

Probiotics and Disease: A Comprehensive Summary—Part 8, Gastrointestinal and Genitourinary Disorders

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Abstract

This article series provides a literature review of the disease-specific probiotic strains associated with gastrointestinal and genitourinary disorders studied in published clinical trials in humans and animals. This is not an exhaustive review. The table design allows for quick access to supportive data and will be helpful as a guide for both researchers and clinicians. The goal of the probiotics and disease series is to provide clinically useful tools. The first article (part 1) focused on mental health and neurological conditions; the second article (part 2) explored cultured and fermented foods that are commonly available in the United States; the third article (part 3) explored the relationship between bacterial strains and 2 of the most prevalent diseases we have in modern society: cardiometabolic disease and fatigue syndromes; the fourth article (part 4) elucidated

the role of the microbiome in infectious diseases; the fifth article (part 5) explored respiratory conditions of the ears, nose, and throat; and the sixth article (part 6) explored the relationship between beneficial microbiota and skin disorders. The seventh article (part 7) reviewed the relationship between beneficial microbiota and autoimmune diseases, allergies, asthma, and other immunity-related disorders. This article (part 8) will explore the unique relationship between bacterial strains and gastrointestinal and genitourinary diseases associated with dysbiosis. Future articles will review the influence of the microbiome on cancer development and prognosis, followed by an article focused on probiotic supplements. This literature review is specific to disease condition, probiotic classification, and individual strain.

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We investigated disease-specific probiotic strains associated with gastrointestinal and genitourinary diseases such as irritable bowel syndrome (IBS), Crohn's disease, *Helicobacter pylori*, bacterial vaginosis, *Candida albicans*, cystitis, prostatitis, and chronic kidney disease (CKD). This is not an exhaustive review.

The purpose of this summary is to provide nutritionists and other medical practitioners with a reference guide for recommending health-promoting commercially produced cultured and fermented food products to patients. There is considerable research on the gut microbiome and role of probiotics; however, this research has not been clearly connected with clinical practice. The authors undertook a review of current literature to explore which specific probiotics and probiotic strains have been utilized in clinical and laboratory studies.

To make this clinically valuable, product names of probiotics and fermented foods have been included. Finished products vary between manufacturers; thus, the researchers included brand listings to provide transparency and to facilitate a functional probiotics guide for clinicians. Exclusions of products meeting our criteria do not imply that these products are not effective—we simply were not aware of them.

Methodology

This literature review originated from a group project that was part of the requirements for a course in the doctoral program in functional and clinical nutrition at Maryland

University of Integrative Health (Laurel, MD, USA). The student researchers had approximately 2 months to review the literature and synthesize the paper. The authors agreed on format, templates, and execution. Each author researched and wrote sections reviewing probiotics in relation to various health conditions with literature searches conducted in PubMed, Biomed Central, EBSCO Research Premier, PLoS One, Cochrane reviews, and topic-specific open-source journals.

The review of specific probiotic products in the professional marketplace and specific probiotics products was performed using Internet searches, primarily Shop Google, in addition to topic specific databases to search for specific probiotic species including the strains listed in the research. Novel strains were cross-referenced to determine whether the strain was available only for research purposes. If a probiotic combination was used in the research, formulas that closely matched the combination were included. Formulas that contain all or most of the specific probiotics and strains were also included. The food survey focused on bacterial strains in food and includes foods that are commercially produced and commonly available in the refrigerated sections of grocery stores in the United States. Information was gleaned from commercial Web sites, communications with food company personnel, and by visiting grocery stores (primarily in California).

Gastrointestinal diseases such as celiac disease, IBS, parasites, and Crohn's disease may be directly impacted by perturbation of the bacterial microflora. For more than a century, probiotics have been utilized clinically to help restore normal bacterial microflora and promote proper functioning of the gastrointestinal tract; however, they have been extensively researched in only recent years. Their use in the treatment and prevention of disease has provided many insightful clinical applications, which are summarized in this review. Probiotics have been clinically studied in Crohn's disease, IBS, celiac disease, and other disorders. The results of these studies are summarized in the tables.

Research Overview: Gastrointestinal Disease

Efficacy of probiotic compounds has been shown in a wide range of gastrointestinal diseases including gastric ulcers, IBS, ulcerative colitis, celiac disease, and other inflammatory bowel diseases. *Lactobacillus* GG alone, or in the combination of *Bifidobacterium bifidum* and *Streptococcus thermophilus*, is effective in the treatment of *Clostridium difficile*. Probiotics have been used to prevent antibiotic induced diarrhea.¹

Pouchitis is a common complication in patients undergoing restorative proctocolectomy for ulcerative colitis. Probiotics and prebiotics in the treatment of these patients has been proved effective when the probiotic strains *Bifidobacterium*, *Lactobacillus*, and *Saccharomyces boulardii* are utilized.² VSL#3 is a common probiotic utilized for

ulcerative colitis patients.³ Profermin is also effective in reducing remission in ulcerative colitis.⁴

In patients with celiac disease, *Bifidobacterium infantis* provided improvement in symptoms of indigestion and constipation; *Bifidobacterium* also produced some immunologic changes but was not successful in modifying intestinal permeability.⁵ *Bifidobacterium breve* has shown a positive effect on increasing the production of proinflammatory cytokine tumor necrosis factor alpha in children with celiac disease.⁶ Several strains of *Lactobacillus* (*paracasei*, *rhamnosus*) show potential for the treatment of celiac disease and preventing undigested gliadin peptides toxic effects.³

