

Global research trends on diet and nutrition in Crohn's disease

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Abstract

BACKGROUND

Crohn's disease represents a challenge for patients concerned with the modified diet regimen as well as practitioners who seek the best nutritional therapy. Crohn's disease can alter the body's ability to digest food and to absorb nutrients, resulting in severe vitamin deficiencies, malnutrition and sometimes life-threatening complications. However, a comprehensive bibliometric analysis is lacking to map the current links between nutrition and Crohn's disease in terms of the number of citations, geographic distribution and growth trends of publications.

AIM

To introduce the current state of research as well as hotspots in the field of nutrition and Crohn's disease from a bibliometric standpoint.

METHODS

We searched the Scopus database and selected the relevant literature on nutrition and Crohn's disease that met the inclusion criteria. We analyzed the publication trends and research hotspots by using video object segmentation viewer software.

RESULTS

We included 1237 publications. The number of documents published each year has increased steadily. The United States and the University of Otago, Christchurch, have had the highest productivity, with 208 (16.81%) and 29 (2.34%) documents, respectively. The "role of exclusive enteral nutrition for complicated Crohn's disease" and "manipulation of the gut microbiota as a key target for

Crohn's disease" were the major research areas in 2016-2021, and they could be extensively investigated in the future. Meanwhile, research on "malnutrition in patients with Crohn's disease" appeared to be an area that attracted more research attention before 2016.

CONCLUSION

This is the first bibliometric analysis to map the knowledge structure and trends regarding nutrition in Crohn's disease research over the past two decades. The results provide a comprehensive summary and identification of the frontiers of nutrition and Crohn's disease-related research, which may be used as a resource by researchers in the field.

Key Words: Nutrition; Diet; Crohn's disease; Bibliometric; Microbiota; Malnutrition

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Core Tip: There is much interest in using nutrition therapy approaches to treat Crohn's disease, while the current state of knowledge is still inadequate to make general recommendations. Therefore, a bibliometric analysis of the global trend in research on nutrition and Crohn's disease was conducted. This study outlines the current state of research themes and hotspots in nutrition and Crohn's disease research because no bibliometric research has been conducted to determine worldwide trends in nutrition and Crohn's disease. This facilitates researchers and healthcare providers in identifying potential future research directions.

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INTRODUCTION

Crohn's disease is a relapsing transmural inflammatory disease of the gut with an unclear etiology; it involves acute attacks followed by periods of remission[1,2]. Crohn's disease can affect the entire gastrointestinal tract, from the mouth to the anus[3]. However, the disease affects the terminal ileum and the colon in most cases, which can result in complications such as stenosis, abscesses and fistula[4]. The prevalence rate of Crohn's disease ranges from 0.6 to 322 per 100000 people[5].

Malnutrition is frequently visible in approximately 65%-75% of patients with Crohn's disease[6]. Malabsorption, gut dysbiosis, small intestinal bacterial overgrowth and symptoms such as weight loss, reduced dietary intake, deficiency of individual nutrients or many nutrients are just a few of the mechanisms that can be related to Crohn's disease-related malnutrition[7,8]. In this case, nutrition, which may take the form of dietary adjustments, parenteral nutrition, or enteral nutrition, plays an important role in treating Crohn's disease[7,9,10]. Parenteral nutrition is a type of nutrition support that is given through an intravenous line. It is used when the digestive tract cannot properly absorb nutrients. In severe cases of Crohn's disease, where the digestive tract is severely damaged, parenteral nutrition may be necessary[7,11]. Furthermore, enteral nutrition is a type of nutrition support that is given through a feeding tube. It can help reduce inflammation and promote healing of the digestive tract. Enteral nutrition may be used as a primary treatment for Crohn's disease or as a supplement to other treatments[7,11].

