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Effects of Probiotics on Inflammatory Bowel Diseases: A Bibliometric Analysis

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ABSTRACT

Inflammatory bowel disease (IBD) is a chronic intestinal inflammatory disease Loss of tolerance to intestinal microorganisms and abnormal intestinal immunity that lead to intestinal mucosa inflammation are its characteristics. This study aimed to evaluate the global research trends (2014–2023) on the effect of probiotics on IBD, focusing on publication patterns, subject areas, involved countries, and citations. In this study, Web of Science Core Collection and Scopus databases and VOSviewer software were used for bibliometric analysis. Studies covering the years 2014-2023 and keywords 'microbiome' OR 'microbiota' OR 'gut microbiota' OR 'intestinal microbiome' OR 'dysbiosis' OR 'probiotics' AND 'IBD' OR 'Inflammatory Bowel Disease' OR 'Ulcerative colitis' OR 'Enterocolitis' OR 'Crohn's Disease' in the title were included. Based on the analysis, the current situation on this topic has been determined. A total of 255,236 and 12,286 scientific documents were identified in the Web of Science and the Scopus, respectively between 2014-2023 years worldwide. Gastroenterology and Hepatology followed by Microbiology are the disciplines with the most studies in this field. The most frequently used keywords include "Probiotics", "Inflammatory Bowel Disease", "Gut Microbiota", and "Ulcerative Colitis". Recent studies address topics such as epigenetics, metabolites, and fecal microbiota transplantation. This study shows that further research into the links between the microbiota and inflammatory bowel diseases could improve the clinical application and treatment strategies of probiotics. Future research focusing on epigenetic and molecular regulatory mechanisms could contribute to the development of new approaches in this field.

Keywords: Bibliometrics, Gastrointestinal Microbiome, Inflammatory Bowel Disease, Microbiota, Probiotics

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1. Introduction

Inflammatory bowel disease (IBD) is a chronic intestinal immune-inflammatory disease of unknown etiology, including Crohn's disease and ulcerative colitis **(1, 2)**. IBD is characterized by loss of tolerance to intestinal microorganisms and abnormal intestinal immunity, leading to inflammation in the intestinal mucosa **(3)**.

Recent research suggests that intestinal microbial imbalance may be among the causes, as well as related to autoimmune factors **(4, 5)**. With advances in technologies such as metagenomics and metatranscriptomics, the physiological functions of the gut microbiota have been discovered and validated at the genetic level **(6)**. In addition, differences in the gut microbiome between healthy

individuals and patients with IBD have also been extensively studied **(7)**.

Patients with IBD have been reported to have altered signalling pathways with decreased diversity of gut microbiota and increased content of harmful metabolites and pro-inflammatory factors.

The potential role of probiotics in the treatment of inflammatory bowel diseases is of increasing interest as the importance of the microbiota in pathogenesis is recognised. Recent evidence indicates that probiotics-particularly multi-strain formulations-may be effective in inducing clinical remission and preventing relapse in ulcerative colitis, and in managing relapsing pouchitis, although no significant benefit has been demonstrated for Crohn's disease **(8)**. Another recent systematic review and meta-analysis reported that probiotic supplementation in IBD can reduce serological inflammatory markers such as C-reactive protein and increase beneficial bacteria in gut (*Bifidobacterium, Lactobacillus*), even though improvements in disease activity scores were inconsistent **(9)**. Furthermore, evidence indicates that pro-, pre-, and synbiotics can contribute to inducing and maintaining remission in IBD, particularly in ulcerative colitis. Among these, synbiotics appear to be more effective, and multi-strain preparations containing *Lactobacillus* and *Bifidobacterium* at daily doses of 10^{10}–10^{12} CFU may offer the greatest benefit **(10)**.

In the literature, it is observed that the number of studies on probiotics and IBD is steadily increasing. However, scientometric data that could guide future research is insufficient, such as which subtopics have been trending in research over the years, and identification of the leading publications, researchers, and institutions in this field. Bibliometric analysis examines articles published in a specific field or academic journal based on certain bibliometric indicators (e.g., annual number of articles, most studied topics, universities with the most publications, top journals in the field, authors with the most articles, number of citations, and keywords). To do this, it separates the items (e.g., articles, authors, journals, and words) into different groups. Then, it presents a mapping of the classification obtained from the analysis through the visualisation process. Bibliometric analysis provides a comprehensive understanding of the actual structure of any field. This includes identifying the evolutionary nuances of the field, defining the research clusters that constitute it, capturing emerging trends, and gaining a broad perspective on the concepts the field focuses on and the relationships between them **(11)**. In this context, clarification of the current status of literature has become even more important with this study and a bibliometric analysis of the effects of probiotics on IBD was planned.