In the treatment of parasites, *Bifidobacterium animalis* had an immunomodulatory action, whereas *Lactobacillus casei* and *Enterococcus faecium* were both effective at eliminating giardia infection.^{7,8} In addition, *Aymomonas mobilis* was reported to provide 60% protection from the infection of *Schistosoma masoni* in mice.⁷

Lactobacillus johnsonii, *Saccharomyces boulardii*, *Lactobacillus acidophilus*, and *Bifidobacterium lactis* were all proven effective in treating *H pylori*. *L johnsonii* was found effective in inhibiting adhesion of *H pylori* to gastric epithelial cells and several studies have recommended *S boulardii* or *Lactobacillus* species in combination with standard triple therapy.⁹

Unfortunately, most studies show there is no efficacy for probiotics in Crohn's disease treatment at this time.^{2,3}

The treatment of small intestinal bacterial overgrowth (SIBO) can be improved with probiotics. *Bifidobacterium* triple viable capsule, *B bifidum*, *B lactis*, *Bifidobacterium longum*, *L acidophilus*, *Lactobacillus rhamnosus*, *L casei*, and *Streptococcus thermophilus* are all beneficial for SIBO. There are data that show a good outcome with sequential antibiotic probiotic/prebiotic administration in patients with SIBO.¹⁰⁻¹² In patient with diarrhea-predominant IBS, dual coating capsules containing 5 billion bacteria were utilized for 4 weeks. Results indicated a significant improvement in intestinal microbiota and overall discomfort when compared with the group utilizing noncoated probiotics. Multistrain probiotics have been found best for IBS.¹³

It is evident that a variety of probiotic strains are helpful in combating gastrointestinal diseases, and more research is needed to evaluate other strains. The natural microbes can be found in foods as well as supplements that come in pills, capsules, powders, and liquids. Each strain has a different effect on the microbiome and offer clinical improvement for patients with IBS, ulcerative colitis, antibiotic-associated diarrhea, parasites, and SIBO with minimal risk or adverse side effects.

Research Overview: Genitourinary

The use of probiotics for maintaining genitourinary health in males and females may be a cost-effective alternative treatment for those suffering from a variety of

Table 1. Gastrointestinal Disorders

| Gastrointestinal Infections | Strains | Overview | Professional and Commercial Products | Foods |
|--|--|--|---|--|
| Celiac Disease Smecuol et al ⁵ (2013); Klemenak et al ⁶ (2015) Smecuol et al ⁵ (2015); Lorenzo et al ¹⁴ (2015) Sarno et al ¹⁵ (2014) Durchschein ³ (2016) | <i>B infantis</i> NLS, <i>B breve</i> BR03, <i>B breve</i> B632, <i>B longum</i> CECT 7347 <i>L rhamnosus</i> , <i>L paracasei</i> <i>L paracasei</i> CBA L74 & P31-43 | <p>In patients with celiac disease, <i>B infantis</i> NLS provided improvement in symptoms of indigestion and constipation; produced some immunologic changes but did not modify intestinal permeability</p> <p><i>B breve</i> BR03; <i>B breve</i> B632 has shown a positive effect on decreasing the production of pro-inflammatory cytokine TNF-α in children with celiac disease on gluten-free diet.</p> <p><i>B longum</i> CECT7347 produces minimal changes in gut microbiota with gluten-free diet. <i>Lactobacillus</i> shows high percentages of autoaggregation and <i>Lactobacillus</i> shows high hydrophobicity. which makes them potential for treatment associated with celiac disease.</p> <p><i>L paracasei</i> CBA L74 & P31-43 prevent undigested gliadin peptides toxic effects.</p> <p>Precaution: When probiotics are used, the risk of bacterial translocation and subsequent bacteremia has to be considered.</p> | <p><i>B breve</i>, <i>B longum</i>, <i>L rhamnosus</i>, <i>L paracasei</i>: Renew Life Ultimate Flora Extra Care 50 Billion</p> <p><i>B infantis</i> NLS: Natren Life Start Probiotics for Infants and Life Start Vegan, Natren</p> <p><i>B breve</i> BR03 Bifidus Balance+FOS (Jarrow Formulas)</p> <p><i>B breve</i> BR03 and B632 (Bifibaby, Probiotical Spa)</p> <p><i>B longum</i> CECT 7347 (not available)</p> <p><i>L rhamnosus</i> (common in multistrain options)</p> <p><i>L rhamnosus</i> with FOS (Swanson Ther-Biotic Factor 1, Klaire Labs)</p> <p>Gr8-Dophilus (NOW Foods)</p> <p><i>L paracasei</i> CBA L74 & P31-43 (not available)</p> | <p><i>B infantis</i> NLS: None</p> <p><i>B breve</i> BR03: None</p> <p><i>B breve</i> B632, <i>B longum</i> CECT 7347, <i>L rhamnosus</i>: Kevita kombucha drinks, yogurt</p> <p><i>L paracasei</i>: Kevita probiotic drinks, Wallaby organic cow's milk yogurt</p> <p><i>L paracasei</i> CBA L74 & P31-43: None</p> |
| Parasites Ribeiro et al ⁸ (2016); Berrilli et al ⁷ (2012) | <i>B animalis</i> subsp <i>lactis</i> <i>L casei</i> MTCC <i>E faecium</i> SF68 | <p>The probiotic <i>B animalis</i> had an immunomodulatory action, inducing CD19 lymphocyte proliferation. and consequently increasing anti-<i>T gondii</i> antibody level-B provided protection in supplemented mice.</p> <p><i>L casei</i> and <i>E faecium</i> were both effective at eliminating Giardia infection.</p> <p>Oral treatment of <i>L casei</i> appears to reduce the parasite burden <i>T spiralis</i> in mice.</p> <p><i>E faecalis</i> has inhibitory activity against Gram-positive and Gram-negative bacteria.</p> <p><i>A mobilis</i> was reported to provide 60% protection from the infection of <i>S mansoni</i> in mice.</p> | <p><i>B animalis</i> subsp <i>lactis</i> (HLC Maintenance, Pharmax)</p> <p><i>L casei</i> MTCC (not available)</p> <p><i>E faecium</i> SF68 (not available)</p> | <p><i>B animalis lactis</i>, DN-173 010/CNCM</p> <p>I-2494: Activia yogurt</p> <p><i>L casei</i> MTCC: None</p> <p><i>E faecium</i> SF68: None</p> |
| H. Pylori Khoder et al ⁹ (2016) | <i>L johnsonii</i> , <i>S boulardii</i> , <i>L acidophilus</i> , <i>B lactis</i> | <p><i>L johnsonii</i> inhibits adhesion of <i>H pylori</i> to gastric epithelial cells in vitro.</p> <p>Meta-analytic studies have recommended the use of either <i>S boulardii</i> or <i>Lactobacillus</i> species supplementation in combination with the standard triple therapy.</p> | <p><i>L johnsonii</i> (not available)</p> <p><i>S boulardii</i> (Jarrow Formulas, Biotics Research, Ortho Molecular Products, Klaire Labs, Bronson Vitamins, Pure Encapsulations, Nutricology, Kirkman Labs, Thorne Research)</p> <p><i>L acidophilus</i> and <i>B lactis</i> (widely available in commercial formulas)</p> <p>Gr8-Dophilus (NOW Foods, Ther-Biotic Factor 4: Bifidobacterium Complex, Klaire Labs, Dr Formulated Probiotics—various formulas, Garden of Life, Ultimate Flora Extra Care Probiotic, Renew Life)</p> | <p><i>L johnsonii</i>: Milk and fermented dairy products</p> <p><i>S boulardii</i>: None</p> <p><i>L acidophilus</i>: Lassi, kefir, yogurt</p> <p><i>B lactis</i>: Almond Dream nondairy yogurt, Nancy's Organic cultured soy, goat milk yogurt, vow's milk lassi, Nancy's Organic cow's milk kefir</p> |