There is much interest in using nutritional approaches to control and reduce the symptoms of Crohn's disease and to increase the remission time. Nevertheless, there is insufficient scientific support to give health care providers more options regarding dietary therapies. As a result, we performed a bibliometric analysis of the global trends in research on nutrition and Crohn's disease. We summarize the current state of research themes and hotspots in nutrition and Crohn's disease to look for global trends. Our findings will make it easier for researchers and newcomers to understand the current state of the field, to strategize future goals in research and to identify potential future research directions.

MATERIALS AND METHODS

Data sources

We conducted a shortlisted quantitative analysis with an approach based on previously published

scientific outputs to characterize the development of research on nutrition and Crohn's disease over the past two decades. On December 30, 2022, we searched the Scopus database for studies that had been published between 2002 and 2021. The Scopus database is often an essential source of information for bibliometric research and evaluations of scientific publications[12]. Numerous successful bibliometric studies have been performed using the Scopus database as a data source[13-17].

Search strategy

We used relevant publications on nutrition[18,19] and Crohn's disease[20] to choose keywords to search the Scopus database and to identify studies. Each of the chosen keywords relates to nutrition, and we used them as an entry for the "Article Title" field. Due to the possibility that the title/abstract/keyword search would retrieve unnecessary papers, we searched the titles with specific limits to reduce false-positive results[21-24]. When writing the keywords, we used asterisks (*) and quote marks to narrow and broaden the search scope. The keywords we used were *nutrit** or *nutrient** or *diet** or *eat** or *feeding-pertain to nutrition* or *diet per se* rather than other related terminology such as specific names or classes of dietary compounds. Furthermore, we searched all terms related to Crohn's disease in the "Article Title" and/or "Abstract" fields.

Bibliometric indicators

We imported the retrieved data into Microsoft Excel so that we could analyze and tabulate it. We retrieved relevant bibliometric data (such as the number of articles published per year, the types of documents retrieved, countries/regions, institutions, funding agencies, journals and their impact factors (*IF*), citation patterns and the *h-index*) for research publications related to nutrition and Crohn's disease. We used descriptive statistics to analyze our findings. The *Impact Index Per Article* that is being shown refers to the top 10 papers with the highest number of citations, which were obtained from the *Reference Citation Analysis (RCA)*, <https://referencecitationanalysis.com/>. RCA is a citation analysis database that is open and covers multiple disciplines. The company is located in Pleasanton, CA 94566, United States [25-27].

Data visualization

We analyzed and visualized the data by using VOSviewer software version 1.6.8, a free online tool[28-30]. The software generated visualization maps that displayed the most commonly occurring keywords in the retrieved publications. The size of the node in each map represented the frequency of a particular keyword, indicating the relevance and popularity of the corresponding topic in the field. Based on these maps, the hot topics in the field were identified, revealing the areas that received the most attention and research focus. This analysis provided valuable insights into the current trends and research directions in the field, which can be used to guide future research and inform the decision-making processes. In addition, visualization maps were used to determine international collaboration. VOSviewer can determine the extent of the collaboration between two countries by considering the width of the connecting line and the total number of publications.

RESULTS

Analysis of publication trends

There were 1237 publications on nutrition and Crohn's disease published between 2002 and 2021. The documents recovered were of 9 types, mainly research articles ($n = 791$; 63.95%), followed by reviews ($n = 285$; 23.04%). The total number of publications by year is shown in Figure 1. The number of publications per year increased from 28 in 2002 to 123 in 2021.

Analysis of the country distribution

The publications were from authors representing 108 countries/regions. The top 10 active countries are shown in Table 1. The top 10 countries contributed 905 (73.16%) of the recovered documents. Among the eligible countries, the United States had the highest number of publications ($n = 208$, 16.81%), followed by the United Kingdom ($n = 192$, 15.52%), China ($n = 109$, 8.81%), Japan ($n = 98$, 7.92%), and Canada ($n = 88$, 7.11%). Furthermore, we analyzed countries that had more than 20 publications on nutrition and Crohn's disease. Based on our findings from 18 eligible countries, the United States, the United Kingdom, and Canada are the central countries with links to other countries (Figure 2).