In our study, the distribution of articles published on IBD and probiotics between 2014 and 2023 according to the journals, publication years, subject areas, types of diseases examined, countries where the studies were conducted, number of citations, and data collection tools were analyzed. This study aims to systematically evaluate global research trends on probiotics in IBD between 2014 and 2023, identifying publication years, subject areas, country contributions and citation performance. Accordingly, this study addresses the following research questions:

- How has the volume and distribution of publications on probiotics and IBD evolved over the past decade?
- Which countries, institutions, and journals have contributed most to this research field?
- What are the most frequently studied keywords, and thematic areas?
- What gaps and opportunities exist for future research on the effects of probiotics in IBD?

2. Materials and Methods

2.1 Data Sourcing and Search Strategies

The study was conducted using the Web of Science Core Collection (WoSCC) (Clarivate Analytics, Philadelphia, PA, USA) and Scopus (Elsevier, Gainesville, FL, USA) databases.

The search strategy was determined to investigate the association of terms related to "probiotic" with inflammatory bowel diseases, which may have potential therapeutic impact. Key words were chosen as "microbiome" OR "microbiota" OR "gut microbiota" OR "intestinal microbiome" OR "dysbiosis" OR "probiotics" AND "IBD" OR "Inflammatory Bowel Disease" OR "Ulcerative colitis" OR "Enterocolitis" OR "Crohn's Disease".

The search time frame was limited to publications from 2014 to 2023, focusing only on studies published in English and categorized as original research articles or reviews. The year 2024 was not included because the study was initiated in late 2024 and the data collection was completed before the end of that year. This period was selected to capture the most recent decade of scientific advancements, highlighting current research trends and developments in the field of probiotics and inflammatory bowel diseases. In addition, studies such as conference abstracts, letters to the editor, book chapters, and documents without sufficient bibliographic information were excluded

from the analysis. The study did not require ethics committee approval as it did not involve direct interaction with human participants and was based on publicly available database records.

2.2 Bibliometric Data Extraction

General bibliometric data, including annual publication trends and identification of the most prolific authors, were extracted directly from Scopus (for publication trends) and WoSCC (for author productivity). The number of publications per year and the ranking of authors based on publication counts were manually analyzed. Further network and mapping analyses were performed using VOSviewer (version 1.6.18). Co-authorship, co-citation, bibliographic coupling, keyword co-occurrence, and source-based analyses were conducted to visualize collaborative networks, thematic structures, and research trends. Network visualization maps were generated, where the size of the nodes represented the number of publications or citations, the thickness of the links indicated the strength of the relationships, and the colors distinguished different clusters based on thematic or methodological similarities.

Bibliometric indicators such as the number of publications, co-authorship links, co-citation frequencies, and keyword co-occurrence rates were analyzed. These metrics were used to identify influential authors and journals, dominant research themes, and collaboration patterns within the field of probiotics and inflammatory bowel diseases.

The visualizations obtained as a result of VOSviewer analyses were used to identify groups of researchers working on similar topics, conduct literature reviews, evaluate research trends, and identify potential collaborations. Close links between authors indicated that they were working on similar topics or had strong collaborative relationships. Colors and groups on the maps often represented thematic or methodological similarities, helping to understand the academic networks and interdisciplinary connections.

Each published article included information such as the authors, study title, journal name, language, document type, keywords, and abstract. The basic information extracted from the analyses included author affiliations, research topics, keywords used, and citation counts. This information was utilized to uncover major trends in the research field, identify influential studies and authors, and explore collaborations between various countries or institutions. The frequent occurrence of the keywords selected for our study in the citation analysis further underscored the significance of the topic within the field. The study only involved bibliometric analysis, no statistical analysis was performed.

3. Results

3.1 Documents by Year

Between 2014 and 2023, a total of 255,236 scientific documents were identified in Web of Science and 12,286 in Scopus worldwide. The annual number of documents is shown in Figure 1-A. According to the data, interest in the subject has gradually increased over the last 10 years, with a total of 1,962 (15.96%) publications in 2023 (Figure 1-A). The number of publications increased gradually between 2014 and 2019, followed by a sharper increase from 2020 onwards, reaching its peak in 2023. This increase may reflect the increasing acceptance of the role of the gut microbiota in IBD pathogenesis, the widespread use of microbiome research technologies such as metagenomics, and growing interest in complementary therapies such as probiotics. The noticeable acceleration seen after 2020 may also be related to the increased global focus on immunity and microbiome interventions during the COVID-19 pandemic.

