

## Review Article

# Manufacturing Technology and Effectiveness of Corona Vaccines: A Bibliometric Review

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## ABSTRACT

The etiology of "Covid-19," a respiratory illness, was first identified in late 2019 as the causative agent of the novel coronavirus. The conclusion of the pandemic was declared in 2023, and during this interval, a range of vaccines employing diverse strategies were developed. The effectiveness and other immunological characteristics of these vaccines have been thoroughly evaluated. The publication of documents related to the vaccines has persisted even after the conclusion of the pandemic. This study was conducted to investigate the research process and published documents related to the manufacturing technology and effectiveness of the vaccines. The documents published in the Scopus database in early 2024 were collected using restrictions in four subject areas and the English language. The bibliographic analysis was conducted using the Bibliometrix package in Rstudio and VOSviewer. A total of 2,810 documents were reviewed. The majority of these documents were articles and reviews, with 2,320 and 394 documents falling into these categories, respectively. Peptides and capillary electrophoresis emerged as prominent subjects in 2024. Furthermore, elasomeran, covilo, and tozinameran emerged as more recent than other keywords based on their temporal distribution. This study examines the documents published in one of the most reliable databases of vaccines against the novel strain of severe acute respiratory syndrome (SARS-CoV-2) from a bibliometric perspective. The findings of this study are expected to provide valuable insights and direction for future research initiatives, opportunities, and challenges in this field.

**Keywords:** Vaccine, COVID-19, 2019-nCov, SARS-CoV-2, Bibliometric.

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## 1. Context

Zoonotic diseases are a common occurrence, manifesting as illnesses transmitted among humans and various species of animals. These diseases are caused by pathogens, which are microscopic organisms that can cause disease. The etiological agent responsible for the global pandemic of severe acute respiratory syndrome (SARS-CoV-2) is a virus belonging to the Coronaviridae family, which is known to cause respiratory illness in humans (1-4). The conclusion of this pandemic was declared in 2023. Concurrent with the pandemic, research was conducted in select countries, and the findings were subsequently disseminated. These investigations have persisted to the present. A prevailing theme in the field of CoV-19 research pertains to the development of vaccines for disease prevention. Among the vaccine candidates under consideration are nucleic acid-based, inactivated, virus-like particles, and live attenuated virus vaccines (5, 6). A number of RNA-based vaccines are currently in development, including Tozinameran, Elasmomeran, and Gemcovac. The ZyCoV-D vaccine, in contrast, is based on deoxyribonucleic acid (DNA). Nuvaxovid, Covovax, Zifivax, Corbevax, and Razi Cov Pars vaccines are of the protein subunit type. Covaxin, Covilo, VLA2001, and CoronaVac represent examples of inactivated coronavirus vaccines. The Covifenz vaccine is a type of virus-like particles (7). A plethora of documents have been published on the subject of the novel coronavirus, including research articles, review articles, conference proceedings, and books. These documents can be found in search databases such as Scopus, Web of Science Core Collection Database, and PubMed. A substantial body of research in the field utilizes mathematical methods for the analysis of large document collections through bibliometric analysis. This bibliometric analysis encompasses the examination of keywords, authors, countries of origin, and organizational affiliations. The obtained results can be classified from the most to the least and from the newest to the oldest mentioned items. A particularly noteworthy and pragmatic analysis entails the identification of the document, author, organizational affiliation, and country that has been cited most frequently. By studying the research process in a bibliographic analysis, researchers are provided with the conditions to identify opportunities, challenges, and hot spots (8-10). The present study is a bibliometric review article that examines the publication process of documents in the Scopus database. The objective of this study is to examine the manufacturing technology and effectiveness of corona vaccines. The study undertakes a comprehensive examination of the existing state of research and published documents in the designated area, presenting the findings in the form of categories of keywords, authors, sources, and trend topics.