Contributions of institutions

Based on the number of publications, Table 2 includes the top 10 institutions that have produced publications on nutrition and Crohn's disease. The University of Otago, Christchurch (New Zealand), has had the highest scientific production ($n = 29$, 2.34%), followed by Tel Aviv University (Israel), with 25 publications (2.02%). Massachusetts General Hospital (United States) and Jinling Hospital (China) have the third highest production ($n = 22$, 1.78%).

Table 1 Top 10 productive countries/regions involved in nutrition and Crohn's disease from 2002 to 2021

Ranking	Country	No. of documents	%
1 st	United States	208	16.81
2 nd	United Kingdom	192	15.52
3 rd	China	109	8.81
4 th	Japan	98	7.92
5 th	Canada	88	7.11
6 th	Germany	73	5.90
7 th	Spain	71	5.74
8 th	Italy	70	5.66
9 th	France	67	5.42
10 th	Poland	61	4.93

Table 2 Top 10 productive institutions ranked by the number of publications

Ranking	Institute	Country	No. of documents	%
1 st	University of Otago, Christchurch	New Zealand	29	2.34
2 nd	Tel Aviv University	Israel	25	2.02
3 rd	Massachusetts General Hospital	United States	22	1.78
3 rd	Jinling Hospital	China	22	1.78
5 th	UNSW Sydney	Australia	21	1.70
6 th	Harvard Medical School	United States	20	1.62
7 th	University of Glasgow	United Kingdom	19	1.54
7 th	Sydney Children's Hospital, Randwick	Australia	19	1.54
9 th	Medical School of Nanjing University	China	18	1.46
9 th	University of Washington	United States	18	1.46

Analysis of funding agencies

We identified 274 (22.15%) articles that were part of financed projects. The United States funding agencies were the most active in this field, with the National Institute of Diabetes and Digestive and Kidney Diseases ($n = 34$, 2.75%) being the most active. This was followed by the National Institutes of Health ($n = 30$, 2.43%), the National Natural Science Foundation for China Diseases ($n = 30$, 2.43%) and the Crohn's and Colitis Foundation ($n = 20$, 1.62%) (Table 3).

Journal analysis

The top 10 journals that have published the most articles concerning nutrition and Crohn's disease are listed in Table 4 with their *IF* in 2022. *Nutrients* was the most productive journal, with 57 documents contributing to 4.61% of the total publications, followed by *Inflammatory Bowel Diseases* ($n = 55$, 4.45%), *Alimentary Pharmacology and Therapeutics* ($n = 39$, 3.15%), *Clinical Nutrition* ($n = 29$, 2.34%), and the *Journal of Pediatric Gastroenterology and Nutrition* ($n = 29$, 2.34%).

Citation analysis

There was an average of 29.46 citations per document, for a total of 36444 citations. The h-index of the retrieved documents was 93. A total of 183 (14.8%) of the retrieved documents did not have citations, but 83 had been cited ≥ 100 times. The top 10 articles were cited 3912 times[31-40]. There was a wide range in the total number of citations for these publications, from 310 to 603 (Table 5). The impact index per article for the top 10 most cited articles varied between 10.4 and 70.6 (Table 5).

Keyword analysis of research hotspots

The co-occurrence network map of author keywords with at least 10 occurrences is displayed in Figure 3. Of the 1589 keywords, 43 met the threshold and were mainly concentrated in three aspects: (1)

Table 3 Top 10 funding agencies involved in nutrition and Crohn's disease from 2002 to 2021

Ranking	Funding agencies	Country	No. of publication	%
1 st	National Institute of Diabetes and Digestive and Kidney Diseases	United States	34	2.75
2 nd	National Institutes of Health	United States	30	2.43
2 nd	The National Natural Science Foundation of China	China	30	2.43
4 th	Crohn's and Colitis Foundation	United States	20	1.62
5 th	Medical Research Council	United Kingdom	16	1.29
6 th	AbbVie	United States	12	0.97
6 th	National Cancer Institute	United States	12	0.97
8 th	Canadian Institutes of Health Research	Canada	10	0.81
9 th	Japan Society for the Promotion of Science	Japan	10	0.81
8 th	National Center for Research Resources	United States	10	0.81
8 th	Nestlé Health Science	Switzerland	10	0.81
8 th	Pfizer	United States	10	0.81