Figure 1-B shows the journals with the highest number of publications on probiotics and inflammatory bowel disease according to the Scopus database. Frontiers in Immunology, launched in 2010 **(12)**, ranks first with 383 publications during the last decade. This is followed by Nutrients (372; launched 2009 **(13)**), Frontiers in Microbiology (298; launched 2010 **(9)**), Inflammatory Bowel Diseases (257; launched 1995 **(14)**), and International Journal of Molecular Sciences (253; launched 2000 **(15)**). When annual trends are examined, it can be observed that Frontiers in Immunology has shown a sharp increase since 2019, suggesting that this reflects an increased interest in the immunological mechanisms of probiotics in IBD. Nutrients and Frontiers in Microbiology demonstrate steady growth, reflecting the integration of nutrition science and microbial ecology in this field. The International Journal of Molecular Sciences has demonstrated an increasing trend, highlighting the growing importance placed on research at the molecular level. These patterns highlight that probiotic–IBD research is increasingly disseminated through multidisciplinary platforms, with immunology, nutrition, microbiology, and disease-specific journals playing complementary roles in advancing the field.

3.2 Departmental Contributions by Institution

A diversity of expertise and contributions to IBD and probiotics - ref: WOS analysis - characterizes institutions leading the research with top-level 1,456 publications in this field (0.571% of the total research). Shanghai Medical University is on the top of the list, which indicates that it is one of the strongest international research centers for this field. Notable others include the Perelman School of Medicine (1,290 publications) and the University of Michigan Medical School (1,226

publications). These institutions contribute 0.506% and 0.481% to the total research publications and both serve essential as well as significant roles in IBD and probiotics research. This analysis is based on bibliometric data extracted from Web of Science, processed by the authors **(16)**.

3.3 Highlighted Research Areas

The multidisciplinary nature of probiotics research for inflammatory bowel disease shows the number of publications and their percentage of total publications for each area of research. The most represented discipline is Gastroenterology and Hepatology with 55,250 publications contributing to 21.65% of research. Microbiology, which is fundamental for these diseases and important for the evaluation of possible probiotic effects, is second with 32,488 publications (12.73%). Third place is Biochemistry and Molecular Biology, with 17,809 publications (6.980%), giving detailed information on disease mechanisms and molecular effects of probiotics. Lastly, Pharmacology and Pharmacy adds 15,004 publications (5.881%), with focus on treatment efficacy and safety (including probiotics). These findings demonstrate the large inter-field collaboration between many different branches of science at the intersection between IBD and probiotics. These findings are based on bibliometric data obtained from Web of Science and processed by the authors **(16)**.

3.4 Citation Topics

"Inflammatory Bowel Diseases & Infections" category accounts for a considerable portion of research publications by about one-third (n = 93351[36.58%]) of the total, underscoring the critical role of understanding the association between IBD and infections as well as the role of probiotics in devising treatment strategies. The second top area is "Immunology" with 6,046 publications (2.37%), and another relevant area is "Dairy and Animal Science" with 4,785 publications (2.005%). These findings are based on bibliometric data obtained from Web of Science and processed by the authors **(16)**.

3.5 VOS Analysis Results

Figure 2 shows the co-author analysis mapping that examines the social networks formed by scientists collaborating on articles. Looking at the clusters on the map in Figure 2, it is seen that the red cluster is made up of researchers like Frank et al **(17)**, Hansen et al **(18)** and Swidsinski **(19)**, The green cluster is made up of researchers like Moayyedi **(20)**, Kruis et al **(21)** and Sokol et al **(22)**, the blue cluster is made up of researchers like Gevers et al **(23)**, Morgan **(24)**, Sartor and Wu **(25)**, and the yellow cluster is made up of researchers like Gionchetti **(26)**, Guslandi **(27)**, Prantera **(28)**. These clusters suggest distinct groups of researchers who tend to collaborate more closely with one another. Sokol et al **(22)** is an important collaborator in this field and seems to be working with many different researchers.

