The Bibliometric Global Overview of COVID-19 Vaccination

Richard Osei Agjei, Frank Adusei-Mensah, Oluwafemi Samson Balogun, Sunday Adewale Olaleye
Department of Health Administration and Education, University of Education Winneba, Ghana
Institute of Public Health and Clinical Nutrition, University of Eastern Finland, Kuopio, Finland
School of Pharmacy, University of Eastern, Finland
School of Business, JAMK University of Applied Sciences, Rajakatu 35, 40100 Jyväskylä, Finland.

Abstract

Given the dynamics of the economic and societal impact of the present COVID-19 pandemic and the global attempt to protect both socioeconomic well-being and human lives through vaccination, essential information and research result on the equitable distribution, effectiveness, and efficacy of vaccines is essential sparse. We conducted a bibliometric analysis to reveal research and knowledge on global vaccination of COVID-19, identify the current challenges of the vaccines rolled out, and find out how all these can influence global COVID-19 vaccine uptake. A systematic and comprehensive search of the Web of Science for literature to unravel the knowledge and research gaps regarding the global overview of the COVID-19 vaccination was conducted. We discovered low literature on COVID-19 vaccinations in Low and Middle-Income Countries (LMICs) and inequitable distribution. Therefore, we underscore the urgent need to activate, advocate, and develop evidence-based solid research to promote the globally efficacious and equitable distribution of COVID-19 vaccines.

Keywords: COVID-19, Vaccination, Vaccine, EHMS; bibliometrics, literature review, citation, and co-citation analysis

1. Introduction

One of the most significant medical discoveries of modern history is vaccines and vaccination. For the history of vaccines, read Pasteur's Louis work on vaccines, which forms the building blocks of all available vaccines, and argues that vaccines have been humanity's most significant medical advancement [1].

Vaccines remain one of the most cost-effective and efficient lifesaving public health interventions. Compared to government bonds, infrastructure investment, or any life science research, using vaccines for immunization returns more value, preventing diseases caused by pathogens through vaccination. The process of administering a vaccine is termed vaccination, and the vaccine, if efficacious, results in immunity, which is the process of immunization. Globally, a high proportion of mortality and morbidity occur by vaccine-preventable diseases. Therefore, improving immunization coverage yearly can save 1.5 million people out of the yearly 2-3 million deaths globally, which are prevented through vaccination and reduce health service pressures [2].

In the light of the COVID-19 pandemic, appreciating vaccination is more relevant in our contemporary time than ever because of the present debate and the challenge of vaccine hesitancy across the globe, particularly in low- and middle-income countries (LMICs) [2].

Informing and stimulating debate on the COVID-19 vaccination agenda for 2022 and promoting a coordinated and equitable distribution of vaccines is one of the greatest aims of COVAX [2]. To whom and when specific vaccines are recommended is often dependent on national vaccination programs and varies between countries. This variation is because each country often differs based on vaccine efficacy (effectiveness of a vaccine in perfect conditions), local disease epidemiology, vaccine effectiveness (effectiveness of a vaccine in real-world conditions). Similarly, Herd Immunity means a sufficient proportion of the population is immune to a disease, cost implications, and programmatic issues in terms of the number of vaccine doses needed. Going forward, therapeutic, and preventive vaccines for COVID-19 infections are critical.

Given the dynamics of the economic and societal impact of the present COVID-19 pandemic and the global attempt to protect both socioeconomic well-being and human lives through vaccination, essential information and research result on the equitable distribution, effectiveness, and efficacy of vaccines is essential sparse. The researchers conducted this study through a systematic and comprehensive search of Scopus and Web of Science for literature to unravel the knowledge and research gaps regarding the global overview of the COVID-19 vaccination. Next, considering some bibliometric indicators, the researchers conducted a bibliometric analysis of the literature obtained to gain insight into the trends of publication and nature of research on COVID-19 vaccination globally. This study is set out to provide answers to some questions:
What is the present situation of COVID-19 vaccination in literature across the globe?
How has research on vaccination, vaccine acceptance, or hesitancy evolved?