Table 1. (continued)

| Gastrointestinal Infections | Strains | Overview | Professional and Commercial Products | Foods |
|--|--|--|---|---|
| Crohn's Disease Durchschein et al ³ (2016); Lichtenstein et al ² (2016) | | There is no evidence for efficacy of probiotics in Crohn's disease. | None | None |
| Bariatric Surgery Tarplin ¹⁶ (2015) | | Both pyridoxine and probiotics have been shown in small studies to reduce hyperoxaluria. | | |
| SIBO Liang ¹¹ (2016) Kwak et al ¹⁰ (2014) Rosania et al ¹² (2013) | <i>Bifidobacterium</i> triple viable capsule, <i>B bifidum</i> <i>B lactis</i> , <i>B longum</i> <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , <i>L casei</i> | <i>Bifidobacterium</i> triple viable capsule was effective in combatting SIBO and was associated with a significant improvement in gastrointestinal cancer related symptoms. Short-term probiotic administration is effective in alleviating SIBO and clinical symptom. Data show a good outcome with sequential antibiotic/probiotic/prebiotic administration in patients with SIBO. | <i>B bifidum</i> , <i>B lactis</i> , <i>B longum</i> , <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , and <i>L casei</i> are formulated together in the following brands: Nexabiotic (Bioprospers Labs) Mega Probiotic-ND (Food Science) Mega Flora Plus (Mega Food) Iflo Multi-Probiotic Formula (Sedona Labs) ProBiota 12 (Seeking Health) Sehat Probiotic (Trivedi) | <i>B</i> triple viable capsule: None <i>B bifidum</i> : Kefir, All yogurt containing "live and active cultures" <i>B lactis</i> : Almond Dream nondairy yogurt, Nancy's Organic cultured soy, Goat milk yogurt, Cow's milk lassi, Nancy's Organic cow's milk kefir <i>B longum</i> : None <i>L acidophilus</i> : Lassi, kefir, yogurt <i>L rhamnosus</i> : None <i>S thermophilus</i> : lassi, kefir, all yogurts <i>L casei</i> : Nancy's Organic cow's milk yogurt, all kefirs |
| Ulcerative Colitis Durchschein et al ³ (2016); Lichtenstein ² (2016); Rembacken et al ¹⁷ (1999); Matthes et al ¹⁸ (2010); Krag ⁴ (2013); Orel et al ¹⁹ (2014) | <i>E coli</i> Nissle 1917, <i>B breve</i> VSL, <i>B infantis</i> VSL, <i>B longum</i> VSL, <i>L acidophilus</i> VSL, <i>L delbrueckii</i> subp <i>bulgaricus</i> VSL, <i>L paracasei</i> VSL, <i>L plantarum</i> VSL, <i>S thermophilus</i> VSL, <i>L plantarum</i> 299v, <i>B clausii</i> (<i>enterogermina</i>), <i>L casei</i> Shirota, <i>S cerevisiae</i> variety <i>boulardii</i> , <i>L casei</i> CRL 431, <i>L acidophilus</i> CRL-730 | For patients with pouchitis, antibiotics treatment followed by VSL#3 or <i>Lactobacillus</i> GG is effective. Prebiotic inulin is capable of reduction of mucosal inflammation in patients with subclinical chronic pouchitis. When treated with nonpathogenic <i>E coli</i> , time to remission and duration of remission was equivalent to a group treated with corticosteroid. Probiotic enemas resulted in dose-dependent remission rate. Supplementation with profermin is safe, well tolerated, palatable, and able to reduce SCCAI scores at a statistically and clinically significant level in patients with mild-to-moderate ulcerative colitis with a flare-up. VSL#3 and <i>E coli</i> Nissle 1917 provide strong clinical evidence for the treatment of active ulcerative colitis. | <i>E coli</i> Nissle 1917 (Mutaflor Tribute Pharmaceuticals) VSL#3 for ulcerative colitis ³ Culturelle (Digestive Health) Culturelle Immune Health (Klaire Labs) Culturelle (Metagenics) Ultra Flora Intensive Care (Jarrow Ideal) Bowel Support 299v (Ther-Biotic Factor) 4 Bifidobacterium Complex 60c by Klaire Labs (<i>B breve</i>) | Strains in VSL: None <i>L plantarum</i> 299v: Good Belly Probiotic Foods <i>Bacillus clausii</i> : None <i>L casei</i> Shirota: Yakult <i>S cerevisiae</i> variety <i>boulardii</i> , <i>L casei</i> CRL-431, <i>L acidophilus</i> CRL -730: None |

