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DISCOVERY SCIENTIFIC SOCIETY

The Role of Probiotics and Prebiotics in the Management of Small Intestinal Bacterial Overgrowth - A review

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ABSTRACT

Introduction: Small Intestinal Bacterial Overgrowth (SIBO) is defined as an excessive growth of bacteria in the small intestine. This condition impairs nutrient absorption and is associated with nonspecific gastrointestinal symptoms. *The aim:* This publication reviews the current literature on the diagnosis and treatment of SIBO, particularly concerning the significance of probiotics and prebiotics. *Results:* Evidence suggests that certain probiotic strains, such as Saccharomyces boulardii and Lactobacillus rhamnosus, enhance the efficacy of antibiotics and contribute to long-term remission, but not all studies confirm the positive effects of probiotics. Prebiotics and fiber should be cautiously introduced, as they may worsen symptoms. *Conclusions:* Personalised therapeutic management is crucial for improving outcomes and minimizing symptom recurrence.

Keywords: SIBO, prebiotics, probiotics, treatment, diagnosis

1. INTRODUCTION

Small Intestinal Bacterial Overgrowth (SIBO) is a form of dysbiosis characterized by excessive growth of bacteria in the small intestine, potentially including species typically found in the colon (Goździewska et al., 2024; Skrzydło-Radomańska and Cukrowska, 2022). The precise prevalence of SIBO in the general population remains uncertain. However, most researchers suggest that it ranges from 2.5% to 22%, highlighting that prevalence tends to rise with age and is frequent with IBD, diabetes, hypothyroidism, and after gastrointestinal surgery (Skrzydło-Radomańska and Cukrowska, 2022). The exact etiopathogenesis of SIBO is not fully explained, as many factors play a role in its development. Impaired intestinal motility, hypochlorhydria, structural and postsurgical abnormalities, digestive secretory dysfunction, and altered microbiota can all

contribute to SIBO (Redondo-Cuevas et al., 2024; Aslan et al., 2023). Symptoms can vary widely, from mild bloating to more severe complications such as enteropathy, which may lead to malabsorption and malnutrition. Common symptoms may include abdominal pain, distention, excessive gas, and diarrhea (Peinado Fabregat et al., 2022). Besides its gastrointestinal effects, SIBO has been associated with several dermatological conditions, such as systemic sclerosis (SSc), psoriasis, and rosacea (Nickles et al., 2021).

SIBO can resemble or occur alongside conditions such as Irritable Bowel Syndrome (IBS), celiac disease, carbohydrate intolerance, Inflammatory Bowel Disease (IBD), and parasitic infections (Quigley et al., 2020). Therefore, a comprehensive differential diagnosis is essential. This process may involve serologic testing, endoscopic evaluation with biopsy, and stool studies (Nickles et al., 2021; Skrzydło-Radomańska and Cukrowska, 2022; Goździewska et al., 2024; Rej et al., 2022). Despite advances in understanding its pathomechanism and improvements in treatment methods, SIBO continues to be both a diagnostic and therapeutic challenge (Litwiniuk et al., 2023). Our publication will present current information on the diagnosis and treatment of SIBO, focusing on probiotics and prebiotics.

2. METHODOLOGY

This review was conducted by searching for current papers on PubMed and Google Scholar using the search phrases (probiotics) AND (small intestinal bacterial overgrowth), (probiotics) AND (SIBO), (prebiotics) AND (SIBO), and (prebiotics) AND (small intestinal bacterial overgrowth). After eliminating duplicates, we appraised all publications using the titles and abstracts. The review included meta-analyses, randomized controlled trials, observational studies, and systematic reviews that significantly contributed to science, published between January 2020 and February 2025. Studies that did not specifically address the influence of probiotics and prebiotics on SIBO and publications regarding pregnancy were excluded. Following an exact revision of complete manuscripts, 20 articles met the inclusion criteria.

3. RESULTS AND DISCUSSION

Diagnosis

The golden standard for diagnosing SIBO is a culture analysis. The current cut-off point for diagnosing SIBO depends on guidelines:≥10^3 colony-forming units (CFU) per milliliter or ≥10^5 CFU/ml in the jejunal aspirate. However, this method is invasive and expensive (Skrzydło-Radomańska and Cukrowska, 2022; Maeda and Murakami, 2023). Due to that, the most commonly used diagnostic tool is breath testing (BT). It works by measuring the levels of gases such as hydrogen (H_2), methane (CH_4), and carbon dioxide (CO_2) in exhaled breath following the ingestion of carbohydrates. A positive result is indicated by an increase of 20 ppm or more in H2 levels within 90 minutes from baseline during glucose or lactulose BT. Similarly, a rise of 10 ppm or more in CH4 levels from the baseline is also considered positive (Maeda and Murakami, 2023). Low sensitivity and specificity are among the drawbacks of breath testing. Breath testing for glucose has a sensitivity of about 55%, while lactulose has a sensitivity of about 42%. False positives may occur due to rapid intestinal transit, the gastro-ileal reflex, and retained stool gases in cases of constipation. Additionally, CH_4 levels can be elevated even in healthy individuals (Alcedo González et al., 2025).

