

# Research Progress on the Association Between Gut Microbiota and Respiratory System Diseases

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**Abstract:** This paper aims to review the association between gut microbiota and respiratory system diseases, and explore their potential mechanisms and clinical significance. Gut microbiota, as an important microbial ecosystem in the human body, has profound effects on host health. Recent studies have shown that the imbalance of gut microbiota is closely related to the occurrence and development of respiratory system diseases, including asthma, chronic obstructive pulmonary disease (COPD), and pneumonia. We comprehensively analyzed the current research progress and found that gut microbiota may affect respiratory system diseases through various pathways, including immune regulation, inflammatory responses, and airway mucus secretion. Additionally, environmental factors, lifestyle, and dietary habits are also closely related to gut microbiota and respiratory system health. Understanding the relationship between gut microbiota and respiratory system diseases not only helps to reveal the mechanisms of disease occurrence but also provides a theoretical basis for the development of new treatment strategies. Future research should focus on exploring the types and functions of gut microbiota, conducting clinical trials based on this, investigating the effects of gut microbiota modulation on the treatment and prevention of respiratory system diseases, and providing new directions for personalized medicine.

**Keywords:** Gut microbiota; Respiratory system diseases; Microbial ecosystem immune regulation; Inflammatory response; Asthma; Chronic obstructive pulmonary disease

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## 1. Introduction

The association between gut microbiota and respiratory system diseases has attracted widespread attention in recent years. Gut microbiota, as an important microbial community in the human body, plays a crucial role in maintaining host immune balance and regulating metabolic functions. Meanwhile, respiratory system diseases, such as asthma, chronic obstructive pulmonary disease (COPD), and pneumonia, severely affect public health worldwide. Past studies have indicated that the imbalance of gut microbiota may be closely related to the occurrence and development of respiratory system diseases, although the specific mechanisms remain incompletely understood. In this context, a comprehensive exploration of the relationship between gut microbiota and respiratory system diseases is of great significance for understanding the pathogenesis of

diseases and seeking new treatment strategies. Understanding how gut microbiota influences respiratory system health can aid in developing personalized treatment methods, improving the level of disease diagnosis and treatment, and thus enhancing patients' quality of life. This paper aims to systematically discuss the relationship between gut microbiota and respiratory system diseases, analyze potential mechanisms, and provide new perspectives and directions for future research.

## **2. Background and current status of research**

### **2.1. Basic concepts of gut microbiota and respiratory system diseases**

Gut microbiota refers to a large microbial community present in the human intestines, including bacteria, fungi, viruses, and other microorganisms. These microorganisms form a symbiotic relationship with the host and are crucial for maintaining the host's physiological functions and health. Gut microbiota participates in regulating immune systems, metabolic functions, nutrient absorption, and other physiological processes, profoundly affecting the overall health of the host. Respiratory system diseases refer to diseases that affect the structure and function of the respiratory system, including but not limited to asthma, chronic obstructive pulmonary disease (COPD), and pneumonia. These diseases can cause symptoms such as difficulty breathing, coughing, and chest tightness, significantly affecting patients' quality of life, and may lead to severe complications and even life-threatening conditions. The association between gut microbiota and respiratory system diseases has received widespread attention in recent years. Increasing evidence suggests that the imbalance of gut microbiota may be closely related to the occurrence and development of respiratory system diseases. The immune system plays a vital role in this association, as gut microbiota can influence respiratory system health by affecting immune system regulation. Additionally, metabolites and inflammatory factors produced by gut microbiota may directly or indirectly affect the respiratory system through blood circulation and other pathways. A comprehensive understanding of the relationship between gut microbiota and respiratory system diseases is essential for the prevention and treatment of respiratory system diseases. Therefore, exploring the role of gut microbiota in the occurrence and development of respiratory system diseases and finding methods to regulate gut microbiota has become one of the current research hotspots <sup>[1]</sup>.

### **2.2. Current research on gut microbiota and respiratory system diseases**

In recent years, an increasing number of studies have shown a close association between gut microbiota and respiratory system diseases. Researchers have conducted a series of studies aiming to explore the mechanisms and clinical significance of this association.