Table 4 Ten most productive journals involved in nutrition and Crohn's disease from 2002 to 2021

Ranking	Journal/source title	No. of documents	%	IF ¹
1 st	<i>Nutrients</i>	57	4.61	6.706
2 nd	<i>Inflammatory Bowel Diseases</i>	55	4.45	7.290
3 rd	<i>Alimentary Pharmacology and Therapeutics</i>	39	3.15	9.524
4 th	<i>Clinical Nutrition</i>	29	2.34	7.643
4 th	<i>Journal of Pediatric Gastroenterology and Nutrition</i>	29	2.34	3.288
6 th	<i>Digestive Diseases and Sciences</i>	24	1.94	3.487
7 th	<i>Journal of Crohns and Colitis</i>	22	1.78	10.020
7 th	<i>World Journal of Gastroenterology</i>	22	1.78	5.374
9 th	<i>Gastroenterology</i>	17	1.37	33.883
9 th	<i>Nutrition in Clinical Practice</i>	17	1.37	3.204

¹Journal Citation Reports (Clarivate, 2022). IF: Impact index.

The “role of exclusive enteral nutrition (EEN) for complicated Crohn's disease” (red cluster); (2) “manipulation of the gut microbiota as a key target for Crohn's disease” (green cluster); and (3) “malnutrition in patients with Crohn's disease” (blue group).

We then divided the keywords by specific colors based on the average number of times they appeared in all publications (Figure 4). The blue color represents prior research (before 2016), while more recent studies are indicated by the yellow color (after 2018). Keywords in the groups of “role of EEN for complicated Crohn's disease”; and “manipulation of the gut microbiota as a key target for Crohn's disease” were the major areas in 2016-2021, and they could be extensively considered in the future. Meanwhile, research on “malnutrition in patients with Crohn's disease” appeared to be a research area that attracted more attention before 2016.

DISCUSSION

This bibliometric analysis represents a comprehensive shortlisted overview of nutrition and Crohn's disease research. In the last decade, there has been significant growth in worldwide research interest in this topic. The steady scientific progress over time shows that “manipulation of the gut microbiota as a key target for Crohn's disease” and “EEN for complicated Crohn's disease” are promising clinical approaches that should receive more investigation.