Furthermore, urinary excretion tests are employed for diagnosing SIBO by using chemically synthesized bile acid conjugates, such as cholic acid (CA) linked to para-aminobenzoic acid (PABA-CA), ursodeoxycholic acid (UDCA) linked to PABA (PABA-UDCA), or conjugated with 5-aminosalicylic acid (5-ASA-UDCA). These conjugates undergo cleavage by bacterial bile acid (cholylglycine) hydrolase. In these tests, the patterns of urinary excretion rates for PABA or 5-ASA, along with their metabolites, are measured to assess the hydrolytic activity of intestinal bacteria. Although the number of clinical trials involving these urinary excretion tests is limited, findings have shown the effectiveness of bile acid conjugates as diagnostic substrates for SIBO (Maeda and Murakami, 2023).

We distinguish four subtypes based on the predominant gas produced during fermentation and the associated symptom profile (Gudan et al., 2023), which are presented in Table 1.

Table 1. Subtypes of SIBO

Subtype	Predominant Gas	Symptoms	Additional information
H_2-SIBO	Hydrogen (H_2)	Diarrhea-predominant, bloating, gas	Caused by hydrogen-producing fermentative bacteria

CH_4-SIBO (IMO)	Methane (CH_4)	Constipation-predominant, bloating	Associated with *Methanobrevibacter smithii* (archaea); also called IMO
Mixed-type SIBO	Hydrogen + Methane	Alternating diarrhea and constipation	Involves dual gas production; symptom pattern is variable
H_2S-SIBO	Hydrogen sulfide (H_2S)	Foul-smelling gas/stools, neurological symptoms, fatigue	Less studied; may be underdiagnosed; associated with *Desulfovibrio* spp.

Probiotics

Probiotics are living microorganisms that provide health benefits to the host when administered in sufficient amounts. They may produce antimicrobial substances, modulate the immune system, prevent pathogenic bacterial adhesion, stimulate mucosal IgA production, and inhibit bacterial toxins (Martyniak et al., 2025). Research indicates variable but promising effectiveness for specific strains. Saccharomyces boulardii CNCM I-745 combined with metronidazole eradicated SIBO in 80% of cirrhotic patients, compared to only 23% with metronidazole alone (Efremova et al., 2024). L. rhamnosus combined with antibiotics led to 81.2% symptom resolution vs. 67.7% with antibiotics alone (Peinado Fabregat et al., 2022). After an initial 3-week therapy with broad-spectrum antibiotics, a 15-day maintenance antibiotic therapy with Lactol (a combination of probiotic Lactobacillus sporogeneses and prebiotic fructooligosaccharides) resulted in 93.3% breath test normalization compared to 66.7% in control (Maeda and Murakami, 2023).

Mutaflor, a probiotic formulation containing Escherichia coli strain Nissle 1917, demonstrated promising results in preventing the recurrence of small intestinal bacterial overgrowth (SIBO) in patients with irritable bowel syndrome (IBS). In a double-blind clinical trial, patients who received Mutaflor following successful antibiotic eradication of SIBO had significantly lower recurrence rates than the placebo group ($P = 0.033$). These findings indicate that Mutaflor could be a helpful addition in maintaining remission and managing symptoms for SIBO-related IBS, especially in cases that are predominantly diarrhoea-predominant (Masjedizadeh et al., 2020).

A pediatric study found that probiotics (alone or with antibiotics) led to a higher symptom resolution rate (81.2%) compared to antibiotics alone (67.7%) (Peinado Fabregat et al., 2022). In a Jordanian multicenter study, concurrent and sequential rifaximin + probiotics showed similar efficacy (~86% symptom response), with the sequential group having a more prolonged clinical remission (Hammour et al., 2024). A Chinese RCT showed that Bacillus subtilis and Enterococcus faecium significantly reduced SIBO prevalence and GI symptoms after 4 weeks (Shi et al., 2020). Combining probiotics with fixed and essential oils, such as coconut and peppermint, significantly improved gut microbiota diversity and reduced intestinal inflammation in a rat model of SIBO (Aslan et al., 2023).

