

RESEARCH VISUALIZATION OF POST – COVID PUBLICATIONS: BIBLIOMETRIC ANALYSIS OF PUBMED DATABASE

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Abstract

COVID-19 is a communicable disease that impacted worldwide in December 2019 and has taken more attention from researchers. Since then, a considerable amount of medical literature on COVID-19 has been generated. However, there is insufficient information on the bibliometric direction of research output associated with Post-COVID. Therefore, this study aims to explore the published research in the PubMed database on Post-COVID using bibliometric analysis techniques from 2020 to 2021. The search was conducted using “Post COVID”[All Fields]) from 2020/1/1 to 2021/12/31. Bibexcel version 2016, Microsoft Excel 2010, and VOSviewer version 1.6.18 were used to analyze different aspects such as source type, top journals, authorship pattern, most prolific authors, language productivity, contributing countries and major keywords. Out of 2,766 research publications, the majority (n=1,374, 49.67%) of research output has been published as journal articles. *Cureus*, *International Journal of Environmental Research and Public Health*, and *Journal of Clinical Medicine* were leading journals regarding publications count. Results indicated that the majority (n=2,650, 95.81%) of publications were written in English by single authors. The most prolific authors were Fernández-de-Las from King Juan Carlos University (Spain), Zhang Y from Biotherapy Center, Affiliated Hospital of Zhengzhou University (China), and Hernández-Barrera V from the Department of Public Health, Universidad Rey Juan Carlos (Spain). The United States with 31.91% (n=165) and England with 21.66% (n=112) were two key contributors to the field. Humans, COVID-19, SARS-CoV-2, and Pandemics were the primary MeSH keywords in the related literature on Post-COVID.

Keywords: *Bibliometric analysis, Post-COVID, PubMed, Research publications, Research visualization*

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Introduction

Due to the prevalence of COVID-19 cases and survivors growing worldwide, the burden of Post-COVID-19 conditions (PCC) also increases (Erinoso, 2022). The terms linked with persisting signs and symptoms following COVID-19 are defined in the UK's National Institute for Health and Care Excellence (NICE) guideline. The recommendation makes a distinction between the terms "long COVID" and "Post-COVID-19 conditions", which were used synonymously (Erinoso, 2022). PCC refers to signs and symptoms that develop during or after COVID-19, which continue for more than 12 weeks and cannot be explained by an alternative diagnosis (Erinoso, 2022).

Post-COVID is an emerging research field after COVID-19 as it has influenced more and more people infected by COVID-19. According to the literature, many cases were reported related to the Post-COVID condition (Naseer *et al.*, 2021). Therefore, researchers from around the globe have been motivated to conduct scientific research on the symptoms associated with COVID-19. As a result of this, new knowledge was generated in unprecedented quantities, and several publishers made their publications on the disease available online for free (Corrales-Reyes *et al.*, 2021). This increases bibliometric studies relating to scientific output on the disease around the world (Corrales-Reyes *et al.*, 2021; Jin *et al.*, 2022; Kambhampati, *et al.*, 2020; Liao *et al.*, 2021; Liu *et al.*, 2020; Naseer *et al.*, 2021; Sharma & Dubey, 2021; Gorriz *et al.* 2022 ; Kim *et al.*, 2022). Even though, direction to the literature on Post-COVID conditions is not yet comprehensively covered by previous researches. Hence, this study will fill the research gap by providing possible direction for the scientific research output on Post-COVID-19 conditions.

Literature Review

Although there are numerous bibliometric studies focused solely on COVID-19, Post-COVID has not received much attention. Literature found that scientific databases like WoS, Scopus, and WHO databases have been used more frequently for bibliometrics research. However, the PubMed database has been used in few studies only. This is the first bibliometric study on Post-COVID-19 using the PubMed database, and only a few other studies have been done on Post-COVID-19 complications and treatment.

