

The effects of the COVID-19 pandemic on microbiology-immunology publications: Bibliometric analysis and visualization

COVID-19 and microbiology-immunology publications

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This study was presented as a poster presentation at the XL. International Turkish Microbiology Congress, Antalya, Turkey, 2022

Abstract

Aim: The aim of this study is to visualize the most cited publications, the most frequently used keywords, and the topics studied in the field of "Microbiology-Immunology" before and during the pandemic and to reveal the differences between the two periods.

Material and Methods: Studies registered in the Scopus database and published in the field of "Microbiology-Immunology" in 2019 and 2022 were included in the study. Data analysis was performed using Microsoft Excel and VOSviewer program. In the keyword analysis, the most recently published and the top 2000 most cited publications in 2019 and 2022 were evaluated.

Results: The most frequently used keywords in the most recent publications in 2019 were "Medicago truncatula", "malaria" and "immunotherapy", while the most cited keywords were "inflammation", "microbiome" and "immunotherapy". In 2019, it was determined that most studies were on immunotherapy. In 2022, the top three most frequently used keywords in the most recently published publications were "malaria", "neuroinflammation" and "inflammation", while the most cited publications were "COVID-19", "SARS-CoV-2" and "vaccination". As a result of the keyword analysis, it was determined that the most frequently published topics and the most cited topics were different from each other in the analysis of current studies in 2022.

Discussion: Since our study reveals the changes in the literature related to our field, we think that it will be a guide in planning new studies. We believe that periodic repetition of bibliometric analyses and keyword mapping studies will contribute to the quantitative and qualitative development of scientific productivity in our field.

Keywords

Bibliometric Analysis, Keyword Mapping, Scientometrics, Bibliometric Visualization, VOSviewer

DOI: 10.4328/ACAM.21745 Received: 2023-04-27 Accepted: 2023-06-05 Published Online: 2023-07-03 Printed: 2023-10-01 Ann Clin Anal Med 2023;14(10):885-890

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Introduction

SARS-CoV-2, which emerged in China at the end of 2019, spread rapidly throughout the world, and the World Health Organization (WHO) declared a COVID-19 pandemic on March 11, 2020. Since the beginning of the pandemic, healthcare professionals have been at the forefront of the fight against the pandemic, and the scientific community has planned studies to understand and prevent the pandemic. During the pandemic, there have been changes in scientific research interests around the world [1-3].

Bibliometric analysis is an interdisciplinary method used to present information at a quantitative level as a result of the analysis of data on a subject in the literature with mathematical and statistical methods. Bibliometric analyses are used to reveal changes, differences, and similarities in components such as article and journal performance, collaboration patterns, and research topics [4,5]. The visualization and mapping of data obtained by bibliometric analysis and the creation of meaningful information has attracted a lot of attention in recent years and has become widespread. The Vosviewer program is a useful application that is frequently used in the visualization of data obtained in data mining and bibliometric analysis studies [6]. By using bibliometric analysis and data mining methods together, researchers can observe and examine changes in the literature related to a particular field or subject. While bibliometric analysis and data mining methods enable the evolutionary change and progression of a particular scientific subject to be revealed by examining it on the basis of authors, countries, or journals, they also shed light on different themes emerging in that subject [7].

During the COVID-19 pandemic, a change in research interests all over the world has been seen due to the pandemic effect. We think that it is important to determine how the pandemic has changed the research interests with quantitative and qualitative data in order to guide the projects and studies to be planned in the future. The aim of this study is to visualize the most cited publications, the most frequently used keywords, and the topics studied in “Microbiology-Immunology” before and during the pandemic and to reveal the differences between the two periods. Our study will help to analyze microbiology and immunology studies during the COVID-19 pandemic and aims to identify popular trends and gaps, which are important for identifying future research and systematic reviews.

This study was previously presented as a meeting abstract at the International Turkish Microbiology Congress on November 16-20, 2022.