What are the ground-breaking publications and research results on COVID-19 vaccination? What impact has publications on COVID-19 vaccinations had over time?
Which researcher(s) has/have been the most productive and highest contributor(s) in COVID-19 vaccination research?

The remaining part of this paper is divided into sections; detailed research methodology; bibliometric methods review; results (sources of COVID-19 vaccination research, leading authors, leading continents, countries, institutions, and publication and citation trend on COVID-19 vaccination); development of a graphical analysis of the bibliographic data of COVID-19 vaccination with Biblioshiny software and the final section summarizes the main findings with a conclusion.

2. Material and Method

This study utilized the six steps of the bibliographic workflow proposed in Olaleye's [8] and Olaleye, Sanusi & Dada's [9] study, as shown in Figure 1. This study introduced five research questions in step one of the bibliometric workflows to answer the proposed research questions. The bibliometric method examines bibliographic data from published literature [10]. In this study, the bibliometric method is used to try to understand the phenomenon of covid-19 vaccination. The study extracted literature on vaccination from the Web of Science database in step two, while step three presents analyzed bibliometric data using Biblioshiny App. This study used Biblioshiny App to visualize the vaccination data in step four. In step five, this study presents the results generated from Biblioshiny and makes necessary interpretations based on the results. Finally, in step six, the study concludes with the finding's summary, the study's limitations, and proposes future studies.

Research Design	Bibliometric Data Source	Bibliometric Data Analysis	Data Visualization	Results and Interpretation	Conclusion

Fig. 1. Bibliographic Systematic Workflow

This study utilized the Web of Science because of its strengths as one of the leading databases worldwide. The search strings ((Abstract-Title-Keyword ("covid-19 vaccination")) were used for academic papers from 2022-222. The initial search generated 1954 academic papers; after rigorous inclusion and exclusion, the data was reduced to 1165. Finally, 1165 bibliometric data was used for data analysis with Biblioshiny App [11]. See below:

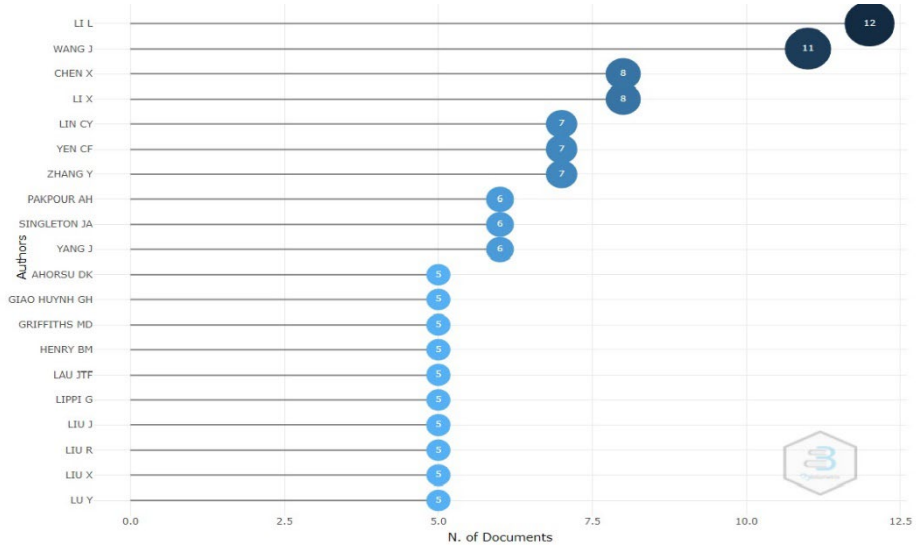
Initial Web of Science Search Results
1,954 results from Web of Science Core Collection.
Refinement
1,165 results from Web of Science Core Collection.
Inclusion and Exclusion Criteria
"Covid-19 vaccination" (Topic) and Articles (Document Types) and English (Languages) and Science Citation Index Expanded (SCI-EXPANDED) or Social Sciences Citation Index (SSCI) or Emerging Sources Citation Index (ESCI) (Web of Science Index).