Studies involving human and animal models, significant differences have been found in the composition and structure of gut microbiota between individuals with respiratory system diseases and healthy individuals. For example, the diversity and abundance of gut microbiota in asthma patients may differ from those in healthy individuals. The composition of gut microbiota in patients with chronic obstructive pulmonary disease (COPD) is also closely related to their disease status. These research findings suggest that gut microbiota may play an important role in the occurrence and development of respiratory system diseases <sup>[2]</sup>. On the other hand, some studies have focused on the potential mechanisms underlying the association between gut microbiota and respiratory system diseases. Gut microbiota may influence respiratory system health through various pathways, including immune regulation, inflammatory responses, and airway mucus secretion. Through these mechanisms, gut microbiota may affect the occurrence and development of respiratory system diseases. Furthermore, some clinical studies have confirmed the association between gut microbiota and respiratory system diseases. For example, some surveys have found that changes in gut microbiota are associated with an increased risk of asthma, COPD, and other respiratory

system diseases. These clinical studies provide important clinical evidence for further exploring the role of gut microbiota in respiratory system diseases. In short, the relationship between gut microbiota and respiratory system diseases has become one of the current research hotspots. Although some progress has been made in related research, many questions remain to be answered. Future research should focus on exploring the mechanisms underlying the relationship between gut microbiota and respiratory system diseases to provide new perspectives and strategies for the prevention and treatment of respiratory system diseases <sup>[3]</sup>.

### **3. The impact of gut microbiota on respiratory system diseases**

#### **3.1. Mechanisms of gut microbiota on respiratory system diseases**

The mechanisms by which gut microbiota influence respiratory system diseases are key areas of current research. Here are some possible mechanisms:

- (1) Immune regulation: Gut microbiota may affect the occurrence and development of respiratory system diseases by influencing immune system regulation. For example, probiotics in the gut microbiota may promote immune system balance, reduce excessive inflammatory responses, and thus lower the risk of respiratory system diseases <sup>[4]</sup>.
- (2) Inflammatory response: Imbalance in gut microbiota may weaken the intestinal mucosal barrier function, allowing inflammatory factors and endotoxins from the intestines to enter the bloodstream, affecting systemic inflammatory status. This inflammatory status may affect the respiratory system through the bloodstream, leading to the occurrence and development of respiratory system diseases.
- (3) Airway mucus secretion: Gut microbiota may affect the health of the respiratory system by influencing the secretion and clearance function of airway mucus. Imbalanced gut microbiota may lead to increased airway mucus or decreased mucus clearance function, increasing the risk of respiratory system infections.
- (4) Metabolites: Metabolites produced by gut microbiota, such as short-chain fatty acids, may affect the inflammatory status and immune response of the respiratory system through the bloodstream, thereby influencing the occurrence and development of respiratory system diseases <sup>[5]</sup>.

These mechanisms may interact with each other, collectively influencing the relationship between gut microbiota and respiratory system diseases. An in-depth exploration of these mechanisms can help uncover the association between gut microbiota and respiratory system diseases, providing new insights and strategies for future prevention and treatment.

#### **3.2. Clinical significance of gut microbiota in respiratory system diseases**

The clinical significance of gut microbiota in respiratory system diseases is of great interest. Increasing evidence suggests that the imbalance of gut microbiota is closely related to the occurrence, development, and treatment outcomes of respiratory system diseases. Firstly, the specific composition and abundance of gut microbiota may serve as diagnostic biomarkers for respiratory system diseases, aiding in improving diagnostic accuracy and early detection rates. Secondly, the status of gut microbiota may be associated with the prognosis of respiratory system diseases, monitoring changes in gut microbiota can help physicians assess patients' prognosis and guide the formulation of treatment and management plans. Additionally, the status of gut microbiota may also affect patients' response to treatment, and personalized treatment strategies may become an important direction for future respiratory system disease treatment. Most importantly, gut microbiota may serve as a new target for the treatment of respiratory system diseases, regulating gut microbiota can improve patients' symptoms and inflammatory responses, driving innovation and progress in the treatment of respiratory system diseases. Therefore, in-depth research on the relationship between

gut microbiota and respiratory system diseases can help improve the diagnosis, treatment, and management of diseases, providing new insights and strategies for personalized medicine <sup>[6]</sup>.