Figure 3 shows the citation analysis map in the context of documents. In Figure 3, Khan et al **(29)** is shown as a large node in the center of the map, indicating that it is widely cited in the literature. Another important node is Zuo and Ng **(30)**, as seen at the top of the circle map, emphasizing the significance of Zuo's work in this area. The degree of connections of Nishida et al **(31)**, located at the bottom-side of the map, reflects the importance of Nishida's work among the literature. Matsuoka and Kanai **(32)**, connected with Khan et al **(29)** and Nishida et al **(31)**, signifies the importance of this document. Another significant study is Hold et al **(33)**, which is placed in the center of the map and also has numerous connections. Eom et al **(34)**, Abraham and Quigley **(35)**, and Wasilewski et al **(36)** are clustered in the green region and are interconnected. Hu et al **(37)** and Li et al **(38)** are in the red cluster, connected to Khan et al **(29)** and Matsuoka and Kanai **(32)**. Overall, the map exhibits a core–periphery structure, with a few central documents concentrating many cross-links.

In the bibliometric map demonstrates in Figure 4, it is monitored that *Inflammatory Bowel Diseases* has a central position and has a broad network of connections. This indicates that this source is commonly referenced in the literature. To the right of the map, *Microorganisms* stands out as another significant node, indicating its important place in the literature. Additionally, Frontiers in Pharmacology also appears as a large node in the center of the map, with significant connections.

Figure 5 shows a co-word analysis map revealing the frequency of words appearing in the titles, abstracts, and keywords of studies in the research field and the networks of relationships between them. The keywords probiotics, inflammatory bowel disease (IBD), gut microbiota, and ulcerative colitis are at the centre of the map, showing strong connections with other keywords and highlighting the fundamental research focus in this area. In addition, newer themes are also emerging. In particular, Faecal Microbiota Transplantation (FMT), Epigenetics and Metabolites, microbiome-based therapies in IBD research, regulatory mechanisms at the molecular level, and metabolic profiling are emerging as current areas of interest. Furthermore, the presence of the keyword 'Inflammation' in the network highlights the ongoing emphasis on understanding inflammatory pathways associated with probiotic interventions. The terms Dysbiosis, Prebiotics, and Gut Microbiota are also frequently seen together, providing further insight into the importance of microbial balance and the complementary role of prebiotics in regulating gut health.