Material and Methods

In our study, Scopus (<https://www.scopus.com/>) database was used to obtain bibliometric data because it has more advantages than other databases and provides more publication results. Studies registered in the Scopus database and published in the field of “Microbiology-Immunology” between January 1 - December 31, 2019 and January 1 - September 2, 2022 were included in the study. The last search query images in Scopus were “SUBJAREA (immu) AND (LIMIT-TO (PUBYEAR, 2019))” and “SUBJAREA (immu) and (LIMIT-TO (PUBYEAR, 2022))”. In the

keyword analysis, the first 2000 most recently published and most cited publications in 2019 and 2022 were evaluated. The quantitative and qualitative analysis of the data obtained was evaluated in terms of the number of publications by year, field, language of publication, journal name, country, authors, year of publication and institution of publication using appropriate bibliometric indicators. For the visualization of bibliometric networks, VOSviewer (Leiden University’s Centre for Science and Technology Studies, Leiden, Netherlands; version 1.6.16), a text mining application, was used to analyze all keywords obtained from the Scopus database to identify research interests and relationships. Percentage, frequency, and mean values were calculated to analyze the collected data. Microsoft Excel (Microsoft Office 365) tool was used for statistical procedures.

The study was conducted in accordance with the Declaration of Helsinki, which was revised in 2013. Ethics committee approval was not required as the study was a document review technique.

Results

The number of publications in the field of microbiology-immunology scanned in the Scopus database was 88,795 in 2019 and 79,824 in 2022. The top 10 preferred languages in 2019 were English (86,143), Chinese (1,143), Russian (836), Spanish (303), Korean (130), French (120), Japanese (95), Turkish (57), Czech (40) and Persian (31). In 2022, the 10 most preferred publication languages were English (78,594), Chinese (502), Russian (405), Spanish (241), Korean (58), French (55), Turkish (53), Persian (19), Portuguese (12) and Czech (5).

The top 10 journals in which the most studies were published are shown in Table 1.

The distribution of 2019 and 2022 publication frequency on the world map is shown in Figure 1. In 2019, the United States of America (USA) ranked first with 23,617 publications, followed by China (17,000), the United Kingdom (6732), Germany (6110), France (4576), Italy (3988), Japan (3928), India (3904), Brazil (3665) and Canada (3422). In 2019, Turkey ranked 26th with a total of 964 publications and was among the countries with 500-1000 publications. In 2022, China ranked first with 22,389 publications, followed by the USA (16,569), the United Kingdom (5009), Germany (4769), India (4302), Italy (3903), France (3345), Japan (3083), Brazil (2976) and Spain (2819). Turkey ranks 22nd with a total of 1097 publications in 2022.

In an analysis of the top 20 institutions producing the most publications, “Ministry of Education China” from China ranks first with 1545 studies in 2019 and 2094 studies in 2022 (Table 2).

When the distribution of these institutions according to countries is examined, five of them are from the USA, five from China, three from France, two from the United Kingdom and one each from Brazil, Sweden, Canada, Denmark, Denmark and Australia in 2019. In 2022, there are major differences in the distribution of institutions, with the number of institutions in China increasing from five to eleven. The distribution of institutions by country is as follows: eleven from China, three from France, two from USA, two from Brazil, one from Australia, one from UK.

According to the keyword analysis, the top ten most frequently used keywords in the most recently published publications in 2019, respectively, were “Medicago truncatula”, “malaria”, “immunotherapy”, “cytokines”, “vaccine”, “inflammation”, “biofilm”, “Plasmodium falciparum”, “rheumatoid arthritis” and “neuroinflammation” (Figure 2, a); the most cited publications included the keywords “inflammation”, “microbiome”, “immunotherapy”, “cancer”, “gut microbiota”, “microbiota”, “immunotherapy”, “microglia”, “cytokines” and “rheumatoid arthritis” (Figure 2, b).

In 2022, the top ten most frequently used keywords in the most recent publications, respectively, were “malaria”, “neuroinflammation”, “inflammation”, “rheumatoid arthritis”, “microglia”, “COVID-19”, “microbiome”, “SARS-CoV-2”, “gut

microbiota” and “Plasmodium falciparum” (Figure 3, a); the most cited publications included the keywords “COVID-19”, “SARS-CoV-2”, “vaccination”, “vaccine”, “coronavirus”, “omicron”, “autoimmune diseases”, “epidemiology”, “vaccine hesitancy” and “inflammation” (Figure 3, b). As a result of the keyword analysis, it was determined that the most frequently published topics and the most cited topics were different from each other in the analysis of current studies in 2022 (Figure 3).

Comparing the studies published in 2019 and 2022, it was found that publications on “Malaria” maintained their importance and rose to the first place among current studies.

The number of COVID-19 publications was detected as 93,735 in 2020, 140,227 in 2021, and 128,485 in 2022 on PubMed.