## 2. Data Acquisition

The present study was conducted by collecting information in the Scopus database (<https://www.scopus.com/>) on

January 30, 2024. The search terms included "Coronavirus disease 2019" OR "Coronavirus disease-2019" OR "Severe acute respiratory syndrome coronavirus 2" OR "Severe acute respiratory syndrome coronavirus-2" OR "COVID-19" OR "COVID 19" OR "2019-nCov" OR "2019 nCov" OR "SARS-CoV-2" OR "SARSCoV- 2." AND ("vaccine" OR "autovaccine") OR "Autogenous vaccine\*" OR "Active immunization" OR "Mass immunization" OR "Mass vaccination" AND ("Effectiveness") AND ("Technology" OR "Technology" OR "Procedure"). OR "Method\*" OR "Performance\*" OR "Biotechnology" OR "Technique\*" was searched in the title, abstract, and keywords. Subsequently, the limitations of the English language and four subject areas were applied: 1) medicine, 2) immunology and microbiology, 3) biochemistry, genetics and molecular biology, and 4) pharmacology, toxicology, and pharmaceuticals. No time filters were applied. The final number of documents collected from the Scopus database was 2,810, meeting the aforementioned conditions. The collected documents were subjected to bibliometric analysis using VOSviewer v.1.6.16 (<http://www.vosviewer.com/>) (11) and Bibliometrix (<http://www.bibliometrix.org/>) in Rstudio (12). Due to the collection of documents from a single database, it was not feasible to eliminate duplicate documents.

## 3. Results

### 3.1. Main Information

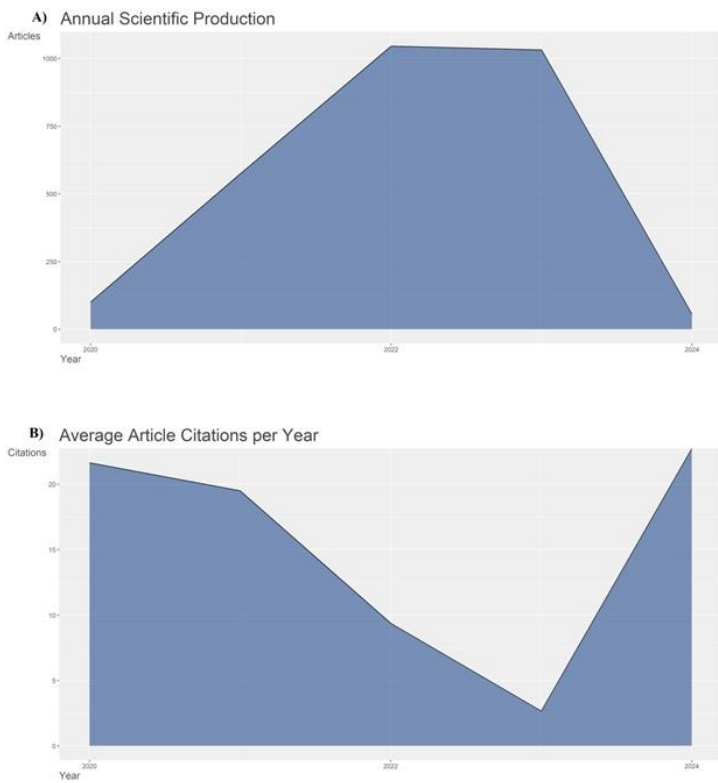
A total of 2,810 documents were subjected to analysis, contingent upon the criteria delineated in Section 2. The documents were classified into the following categories: articles (n=2320), books (n=2), book chapters (n=7), conference papers (n=9), editorials (n=16), erratums (n=8), letters (n=19), notes (n=26), retracted documents (n=1), reviews (n=394), and short surveys (n=8). The majority of the documents are classified as articles and reviews. The ratio of articles to reviews was determined to be 5.88:1. In the analysis of keywords, the number of keywords plus (ID) and author's keywords (DE) were determined as 10,118 and 4,715, respectively. The export of additional collection information from the Scopus database is illustrated in Table 1. As no temporal constraints were imposed during the data collection process, the results obtained from Table 1 indicated that these documents were published in the Scopus database during the period from 2020 to the time of data extraction in 2024. Consequently, as of 2020, no document published in the Scopus database satisfied the criteria outlined in Section 2. The results of annual scientific production and average article citations per year are shown in Figure 1. According to this figure, the highest number of documents was published in 2022 (n=1046). However, a significant decrease in average article citations per year is observed in 2023.