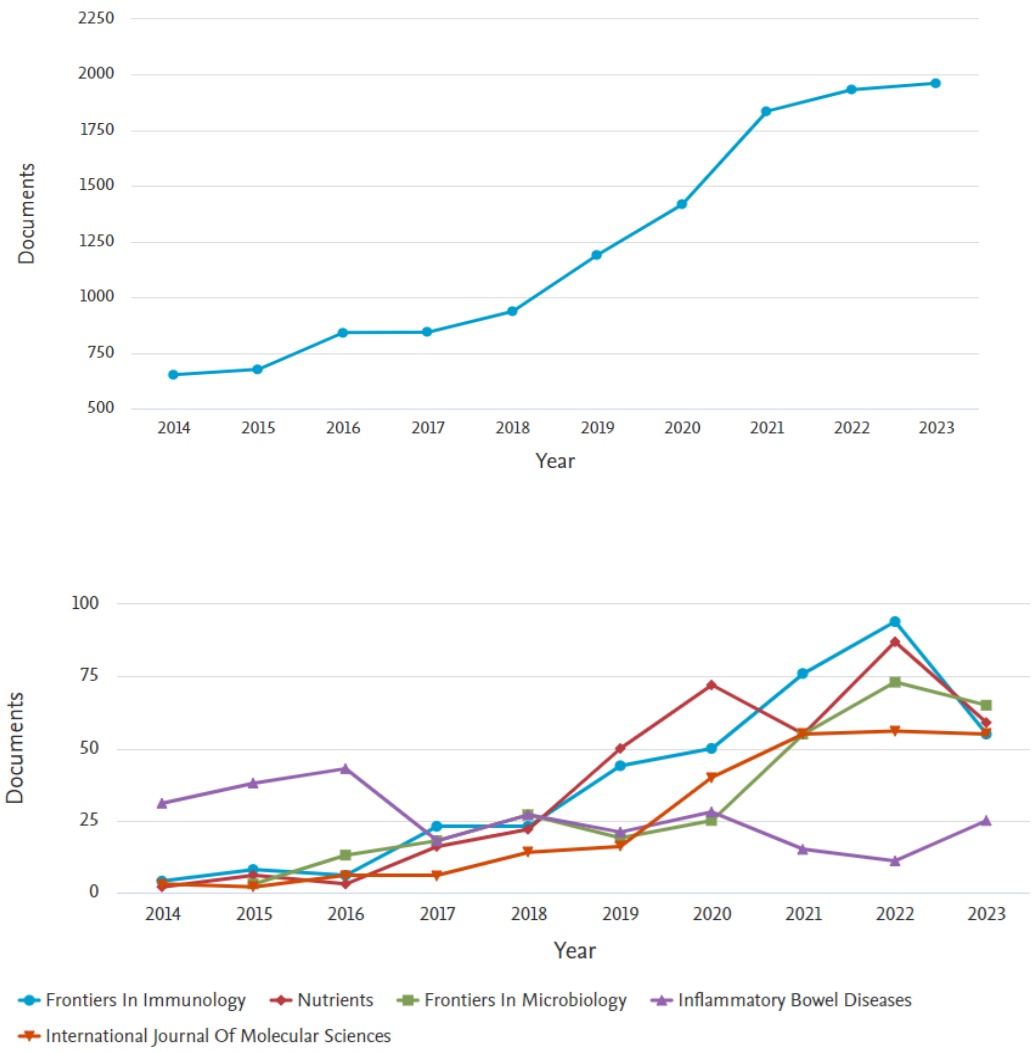


Figure 1. Number of publications and journal distribution on probiotics and IBD research (2014–2023). (A: top) Number of publications worldwide between 2014-2023. (B: bottom) Documents per year by source. **(Created with Scopus database -Prepared by Authors, 2025)**.

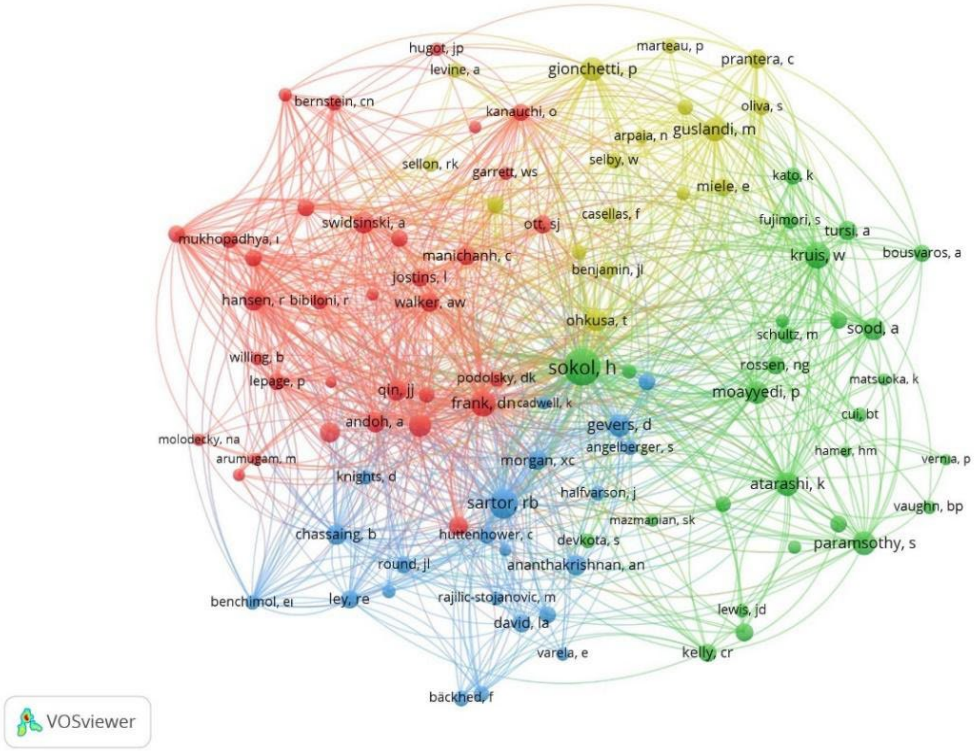


Figure 2. Network map in the context of co-author analysis **(Created with Web of Science database -Prepared by Authors, 2025)**.