Table 1. (continued)

| Gastrointestinal Infections | Strains | Overview | Professional and Commercial Products | Foods |
|---|--|--|--|---|
| Irritable Bowel Syndrome Han et al ¹³ (2016) | <i>L plantarum</i> 299v, <i>B animalis</i> subsp <i>lactis</i> DN-173-010, <i>B infantis</i> 35624, <i>L fermentum</i> VRI-003, <i>L plantarum</i> 299v <i>L acidophilus</i> VSL, <i>S thermophilus</i> VSL, <i>B infantis</i> VSL, <i>B breve</i> VSL, <i>L paracasei</i> VSL, <i>B bifidum</i> CUL-20, <i>B lactis</i> CUL-34, <i>L acidophilus</i> CUL-21, <i>L acidophilus</i> CUL-60, <i>L rhamnosus</i> GG, <i>E coli</i> Nissle 1917 | Dual-coating layers of probiotic supplement (<i>Bifidobacterium</i>) can be candidate for treatment of diarrhea-predominant IBS. | Magnetic Clay Inc Prescript Assist Genestra HMF Pre+Probiotic Pharmax HLC Immunity+Pro Genestra Multi+Pro F Genestra Multi+Pro F50+ Genestra Multi+Pro M Genestra Multi+ProM50+ Sigma Tau VSL#3 (Metagenics) Ultra Flora Intensive Care (Jarrow Ideal) Bowel Support 299v (Pharmanex ProBio PCC, Procter & Gamble Align, Danone Activia, GoodBelly Probiotic Drink Range, Ther- Biotic Factor4) Bifidobacterium Complex) 60c by Klaire Labs (<i>B breve</i>) | <i>L plantarum</i> 299v: GoodBelly Probiotic Products <i>B animalis subps lactis</i> DN-173-010: Activia Yogurt <i>B infantis</i> 35624: None <i>L fermentum</i> VRI-003: None <i>L plantarum</i> 299v: GoodBelly Probiotic Products VSL Strains: None <i>B bifidum</i> CUL-20, <i>B lactis</i> CUL-34, <i>L acidophilus</i> CUL-21, <i>L acidophilus</i> CUL-60, <i>L rhamnosus</i> GG, <i>E coli</i> Nissle 1917: None |

Abbreviations: IBS, irritable bowel syndrome; SIBO, small intestinal bacterial growth;

recurring genitourinary infections. For women, most *Lactobacillus* strains applied topically and containing more than 1 billion colony-forming units (CFUs) showed positive results with most bacterial vaginosis and *Candida* infections.²⁰ One in vivo study on toxic shock syndrome showed that probiotics adhered immediately to the virulent bacterial toxins produced by *Staphylococcus aureus*.²¹ Recurrent urinary tract infections (UTIs) have been associated with depletion of vaginal *Lactobacillus*, and Stapleton et al²² showed that the use of vaginal suppository of *Lactobacillus crispatus* was associated with a reduction of recurrent UTIs in women.

In men, the link between the gut microbiota and prostatitis is just now being recognized and explored in the literature, and VSL#3 combined with rifaxin to address the gut microbiota helped to greatly decrease chronic prostatitis.²³

CKD is another area where probiotics may favorably affect the outcome of disease by influencing the microbiota. The intestine and the kidney influence each other's health in a complex bidirectional manner.²⁴ The intestine generates protein-bound uremic toxins, p-Cresol, and indoxylsulfate. Uremia then many cause structural and functional changes in the intestine including bacterial translocation, increased gut permeability, and generation of protein-bound uremic toxins that lead to inflammation that, in turn, causes increased morbidity and mortality in CKD and non-CKD populations.²⁴ Intestinal dysbiosis may be associated with

increased uremic toxin level that may contribute to the progression of CKD.²⁵ The intestinal microbiota in CKD patients is altered with lower levels of *Lactobacillus* and *Prevotella* species, and 100 times higher with *Enterobacteria* and *Enterococci* species.²⁵ Kidney disease is associated with factors that cause intestinal dysbiosis, including decreased fiber intake, higher antibiotic use, slower colon transit time, metabolic acidosis, volume overload with intestinal wall congestions, intestinal wall edema, and oral iron intake.²⁵ Therefore, targeting the gut microbiota with a lower protein diet and prebiotics and probiotics will help to generate fewer uremic toxins may be a credible adjuvant approach for addressing CKD and the associated high morbidity and mortality.²⁵