Table 5 Top 10 articles on total citations

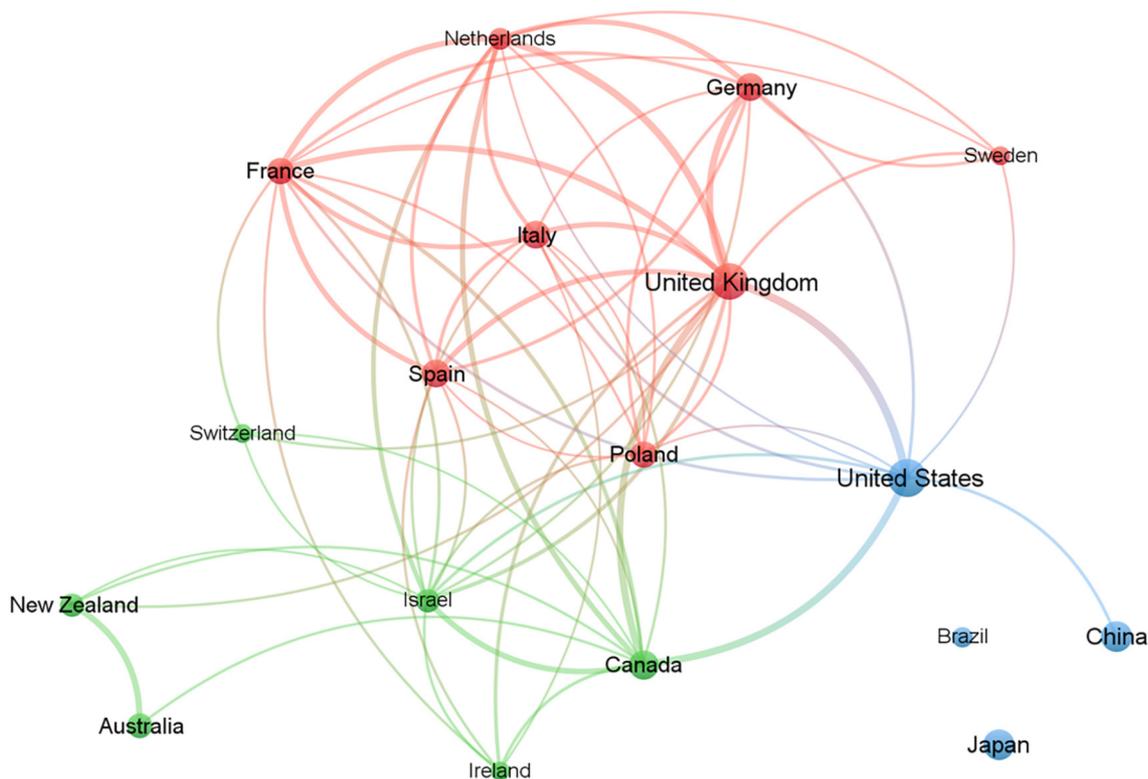
Ranking	Title	Source title	Cited by	Impact index per article ¹	Ref.
1 st	"Dietary intake and risk of developing inflammatory bowel disease: A systematic review of the literature"	<i>American Journal of Gastroenterology</i>	603	29.2	Hou <i>et al</i> [31], 2011
2 nd	"Inflammation, Antibiotics, and Diet as Environmental Stressors of the Gut Microbiome in Pediatric Crohn's Disease"	<i>Cell Host and Microbe</i>	449	70.6	Lewis <i>et al</i> [37], 2015
3 rd	"Diet-induced dysbiosis of the intestinal microbiota and the effects on immunity and disease"	<i>Nutrients</i>	425	36.5	Brown <i>et al</i> [32], 2012
4 th	"Differentiating ulcerative colitis from Crohn disease in children and young adults: Report of a Working Group of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition and the Crohn's and Colitis Foundation of America"	<i>Journal of Pediatric Gastroenterology and Nutrition</i>	377	21.3	North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition[33], 2007
5 th	"Enteral nutritional therapy for induction of remission in Crohn's disease"	<i>Cochrane Database of Systematic Reviews</i>	371	10.4	Zachos <i>et al</i> [34], 2007
6 th	"A prospective study of long-term intake of dietary fiber and risk of Crohn's disease and ulcerative colitis"	<i>Gastroenterology</i>	358	38.1	Ananthakrishnan <i>et al</i> [39], 2013
7 th	"Polymeric Diet Alone Versus Corticosteroids in the Treatment of Active Pediatric Crohn's Disease: A Randomized Controlled Open-Label Trial"	<i>Clinical Gastroenterology and Hepatology</i>	342	18.4	Borrelli <i>et al</i> [38], 2006
8 th	"ESPEN guideline: Clinical nutrition in inflammatory bowel disease"	<i>Clinical Nutrition</i>	341	48.9	Forbes <i>et al</i> [35], 2017
9 th	"Western diet induces dysbiosis with increased e coli in CEABAC10 mice, alters host barrier function favouring AIEC colonization"	<i>Gut</i>	336	38.4	Martinez-Medina <i>et al</i> [40], 2014
10 th	"Fine and ultrafine particles of the diet: Influence on the mucosal immune response and association with Crohn's disease"	<i>Proceedings of the Nutrition Society</i>	310	13.3	Lomer <i>et al</i> [36], 2002

¹The impact index per article is presented based on *Reference Citation Analysis* (<https://referencecitationanalysis.com/>).