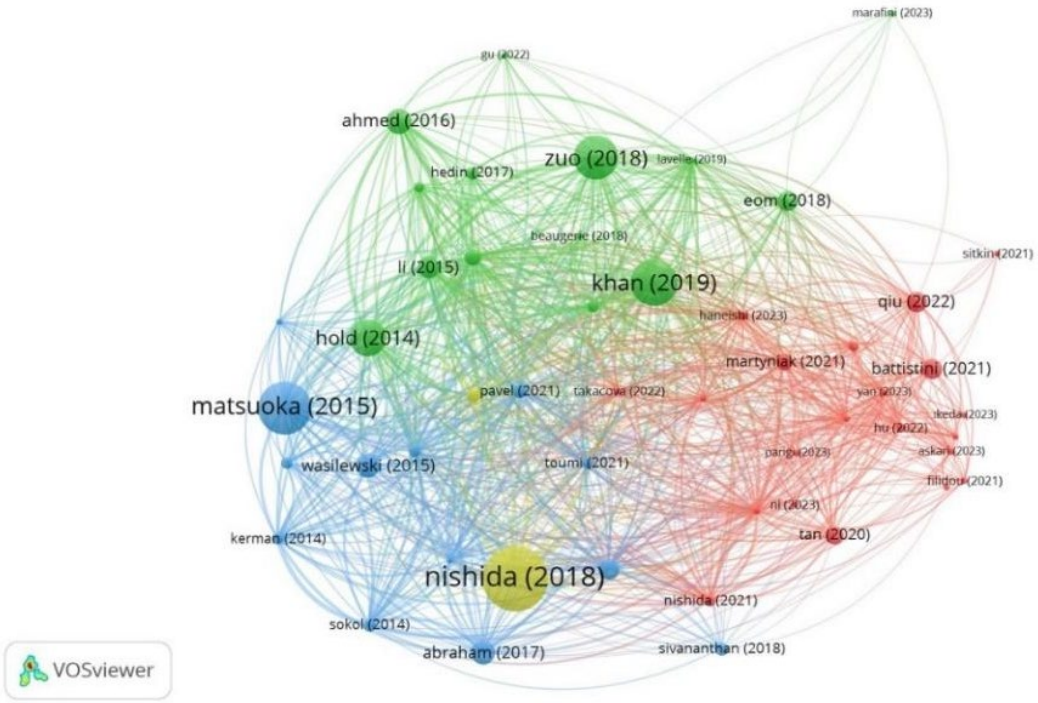


Figure 3. Network map in the context of citation analysis among documents **(Created with Web of Science database -Prepared by Authors, 2025)**.

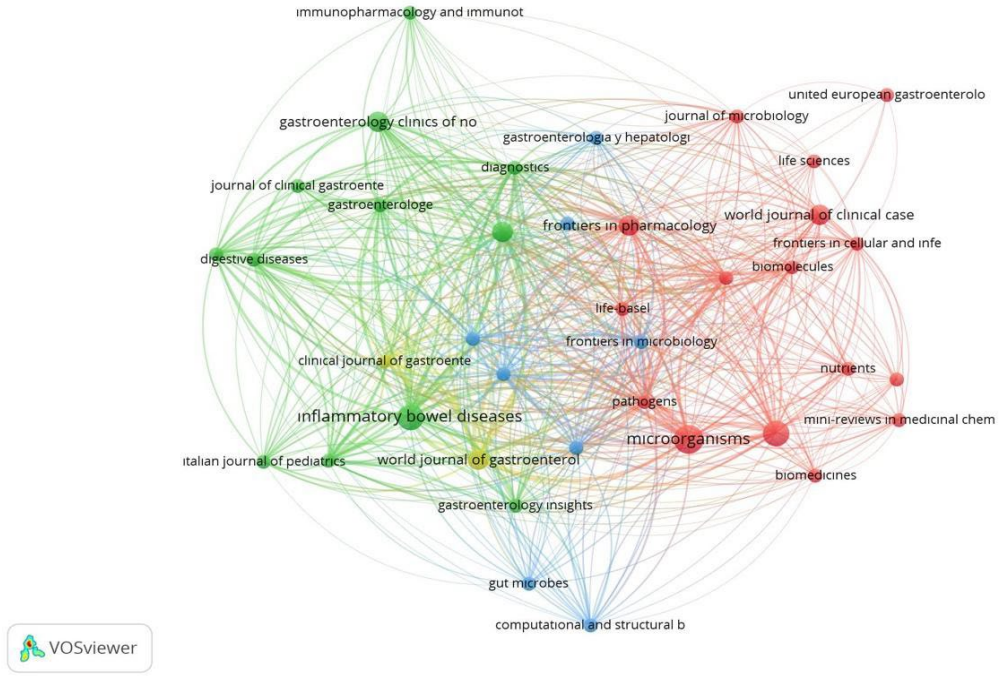


Figure 4. Network map in the context of citation analysis among sources/journals **(Created with Web of Science database - Prepared by Authors, 2025)**.