2.1 Applied Bibliometric Methods In COVID-19 Vaccination

The application of statistical analysis to bibliometric data to analyze a segment of literature or identify patterns, which could include but are not limited to authorship and citation in a particular area to provide understanding, is often referred to as Bibliometrics [12-14]. Borgman [15], on the one hand, presents three types of bibliometrics: analysis of artifacts (websites, book chapters, and journals), analysis of the producers (institution, author), and analysis of concepts (subject areas or topics). Stevens [16], on the other hand, looked at bibliometrics in two ways, evaluative (considers citation trend, usage data, and h-index) and descriptive, which captures the institution, geographical area, and productivity of the author. Bibliometrics has also been categorized using authorship, year of publication, and literature relationships [17]. More importantly, a significant number of indicators earlier discussed were considered in this paper to provide better elucidation and divergent perspectives to proffer understanding to our results. Notwithstanding, productivity (the number of publications in a specified area of research) and influence, often known based on the number of citations, should be the main indicators in evaluating a research paper [18]. Hence, our analysis was based on influence, cites per paper, productivity, cites per year, yearly citation trend, types of outlets, continents (countries and geographical regions), and most productive institutions.

To minimize the potential of missing out on data from PubMed, Embase, etcetera, we used Bibliometrix R-package software [11] to analyze data from the Web of Science. Research by Olayemi et al. [19] suggests that many articles are captured with higher records relative to citations using the Web of Science as a database. Hence, we argue that all the relevant and available data to undertake this study successfully was carefully retrieved and analyzed all the indicators based on the number of papers and citations per million inhabitants. Biblioshiny analysis builds maps of authors' publications based on co-citations, co-occurrence, co-authorship, and citations of author keywords. Citation analysis is used to identify how the documents cite each other, usually by counting the number of times, for instance, 'article I' cites 'article II' and vice versa. However, if the same third source cites two documents (e.g., 'article I' and 'article II'), this is known as co-citation [20]. Co-authorship reveals the linkages or connections in co-authored documents by more than one institution, author, or country. Identifying the most occurring keywords used by the authors and keywords that more frequently appear in the same documents is considered the co-occurrence of author keywords.

3. Results



l

The COVID-19 pandemic is ongoing, and different research teams and health professionals are continuously looking for a better understanding of the disease, transmission mode, vaccination modalities, and efficacy [21], people's perceptions, and efficacy. The magnitude of the COVID-19 in all areas of life [22] has aroused the interest of researchers globally [23]. From the database search results, the top-4 authors produced 39 articles, all together, with Li L. (12) being the most prolific author with 12 publications, Wang with 11 publications, and Chen and Li X had eight publications each. The top 7 authors are dominated by researchers of Chinese origin, which observation buttress the fact that the pandemic originated from Wuhan, China, based on the available epidemiological data [1,24]. Hence, active research started in China before other researchers from other countries became interested in the topic.