Not all trials confirm the benefits. A randomized, double-blind crossover trial using Lactobacillus fermentum KLD showed no significant effects on breath tests, clinical symptoms, or stool frequency, and there was no improvement in bloating, pain, or flatulence (Nickles et al., 2021). Some studies have reported that methane-positive SIBO worsens in patients after using probiotics. Probiotics may stimulate methanogenic archaea, exacerbating bloating and constipation (Hammour et al., 2024). Saccharomyces boulardii CNCM I-745 is generally regarded as safe. However, a few complications have been reported. Rare complications include Saccharomyces fungemia, primarily in immunocompromised patients with catheters, and allergic reactions noted in pediatric cases (Kaźmierczak-Siedlecka et al., 2020).

Prebiotics

Prebiotics are non-digestible food components, such as soluble fibers and oligosaccharides, that selectively stimulate the growth and activity of beneficial gut bacteria like Bifidobacteria and Lactobacilli. Common prebiotics include fructooligosaccharides (FOS), galactooligosaccharides (GOS), inulin, resistant starch, and beta-glucans (Martyniak et al., 2025). FODMAPs act as prebiotics and positively influence the microbiome by stimulating positive microbiota growth and promoting short-chain fatty acid production.

Dietary fiber plays a crucial role in supporting the growth of beneficial microorganisms, showing prebiotic effects. Studies indicated that increasing fiber intake, especially soluble fiber, could benefit individuals with gastrointestinal symptoms and positively influence gut microbiota. It was observed that adding psyllium husk or partially hydrolyzed guar gum to a regular diet may improve symptoms, such as bloating and abdominal pain, as well as improve stool consistency and frequency. Nonetheless, further research in patients with SIBO is necessary (Wielgosz-Grochowska et al., 2022). Although prebiotics support healthy microbiota, they can worsen symptoms in active SIBO due to excessive fermentation and gas production by overgrown bacteria in the small intestine. Typical symptoms include bloating, abdominal pain, diarrhea, and flatulence (Martyniak et al., 2025; Wielgosz-Grochowska et al., 2022)

Synbiotics

A mixture of prebiotics and probiotics is called synbiotics, and it is designed to improve the survival and implantation of beneficial microorganisms in the gastrointestinal tract. In the context of SIBO, synbiotics aim to suppress pathogenic bacterial overgrowth and restore a healthier intestinal microbiota balance (Kaźmierczak-Siedlecka et al., 2020).

Antibiotics

Common antibiotics used to treat SIBO include tetracyclines, fluoroquinolones, metronidazole, and co-trimoxazole. Recently, rifaximin has become the favored option among healthcare professionals for managing SIBO (Hammour et al., 2024). In 2020, the American College of Gastroenterology (ACG), Pimentel et al., (2020) developed guidelines for the use of antibiotics, which are presented in Table 2.

Table 2. Antibiotics used to treat SIBO

Drug	Dosage	Efficacy
Rifaximin	550 mg three times per day	61-78%
Amoxicillin/clavulanic acid	875 mg twice daily	50%
Ciprofloxacin	500 mg twice daily	43-100%
Doxycycline	100 mg one-two times daily	Not Defined
Metronidazole	250 mg three times per day	43-87%
Neomycin	500 mg twice daily	33-55%
Norfloxacin	400 mg once daily	30-100%
Tetracycline	250 mg once daily	87.5%
Trimethoprim-sulfamethoxazole	160 mg/80 mg twice daily	95%

Rifaximin is a broad-spectrum antibiotic that is minimally absorbed and acts locally in the small intestine. It is typically dosed at 550 mg three times a day for a duration of 10 to 14 days. Rifaximin has a high safety profile and an eubiotic effect, meaning it supports beneficial bacteria such as Lactobacillus and Bifidobacterium species. Meta-analyses have reported eradication rates between 60% and 84%, with symptom improvement seen in 33% to 92% of patients (Maeda and Murakami, 2023; Skrzydło-Radomańska and Cukrowska, 2022; Quigley et al., 2020).

Rifaximin combined with Neomycin is particularly effective in treating methane-dominant SIBO (IMO), achieving up to 87% eradication rates (Gudan et al., 2023). Recurrence after successful rifaximin treatment is usual: 12.6% at 3 months, 27.5 % at 6 months, and 43.7% at 9 months. Factors contributing to this recurrence include older age, a history of appendectomy, and long-term use of proton pump inhibitors (PPIs). Prevention strategies include prokinetic agents such as erythromycin (50 mg) and tegaserod (2–6 mg), which can significantly extend the resolution of symptoms and may improve long-term outcomes. These helps maintain gut motility and prevent bacterial reaccumulation (Maeda and Murakami, 2023).