Figure 1 Growth trends of publications on nutrition and Crohn's disease from 2002 to 2021.

The research found that the United States is the dominant country in this field, potentially due to various factors. These factors could include a higher prevalence of Crohn's disease in Western Europe and North America, where the disease affects 100 to 300 per 100000 people[5]. Other reasons may



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Figure 2 Network visualization map depicting international collaboration in research related to nutrition and Crohn's disease during 2002-2021.

involve the country's investment in research, a diverse range of researchers in the field, access to well-resourced research environments, and a well-trained workforce. Researchers may profit from their country's economic success, which may provide financial assistance and travel chances. This finding is consistent with past studies that have shown the United States to be the top in research productivity[41-43]. Nonetheless, it is critical to remember that research productivity is only one component of scientific research. Other elements, such as research impact and societal ramifications, should be included when assessing the overall success of a research field or country.

Studying collaboration networks can offer useful insights into research partnerships and help pinpoint essential collaborators in a particular field. The United States and the United Kingdom have a distinct advantage in this regard because of their greater economic resources and scientific investments. Both countries have invested significantly in research and development, establishing world-class research institutions and universities. Additionally, they have implemented policies to foster global scientific and technological collaboration, leading to the formation of robust networks of researchers and institutions worldwide. Furthermore, these countries' substantial funding and resources enable them to attract the best talent globally, which has facilitated scientific progress and innovation. The extensive cooperation and collaboration among researchers in these countries have resulted in diverse and strong networks that are crucial in addressing complex scientific challenges[44-47].

We may gain insight into the areas of interest and potential future research directions in this field by analyzing the cooccurrence of the keywords. Its key terms often refer to the most important aspects of a publication; the threshold was met by 43 of the 1589 keywords retrieved from the authors' keywords. Therefore, it is helpful to define important concepts and create a framework for nutrition and Crohn's disease studies by analyzing the associated keywords.

One of the main research hotspots in our study was the role of EEN for complicated Crohn's disease. Enteral nutrition is the preferred feeding route in the induction of remission of active Crohn's disease, as it is a minimally invasive procedure with low risk. On the other hand, enteral nutrition has a beneficial effect on the gut microbiota and intestinal inflammation. Therefore, enteral nutrition has several advantages over parenteral nutrition: It can maintain enterohepatic circulation, reduce the inflammatory response, decrease bacterial overgrowth and translocation and avoid intravenous access complications [4]. EEN was first used in the 1970s and has been established over the last 20 years as an effective nutritional therapy that induces mucosal healing in approximately 80% of patients and provides 100% of daily nutrition requirements from high-energy artificial supplements and modified feeds with probiotics, amino acids, and fatty acids[48]. On the other hand, a prospective study showed that 3 mo of