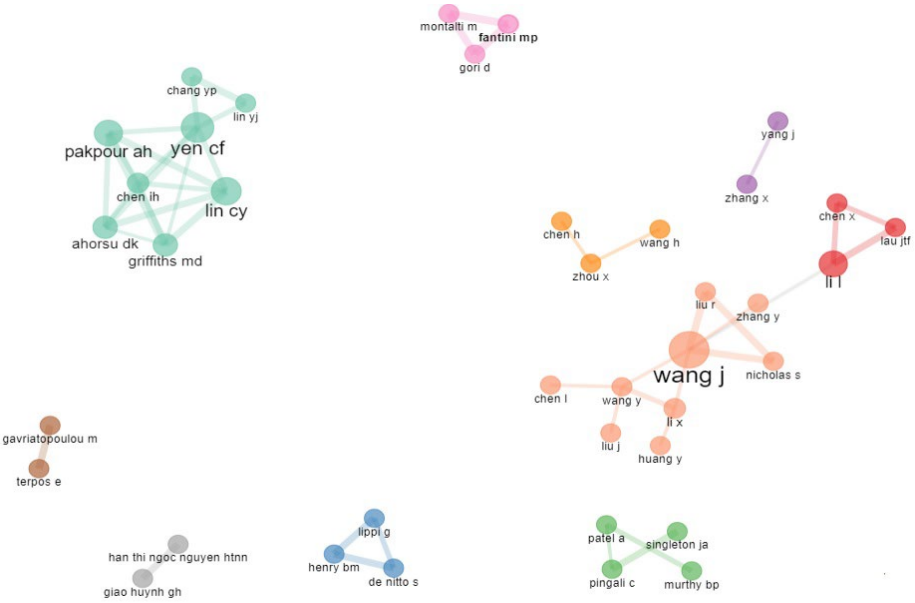


Fig. 4. Authors Collaboration Network

The global spread of the pandemic also boosted the collaborative research of interest groups for a common goal to monitor covid-19 vaccine uptake, efficacy, and covid-19 control. The figure is to scale, and the size of the ball indicates the size of the collaborative network (figure 4). The top three most collaborated researchers are Mang, the second most prolific author on the topic had the most extensive network beyond His/ her research institution (11) contacts in all; the following three are Lin, Yen, and Pakpour, which form a loop of research network within the same institution.

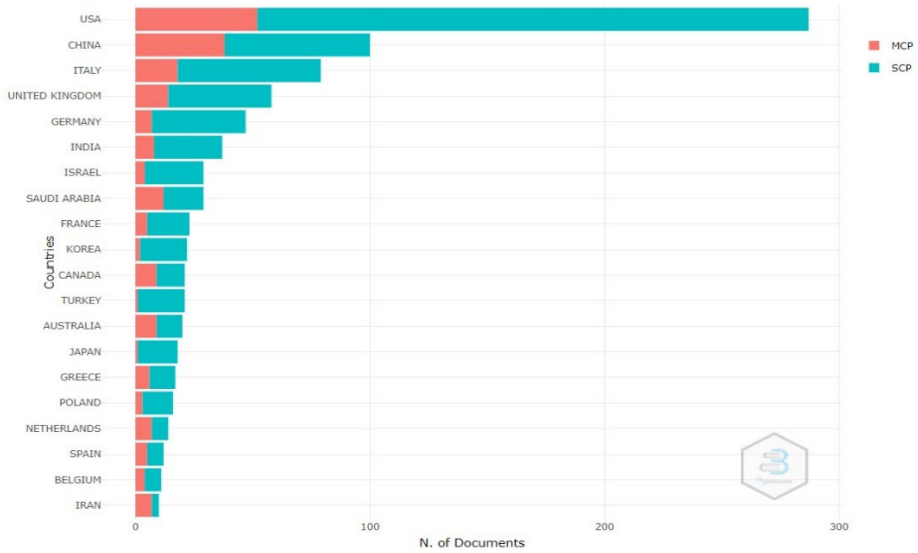


Fig. 5. Authors corresponding countries

The top three countries dominating this field of research are the USA, with over 250 papers, China (100 papers), and over 75 papers in Italy. It is worth mentioning that most of the corresponding authors based in the USA, China, Italy, and United Kingdom institutions have a network with foreign-based institutions. More than 75% of USA, Italy, and United Kingdom-based publications and about 60% of China-based publications were multiple countries; more than one country was involved. In those papers, the corresponding authors collaborated with other institutions and had more contacts outside their country. However, single country publications were higher in Saudi Arabia, constituting about 50% of the total papers published by corresponding authors based in Saudi Arabia.