Using the WHO database, Sharma & Dubey (2021) conducted a bibliometric study on Post-COVID mucormycosis to evaluate the publications related to the disease. They discovered that 51 reports, including 40 articles and one clinical trial, had been published. In addition, the authors revealed that 51 reports were available in Medline out of 38 databases in the WHO

database. According to their research, Indian authors contributed the most to the research papers on Post-COVID mucormycosis. With ten research reports, *Indian ophthalmology* journals emerged as the most productive journals in the field.

Kim & others (2022) conducted a bibliometric study that included databases from Medline, Embase, and the Cochrane Library from inception until November 2021 to identify published studies on the use of Complementary and Alternative Medicine (CAM) interventions for long-term COVID. Using the bibliometric package for research, they analyzed the citations of publications using narrative analysis to determine the effectiveness and safety of CAM interventions. During the study period, there were 16 publications related to CAM, including 14 study protocols of systematic reviews or clinical studies. In addition, the authors revealed that the majority of study protocols were written by Chinese, Korean, and Indian authors, making them current research trends in the field. Finally, the authors emphasized the need for randomized control trials and systematic reviews due to the lack of published research on using CAM for long-term COVID and COVID-19 survivors.

Jin & others (2022) carried out a bibliometric study to assess and analyze the pattern of long COVID research literature and provide insights into the long COVID. The Scopus database yielded 784 papers with bibliographic information on long COVID studies. Regarding paper productivity and citations of long COVID research output, developed nations in Europe and the United States ranking top in the study in 2020 and 2021. *Nature Medicine* also had the most citations, according to the study. In contrast, the *International Journal of Environmental Research* and *Public Health* and the *Journal of Clinical Medicine* had the most publications.

Objectives

This study explores the Post-COVID-19 publications published in the PubMed database from 2020 to 2021. The specific objectives of the study are:

- To find out the publication type of Post-COVID-19 research
- To identify the most productive journals
- To identify the authorship pattern and most prolific authors in Post-COVID-19 research
- To discover the research productivity by language
- To determine the most productive countries in terms of Post-COVID-19 publications
- To detect the most frequently used keywords

Limitations of the Study

This study aims to conduct a bibliometric study on Post-COVID regardless of specific concerns or symptoms. Moreover, the study provides a general overview of the Post-COVID research publications and demonstrates some limitations inherent in the methodology of the bibliometric studies. As Akintunde *et al.* (2021) reported, false-positive and false-negative results are possible in all bibliographic studies. Therefore, only the PubMed database was used in this study, excluding other databases such as WoS, Google Scholar, and Scopus.

Methodology

PubMed database from the National Library of Medicine (NLM), the United States, was searched for Post-COVID-19 related publications from 2020/01/01 to 2021/12/31. The search was conducted during August and September 2022. All the articles retrieved from the above period were considered for the study. To search publications from the PubMed database, the term "Post-COVID"[All Fields] was used in the search field from 2020 to 2021. A bibliometric tool "BibExcel" version 2016, Microsoft excel 2010 and VOSviewer version 1.6.18 were used to analyze the collected data.

Results and Discussion

From the search, 2,766 publications were yielded on Post-COVID. It includes all publication types and source types from 2020/01/01 to 2021/12/31. Results were further analyzed according to different aspects such as top journals, authorship pattern, top contributing authors and co-authorship pattern, language productivity, contributing countries, and major keywords.

Source Type

Almost half of the publications related to Post-COVID are the Journal articles (n=1,374, 49.67%) followed by Journal article: Reviews (n=322), Case reports (n=181), Journal articles: Research support (n=143), Editorials (n=116) and Letters (n=110) respectively (Table 1).

Table 1: Source Type of Post-COVID-19 Research Publications

Document Type	Number of articles
Journal Articles	1,324
Journal Article: Reviews	322
Case Reports	181

Editorials	116
Letters	110
Other document types	520

Top Contributing Journals

The top 10 active journals contributed 17.66% of the articles to the field. Table 2 demonstrates the top 10 active journals in descending numerical order. The top three productive journals are *Cureus* ($n=65$), *International Journal of Environmental Research and Public Health* ($n=57$), and *Journal of Clinical Medicine* ($n=31$).