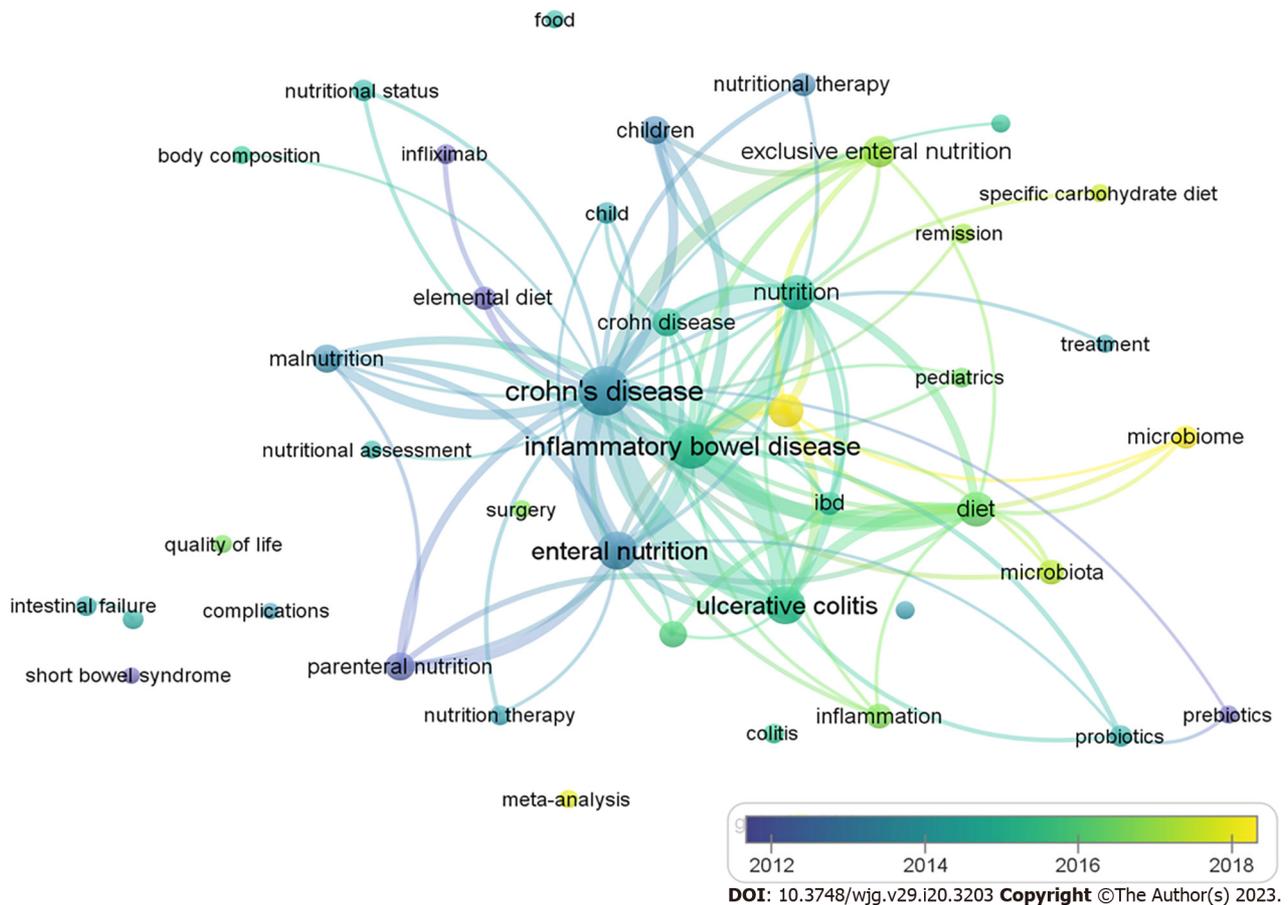


Figure 4 Co-occurrence overlay visualization of the authors' keywords. Yellow highlights indicate the most recent keywords.

One of the most important techniques for assessing the impact of an article or demonstrating its recognition is citation analysis[56,57]. It is possible to determine which study areas have received the most attention from the scientific community by analyzing the most cited papers. Those interested in becoming authorities on nutrition-related studies of Crohn's disease should become familiar with the most widely referenced works. We found several articles on the connections between nutrition and Crohn's disease[31-40] that highlighted a number of subtopics that are closely related to the aforementioned hotspots. For example, the article on this subject that has been cited the most has 603 references and was published in the *American Journal of Gastroenterology*. High dietary intakes of total lipids, omega-6 fatty acids, polyunsaturated fatty acids, and meat were associated with an elevated risk of Crohn's disease, according to this systematic analysis[31]. Conversely, fruit and high-fiber diets were linked to a lower risk of developing Crohn's disease[31]. The article by Lewis *et al*[37], published in *Cell Host and Microbe*, was the second most cited. This study established that fungi are involved in the dysbiosis of Crohn's disease in addition to bacteria. Inflammation, exposure to antibiotics, and dietary modifications contribute to dysbiosis in different ways by altering the composition of the gut microbiota [37]. These results shed light on the therapeutic options for Crohn's disease by showing that dysbiosis develops from independent influences of diet, inflammation, and antibiotics[37]. The third most cited paper was published in *Nutrients*[32]. The study presented proof that the microbiota structure in the intestines can influence the likelihood of developing chronic illnesses in the gastrointestinal tract, including celiac disease, Crohn's disease, ulcerative colitis, and irritable bowel syndrome. Nevertheless, the enduring advantages of probiotics and prebiotics are still uncertain, despite their potential as efficacious treatments for inflammatory disease symptoms[32].