There is only a small body of pilot research on the utilization of probiotics in people with CKD. According to Rossi et al,²⁶ the studies that have been done on evaluating the effects of probiotics on CKD have been poorly designed, often did not have a control group, the strains were not been selected with any clear rationale, and for the most part have shown a poor outcome on urea levels and uremic toxins. Furthermore, the population that might benefit the most, the predialysis population, has not been targeted for studies.²⁶ A pilot study of 25 people with PKD included some in stage III, with creatinine levels of 1.7, compared with other studies with only people in stages IV to V CKD. This cross-over study compared the effects on a probiotic supplement containing

Streptococcus thermophilus (KB19), *L. acidophilus* (KB27), and *B longum* (KB31) in subjects with diabetes versus people with CKD who did not have diabetes. Placebo and probiotic were each taken for 3 months. All subjects had reductions in blood urea levels. Only subjects without diabetes had significant stabilization or reductions in glomerular filtration rate (GFR). Approximately 54% of subjects with diabetes were taking chronic antibiotics for neurologic bladder, which may have attributed to the nonsignificant changes in GFR in the subjects with diabetes.²⁷

At this time, no strains of probiotics have been identified that produce definite benefits in CKD patients. A study in rats showed that *Bacillus pasteurii* and *Lactobacillus sporogenes* decrease BUN and serum

creatinine. *L. casei* Shirota in high doses of 16 billion decreased BUN by 11% but not creatinine. *L. acidophilus* and *B longum* have shown a borderline decrease in BUN in only 40% of subjects.²⁶ A recent study analyzing National Health and Nutrition Survey (NHANES) data found that frequent consumption of yogurt and or probiotics use was associated with decreased risk of proteinuria kidney disease.²⁵

As antibiotic resistance increases, it is important to consider having cost effective, evidence-based alternative treatments available such as the use of certain probiotic strains for specific recurring genitourinary infections. The use of probiotics for maintaining the health of the genitourinary tract warrants continued research.

Table 2. Genitourinary Disorders

| Genitourinary | Strains | Overview | Professional and Commercial Products | Foods |
|---|--|--|--|---|
| Bacterial Vaginosis Coudeyras ²⁸ (2008) Mastromarino et al ²⁹ (2009) Mastromarino ³⁰ (2013) Parolin et al ³⁰ (2015) Vicariotto ³¹ (2014) | <i>L. rhamnosus</i> , <i>L. reuteri</i> (vaginally) <i>L. brevis</i> + <i>L. salivarius</i> + <i>L. plantarum</i> <i>L. acidophilus</i> + <i>estriol</i> | Most clinical trials using 1 billion CFU of any lactobacillus species applied externally were positive. All strains showed cure of BV and decreased incidence of recurrence through anti-microbial action and preventing adherence of pathogen. | Femdophilus (Nature's Way contains <i>L. reuteri</i> + <i>L. rhamnosus</i>) | <i>L. rhamnosus</i> : Almond Dream nondairy yogurt, Amande cultured almond milk, Trader Joe's cultured coconut milk, Nancy's Organic cultured soy, Nancy's Organic cow's milk yogurt, all kefir, Kevita kombucha and sparkling probiotic drinks <i>L. brevis</i> : pickled beets, kimchi, sauerkraut, all wildbrine brand products <i>L. plantarum</i> : fermented vegetables, Kevita probiotic drinks, olives (green) <i>L. acidophilus</i> : lassi, kefir, yogurt <i>L. reuteri</i> , <i>L. salivarius</i> : None |
| Toxic Shock Younes ²¹ (2012) | <i>L. reuteri</i> RC-14 (4.0-6.4 nN) | Shown to adhere to three virulent toxic shock syndrome toxin 1-producing. <i>S. aureus</i> strains, demonstrating the potential for rapid antipathogen effects. | | None |
| Candida Albicans De Seta et al ³² (2014) | <i>L. plantarum vaginal</i> | Cure and decreased incidence of recurrence. | Widely available | <i>L. plantarum</i> : fermented vegetables, Kevita, probiotic drinks, olives (green) |

Table 2. (continued)

