



An Overview of the Microbiome and the Effects of Antibiotics

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ABSTRACT

The human microbiome is a complex and ecologically active community that plays an integral role in health and disease. This review provides a basic introduction of what the microbiome is and how it plays a role in obesity, gastrointestinal, immune, and mental health, including a brief mention of implications for the pediatric population. It also explores the negative effects of antibiotics on the microbiome and discusses inappropriate antibiotic practices in the United States. Lastly, it analyzes varying approaches to maintain and/or achieve a healthy microbiome through diet, probiotics, and fecal microbiota transplants.

Keywords: *Clostridium difficile* infection, fecal microbiota transplantation, inappropriate antibiotic use, irritable bowel disease, irritable bowel syndrome, microbiome, probiotics

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The human microbiome is defined as the composite of the microorganisms that live inside and on humans along with their genomes.¹ The microbiota, although frequently used synonymously with the microbiome, more specifically refers to the commensal microorganisms in and on the body, but not necessarily to their genome. It is estimated that 10–100 trillion microbial cells make up the microbiome, roughly 10 times more than human cells.¹ Although the concept of

the microbiome is not new, interest in it has increased with advances in DNA sequencing and 16S ribosomal RNA polymerase chain reaction amplification technology.

DEVELOPMENT OF THE MICROBIOME

Within 20 minutes of birth, the infant's microbiota resembles that of the mother's vagina or skin, depending on whether they were born vaginally or via cesarean section, respectively.² Highly

This CE learning activity is designed to augment the knowledge, skills, and attitudes of nurse practitioners and assist in their understanding of antibiotic effects on the microbiome.

At the conclusion of this activity, the participant will be able to:

- Describe the characteristics of the microbiome
- Explain how the microbiome plays a role in health and disease
- Analyze how antibiotics affect the microbiome

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impressionable in the first few years of life, the microbiome is influenced by the environment, diet, illness, breastfeeding, introduction of formula and table foods, and antibiotic treatment.³ By 1–2 years of age, a child’s microbiome begins to resemble that of an adult’s.⁴

THE MICROBIOME’S ROLE IN HEALTH AND DISEASE

Obesity

Although the microbiome consists of organisms from all 3 different domains of life—archaea, eukaryotes, and bacteria (viruses are also found in the microbiome, but they are classified differently)—the vast majority of the biomass consists of bacteria.⁵ Furthermore, more than 90% of the phylogenetic types of bacteria found in the colon belong to 2 of the 70 phyla divisions of bacteria: Firmicutes and Bacteroidetes.¹ The percentage of these 2 plays a role in a person’s weight. Arora and Sharma⁶ note that in obese mice and obese humans, there is a correlation between an increased ratio of Firmicutes to Bacteroidetes. It is speculated that obesity can be a consequence of increased enzymatic breakdown of otherwise indigestible dietary carbohydrates by Firmicutes, resulting in increased energy extraction from food.⁶

Gastrointestinal Health

Functional gastrointestinal disorders (FGIDs), which include both irritable bowel syndrome (IBS) and inflammatory bowel disease (IBD), are common diseases in the United States. Recently, the Rome Foundation performed a critical review of current thinking of the role the microbiome plays in FGID.⁷ Some of their most notable findings are the following:

- Small intestinal bacterial overgrowth and dysbiosis of the microbiota are found in subgroups of patients with FGID.
- Proton pump inhibitor use may lead to small intestinal bacterial overgrowth and potentially cause IBS symptoms.
- Fecal microbiota in IBS patients differs significantly from that of healthy controls, and an association exists between antibiotic use and an increased risk of post infectious IBS.

- Some studies have shown promising results with the administration of a broad-spectrum nonabsorbable antibiotic, such as rifaximin, which improved symptoms of bloating and flatulence in patients with IBS.

Sokol et al⁸ found that a reduced number of *Faecalibacterium prausnitzii*, an anaerobic Firmicute bacteria with anti-inflammatory properties, was common in patients with Crohn disease. A lower proportion of *F prausnitzii* in the microbiome was associated with higher endoscopic and postoperative recurrence rates.

Immune Health

Found within portions of the gastrointestinal tract, Peyer patch sites are organized lymphoid tissues that perform direct antigen sampling within the gut.⁹ The Peyer patches, along with other lymphoid tissue, make up the gut-associated lymphoid tissue, which comprises nearly 70%–80% of the body’s immune cells.¹⁰

As humans ingest substances, the antigens are presented in the Peyer patches, which stimulate B cells, T cells, and memory cells to initiate an immune response, playing a critical role in immunoglobulin A and immunoglobulin M production.⁹ Furthermore, the crosstalk between the microbiota and gut mucosal cells influence cytokine and chemokine production, which can be proinflammatory or anti-inflammatory, playing a critical role in reducing excessive bowel inflammation.¹¹

These immune responses are not just limited to the gut, either. They are the foundation for systemic immune responses and most likely play a pivotal role in autoimmune diseases. Instead of suppressing the immune system, as is the current course of treatment for most autoimmune diseases, future treatments may include promoting healthy bacteria that have natural anti-inflammatory effects.¹²

Mental Health

The gut-brain axis allows a communicative relationship between the gastrointestinal tract and the amygdala, hippocampus, and cingulate cortex, which plays a major role in emotions, behavior, learning, memory, and spatial navigation.^{13–15} Alterations in the microbiome because of diet, stress, inflammatory

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