SYMPROVE FOR PROFESSIONALS

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A Comprehensive Guide to the Gut Microbiome

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Target audience: For healthcare professionals interested in learning about the gut microbiome.

Publication date: 09/2020

Review date: 09/2022

Learning Objectives

By the end of this article, you should understand:

- The role of the gut microbiome and microbiota
- How the gut microbiome contributes to health
- Dysbiosis of the gut microbiome and its impact on health
- Current research surrounding the link between the gut microbiome and disease

What is the Microbiome

A microbiome (see table 1 for complete definitions) refers to the collective genetic material of microorganisms in a specific environment (1). Throughout the gastrointestinal tract (GI tract), there exists bacteria, viruses, yeasts and fungi (known as microbiota) (2). Like fingerprints, we each have a unique gut microbiome.

The gut microbiome is home to approximately 100 trillion microbes and is best described as a virtual organ (1). By three years of age, a child's microbiome composition resembles that of an adult and contains a blueprint of microbiota (3).

Table 1: Common gut terminology

Term	Definition
Microbe	A singular microorganism (bacteria, viruses, yeasts and fungi).
Microbiota	A community of microorganisms in an environment.
Microbiome	The collective genetic material of a community of microorganisms in a specific environment.

The Role of the Microbiome

The composition of our gut microbiome is dynamic, and it is influenced by multiple factors including genetics, diet, medications, stress, age and health status (3).

Gut microbiota are responsible for widespread functions, including:

- The development and regulation of the immune system
- The prevention of gut colonisation by pathogens (such as *Salmonella* and *E. coli*)
- The breakdown of non-digestible carbohydrates, including dietary fibre
- The synthesis of water and fat-soluble vitamins (vitamins B2, B6, B12, K)

The Microbiome and Health

The gut microbiome is known to play an important role in health status. This section will explore its role in immunity, metabolism and the gut-brain axis.

Immunity

Gut microbiota interacts with gut-associated lymphoid tissues (GALT), which represents 70% of the entire immune system (4). GALT consists of lymphoid cells including B-cells, T-cells, macrophages and dendritic cells. This tissue regulates a balance between tolerance of antigens from food and beneficial bacteria, with protection against pathogens via the initiation of an immune system response (5).

Specific microbial strains, for example *Lactobacillus* and *Bifidobacterium* can inhibit the growth of pathogens. Metabolites produced by gut microbiota can stimulate immunoglobulin antibody production, which prevents pathogens from entering the circulatory system. Altered microbial diversity can cause an overreaction or suppression of the immune response, which can lead to autoimmune conditions (6; 1).

Metabolism

Microbes within the colon help to ferment non-digestible carbohydrates such as dietary fibre. Carbohydrate fermentation by microbes results in the production of beneficial short-chain fatty acids (SCFAs). The main SCFAs produced are propionate, butyrate and acetate (1). Propionate is involved in satiety signalling and high populations have shown to be protective against diet-induced obesity (7). Butyrate supports the proliferation of colonic cells for the maintenance of a healthy gut barrier and reduces the risk of colorectal cancer. Acetate is most abundant and supports growth of beneficial bacteria (8; 1).

Gut microbiota also aids the synthesis of fat-soluble (vitamin K) and water-soluble vitamins (B vitamins) which contribute to the immune system (3).

The Gut-Brain Axis

Gut microbiota and the brain have a two-way communication channel via the vagus nerve and the GI tract's own nervous system, called the enteric nervous system. SCFAs are involved in connecting the brain (i.e. emotion and cognition) with gut functions through the endocrine system, the immune system and the gut microbiome. Studies continue to examine the effects of microbe diversity in infancy on neurodevelopment, and the impact that stress has on the gut-brain axis throughout the life cycle (9).

Dysbiosis

Dysbiosis is defined as an imbalance of microbial diversity in the gut microbiome. It has been shown to increase susceptibility to obesity and disease (1).

Causes of Dysbiosis

There are many genetic, environmental and lifestyle components which can alter the abundance and diversity of microbiota within the gut microbiome (11).

Factors That Affect Dysbiosis	
Mode of birth delivery	A study found hospital-associated pathogens in infants delivered by caesarean section. Dysbiosis was also seen, to a lesser extent, in vaginally delivered babies whose mothers had prophylactic antibiotics and in infants who were not breastfed during the neonatal period (12).
Weight	Studies have shown that overweight and obese people have a lower diversity of gut microbiota (1).
Dietary intake	Restrictive diets have been associated with reduced abundance and diversity of gut microbiota. A study found that the low FODMAP diet, which is used as a dietary management tool in patients with Irritable Bowel Syndrome (IBS), was associated with low numbers of *Bifidobacterium* (13).
Age	The ageing process alters the composition of gut microbiota. Changes have been associated with older people living in care home settings who had a poor-quality diet (14).
Medications	Medications including proton pump inhibitors and antibiotics have been found to cause disruption to gut microbiota (1).
Environment	Studies have shown that air pollution may contribute to adverse changes in the composition of the gut microbiome (15).

Dietary Manipulation of the Gut Microbiome

Nutritional strategies to selectively increase the population of beneficial microbes include:

Probiotics

Live microorganisms which when administered in adequate amounts confer a health benefit on the host (16). There are currently no approved health claims for probiotics in the UK (17).