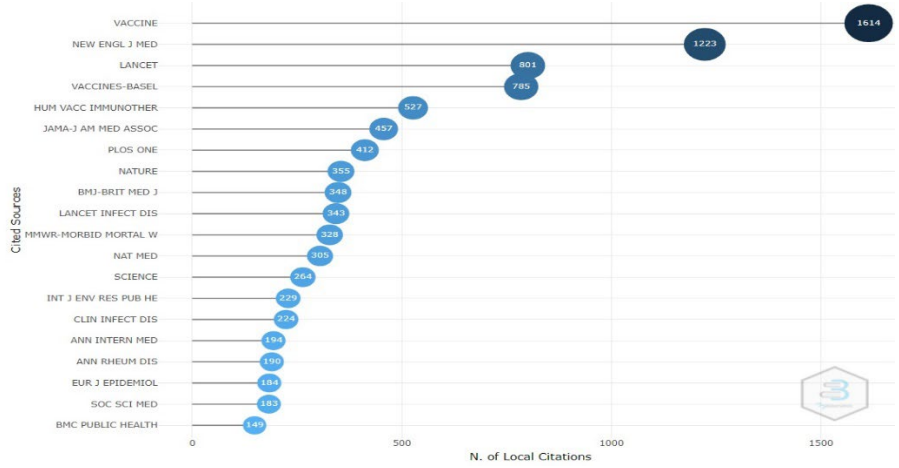


Fig. 9. Local Cited Sources

Figure 9 gives an overview of the journal citations concerning COVID-19 vaccine research. Vaccines as a source received 1614 citations leading to this category, followed by New England Journal of Medicine (1223) citations and the third place by the Lancet with 801 local citations.

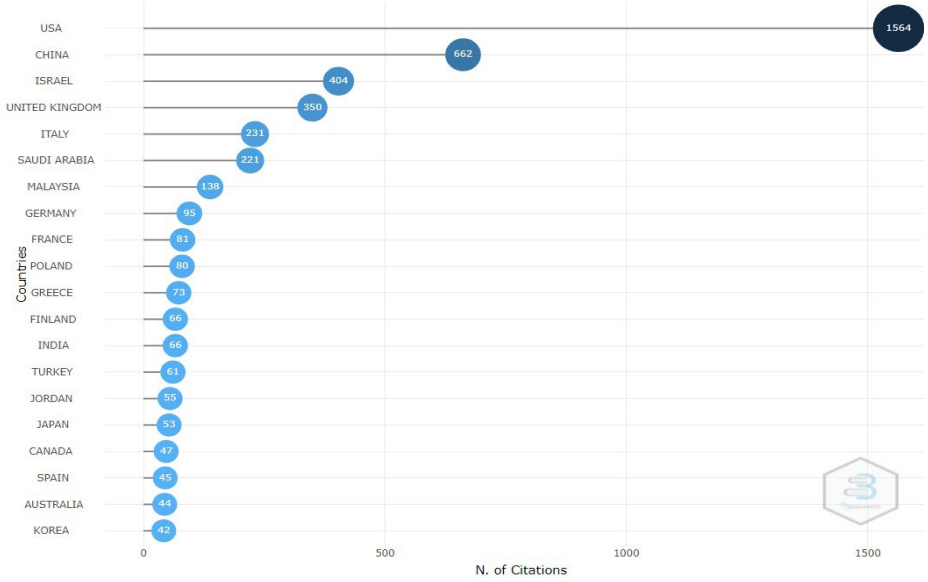


Fig. 14. Cited Countries

The country citations further buttress the country's performance doing well in this area of research. From the selected studies, the USA received 1564 citations leading all the countries and having over 200% more citations than the second-highest country (662). China received the second-highest citations with 662, and Israel received the third-highest citations with 404 citations.

4. Discussion

The availability of a safe and effective vaccine alone does not translate into saving lives; it is the inoculation plus other public health measures that do [24]. Vaccines train the immune system to create antibodies to the disease of interest. Though data on how long the obtained immunity from the various COVID-19 vaccine platforms will wan/last are lacking, the available data indicate their ability to safely protect the population from severe COVID-19 and mortality from the disease [25] and their ability to activate the cell-mediated immune response. Analysis of published data on the COVID-19 vaccine is a practical approach to evaluate scientific research output and trends in publication, active institutions, funding bodies, and top publishers active in COVID-19 vaccine research. Though there are thousands of data on the COVID-19 pandemic, data on its vaccines are yet to pick pace, and

bibliometric studies on COVID-19 vaccines are therefore very scanty. As a result, information finding by health practitioners, policymakers, and interested researchers for an informed decision is difficult. Bibliometric studies, therefore, helps in identifying the key players in the field for quick identification and policymaking. In a little of a year after the COVID-19 vaccine inception, knowledge on COVID-19 vaccine and vaccine uptake is already growing at a swift pace.