### 3.2. Analysis of keywords, Authors, and Sources

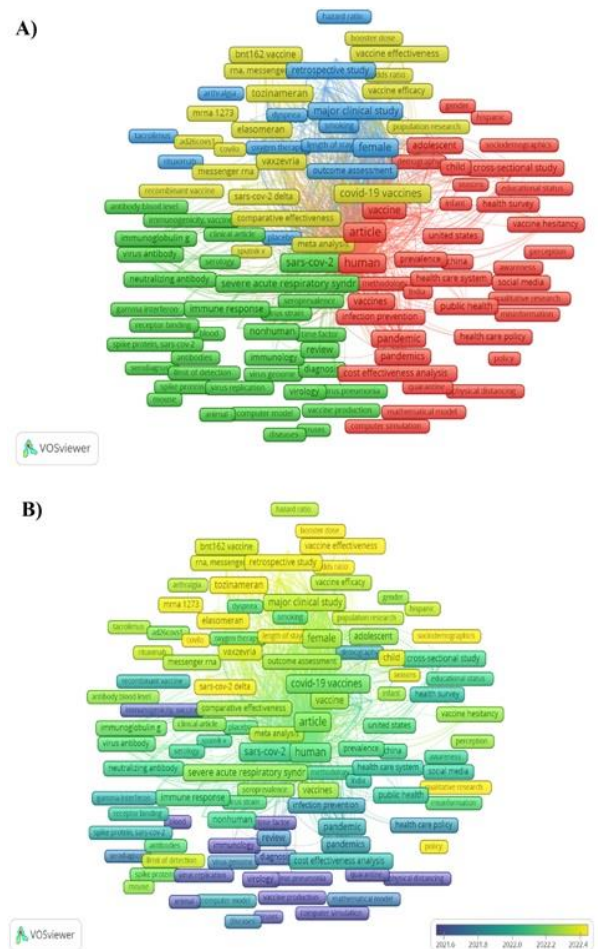
The results of the keyword analysis, as performed with the VOSviewer software, are displayed in Figure 2. The co-occurrence of both author keywords and index keywords

**Table 1:** The main information of the documents exported from the Scopus database (n = 2810).

Main Information About Data		Authors		Authors Collaboration	
Timespan	2020:2024	Authors	23816	Single-authored documents	76
Sources (Journals, Books, etc)	866	Author Appearances	32109	Documents per Author	0.118
Documents	2810	Authors of single-authored documents	73	Authors per Document	8.48
Average years from publication	1.87	Authors of multi-authored documents	23743	Co-Authors per Documents	11.4
Average citations per documents	23.04			Collaboration Index	8.71
Average citations per year per doc	6.435				



**Figure 1:** Analysis of documents and citations by year. A) Annual scientific production, and B) average article citations per year



**Figure 2:** keyword analysis. A) Keyword clustering: Each color belongs to a cluster. B) Classification of keywords by year: Light-colored boxes (yellow) are newer than dark-colored boxes (purple).

with a minimum occurrence of 20 times for a keyword was considered. This analysis identified 716 keywords that met these criteria, which were subsequently grouped into four distinct clusters. Furthermore, keywords such as interleukin 2, sars-cov-2 delta, elasomeran, covilo, and tozinameran are more recent than other keywords based on time. The top authors and their productions are shown in Figure 3. The results of this analysis indicate that a small number of

authors have continuously published documents from 2020 to the time of this review. The top document publishing sources and their growth trends by year are shown in Figure 4. The analysis reveals that the Vaccines (<https://www.mdpi.com/journal/vaccines>) and Vaccine (<https://www.sciencedirect.com/journal/vaccine>) journals have the highest number of documents during the years 2022 until the time of this review.