| Genitourinary | Strains | Overview | Professional and Commercial Products | Foods |
|---|---|---|--|--|
| Cystitis Stapleton et al ²² (2011) Uehara et al ³³ (2006) Vicariotto ²¹ (2014) | <i>L. crispatus</i> <i>L. plantarum</i> + <i>S. thermophilus</i> + <i>L. paracasei</i> + mannose + Tara | <i>L. crispatus</i> resulted in significant reduction in recurrent UTIs. <i>L. plantarum</i> , <i>S. thermophilus</i> , <i>L. paracasei</i> , mannose, and Tara treatment resulted in decreased adhesion of bacteria, significantly reduced positive nitrites and leukocyte esterase and negative results after 60 d. Typical symptoms of cystitis significantly decreased. | <i>L. crispatus</i> (not found) Other strains ubiquitous in many multistrain probiotics | <i>L. plantarum</i> : fermented vegetables, Kevita probiotic drinks, olives (green) <i>S. thermophilus</i> : All yogurts and kefirs containing “live active cultures” <i>L. paracasei</i> Kevita probiotic drinks, Wallaby organic cow’s milk yogurt <i>L. crispatus</i> : None |
| Prostatitis Vicari et al ²³ (2014) | VS#3: <i>B. longum</i> , <i>B. infantis</i> , <i>B. breve</i> , <i>L. acidophilus</i> , <i>L. casei</i> , <i>L. delbrueckii</i> , <i>L. bulgaricus</i> , <i>L. plantarum</i> , <i>S. salivarius</i> subsp <i>thermophiles</i>) + Rifaxim (IBS + CP) | Men with chronic prostatitis and IBS were treated with VSL#3 and rifaxin with the hypothesis that gut dysbiosis may be a factor in chronic prostatitis. The treatment lowered the frequency of bacteriospermia. | Ther-Biotic Factor 4 (Bifidobacterium Complex) 60c by Klaire Labs (<i>B. breve</i>) <i>L. plantarum</i> : Jarrow Formulas Ideal Bowel Support, 10 Billion Organisms V-Capsules Probiotic Supplement (GoodBelly) Probiotic GX (Nature’s Bounty) Probiata Digestion Support and Critical Care (Kyolic) Probiotic Balance (Sundown Naturals) Heart Healthy Probiotic Solutions (Dr Sinatra) Digestive Health Probiotic (Nature Made) | Specific VSL#3 strains: None |
| Kidney Stones/Hyperoxaluria Barnett et al ³⁴ (2016) | <i>O. formigenes</i> | <i>O. formigenes</i> is commonly found in the human microbiome where it uses oxalates for energy. This Gram-negative anaerobic bacterium helps to increase intestinal absorption of oxalates and ultimately urinary oxalate excretion. This bacterial species, unfortunately, is quite susceptible to commonly prescribed antibiotics which will decrease an individual’s level of this beneficial species and increase oxalate levels which may lead to an increased risk for kidney stones. | None | None |

Table 2. (continued)

| Genitourinary | Strains | Overview | Professional and Commercial Products | Foods |
|---|--|--|---|---|
| Chronic Kidney Disease Rossi et al ²⁶ (2014) | <i>B pasteurii</i> + <i>L sporogenes</i> | <i>B pasteurii</i> + <i>L sporogenes</i> showed a decrease in BUN and serum creatinine in rats. | Thorne Bacillus Coagulans (contains <i>L sporogenes</i>) | <i>B pasteurii</i> + <i>L sporogenes</i> : None |
| Vanholder et al ²⁴ (2015) | <i>L casei</i> Shirota | <i>L casei</i> Shirota in higher doses | Energetics Flora Chewable— <i>L sporogenes</i> (<i>B coagulans</i>) | <i>L casei</i> Shirota: Yakult |
| Pavan ³⁵ (2016) | <i>L acidophilus</i> + <i>B longum</i> | (16 billion CFU showed a small 11% decrease in BUN but not serum creatinine). | Energetics Flora Synergy (<i>L sporogenes</i>) | <i>L acidophilus</i> : Lassi, kefir, yogurt |
| Ranganathan et al ³⁶ (2017) | <i>S thermophiles</i> , <i>L acidophilus</i> , <i>B longum</i> + <i>F saccharides</i> | <i>L acidophilus</i> and <i>B longum</i> have shown a small, borderline significant decrease in BUN in 40% of subjects. | Pure Encapsulations (<i>L sporogenes</i>) | <i>B longum</i> : None |
| Awn et al ²⁷ (2016) | <i>S thermophilus</i> (KB19), <i>L acidophilus</i> (KB27) + <i>B longum</i> (KB31) | <i>S thermophiles</i> , <i>L acidophilus</i> , <i>B longum</i> (all at dosages of 15 billion CFU), plus fructooligosaccharids 100 mg given to patients with CKD stable in stages III to V. in open label RCT. Patients on low-protein diet plus pro- and prebiotics demonstrated a nonsignificant decline in GFR than in control group on low-protein diet alone over 1 y. There were no changes in blood pressure, hemoglobin, calcium, phosphorus, or albumin. | Widely available Kibow Tech: Renadyl | <i>S thermophilus</i> . Yogurt; fermented milk products |
| | <i>S thermophilus</i> (KB19), <i>L acidophilus</i> (KB27) + <i>B longum</i> (KB31) | 214 people with CKD responded to survey or product users and independently analyzed. Average use: 2.05 y. Longest 7 y, shortest 6 m. Reported stabilization, or decreased progression of GFR which improved with time. | Kibow Tech: Renadyl | |
| | | 25 patients with CKD, stages III to IV, treated in a cross-over study for 3 mo each of placebo or probiotic. Significant reductions in blood urea on probiotic in diabetic and nondiabetic subjects. Significant reductions in serum creatinine levels in nondiabetic subjects, but in diabetic group, changes in serum creatinine were not significant. Differences may be due to antibiotics in diabetic patients on chronic antibiotics for neurologic bladder. | | |
| | | In summary, only pilot studies and poor research has been conducted in this area showing conflicting outcomes. See the overview. | | |

Abbreviations: IBS, irritable bowel syndrome; SIBO, small intestinal bacterial overgrowth; UTI, urinary tract infection; CKD, chronic kidney disease; RCT, randomized clinical trial.

Nutritional Supplements Overview

Professional and commercial dietary supplements containing probiotics are widely available.³⁷⁻⁴² In 2002, it was estimated that more than 100 companies in the United States marketed probiotic supplements, and nearly 2 million adults consume them regularly.³⁸ In 2012, probiotic or prebiotic use was the third most commonly used nonvitamin, nonmineral dietary supplement, and global sales were projected to reach to \$42 billion by the end of 2016.³⁹ Using probiotics for general health versus targeting a specific health concern is more complex as the properties of probiotic species are strain specific.⁴⁰ Unfortunately, research models lack consistency in naming therapeutic strains while in addition, specific strains are often not listed on supplement labels. This challenge prevents the practitioner from distinguishing the researched strain from the supplemental product and is a limitation of these tables. If the researched strain was not readily available on the label or marketing material, the brand, potentially containing the strain, was not included in the table.