Table 1. Top 10 most preferred journals in 2019 and 2022

	Journal Name 2019	Impact Factor 2021	Cite Score 2021	Number of Publications	Journal Name 2022	Impact Factor 2021	Cite Score 2021	Number of Publications
1	Frontiers in Immunology	8.786	9.8	3097	Frontiers in Immunology	8.786	9.8	4638
2	Frontiers in Microbiology	6.064	8.2	2996	Frontiers in Microbiology	6.064	8.2	3259
3	Biomed Research International	3.246	5.0	1862	Foods	5.561	4.1	2150
4	Elife	8.713	11.6	1663	Viruses	5.818	6.6	1621
5	Journal of Visualized Experiments	1.424	2.5	1315	Microorganisms	4.926	4.1	1387
6	Viruses	5.818	6.1	1217	Biomed Research International	3.246	5.0	1350
7	Microbiology Resource Announcements	N/A	1.1	1080	Frontiers in Cellular And Infection Microbiology	6.073	5.9	1284
8	Vaccine	4.169	6.7	1036	Elife	8.713	11.6	1195
9	Cell Death and Disease	9.696	13.5	958	Computational and Mathematical Methods in Medicine	2.809	2.8	1152
10	Journal of Virology	6.549	10.2	802	Vaccines	4.961	4.5	1139

N/A: Not applicable

Table 2. Top 20 institutions producing the most publications

	Institutions 2019	Country	Number of Publications	Institutions 2022	Country	Number of Publications
1	Ministry of Education China	China	1545	Ministry of Education China	China	2094
2	Chinese Academy of Sciences	China	1384	Chinese Academy of Sciences	China	1467
3	CNRS Centre National de la Recherche Scientifique	France	1263	CNRS Centre National de la Recherche Scientifique	France	1073
4	Inserm	France	1198	Zhejiang University	China	1071
5	National Institutes of Health NIH	USA	1056	Inserm	France	1017
6	Harvard Medical School	USA	1039	Harvard Medical School	USA	805
7	Universidade de São Paulo	Brazil	807	University of Chinese Academy of Sciences	China	798
8	University of Chinese Academy of Sciences	China	714	Ministry of Agriculture of the People's Republic of China	China	756
9	University of Oxford	United Kingdom	682	Chinese Academy of Agricultural Sciences	China	711
10	University of Melbourne	Australia	657	Chinese Academy of Medical Sciences & Peking Union Medical College, China	China	667
11	Karolinska Institutet	Sweden	625	Fudan University	China	640
12	University of California, San Francisco	USA	622	University of Oxford	United Kingdom	634
13	Chinese Academy of Agricultural Sciences	China	615	National Institutes of Health NIH	USA	575
14	Université Paris Cité	France	608	Universidade de São Paulo	Brazil	569
15	Imperial College London	United Kingdom	604	Université Paris Cité	France	530
16	University of Washington	USA	580	Sun Yat-Sen University	China	516
17	University of California, San Diego	USA	567	University of Melbourne	Australia	502
18	Ministry of Agriculture of the People's Republic of China	China	550	Capital Medical University	China	482
19	University of Toronto	Canada	549	Fundacao Oswaldo Cruz	Brazil	474
20	Københavns Universitet	Denmark	528	Huazhong University of Science and Technology	China	455

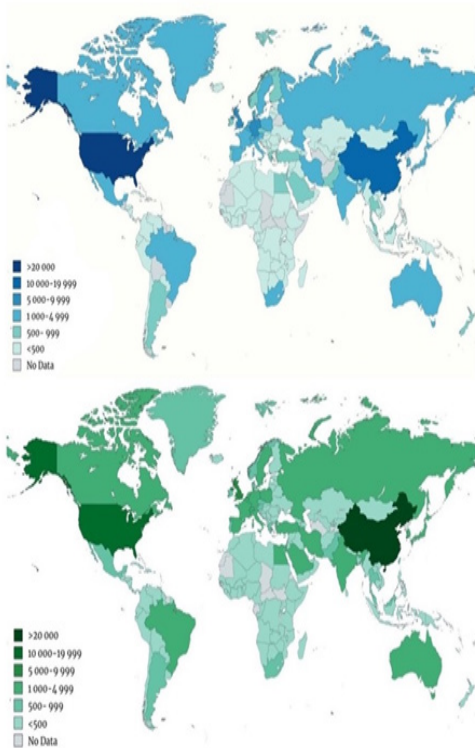


Figure 1. a, b. Distribution of studies published in 2019 (a) and 2022 (b)