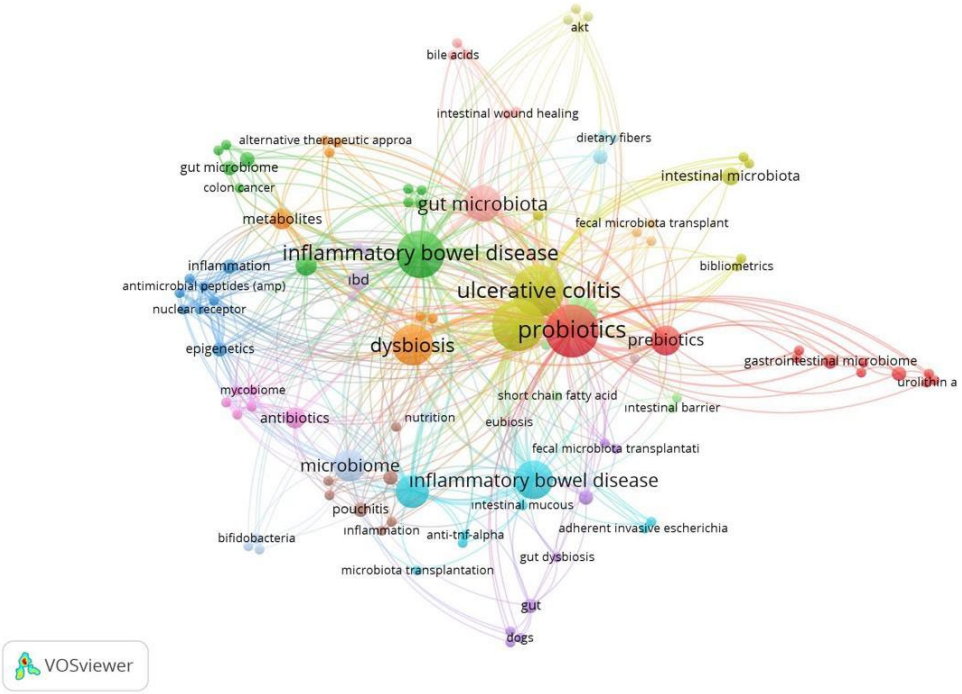


Figure 5. Network map in the context of co-occurrence/co-word analysis **(Created with Web of Science database -Prepared by Authors, 2025).**

4. Discussion

Despite the increase in the number of publications on the role of probiotics in inflammatory bowel diseases, bibliometric analysis studies examining trends in publications in this field and current research

focuses are very limited. This situation highlights the need for a comprehensive overview of the research field. Bibliometric analysis has emerged as a valuable tool for identifying publication trends, research focuses, and collaboration networks in specific scientific fields. In this context, our study provides a current overview of this emerging field and highlights future trends by analyzing publication outputs, citation patterns, and collaboration networks.

Several studies have supported that probiotics can reduce inflammation and restore microbial balance by regulating the immune function of the intestinal mucosa. However, results have been inconsistent in some cases, as different species and strains of probiotics may have different effects.

In discussion section, data on the scientific studies of the leading authors in the field are presented. Several studies have supported that probiotics can reduce inflammation and restore microbial balance by regulating the immune function of the intestinal mucosa. However, results have been inconsistent in some cases, as different species and strains of probiotics may have different effects.

According to the bibliometric data obtained in this study, Sokol et al **(22)**, who collaborate with many authors and are leading collaborators in the field, investigated the anti-inflammatory effects of *Faecalibacterium prausnitzii* in patients with Crohn's disease. They found that *Faecalibacterium prausnitzii* plays an important role in the gut microbiome and has anti-inflammatory effects. Gevers et al **(23)** investigated the effects of probiotics on the gut microbiota at the genetic level in patients with new-onset Crohn's disease and made significant contributions in this field. Gevers et al **(23)** showed that changes in the *Bacteroides* and *Clostridium* groups play an important role in the pathogenesis of Crohn's disease and that these changes can be improved by probiotic interventions. Hansen et al **(18)** investigated the role of probiotics in the treatment of Crohn's disease in childhood and emphasized the potential benefits of this treatment method. In the study published by Hansen et al **(18)** in 2022, *Bifidobacterium breve* and *Lactobacillus rhamnosus GG* were used. The results showed that these probiotics can ease the symptoms of Crohn's disease and improve microbial balance.