Table 2: Top 10 Most Active Journals in Publishing Post-COVID-19 Research

Journal titles	Number of articles
Cureus	65
Int J Environ Res Public Health	57
J Clin Med	31
PLoS One	23
Front Public Health	23
Indian J Ophthalmol	22
J Med Virol	18
Front Psychol	17
Ann Med Surg (Lond)	16
Environ Sci Pollut Res Int	16
Sci Total Environ	16
BMJ Case Rep	15
Front Psychiatry	14

Authorship Pattern

A total of 292 authors contributed to Post-COVID research, of which 2,671 publications were written by single authors (96.57%) while multiple authors contributed in 95 (3.43%) publications only.

Top Contributing Authors

There were 292 authors contributed in 2766 articles included in this study, with an average of 0.11 authors per article. Table 3 indicates the top three contributing authors for Post-

COVID related research. The most prolific authors (n=33) were Fernández-de-Las from King Juan Carlos University (Spain), Zhang Y from Biotherapy Center, Affiliated Hospital of Zhengzhou University (China), and Hernández-Barrera V from the Department of Public Health, Universidad Rey Juan Carlos (Spain). An Author, Co-authorship map is shown in Figure 1, which illustrates that Fernández-de-Las had the greatest total link strength (37) as he contributed in 16 papers, each with more than 14 authors.

Table 3: Top Most Prolific Authors Contributed in Post-COVID Research

Author	Number of articles
<i>Fernández-de-Las</i>	12
<i>Zhang Y</i>	11
<i>Hernández-Barrera V</i>	10

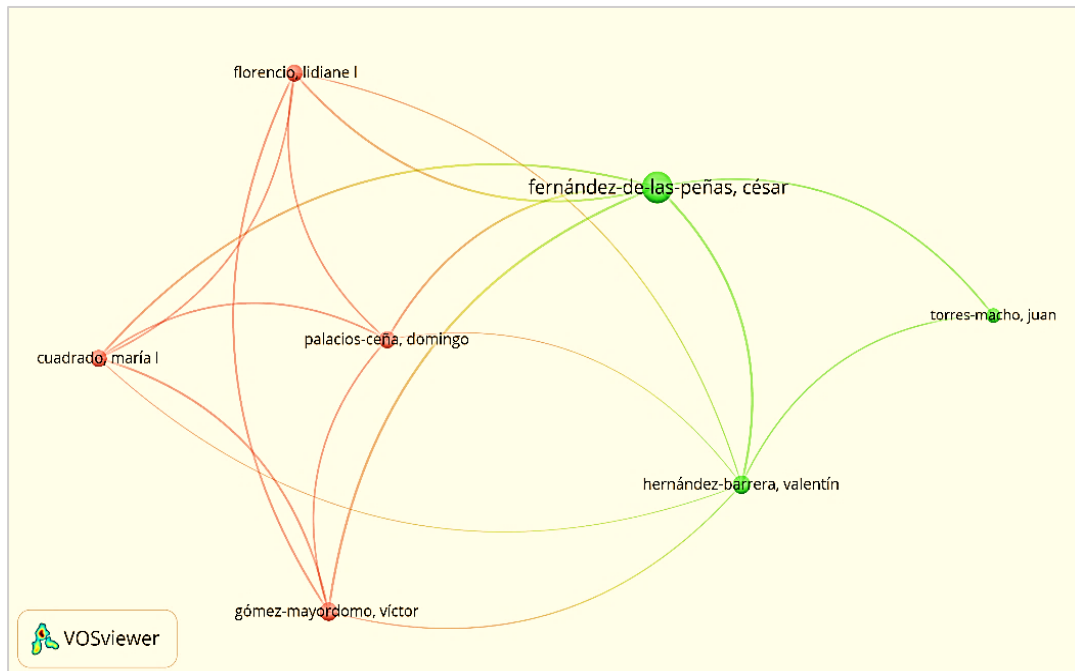


Figure 9: Network Visualization Map for Author Co-Authorship Relations

Language Productivity

Out of 2,766 publications, 95.81% (n=2,650) of the research were published in English, whereas only 116 (4.19%) were written in other languages.