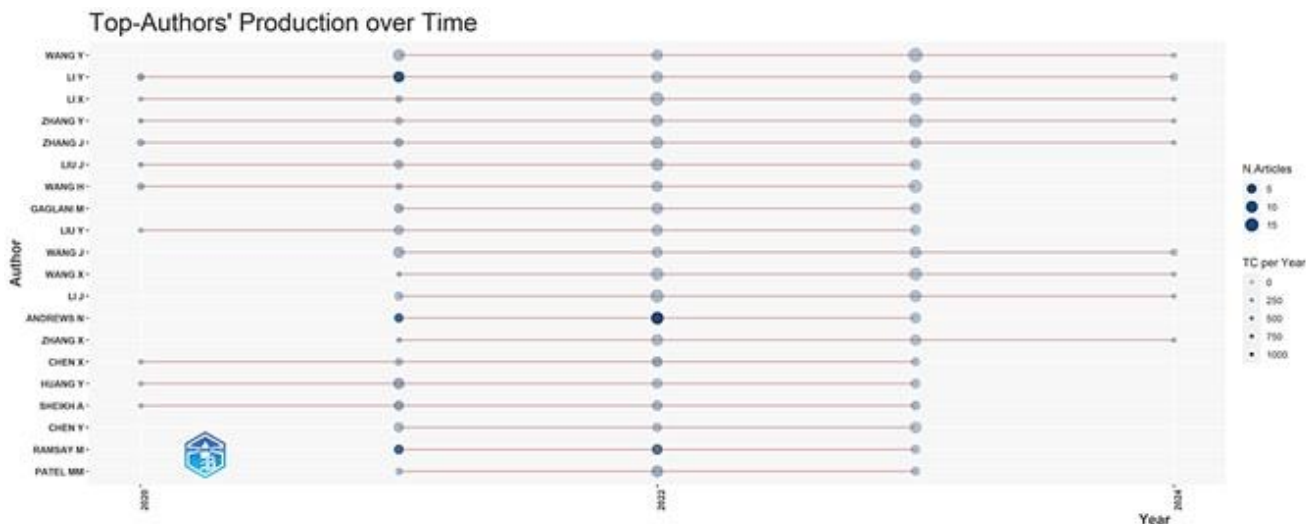


Figure 3: The productions of the top authors over time.

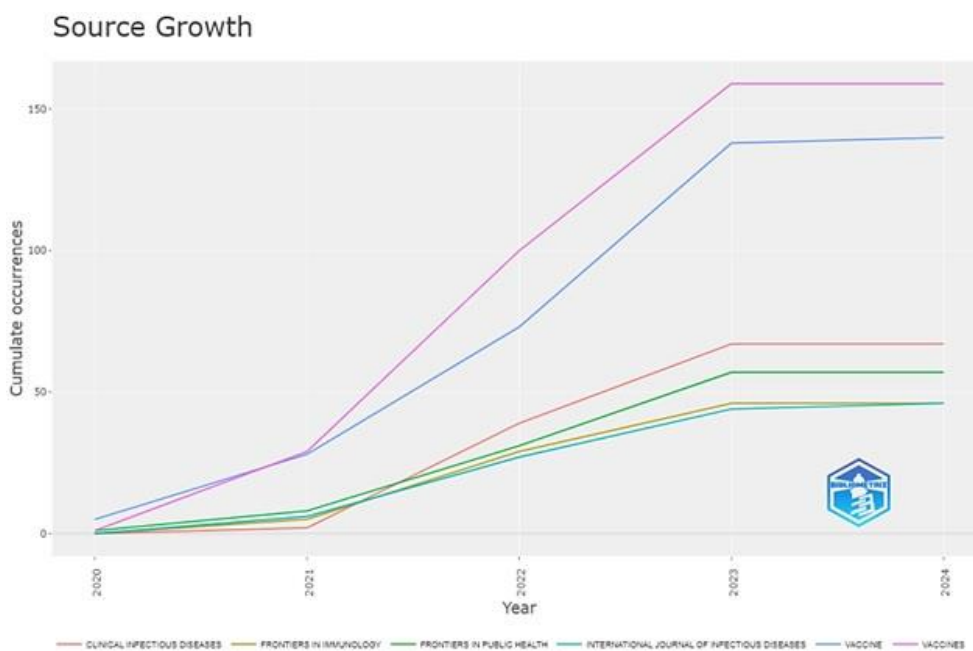


Figure 4: The source dynamics of research shown regard to year of publication.