Another important scientist, Moayyedi **(20)**, investigated the effects of probiotics such as *Lactobacillus rhamnosus GG* and *VSL#3* in the treatment of ulcerative colitis and found that *VSL#3* was effective in initiating and maintaining remission in patients with ulcerative colitis. Kruis et al **(21)** demonstrated that *Escherichia coli (E. coli) Nissle* 1917 could be an effective alternative in the treatment of ulcerative colitis and it was no different from mesalazine in inducing remission. Bjarnason et al **(39)** showed that probiotic supplementation containing four bacterial strains, *Lactobacillus rhamnosus, Lactobacillus plantarum, Lactobacillus acidophilus* and *Enterococcus faecium*, was associated with reduced intestinal inflammation by reducing faecal calprotectin levels in ulcerative colitis patients. There was no effect observed in patients with Crohn's disease. Frank et al **(17)** emphasized in their study the potential of *Bifidobacterium* and *Lactobacillus* species to reduce inflammation and maintain the balance of the gut flora. In this study, a decrease in inflammation markers was observed with the use of *Bifidobacterium longum* and *Lactobacillus acidophilus*.

Our results show that probiotics, IBD, gut microbiota, and ulcerative colitis remain at the centre of the research network. In addition, themes such as faecal microbiota transplantation (FMT), epigenetics, metabolites, inflammation, dysbiosis, and prebiotics have come to the fore. In a bibliometric analysis study conducted by Xu et al **(40)** research trends related to gut microbiota and IBD were evaluated, and “gut microbiota”, “metagenomics”, “bacterial community”, “faecal microbiota transplantation” and “probiotics” were identified as the main research focuses. In another bibliometric study examining research trends in ulcerative colitis, terms that could be related to our research, such as ‘*Faecalibacterium prausnitzii*’ and ‘faecal microbiota transplantation (FMT)’, were among the most popular topics. The researchers defined FMT as a research focus **(41)**. In another bibliometric analysis related to gut microbiota and inflammatory bowel disease, it was reported that proteobacteria and parabacteria were the most researched topics over the last twenty years and formed the focus of research in this field **(42)**.

Our results indicate that probiotics maintain their central position in IBD research, but the research trend is increasingly shifting toward new mechanistic and complementary approaches. Therefore, future studies should focus on multicentre and standardized designs that link clinical outcomes to microbial changes and inflammatory pathways, thereby more comprehensively elucidating the potential of probiotics in IBD management.

5. Conclusion

From a bibliometric perspective, the results of our analysis showed that research on probiotics in IBD is increasingly being published in journals covering a wide range of disciplines, including immunology, nutrition, microbiology, and molecular biology. The most represented discipline is Gastroenterology and Hepatology. Additionally, data showed that research is

concentrated in a few leading centres, such as Shanghai Medical University, Perelman School of Medicine, and the University of Michigan Medical School. Keyword matching results indicate that terms such as 'Probiotics,' 'Inflammatory Bowel Disease,' 'Gut Microbiota,' and 'Ulcerative Colitis' dominate this field and are often associated with "Dysbiosis" and 'Prebiotics.' Recent studies have addressed topics such as epigenetics, metabolites, and faecal microbiota transplantation. Future research focusing on epigenetic and molecular regulatory mechanisms may contribute to the development of new approaches in this field. In conclusion, this study provides important information for future research by revealing the potential complementary role of probiotics in the treatment of inflammatory bowel diseases and identifying research trends in this field. However, more randomized controlled trials are needed to strengthen the evidence base. Further studies focusing on the links between gut microbiota and inflammatory bowel diseases may lead to a more effective use of probiotics in treatment, and ultimately improve clinical applications and treatment strategies.

6. Declarations

6.1 Acknowledgment

The authors thank all those who helped in writing this paper.

6.2 Ethical Considerations

This study did not require ethical approval as it is based on publicly available data.

6.3 Authors' Contributions

EÇ contributed to data analysis, manuscript writing, bibliometric data collection, and methodology. EEA was involved in bibliometric data collection, revisions, and methodology. TE contributed to data analysis, bibliometric data collection, and statistical analysis. FÇ supervised the study, provided methodological guidance, and performed the final proofreading. All authors read and approved the final manuscript.

6.4 Conflict of Interests

The authors declare no conflict of interest.

6.5 Financial Support and Sponsorship

The authors did not receive support from any organization for the submitted work.n

6.6 Using Artificial Intelligence Tools (AI Tools)

All authors declare that there is no use of AI Tools in this study, including the writing of this manuscript.

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