Prebiotics

Ingredients selectively used by host microorganisms that confer a health benefit (16). Dietary sources of prebiotics include onions, leeks, celery, legumes and oats (3).

Synbiotics

A dietary supplement containing a combination of probiotics and prebiotics, which together, confer a health benefit (16).

Microbiome and Disease

Microbiota-mediated changes have been identified in multiple diseases. Despite its infancy, research has identified a potential in clinical practice for the gut microbiota to be targeted as part of therapeutic treatments (18).

Obesity

Research has found that overweight and obese individuals have limited diversity of gut microbiota (1). A study of UK twins found that *Christensenella* was rarely found in overweight people. When given to germ-free mice, it was found to prevent weight gain (19). Although most of the current evidence originates from animal studies, human studies have also found associations between long-term weight gain and low microbiota diversity (1). Further research is needed to determine the extent to which microbial populations must be altered before measurable changes (i.e. weight loss) are obtained (20).

Irritable Bowel Syndrome (IBS)

A recent study examined stool samples of a large cohort of people with IBS. It was identified that specific gut microbes including *Streptococcus* and *Gardnerella vaginali* were associated with a significantly increased risk of having IBS. *Faecalibacterium*, a microbe with anti-inflammatory properties, was found to be protective against IBS. Further investigation of microbiome composition in patients with IBS is needed to develop dietary and drug therapies targeted at gut microbiota (10).

Current IBS guidelines from the British Dietetic Association (BDA) recommend a high-fibre diet which includes prebiotic foods to help populate beneficial gut microbiota (21). A systematic review by the BDA found that no specific recommendations could be made regarding probiotics and IBS, although the guidelines state that taking a probiotic product is considered safe (22).

Depression

Depression is associated with dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis. Gut microbiota have been found to influence the activity of the HPA axis, however the mechanisms remain unclear. Activation of the HPA axis by gut microbiota is thought to happen due to increased permeability of the intestinal barrier (23).

Faecal samples from individuals with depression have shown differences in gut microbiota compared with healthy controls (24). This prompts the need for research into the manipulation of microbiome composition in patients with depression.

Type 2 Diabetes

Disturbances in the diversity of gut microbiota have been associated with several metabolic disorders including type 2 diabetes (T2DM).

A study found that participants who followed a high-fibre diet containing prebiotic food sources achieved a significant change in microbiome composition, with greater diversity of SCFA-producing microbiota. This correlated with a decline in haemoglobin A1c (HbA1c), partly due to raised levels of glucagon-like peptide-1 (a hormone produced in the gut that stimulates insulin production). It is unclear whether increased SCFAs were the only mechanism at work. The study demonstrates that promoting greater diversity of SCFA-producing microbiota may be of clinical benefit in the management of T2DM (25).

Parkinson's Disease

Parkinson's Disease (PD) is a disease of the central nervous system. Patients with PD can experience GI disturbances including constipation prior to the onset of motor symptoms, which implicates gut involvement. A number of recent studies have found differences in gut microbiota in patients with PD, compared with healthy controls (26). A recent study using roundworms identified that a specific probiotic *Bacillus subtilis* prevented the build-up of alpha-synuclein protein, which causes death of nerve cells and stimulates motor symptoms in people with PD (27). Whilst probiotics have potential in clinical practice, the few studies that have measured their effect are of mixed methodological quality; therefore, drug therapy is the preferred treatment in PD (28).

Summary

- The gut microbiome is considered an organ and is responsible for a variety of functions crucial for health
- The gut microbiome contributes to health due to its influence on immunity, metabolism and the gut-brain axis
- Dysbiosis indicates poor microbial diversity and has been shown to increase susceptibility to obesity and certain autoimmune and metabolic diseases
- Research has identified a potential for therapeutic treatments to target the gut microbiome in the management of diseases including Type 2 Diabetes and IBS

Continuing Professional Development (CPD) Questions:

1) What is a microbiome?

a. ◯ The collective genetic material of microorganisms in a specific environment
b. ◯ The collective name given to the bacteria in the gut
c. ◯ A collection of pathogenic cells

Comment

2) Which of the following is a potential cause of dysbiosis?

a. ◯ Gender
b. ◯ Height
c. ◯ Antibiotics

Comment

3) How do gut microbiota communicate with the brain?

a. ◯ Via the vagus nerve
b. ◯ Via the hypothalamus
c. ◯ Via the pituitary gland

Comment

4) What is a synbiotic?

a. ◯ A specific strain of probiotic
b. ◯ A carbohydrate
c. ◯ A combination of probiotics and prebiotics that together confer a health benefit

Comment

5) Name a vitamin that is synthesised by gut microbiota?

a. ◯ Vitamin D
b. ◯ Vitamin K
c. ◯ Iron

Comment

6) Which diet is associated with an increased diversity of gut bacteria?

a. ◯ High fibre diet
b. ◯ Low carbohydrate diet
c. ◯ Low FODMAP diet
d. ◯ High fat diet

Comment

You can review your answers on the last page

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Answers

1) a
2) c
3) a
4) c
5) b
6) a