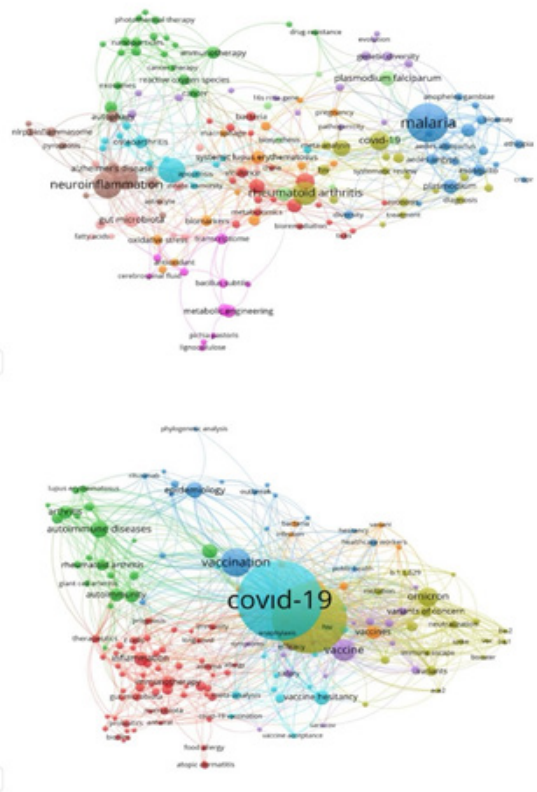


Figure 3. a, b. Network map of the most frequently used keywords in 2022 (a) and keyword network map of the most cited articles (b)

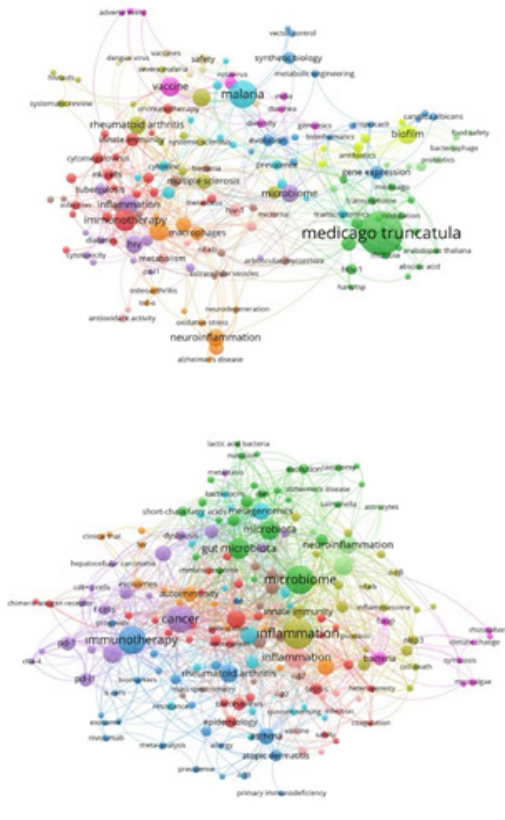


Figure 2. a, b. The network map of most frequently used keywords in 2019 (a) and the keyword network map of the most cited articles (b)

Discussion

With the COVID-19 pandemic, many trends in the scientific world have undergone a radical change, and the number of publications on COVID-19 in the first three months of the pandemic has multiplied the number of publications on the H1N1 swine flu pandemic by five [3,8]. In this process, an increase in publications in parallel with the increase in COVID-19 studies can be considered normal. However, this situation has created a tough competitive environment for the publication of studies other than COVID-19, and pandemic-related publications were prioritized in many journals [9].

As expected, English was the dominant language of publication in both periods [10,11]. Turkish ranked eighth in 2019 and seventh in 2022, maintaining its position among the top 10 most frequently used publication languages. When the journals in which the studies were published were analyzed, “Frontiers in Immunology” and “Frontiers in Microbiology”, which are among the Frontiers group journals, ranked in the first two places in both years (Table 1). Although the journals in the first two ranks did not change, the number of articles published increased in both journals in 2022. While nine of the top ten journals with the highest number of articles were included in the Web of Science Science Citation Index Expanded (SCIE) database, “Microbiology Resource Announcements” is included in the Emerging Sources Citation Index and has no impact factor. The fact that a journal not indexed in SCIE is among the most published journals shows that the impact factor alone is not effective in authors’ choice of journals [12-15].