DIET

Low FODMAP diet

The low FODMAP diet is a recommended nutritional approach for SIBO-related symptoms such as bloating and gas. This diet limits fermentable oligosaccharides, disaccharides, monosaccharides, and Polyols, which are poorly absorbed and fermented by gut bacteria, leading to gas production and bloating. Additionally, it is important to avoid prebiotics like inulin (Pimentel et al., 2020). The diet is usually divided into three phases. The first phase involves eliminating all foods high in FODMAPS under dietitian supervision. The

second phase is the reintroduction, which means gradually introducing FODMAPs to assess tolerance levels. The third phase is creating a long-term plan based on individual sensitivities (Goździewska et al., 2024; Wielgosz-Grochowska et al., 2022)

While diet can be effective, long-term use may decrease beneficial bacteria, such as Bifidobacteria and Faecalibacterium prausnitzii, and increase dysbiosis risk (Wielgosz-Grochowska et al., 2022). It may also lead to nutritional deficiencies in fiber, calcium, and B vitamins (Goździewska et al., 2024).

Elemental diet

An elemental diet consists of a nutritionally complete formula of free amino acids and simple carbohydrates devoid of fiber and fat. In one study, 80% of patients achieved normalization of breath tests after 14 days and an additional 5% by day 21. The simplest explanation for this diet is that the elemental formulation is quickly absorbed; therefore, no substrate is available for the small intestine bacteria. This approach can lead to rapid symptom relief, but it may be challenging to follow due to its restrictive nature (Nickles et al., 2021).

Other diets

For H2S-dominant SIBO, a low-sulfur diet can be applied to reduce substrates for hydrogen sulfide-producing bacteria. Foods high in sulfur, such as red meat, eggs, garlic, onions, and cruciferous vegetables, are limited. The ketogenic diet (high-fat, low-carb) is not routinely advised due to potential side effects like constipation and unclear impact on microbiota diversity (Goździewska et al., 2024).

Herbal Supplements

Herbal supplements are increasingly used as alternatives to antibiotics, especially in patients who experience antibiotic resistance, intolerance, or relapse. The effectiveness of herbal therapy in treating SIBO may be explained by the various herbs that exhibit antimicrobial properties. Herbs known for their antimicrobial activity include garlic, black cumin, cloves, cinnamon, thyme, and many others, which can be used therapeutically (Nickles et al., 2021; Maeda and Murakami, 2023).

Some studies indicate comparable efficacy between some herbal preparations and rifaximin, although the quality of evidence remains low. Comprehensive, randomized, placebo-controlled studies are crucial for evaluating effective methods for integrating alternative therapies, such as probiotics, specialized diets, and herbal treatments, into managing SIBO (Nickles et al., 2021). Adjunctive herbal supplements did not significantly impact gas levels but showed potential for clinical improvement, especially in CH4-SIBO patients (Redondo-Cuevas et al., 2024).

Faecal Microbiota Transplantation

Faecal Microbiota Transplantation (FMT) is a procedure that involves transferring stool from a healthy donor into a patient's digestive system. It aims to restore a balanced and diverse microbiota. FMT is not a first-line treatment for SIBO, although some exploratory studies and reviews have indicated promising outcomes, especially in patients with recurrent or antibiotic-resistant SIBO. The therapy may also be beneficial when SIBO coexists with other dysbiosis-related diseases, like irritable bowel syndrome or inflammatory bowel disease. Current evidence is limited to case reports, small studies, and systematic reviews, indicating a need for large-scale randomized controlled trials (Pimentel et al., 2020; Maeda and Murakami, 2023)

4. CONCLUSIONS

The clinical management of Small Intestinal Bacterial Overgrowth remains challenging due to its heterogeneous etiology, coinciding symptoms with other gastrointestinal diseases, and high recurrence rates. Accurate diagnosis, primarily through hydrogen and methane breath testing, is essential but should be accompanied by careful differential evaluation to rule out other causes of symptoms. Conventional treatment still relies on antibiotics. Probiotics have emerged as a promising addition to SIBO management. Specific strains such as Saccharomyces boulardii, Lactobacillus rhamnosus, and Bacillus subtilis have shown positive results when combined with antibiotics, improving eradication rates and prolonging remission. Prebiotics and probiotics, while beneficial for microbiota diversity, must be carefully introduced due to the risk of symptom exacerbation. Fiber intake, especially soluble fiber like psyllium or guar gum, shows promise for post-treatment maintenance but requires further clinical validation. Herbal therapies show encouraging results but require clinical validation. New treatments like fecal microbiota transplantation and prokinetic agents may prevent relapse.

In conclusion, effective treatment of SIBO requires an individual approach, which comprises antibiotics, probiotics, prebiotics, and dietary modifications such as a low-FODMAP or elemental diet. Well-controlled studies are needed to evaluate optimal treatment protocols.

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Data and materials availability
All data associated with this study are present in the paper.

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