Thousands of documents have already been published on COVID-19 vaccines. During the present studies, we observed 1065 documents on the SARS-CoV-2/COVID-19 vaccine from the Web of Science database (Table 1) after removing duplications and non-journal, non-peer-reviewed papers. In previous studies, Xu et al. [26] identified 5070 from their database search on the COVID-19 vaccine in late 2021 [26]. The difference was based on a more stringent and focused search in the present study removing most documents that did not meet the study's goals. A total of 1065 documents published on the COVID-19 vaccine by 453 journals were included in the final analysis.

There is growing author productivity in the COVID-19 research. The selected articles were authored by 3526 authors showing high productivity by the author of 0.302 in the current study compared to the 0.234 papers/ author in Xu et al.'s study [26]. Though research on COVID-19 has reached an acceptable level already, the knowledge on COVID-19 vaccines, vaccine safety, efficacy, waning, and adverse health surveillance studies is now growing. A bibliometric study by Sarirete on COVID-19 and COVID-19 vaccines identified more papers than the present study; the authors used a different database platform, Web of Science, in the present study. Moreover, the search was not more specific as the research focused on two different themes in that study: trends in COVID-19 Vaccines and sentiment analysis [27] and similarly by Xu and colleagues [26].

In our present study, we observed the USA, China, Italy, and United Kingdom to be the top 4 most active countries in COVID-19 vaccine research from first to fourth positions, respectively. This observation, however, is like the previous work by [19]. Sarirete used Scopus compared to the Web of Science as used in the present studies. However, the differences in the database set may contribute to some extent to the variation in indexing bias. However, this could, if any, have been a negligible effect on the rapid change in trends. In another previous study by Xu and colleagues who used the Web of Science, the trend was USA, United Kingdom, Italy, and China from the first to fourth positions respectively compared to USA, China, Italy, and the United Kingdom in our present study. The rapid change in trend shows the rapid development of interest in COVD-19 and COVID-19 vaccine research. There has been a rise in interest in COVID-19 vaccine research in China and Italy in the past year leading to the United Kingdom moving to the fourth position from the second. Again, there is a sharp rise of Israel into the top-7 countries in COVD-19 research (figure 4) from below 10th in the previous research by Sarirete, [27] and Xu et al., [26]. Such finding depicts the active and vibrant COVID-19 vaccination program in Israel within the past year. Israel is indeed currently a leader in the world's COVID-19 vaccination campaign, thereby arousing the interest of researchers in Israel to want to know about the field and to monitor safety, efficacy, and waning of the immune response.

It is also important to note the variation and resemblances in research trends in COVID-19 research by both countries, authors, and institutions [28] and COVID-19 vaccine research trend as observed in Xu et al.'s study and in the present study. China dominated the most productive authorship position as in the present study but also dominated the most productive institution on COVID-19 research [28] compared to the USA in the present study.

It must be brought to notice at this point that the current study is more reliable in terms of the preciseness of the search and selected studies with COVID-19 and vaccination being the most used keywords whiles hesitancy is the most used keyword plus figures 17 and 18, respectively confirming the afore mention interest and dominant field of research. Authors interested in COVID-19 research are published in high-impact journals like Vaccines (129), followed by human vaccines and immunotherapies (64), and thirdly by the International Journal of Environmental Research and Public Health (34) (figure 9), forming the relevant journals. It is interesting to note that productive journals do not always translate into impact as they are not interchangeable. These groups of journals could be sources of reliable information for researchers and policymakers on COVID-19 vaccines.

5. Conclusion

A bibliometric approach is used in this study to look at the worldwide immunization against covid-19. Bibliometrics is a powerful and valuable instrument in this study because of its objective and the nature of the research [29-30]. More than a dozen topics were covered, including the most prominent authors and collaborators, the most referenced journals, nations, and institutions, and the most common and rising research terms. While previous research has focused on covid-19 vaccination, this study expands the scope to include investigations on

other vaccines and their efficacy. Using the Web of Science database, this study obtained a total of 1065 records. The scientific community will benefit greatly from this study's numerous contributions. According to the study, there are three clusters for the author's keyword and six clusters for the author's keyword plus. Countries from Asia, South America, North America, Europe, and Africa accounted for most country collaborations. According to the results, Fudan University, with 50 papers on covid-19 vaccination, has the most robust collaborative network.

