

# Antibiotics and probiotics: How antibiotics affect the gut microbiome and the role of probiotics in its recovery

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## Abstract

The human gut microbiome plays a vital role in maintaining health. Disruption of this ecosystem, or dysbiosis, is linked not only to gastrointestinal disorders such as inflammatory bowel disease, but also to systemic conditions including obesity, type 2 diabetes, atopy, and neurodegenerative diseases. Antibiotics are a major contributor to dysbiosis, depleting beneficial bacteria, reducing microbial diversity, and promoting the proliferation of opportunistic and antimicrobial-resistant pathogens. Probiotics have demonstrated efficacy in reducing antibiotic-associated diarrhoea. Probitec<sup>®</sup>, containing 15 billion CFUs of *Lactobacillus acidophilus* La-14, offers targeted support for restoring microbial balance and addressing antibiotic-associated dysbiosis.

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## Introduction

The human intestinal tract harbours a diverse and complex microbial community, the gut microbiome, which plays a central role in health and disease.<sup>1,2</sup> It has been estimated that the adult colon contains over 40 trillion bacterial cells from about 1 000 different bacterial species.<sup>1,3</sup> At the level of species and strains, the microbial diversity between individuals is remarkable and each individual harbours a distinctive microbial composition in the gut.<sup>3</sup>

Disruption of the gut microbiome or *dysbiosis* can have major consequences for health and has been associated with gastrointestinal conditions such as inflammatory bowel disease and irritable bowel syndrome, as well as wider systemic manifestations of disease, such as obesity, type 2 diabetes and atopy.<sup>2</sup> Emerging evidence links dysbiosis with neurodegenerative diseases, underscoring the relevance of the microbiota-gut-brain axis.<sup>4</sup> Dysbiosis, therefore, correlates not only with gastrointestinal disorders but also with other systemic pathologies.<sup>4</sup>

## Insights into dysbiosis

Dysbiosis, defined by the loss of beneficial microbes, the overgrowth of pathogens, and reduced microbial diversity, may be the result of environmental stressors (including diet), immune dysregulation, metabolic changes, as well as antibiotic use.<sup>4</sup>

A stable gut ecosystem is sustained by dominant phyla such as Firmicutes and Bacteroidetes, which modulate immune function, produce short-chain fatty acids (SCFAs), and maintain mucosal integrity.<sup>4</sup> Although the intestinal tract is colonised by a varied community of commensal microorganisms, many gut microbial species have the potential to cause disease.<sup>5</sup> Species from the *Enterobacteriaceae* family such as *Escherichia coli* (*E. coli*), are opportunistic pathogens with the potential to cause severe infections.<sup>5</sup>

Dysbiosis associated with antibiotic use can destabilise gut homeostasis and favour the expansion of opportunistic pathogens like *Enterobacteriaceae*.<sup>4</sup>

Although antibiotics are essential for treating many bacterial infections, they can dramatically disrupt the gut microbiome.<sup>4</sup> Broad-spectrum agents such as aminopenicillins with/without clavulanate, cephalosporins, clindamycin and the fluoroquinolones often drive dysbiosis, resulting in loss of microbial diversity by depleting beneficial genera.<sup>4</sup> Weakened colonisation of beneficial genera paves the way for opportunistic pathogens.<sup>4</sup>

The effects of antibiotics on gut microbiota composition and diversity can last from weeks to months.<sup>6</sup> Short-term effects include antibiotic-associated diarrhoea, *Clostridiodes difficile*-associated diarrhoea and *Helicobacter pylori* infections.<sup>6</sup> Long-term effects have been linked to obesity, type 2 diabetes and inflammatory bowel disease.<sup>3</sup>

Use of antibiotics can also accelerate antibiotic resistance.<sup>4</sup> Antibiotic-induced dysbiosis accelerates the transfer of antimicrobial resistance genes within the gut microbiome, enabling the proliferation of multidrug-resistant organisms, including extended-spectrum  $\beta$ -lactamase (ESBL)-producing *Enterobacteriaceae*.<sup>4</sup>

Recovery from these changes in the gut microbiome depends on antibiotic spectrum, dose, and duration of use, potentially taking months or even years in some cases.<sup>4</sup> Emerging interventions like faecal microbiota transplantation and probiotics may counter these changes while preserving the integrity of the broader microbial ecosystem.<sup>4</sup>

## Probiotics and prebiotics – the concepts

Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host.<sup>3</sup> The term 'probiotic' should be reserved for live microbes that