Top Contributing Countries

The United States (n=165, 31.91%) and England (n=112, 21.66%) are the top in the list of countries most publishing Post-COVID related publications on the PubMed database.

Frequently used Keywords

Keyword analysis helps researchers to gain quick insight into specific areas. Therefore, in this study, VOSviewer was used for keyword co-occurrence analysis for the Post-COVID research publications via the PubMed database. A total of 100 keywords appeared more than five times and it was observed that predominantly MeSH was used for the selection of keywords, which is illustrated in Figure 2.

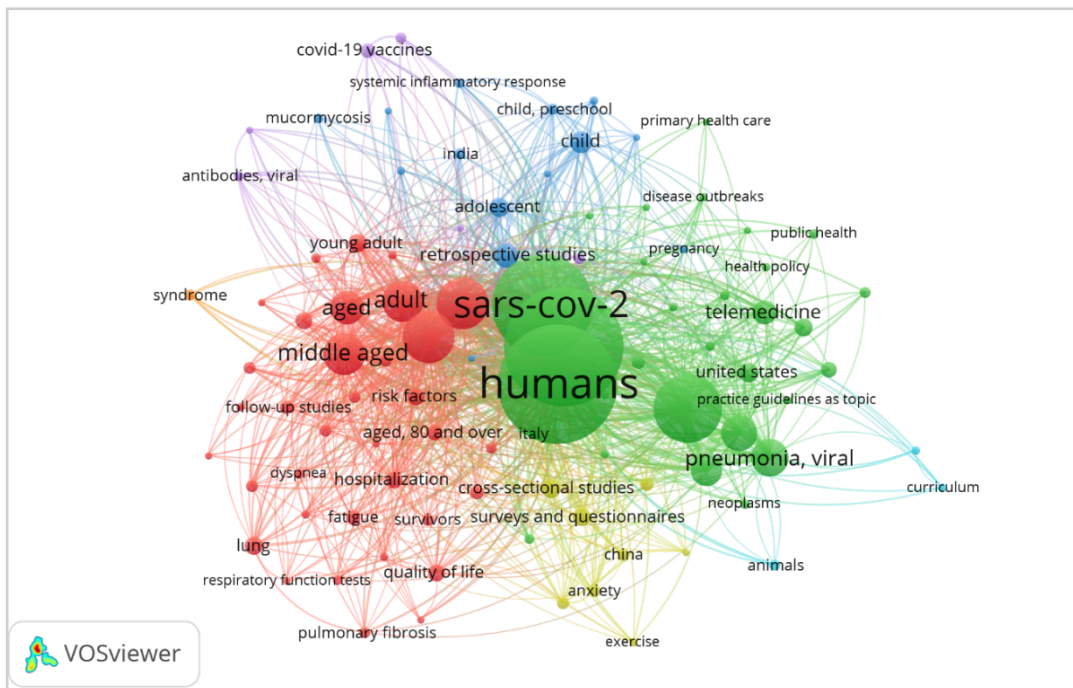


Figure 2: Co-occurrence Networks of MeSH Keywords Visualized by VOSviewer

Figure 3 demonstrates the ten most frequently used keywords. "Humans" was the most frequently used keyword, followed by "COVID-19" and "SARS-CoV-2". SARS-CoV-2 and COVID-19 often appear together in a paper, since both terms are used synonymously to describe the cause of a coronavirus. In addition, terms such as "Pandemics," "Female," and "Male," which describes the gender-wise effect of Post-COVID symptoms also used as keywords. Besides, "Middle-aged" and "Adult" were the next group of keywords used to indicate different age groups affected by Post-COVID symptoms and their frequencies were 304 and 285 times, respectively.