China and the UK were found to be the most influential in this research field, followed by China and Sweden. The dendrogram showed the hierarchical cluster of the topics used in the research. Using authors' keywords and keywords plus, the investigation uncovered the most trending topics in worldwide covid-19 vaccine research.

This study makes a two-fold contribution to the body of knowledge. Firstly, a Bibliometric study of a vast body of literature yields an in-depth look into the worldwide covid-19 vaccine research, including current hot topics, patterns in development, and potential future research areas. Research on global covid-19 vaccination might be expanded considering the findings presented here. As a result of this study's focus on themes and clusters will serve as a model for future investigations and contributions to the future research agenda.

5.1 Limitations of The Study

There are certain limitations to this research. The study's major flaw is the collecting of sample data. The software used to analyze the data had a technical issue preventing the study's authors from combining multiple sources. This analysis relied on a sample drawn from the Scopus database, which omitted important information. Collecting data from many databases, independent of the others, would add a great deal to the study's value. Search terms should also be adjusted to include more relevant keywords when searching the database. In the future, researchers should investigate ways to collect data from numerous databases with broader keywords to conduct a more comprehensive study.

In summary, this study believes that its findings will help academics, particularly new researchers, understand the research environment and potential research hotspots related to the worldwide covid-19 vaccine. Those new to the subject of worldwide covid-19 vaccine research will be able to quickly find the most important papers, prolific authors, and research hotspots. It also reveals new areas of research in global covid-19 immunization that should be explored further to link to examine the global covid-19 vaccination.

5.2 Future studies

Using AI to research the worldwide vaccination of covid-19 highlights the need for more studies to examine the vaccine's efficacy. This study's conclusions include some recommendations for further research towards the worldwide covid-19 vaccine, including. Research cooperation between academics and institutions should be expanded to have a more significant worldwide influence on examining the global vaccination potentials for covid-19. Second, the study suggests that learning analytics, machine learning, and deep learning are future research issues in the investigation of global covid-19 immunization. It is recommended that scientists devote more time and resources to these areas.

References

[1] Worboys, M.: Vaccines: conquering untreatable diseases. BMJ, 334(suppl 1): s19–s19, (2007).
[2] World Health Organization.: The Global COVID-19 Vaccination Strategic Vision for 2022, (2021).
[3] United Nations Children's Fund (UNICEF).: COVID-19 Vaccine Hesitancy Survey Report 2021, (2021).
[4] World Health Organization.: The access to COVID-19 tools (ACT) accelerator, (2020).
[5] Gavi the Vaccine Alliance.: About our alliance, [Accessed 1st August 2022]. https://www.gavi.org/our-alliance/about.
[6] Eccleston-Turner, M. & Upton, H.: International collaboration to ensure equitable access to vaccines for COVID-19: the ACT-Accelerator and the COVAX facility, Milbank Q; 99:426–49, (2021).
[7] Fedson, D. S. & Dunnill P.: Commentary: From scarcity to abundance: pandemic vaccines and other agents for "have not" countries. J. Public Health Policy; 28:322–40, (2007).
[8] Olaleye, S.: Visualizing Cultural Emotional Intelligence Literature: A Bibliometric Review 2001 – 2020. Publications of *Seinäjoki University of Applied Sciences* B. Reports 160: 142 – 156 (2020).
[9] Olaleye, S. A., Sanusi, I. T., Dada, O. A.: Bibliometric Structured Review of Mobile Information Systems, *In International Conference on Human-Computer Interaction* (pp. 284-297). Springer, Cham, (2021, July).