**Table I:** Nomenclature used for some probiotics

Genus	Species	Subspecies	Strain designation	International strain depository designation	Common name
<i>Lactocaseibacillus</i> Former name: <i>Lactobacillus casei</i>	<i>rhamnosus</i>	None	GG	ATCC 53103	LGG
<i>Bifidobacterium</i>	<i>animalis</i>	<i>lactis</i>	DN-173 010	CN-CM I-2494	<i>Bifidus regularis</i>
<i>Bifidobacterium</i>	<i>longum</i>	<i>longum</i>	35624	NCIMB 41003	<i>Bifantis</i>
<i>Lactobacillus</i>	<i>acidophilus</i>	None	La-14	ATTCSD5212	<i>Acidophilus</i>

have been shown in clinical studies to impart a health benefit.<sup>3</sup> Many lactobacilli, *Saccharomyces boulardii* and some species of *Bifidobacterium* have historically been used as probiotics.<sup>3</sup> Some strains of *E.coli* and *Alkalihalobacillus clausii* (formerly known as *Bacillus clausii*) are also used as probiotics.<sup>3,6</sup>

Prebiotics are selectively fermented components that result in specific changes in the composition and/or activity of the gastrointestinal microbiota, thereby conferring benefits for the host's health.<sup>3</sup> The key aspects of a prebiotic are that it is nondigestible by the host and that it leads to health benefits through a positive influence on the resident beneficial microbes.<sup>3</sup> Prebiotics affect intestinal bacteria by enhancing the numbers or activities of beneficial bacteria.<sup>3</sup> Most prebiotics are food ingredients and include oligofructose (fructooligosaccharide, FOS), inulin, galactooligosaccharides (GOS) and lactulose.<sup>3</sup>

Synbiotics are mixtures comprising live microorganisms and substrate(s) selectively used by the host microorganisms that confer a health benefit on the host.<sup>3</sup> There are two types of synbiotic: complementary (mixtures of probiotics and prebiotics) and synergistic (mixtures of live microbes selected to use a co-administered substrate for a health effect.<sup>3</sup>

### Genera, species and strains used as probiotics

A probiotic strain is identified by the genus, species, subspecies (if applicable) and an alphanumeric designation that identifies a specific strain.<sup>3</sup> In the scientific community, there is an agreed nomenclature for genus, species and subspecies names.<sup>3</sup> However, commercial strain names, product names and trade names are not controlled by the scientific community and strains names may vary. Table I shows a few examples of commercial strains and the names associated with them.<sup>3</sup>

Strain designations are important because the most robust approach to probiotic evidence is to link benefits to specific strains or strain combinations of probiotics at the effective dose.<sup>3</sup> Some strains have novel properties that account for certain neurological, immunological, and antimicrobial activities while some mechanisms of probiotic activity are likely shared among different strains, species, or even genera.<sup>3</sup>

The dose needed for probiotics varies depending on the strain and the indication.<sup>3</sup> Although many over-the-counter probiotics deliver in the range of 1–10 billion colony-forming units (CFUs) per dose, it is not possible to state a general dose needed for probiotics.<sup>3</sup> The dosage should be based on human studies showing a health benefit for a particular probiotic for a particular

indication.<sup>3</sup>

### Probiotics and antibiotic-associated diarrhoea

Probiotics have been shown to alleviate gut dysbiosis caused by antibiotic treatment and to confer protection against antibiotic-associated diarrhoea.<sup>6</sup>

- Several studies have shown that consumption of probiotics such as *Lactobacillus acidophilus*, *Lactocaseibacillus casei*, *Lactocaseibacillus rhamnosus*, *Saccharomyces boulardii* and *Bifidobacterium* reduce the risk of antibiotic-associated diarrhoea.<sup>6</sup>
- Meta-analyses have concluded that probiotics provide a moderate effect in preventing antibiotic-associated diarrhoea in children, adults and in the elderly, with larger doses (e.g. 5 billion CFUs per day) being preferred.<sup>3,6</sup>

### Probiotic safety

Traditional lactic acid bacteria, long associated with food fermentation, are generally considered safe for oral consumption for the generally otherwise healthy population and at levels traditionally used.<sup>3</sup> However, use in people with compromised immune function or serious underlying disease should be restricted to the strains and indications with proven safety and efficacy for these patients.<sup>3</sup>

#### A word on Probitec®

- Contains 15 billion CFUs of *Lactobacillus acidophilus* La 14 per capsule.<sup>7</sup>
- May be used to normalise microbial balance in the gut, improve gut function, dysbiosis, and antibiotic-associated dysbiosis.<sup>8</sup>
- Contains fructooligosaccharides as the prebiotic to support the resident beneficial microbes in the gut.<sup>3,7</sup>
- Formulated using DUOCAP™ technology which allows the outer capsule to dissolve in the stomach releasing the prebiotic (fructooligosaccharides) while protecting the inner capsule until it reaches the small intestine (pH~6.5) where it releases the probiotic.<sup>8,9</sup>
- Can be taken with/without food and at the same time as the antibiotic.<sup>7,10</sup>
- Maintains 100% of its dose over two years, providing an acceptable CFU count for clinical efficacy.<sup>8</sup>

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