The Joint Food and Agriculture Organization of the United Nations/World Health Organization Expert Consultation on Evaluation of Health and Nutritional

Properties of Probiotics developed guidelines for evaluating probiotics in food. A combination of phenotypic and genotypic tests must be performed to determine the strain; however, regulations on species identification is not in place and supplement companies are not required to list this information on labels. During this multiseries review, it was identified that 30 species were specifically isolated for research purposes and were unavailable and another 56 strains were not commercially available. Due to the wide variety of formulations on the market, lack of knowledge, and poor labeling, it is difficult for practitioners and consumers to determine which brand contains specific strains researched to address a particular health concern.

This table is designed to be a resource to see what is available “at-a-glance.” The brands were chosen by searching the probiotic strain and strain-species in Google, several supplement companies, Probiotics Advisor,⁴¹ and the Clinical Guide to Probiotic Products.⁴² Based on the results and to determine what was commercially available, the search was refined using Google Shopping. In some instances, the supplement company was called to determine whether the formula contained a specific species.

Table 3. Supplemental Information on Gastrointestinal and Genitourinary Disorders

| Disease | Supplement | Probiotic Strain(s) |
|-------------------------|--|--|
| Celiac Disease | Bifibaby, Probiotal Spa | <i>B breve</i> BR03 and B632 |
| Celiac Disease | Bifidus Balance+FOS (Jarrow Formulas) | <i>B breve</i> BR03 |
| Celiac Disease | Natren Life Start Probiotics for Infants and Life Start Vegan (Natren) | <i>B infantis</i> NLS |
| Celiac Disease | Not available | <i>B longum</i> CECT 7347 |
| Celiac Disease | Not available | <i>L paracasei</i> CBA L74 & P31-43 |
| Celiac Disease | Renew Life Ultimate Flora Extra Care 50 Billion | <i>B breve</i> , <i>B longum</i> , <i>L rhamnosus</i> , <i>L paracasei</i> |
| Celiac Disease | Widely available | <i>L rhamnosus</i> |
| <i>H pylori</i> | Biotics Research | <i>S boulardii</i> |
| <i>H pylori</i> | Bronson Vitamins | <i>S boulardii</i> |
| <i>H pylori</i> | Jarrow Formulas | <i>S boulardii</i> |
| <i>H pylori</i> | Kirkman Labs | <i>S boulardii</i> |
| <i>H pylori</i> | Klaire Labs | <i>S boulardii</i> |
| <i>H pylori</i> | Not available | <i>L johnsonii</i> |
| <i>H pylori</i> | Nutricology | <i>S boulardii</i> |
| <i>H pylori</i> | Ortho Molecular Products | <i>S boulardii</i> |
| <i>H pylori</i> | Pure Encapsulations | <i>S boulardii</i> |
| <i>H pylori</i> | Thorne Research | <i>S boulardii</i> |
| <i>H pylori</i> | Widely available in commercial formulas | <i>L acidophilus</i> and <i>B lactis</i> |
| Irritable Bowel Disease | Digestive Health Probiotic (Nature Made) | <i>L plantarum</i> 299v |
| Irritable Bowel Disease | Heart Healthy Probiotic Solutions (Dr Sinatra) | <i>L plantarum</i> 299v |
| Irritable Bowel Disease | Ideal Bowel Support (Jarrow Formulas) | <i>L plantarum</i> 299v |
| Irritable Bowel Disease | Probiata Digestion Support and Critical Care (Kyolic) | <i>L plantarum</i> 299v |
| Irritable Bowel Disease | Probiotic Balance (Sundown Naturals) | <i>L plantarum</i> 299v |
| Irritable Bowel Disease | Probiotic GX (Nature's Bounty) | <i>L plantarum</i> 299v |
| Irritable Bowel Disease | Probiotic Supplement (GoodBelly) | <i>L plantarum</i> 299v |
| Irritable Bowel Disease | Activia yogurt | <i>B animalis</i> subsp <i>lactis</i> DN-173-010 |
| Irritable Bowel Disease | Align Probiotics (Proctor & Gamble) | <i>B infantis</i> 35624 |
| Irritable Bowel Disease | Probiomics Ltd, Sydney, Australia | <i>L fermentum</i> VRI-003 |
| Irritable Bowel Disease | VSL#3 (Sigma Tau) | <i>L acidophilus</i> VSL |
| Irritable Bowel Disease | VSL#3 (Sigma Tau) | <i>S thermophilus</i> VSL |
| Irritable Bowel Disease | VSL#3 (Sigma Tau) | <i>B infantis</i> VSL |

Table 3. (continued)