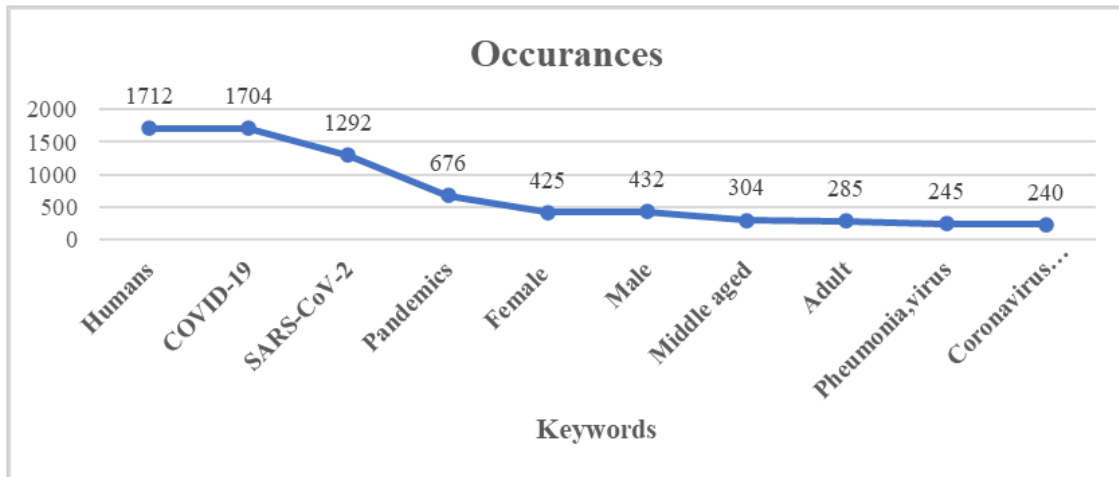


Figure 3: Top Ten Most Frequently used Mesh Keywords in Post-COVID-19 Research Publications During 2020-2021

Since this study covers only the period of 2020-2021, the search results are different with the exact keywords used in different periods due to the updates of the PubMed Database. Therefore, future studies need to be carried out in relation to keyword occurrences as per the relevance of the research studies.

Conclusion and Recommendations

This bibliometric study examined the research publications related to Post-COVID available in the PubMed database during the period 2020 to 2021, and analyzed the bibliometric characteristics such as source type, contributing journals, language productivity, authorship pattern and most prominent authors, contributing countries, and keywords used. The results showed significant progress in Post-COVID publications from 2020 to 2021.

Regarding the source type which has contributed as an evidence for research information, journal articles followed by reviews, case reports, editorials, letters, etc. were identified. Three prominent and prolific journals contributing to Post-COVID research are *Cureus*, *International Journal of Environmental Research and Public Health*, and *Journal of Clinical Medicine*.

Most research evidences published by individual authors and in English language. Furthermore, most contributed authors of the research output on Post-COVID were from Spanish, namely Fernández-de-Las from King Juan Carlos University and Hernández-Barrera V from the Department of Public Health, Universidad Rey Juan Carlos, who explored the Post-COVID symptoms (Fernández-De-las-peñas *et al.*, 2021).

The study also revealed that 45 countries, including both developed and developing countries, have contributed massively towards Post-COVID research. The majority of publications on Post-COVID were from USA and England, followed by Italy, Netherlands, and India. However, contributions to the study from developed countries are observed to help the people to identify the Post-COVID conditions regarding the COVID-19 pandemic.

Network visualization of keywords obtained from Post-COVID publications identified that "Humans," "COVID-19", and "SARS-CoV-2" are in the top three positions in the related field of study.

As per the retrieved research output, there were different research topics, such as management strategies, policies, complications, symptoms, treatment, therapies, etc. Therefore, the study recommends researching the effects of Post-COVID in different fields. Since this study covers only the literature available in the PubMed database, it is suggested to conduct future studies in broader perspectives by covering other relevant databases such as WoS, Science Direct, and Scopus. Further, this study recommends to conduct bibliometric analysis on a continued basis to elaborate on the findings of Post-COVID conditions.

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