In 2019, while the USA ranked first by far in terms of publication

frequency, studies in the field of microbiology-immunology in China, the starting center of the COVID-19 pandemic, started to increase with great momentum and became the country that published the most studies in this field in 2022. While the number of publications related to COVID-19, on the one hand, continued to increase, on the other hand, the withdrawal of some publications that were rapidly published at the beginning of the pandemic by journals caused many discussions. Soltani and Patini [16] showed in their study that the countries with the most retracted articles in 2020 were China and the USA, in line with the number of publications. Even in prestigious journals such as the New England Journal of Medicine and the Lancet, some articles were withdrawn due to controversy over data published in COVID-19 publications [17, 18]. The most important factor here can be considered the incomplete/inadequate peer review process triggered by the pandemic effect, the desire to publish new data quickly with the scientific world, and the desire to publish quickly. In this process, post-publication evaluations were applied in many journals, different from the traditional evaluation process. Following these developments in 2020, publishers, editors, and reviewers have become more sensitive about COVID-19 studies.

While Turkey was in the class of countries publishing between 500-1000 publications with 964 publications in 2019, the number of publications exceeded 1000 in 2022.

The clusters formed in the pre-pandemic period as a result of keyword analysis showed that published studies were concentrated around immunological studies on immunotherapy, microbiome studies, and model organisms used in transcriptomic and genomic studies such as *Medicago truncatula*. The pathogenic organisms most frequently used as keywords were *Plasmodium falciparum*, HIV, *Mycobacterium tuberculosis*, CMV, and *Candida albicans*. The most prominent clusters in the most recent 2000 studies conducted in 2022 were malaria and inflammation, while the most cited 2000 studies were COVID-19 and vaccines. The most frequently used microorganisms as keywords in 2022 are SARS-CoV-2, *Plasmodium falciparum*, *Escherichia coli*, *Saccharomyces cerevisiae*, and HIV. Malaria, which has always found its place in the keyword network map, stands out as the most popular and most studied topic again in 2022, when the devastating effects of the pandemic started to decrease. Unlike 2019, COVID-19, SARS-CoV-2, and vaccine studies were found to rank high in the keyword frequency table in 2022. According to Pubmed search results, COVID-19 publications, which increased in 2020 with the pandemic, peaked in 2021 (2020: 93735; 2021: 140227; 2022: 128485). The emergence of worrying new variants continues to attract the attention of researchers as the pandemic has not yet ended and there are still many problems to be solved. With the pandemic, the increasing number of mucormycosis cases reported especially from India led to an increase in mucormycosis publications in the literature during the pandemic, and India became one of the prominent countries in the publication list [19]. The keywords of the most cited publications before the pandemic were inflammation, microbiome, immunotherapy, cancer, and microbiota. Cancer studies, which have always maintained their popularity in the

scientific community, also stand out in the most cited studies. Many systematic reviews and meta-analyses have found that the number of articles investigating the impact of COVID-19 on cancer worldwide has increased during the pandemic. COVID-19 publications related to cancer research have focused on “care and management of cancer patients during the COVID-19 pandemic” and “COVID-19 vaccines in cancer patients” [20].

Especially in recent years, microbiome and microbiota studies, which have come to the fore in the field of microbiology, are at the top of the citation list, showing that the interest in these topics continues in both microbiological and multidisciplinary studies. In 2022, a keyword analysis of the most cited publications shows that the entire literature is dominated by pandemic-related studies such as COVID-19, SARS-CoV-2, vaccination, new Vaccines, and omicron variant. When pandemic-related studies are eliminated from the most cited publications in microbiology and immunology, autoimmune diseases, rheumatoid arthritis, and antimicrobial resistance come to the fore.

The impact of pandemics on scientific research trends and year-based differences are clearly seen in the keyword analysis used in the most cited studies in 2022. In our study, it was seen that even when the effects of the pandemic eased, it still dominated the studies in our field. Although the pandemic has attracted all the attention in our field of science, it is pleasing that malaria and tuberculosis, which are among the most important public health problems, are not overshadowed by the pandemic.

Conclusion

It has been clearly shown in our study that it is important to determine and examine the direction in which the literature has evolved, especially after events such as pandemics and natural disasters that affect all layers of society and thus the scientific world. We believe that periodic repetition of bibliometric analyses and keyword mapping studies will contribute to the quantitative and qualitative development of scientific productivity in our field.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: None

Conflict of interest

The authors declare no conflict of interest.

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How to cite this article:

Yađmur Ekenođlu Merdan, Okan Aydođan, Selim Merdan. The effects of the COVID-19 pandemic on microbiology-immunology publications: Bibliometric analysis and visualization. *Ann Clin Anal Med* 2023;14(10):885-890