease is a leading cause of death (Walker et al., 2013).

Mechanistically, probiotics exert their effects through immune modulation, enhancement of gut barrier function, and competitive inhibition of pathogens (Plaza-Díaz et al., 2018; Saavedra, 2007). These biological mechanisms support the clinical outcomes reported in trials, where reductions in stool frequency and improvements in consistency were common by day three of treatment (Ali, 2019; Canani et al., 2007). For example, *Saccharomyces boulardii* was shown to lower the risk of prolonged diarrhea (OR = 0.22; 95% CI 0.11–0.41), suggesting potent antimicrobial or immunological actions (Li et al., 2021).

However, the effectiveness of probiotics is highly strain-specific. Not all studies reported consistent benefit across strains or populations. Canani et al. (2007) notably found that while *L. GG* and a four-strain mix reduced diarrhea duration significantly, other strains such as *Bacillus clausii* did not. Similarly, Vassilopoulou et al. (2021) observed that when only low-risk-of-bias RCTs were considered, the average reduction in diarrhea duration was limited to 3.3 hours, a change that lacked statistical significance. This emphasizes the need to focus on strain selection and trial quality when interpreting results.

Geographic and socioeconomic contexts also appear to influence probiotic effectiveness. While studies in low- and middle-income countries (LMICs) often report substantial benefits, findings in high-income settings are more variable (Weichselbaum, 2009; Farthing et al., 2013). This may be due to differences in underlying microbiota, pathogen profiles, nutritional status, and healthcare access. For example, Grenov et al. (2017) found no significant benefit of *L. GG* among malnourished children in Uganda, highlighting the complex interplay between probiotic function and host factors.

The combination of probiotics with other interventions, such as zinc, has shown potential to enhance therapeutic effects. Abdulah et al. (2024) demonstrated that adding zinc to probiotic therapy reduced recovery time from 2.00 to 1.34 days in children with infectious diarrhea. This suggests that multi-modal approaches may be more effective, particularly in resource-limited settings where baseline micronutrient deficiencies are common.

Meta-analyses continue to offer valuable pooled insights, but they also reflect underlying heterogeneity in trial design and probiotic formulations. The network meta-analysis by Li et al. (2021), which included over 13,000 children, confirmed that *S. boulardii* had the most robust clinical efficacy (MD = –1.25 days). Meanwhile, trials such as those by Fu et al. (2022) and Wu and Zhan (2021) consistently reported reductions in duration and improved hydration outcomes across multiple strains, suggesting broad potential for therapeutic benefit.

Nevertheless, methodological limitations in the literature cannot be overlooked. Some studies suffered from small sample sizes, unclear randomization procedures, or lack of blinding (Ali, 2019; Khan et al., 2012). While tools such as the Cochrane Risk of Bias instrument help mitigate interpretive uncertainty, the presence of publication bias and selective reporting remains a concern (Collinson et al., 2020; Johnston et al., 2012). Rigorous, multicenter trials with clear outcome definitions are needed to strengthen the evidence base.

Beyond direct clinical outcomes, probiotics may confer longer-term immunological and gastrointestinal benefits. Emerging evidence suggests that they modulate systemic inflammatory markers and may reduce recurrence of diarrheal episodes (do Carmo et al., 2018; Feng et al., 2022). Although this review focused on acute interventions, future research should evaluate the prophylactic potential of probiotics in high-risk pediatric populations.

In summary, this review affirms that probiotics—particularly *S. boulardii* and *L. rhamnosus GG*—can meaningfully reduce the duration and severity of acute diarrhea in children. While findings are generally favorable, results depend heavily on strain specificity, patient characteristics, trial design, and geographic context. Future efforts should focus on refining strain selection, ensuring quality assurance in probiotic manufacturing, and integrating probiotic use with established therapies like ORS and zinc to maximize clinical impact.

CONCLUSION

This systematic review confirms that probiotics offer a significant benefit in reducing the duration and improving the severity of acute diarrhea in pediatric populations. Notably, *Saccharomyces boulardii* and *Lactobacillus rhamnosus GG* emerged as the most effective strains, reducing illness duration by approximately 1 to 2 days and improving stool frequency and consistency. These findings are especially relevant in resource-limited settings, where reducing diarrhea burden can significantly impact child survival and recovery.

However, efficacy is not universal across all strains, formulations, or patient populations. The benefits of probiotics depend on strain specificity, host health, comorbidities, and concurrent interventions such as zinc or antibiotics. While most studies demonstrate good tolerability and safety, further large-scale, high-quality trials are essential to refine probiotic recommendations, standardize doses, and understand long-term benefits.

Limitations

This review has several limitations. First, the heterogeneity across included studies—in probiotic strains, outcome definitions, dosing, and treatment duration—limits the ability to perform quantitative meta-analysis. Second, while all studies were peer-reviewed, some had unclear blinding or randomization processes, increasing the risk of bias. Lastly, language restrictions and reliance on published data may introduce publication bias and underrepresentation of negative findings.

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