## **4. Factors and regulatory mechanisms**

### **4.1. Analysis of factors influencing the association between gut microbiota and respiratory system diseases**

The factors influencing the association between gut microbiota and respiratory system diseases cover various aspects, including but not limited to diet, lifestyle, and medication use. Firstly, diet is one of the key factors affecting gut microbiota. A high-fiber, low-fat diet may help maintain the stability and diversity of gut microbiota, while a high-sugar, high-fat diet may lead to gut microbiota imbalance, thereby affecting respiratory system health. Secondly, lifestyle factors such as sleep quality and exercise frequency may also influence the stability of gut microbiota, thereby affecting the development of respiratory system diseases. Regarding medication use, antibiotics are common drugs that can affect the gut microbiota, and long-term or excessive use of antibiotics may lead to gut microbiota imbalance, increasing the risk of respiratory system diseases <sup>[7]</sup>. Additionally, environmental factors such as air pollution and household environment may also affect the composition and function of gut microbiota, indirectly influencing respiratory system health. In summary, multiple factors including diet, lifestyle, medication use, and environmental factors may influence the association between gut microbiota and respiratory system diseases. Further research into the impact of these factors on the association can provide a more comprehensive understanding of the relationship between gut microbiota and respiratory system diseases, offering new insights and strategies for prevention and treatment <sup>[8]</sup>.

### **4.2. Regulatory mechanisms**

The association between gut microbiota and respiratory system diseases may be influenced by various regulatory mechanisms. Firstly, immune regulation is one of the important regulatory mechanisms. Gut microbiota may affect the occurrence and development of respiratory system diseases by modulating the balance of the host immune system. Probiotics, prebiotics, and symbiotic organisms may promote immune system health by regulating host immune responses, thereby reducing the risk of respiratory system diseases. Secondly, the gut-lung axis may be another important regulatory mechanism. There is a close interaction between the gut and respiratory systems, and gut microbiota imbalance may affect respiratory system health by influencing the function of the gut-lung axis. Furthermore, the application of drugs and biologics may also be an important means of regulating the association between gut microbiota and respiratory system diseases. Biological preparations such as probiotics, prebiotics, and symbiotic organisms may improve host immune status and inflammatory responses by regulating the composition and function of gut microbiota, thereby affecting the occurrence and development of respiratory system diseases. In summary, immune regulation, the gut-lung axis, and drug biologics may be the main mechanisms regulating the association between gut microbiota and respiratory system diseases. In-depth research into these mechanisms can help reveal the relationship between gut microbiota and respiratory system diseases, providing new insights and strategies for the treatment and prevention of related diseases <sup>[9]</sup>.

## **5. Future research directions**

Future research should focus on several directions based on a thorough exploration of the relationship between gut microbiota and respiratory system diseases. Firstly, mechanistic studies are essential, it is important to

further investigate the mechanisms by which gut microbiota influence respiratory system diseases, including immune regulation, inflammatory responses, and the gut-lung axis. Secondly, intervention studies are needed to assess the effects of regulating gut microbiota on respiratory system diseases. Through the application of probiotics, prebiotics, symbiotic organisms, etc., we can explore the potential effects of regulating gut microbiota on the treatment and prevention of respiratory system diseases. Personalized medicine is also an important direction, conducting research on personalized medicine based on individual gut microbiota characteristics, and exploring customized treatment plans tailored to individual gut microbiota characteristics to improve the precision and effectiveness of respiratory system disease treatment are necessary. Additionally, microbiome studies can reveal potential connections between gut microbiota and respiratory system diseases, discovering new treatment targets and biomarkers. Considering the impact of environmental factors such as diet, lifestyle, and medication use on the association between gut microbiota and respiratory system diseases, it is also crucial to explore the role of environmental factors in regulating the relationship between gut microbiota and respiratory system diseases. Finally, clinical research is indispensable, strengthening large-sample clinical studies to validate the association between gut microbiota and respiratory system diseases, and evaluating the clinical application value of gut microbiota in the diagnosis, treatment, and prognosis assessment of respiratory system diseases are imperative. In summary, future research should combine multiple aspects, providing a more in-depth theoretical basis and clinical guidance for the prevention and treatment of gut microbiota-related respiratory system diseases <sup>[10]</sup>.

## 6. Conclusion

The association between gut microbiota and respiratory system diseases is a highly researched area with complex and diverse mechanisms. This article provides a review of the mechanisms of gut microbiota on respiratory system diseases, clinical significance, regulatory mechanisms, and future research directions. Through the analysis and synthesis of existing research, we recognize the significant role of gut microbiota in the occurrence, development, and treatment of respiratory system diseases. Future research should explore the impact of factors on gut microbiota and respiratory system diseases, combined with intervention studies, personalized medicine, microbiome studies, environmental factor studies, and clinical research, to provide a more in-depth theoretical basis and clinical guidance for the prevention and treatment of gut microbiota-related respiratory system diseases. With continued technological advancements and research progress, we believe that we can better understand the relationship between gut microbiota and respiratory system diseases, providing more effective interventions and treatment strategies for human health.

## Disclosure statement

The authors declare no conflict of interest.

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