[10] Liu, Z., Yin, Y., Liu, W., & Dunford, M.: Visualizing the intellectual structure and evolution of innovation systems research: a bibliometric analysis. *Scientometrics*, *103*(1): 135-158, (2015).
[11] Aria, M., Cuccurullo, C.: Bibliometrix: An R-tool for comprehensive science mapping analysis, Journal of Informetrics, 11(4): 959–975, (2017).
[12] Pritchard, A.: Statistical bibliography or bibliometrics. Journal of Documentation, 25(4): 348–349, (1969).
[13] Broadus, R.: Toward a definition of 'bibliometrics. Scientometrics, Vol. 12, Nos. 5–6: pp.373–379, (1987).
[14] Welsh, T. S.: Qualitative and quantitative methods in libraries journal special issue: bibliometrics and scientometrics. Qualitative and Quantitative Methods in Libraries, 1–3, (2017).
[15] Borgman, C. L.: Bibliometrics and scholarly communication: editor's introduction. Communication Research, 16(5): 583–599, (1989).
[16] Stevens, R. E.: Characteristics of Subject Literatures, Publications Committee of the Association of College and Reference Libraries, Chicago, (1953).
[17] Nicholas, D., Ritchie, M.: Literature and Bibliometrics, C. Bingley, London, (1978).
[18] Podsakoff, P., Mackenzie, S. B., Podsakoff, N. P., Bachrach, D. G.: Scholarly influence in the field of management: A bibliometric analysis of the determinants of university and author impact in the management literature in the past quarter century. Journal of Management, 34(4): 641–720, (2008).
[19] Olawumi, Olayemi, Olaleye, Sunday, Adusei-Mensah, Frank & Olawuni, Adedayo, Agjei, Richard: Adoption and implementation of electronic healthcare management system -a bibliometric approach. International Journal of Electronic Healthcare, 12, (2021).
[20] Small, H.: Co-citation in the scientific literature: A new measure of the relationship between two documents. Journal of the American Society for Information Science, 24(4): 265–269, (1973).
[21] Adusei-Mensah, F.: Pertussis Vaccine; the Past, the Present and the Future (A Mini Review). Texila International Journal of Public Health, 6(2):129–137, (2018).
[22] Sauramäki, J., Adusei-Mensah, F., Hakalehto, J.-P., Armon, R., Hakalehto, E.: 7 Pandemic situation and safe transportation, storage, and distribution for food catering and deliveries, (pp. 149–172), (2021).
[23] Hakalehto, E., Heitto, A., Adusei-Mensah, F., Pesola, A., Pesola, J., Armon, R.: 6 Different strategies for viral and bacterial prevention and eradication from foods, (pp. 107–148), (2021).
[24] Adusei-Mensah, F., Inkum, I. E.: Overcoming COVID-19 vaccine preferential bias in Europe: Is the end of the pandemic still foreseeable? (p. 2021.06.23.21259422), medRxiv (2021).
[25] Adusei-Mensah, F., Agjei, R. O., Awoniyi, L. O., David, L. K., Awoniyi, F. B., Adeyemi, O. S., Olawuni, A., Adegbite A.: Prevention and Control of Acute Respiratory Viral Infections in Adult Population: A Systematic Review and Meta-Analysis on Ginseng-Based Clinical Trials, (p. 2021.07.23.21260970). medRxiv (2021).
[26] Xu, Z., Qu, H., Ren, Y., Gong, Z., Ri, H. J., Zhang, F., Chen, X., Zhu, W., Shao, S., Chen, X. "Update on the COVID-19 Vaccine Research Trends: A Bibliometric Analysis", Infection and Drug Resistance, 14: 4237–4247, (2021).
[27] Sarirete, A.: A Bibliometric Analysis of COVID-19 Vaccines and Sentiment Analysis. Procedia Computer Science, 194:280–287, (2021).
[28] Abd-Alrazaq, A., Schneider, J., Mifsud, B., Alam, T., Househ, M., Hamdi, M., Shah, Z.: A Comprehensive Overview of the COVID-19 Literature: Machine Learning–Based Bibliometric Analysis. Journal of Medical Internet Research, 23(3): e23703, (2021).
[29] Mayr, P., Scharnhorst, A.: Combining bibliometrics and information retrieval: Preface. Scientometrics, 102(3): 2191–2192, (2015).
[30] Cobo, M. J., Martínez, M. Á., Gutiérrez-Salcedo, M., Fujita, H., Herrera-Viedma, E.: 25 years at knowledge-based systems: A bibliometric analysis. Knowledge-Based Systems, 80: 3–13, (2015).