Research strengths and limitations

Our study has several strengths. We systematically reviewed the literature on nutrition and Crohn's disease. Our findings offer a comprehensive and quantitative analysis of the most important articles related to nutrition and Crohn's disease. We have also acknowledged the important contributions that have been made to the development and progress of this specialized field. However, our study has several limitations. First, we only searched Scopus and we did not include data from other databases, such as PubMed, Web of Science, and Google Scholar. This approach could have led to the exclusion of papers relevant to the investigated topic. Second, the research strategy has certain errors, even though it has been validated. Consequently, researchers should keep in mind that both false-positive and false-

negative results could have been included. Nevertheless, we believe that the use of title searches significantly reduces research errors. Third, regarding the credibility of the data gathered for our study, the precision and completeness of the keywords we used have a considerable impact. Hence, certain significant and influential articles could have been left off the representative list because the titles of those articles could contain specific types of nutrition or diet.

CONCLUSION

We employed bibliometric techniques to gather 1237 articles on nutrition and Crohn's disease that were published from January 2002 to December 2021. Our findings highlight a network of collaboration among countries, institutions, journals and funding agencies, shedding light on the latest trends and areas of interest in the field of emerging nutrition and Crohn's disease. Research in this area has been increasing steadily over the past decade. The United States and the United Kingdom are the leading contributors to this field, with the highest number of publications and a strong emphasis on international cooperation. The "role of EEN for complicated Crohn's disease" and "manipulation of the gut microbiota as a key target for Crohn's disease" are the current research hotspots. This bibliometric study provides a detailed analysis of nutrition and Crohn's disease research, which can serve as a resource for academics and policymakers in this field.

ARTICLE HIGHLIGHTS

Research background

Crohn's disease symptoms can include abdominal pain, diarrhea, fatigue, and weight loss. While Crohn's disease has no cure, there are techniques to control symptoms, including food and nutrition.

Research motivation

Assessing the current status of research and hotspots in nutrition and Crohn's disease is critical for identifying knowledge gaps and informing future research paths.

Research objectives

Using bibliometric analysis, the purpose of this study is to provide an overview of the current state of nutrition and Crohn's disease research.

Research methods

We conducted a thorough and rigorous analysis utilizing SciVerse Scopus to identify relevant material on nutrition and Crohn's disease. Next, we used VOSviewer software to examine prevalent areas of study and publishing patterns in related domains.

Research results

Over the past 20 years, there has been a rise in cross-border partnerships and interdisciplinary studies concerning the relationship between nutrition and Crohn's disease. Currently, the key areas of research in this field are the use of exclusive enteral nutrition for complicated cases of Crohn's disease and the manipulation of the gastrointestinal microbiome.

Research conclusions

There has been no bibliometric analysis of nutrition and Crohn's disease research in the last two decades. This study provides a complete assessment of the knowledge structure and developments in this topic. As such, the findings are a helpful resource for academics because they provide a detailed assessment and emphasize the frontiers of nutrition and Crohn's disease research.

Research perspectives

The purpose of this research is to identify current trends and focus areas in the field of nutrition and Crohn's disease to guide future research and treatment practice. Using bibliometric analysis, this study provides a comprehensive assessment of the relevant literature, assisting researchers and clinicians in staying up to date on the most recent advances in this field.

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FOOTNOTES

Author contributions: Zyoud SH designed the study, collected the data, analyzed the data, made major contributions to the manuscript's literature search and interpretation, and drafted the manuscript; Shakhshir M made major contributions to the manuscript's literature search and interpretation and made revisions to the initial draft; all authors provided a critical review and approved the final manuscript before submission.

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