| Disease | Supplement | Probiotic Strain(s) |
|---------------------------------|--|--|
| Irritable Bowel Disease | VSL#3 (Sigma Tau) | <i>B breve</i> VSL |
| Irritable Bowel Disease | VSL#3 (Sigma Tau) | <i>L paracasei</i> VSL |
| Irritable Bowel Disease | HMF (Genestra) | <i>B bifidum</i> CUL-20 |
| Irritable Bowel Disease | Ultra Probiotic Complex (GNC) | <i>B bifidum</i> CUL-20 |
| Irritable Bowel Disease | HMF Fit for School | <i>B bifidum</i> CUL-20 |
| Irritable Bowel Disease | HMF (Genestra) | <i>B lactis</i> CUL-34 |
| Irritable Bowel Disease | Ultra Probiotic Complex (GNC) | <i>B lactis</i> CUL-34 |
| Irritable Bowel Disease | HMF Fit for School | <i>B lactis</i> CUL-34 |
| Parasites | HLC Maintenance (Pharmax) | <i>B animalis</i> subsp <i>lactis</i> |
| Parasites | Not available | <i>L casei</i> MTCC |
| Parasites | Not available | <i>E faecium</i> SF68 |
| SIBO | lflora Multi-Probiotic Formula (Sedona Labs) | <i>B bifidum</i> , <i>B lactis</i> , <i>B longum</i> , <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , and <i>L casei</i> |
| SIBO | Mega Flora Plus (Mega Food) | <i>B bifidum</i> , <i>B lactis</i> , <i>B longum</i> , <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , and <i>L casei</i> |
| SIBO | Mega Probiotic-ND (Food Science) | <i>B bifidum</i> , <i>B lactis</i> , <i>B longum</i> , <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , and <i>L casei</i> |
| SIBO | Nexabiotic (Bioprosper Labs) | <i>B bifidum</i> , <i>B lactis</i> , <i>B longum</i> , <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , and <i>L casei</i> |
| SIBO | ProBiota 12 (Seeking Health) | <i>B bifidum</i> , <i>B lactis</i> , <i>B longum</i> , <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , and <i>L casei</i> |
| SIBO | Sehat Probiotic (Trivedi) | <i>B bifidum</i> , <i>B lactis</i> , <i>B longum</i> , <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>S thermophilus</i> , and <i>L casei</i> |
| Ulcerative Colitis | Jarrow Ideal Bowel Support 299v | <i>L plantarum</i> 299v |
| Ulcerative Colitis | Mutaflor (Tribute Pharmaceuticals) | <i>E coli</i> Nissle 1917 |
| Ulcerative Colitis | Ther-Biotic Factor 4 (Klaire Labs) | <i>B breve</i> |
| Ulcerative Colitis | VSL#3 (Sigma-tau Pharmaceuticals, Inc) | VSL#3, <i>B longum</i> , <i>B infantis</i> , <i>B breve</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>L delbrueckii</i> , <i>L bulgaricus</i> , <i>L plantarum</i> , <i>S salivarius</i> subsp <i>hermophiles</i> |
| Bacterial Vaginosis | Advanced Probiotic 10 (Nature's Bounty) | <i>L brevis</i> + <i>L salivarius</i> + <i>L plantarum</i> |
| Bacterial Vaginosis | Complete Probiotics (Dr Mercola) | <i>L brevis</i> + <i>L salivarius</i> + <i>L plantarum</i> |
| Bacterial Vaginosis | FemDophilus (Nature's Way) | <i>L reuteri</i> + <i>L rhamnosus</i> |
| Bacterial Vaginosis | Flora 20-14 (Innate Response) | <i>L brevis</i> + <i>L salivarius</i> + <i>L plantarum</i> |
| Bacterial Vaginosis | Flora 50-14 (Innate Response) | <i>L brevis</i> + <i>L salivarius</i> + <i>L plantarum</i> |
| Bacterial Vaginosis | lflora Multi-Probiotic Formula (Sedona Labs) | <i>L brevis</i> + <i>L salivarius</i> + <i>L plantarum</i> |
| Bacterial Vaginosis | Mega Flora (Mega Food) | <i>L brevis</i> + <i>L salivarius</i> + <i>L plantarum</i> |
| Bacterial Vaginosis | Nexabiotic (Bioprosper Labs) | <i>L brevis</i> + <i>L salivarius</i> + <i>L plantarum</i> |
| <i>Candida albicans</i> | Widely available in commercial brands | <i>L. plantarum vaginal</i> |
| Cervical | Isolated for research purposes only | LC9018 (a biologic response modifier prepared from heat-killed <i>L casei</i> YIT9018) |
| Chronic Kidney Disease | Energetics Flora Chewable | <i>L sporogenes</i> (<i>B coagulans</i>) |
| Chronic Kidney Disease | Energetics Flora Synergy | <i>L sporogenes</i> (<i>B coagulans</i>) |
| Chronic Kidney Disease | Kibow Tech Renadyl | <i>S thermophilus</i> (KB19), <i>L acidophilus</i> (KB27), <i>B longum</i> (KB31) |
| Chronic Kidney Disease | Not available | <i>B pasteurii</i> |
| Chronic Kidney Disease | Not Available | <i>L casei</i> Shirota |
| Chronic Kidney Disease | Pure Encapsulations | <i>L sporogenes</i> (<i>B coagulans</i>) |
| Chronic Kidney Disease | Thorne | <i>L sporogenes</i> (<i>B coagulans</i>) |
| Chronic Kidney Disease | Widely Available | <i>L acidophilus</i> + <i>B longum</i> |
| Cystitis | Not available | <i>L crispatus</i> |
| Cystitis | Widely available | <i>L plantarum</i> + <i>S thermophilus</i> + <i>L paracasei</i> +mannose+Tara |
| Kidney Stones/ Hyperoxaluria | Not available | <i>O formigenes</i> |
| Prostatitis | VSL3 (Sigma-tau Pharmaceuticals, Inc) | <i>B longum</i> , <i>B infantis</i> , <i>B breve</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>L delbrueckii</i> , <i>L bulgaricus</i> , <i>L plantarum</i> , and <i>S salivarius</i> subsp <i>thermophiles</i> |
| Toxic Shock | OptiBac Probiotics for Women (Wren Laboratories) | <i>L reuteri</i> RC-14 (4.0-6.4 nN) |

Abbreviation: SIBO, small intestinal bacterial overgrowth.

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