**3. 3. Most Cited Documents and Countries**

The most frequently cited global documents, as determined by total citation (TC) per year, are enumerated in Table 2. According to the data presented in the table, the document authored by Voysey et al. (2021) has the highest total citation (TC) and also the highest TC per year (13). The document's authorship is attributed to a collaborative effort involving over 50 researchers and authors. The United Kingdom and the USA have the highest total citations, with 15,377 and 11,083, respectively. The average article

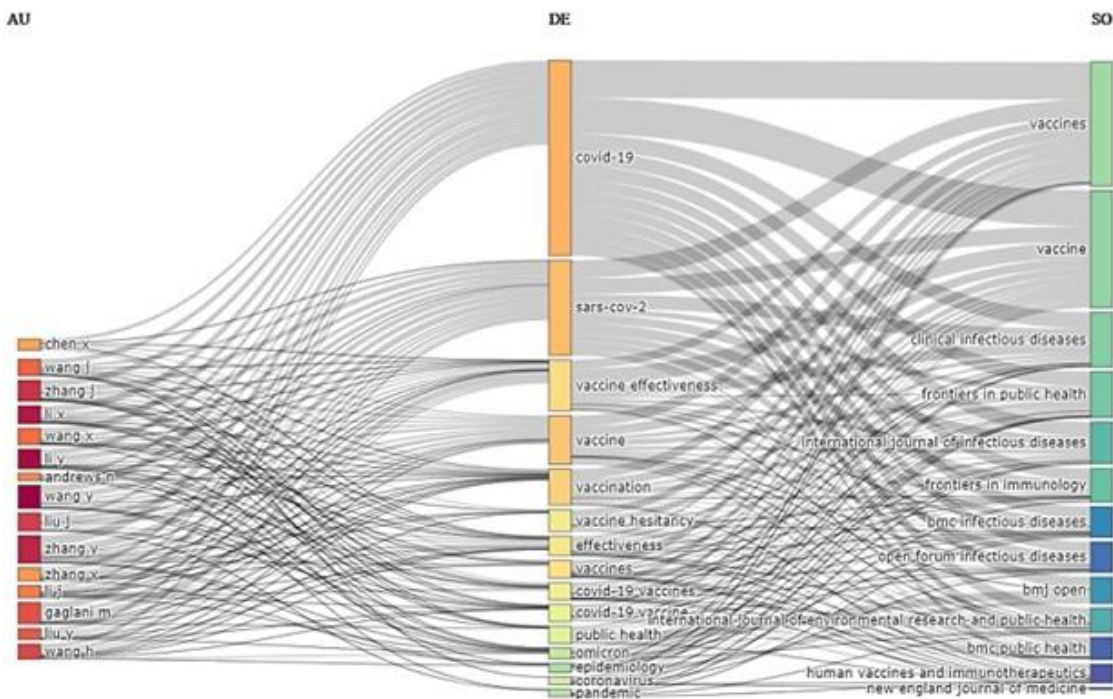
citations for the United Kingdom and the USA were determined to be 83.119 and 20.833, respectively.

**3. 4. Three-Fields Plot**

The relationship between the best in the three fields of keyword, author, and source is illustrated in Figure 5. In each column of the figure, boxes with taller heights are superior to their counterparts. A further analysis reveals that the keywords "Covid-19" and "sars-cov-2" are mentioned in the documents of all the authors listed in Figure 5.

**Table 2:** Most global cited documents based on TC per year.

Rank	Title	Total Citations	TC per Year	Normalized TC	Ref
1	Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK	3185	796.25	54.4509	(13)
2	Effectiveness of Covid-19 Vaccines against the B.1.617.2 (Delta) Variant	1764	441	30.1574	(14)
3	BNT162B2 mRNA covid-19 vaccine in a nationwide mass vaccination setting	1658	414.5	28.3452	(15)
4	Safety and efficacy of single-dose Ad26.CoV2.s vaccine against covid-19	1531	382.75	26.174	(16)
5	Covid-19 Vaccine Effectiveness against the Omicron (B.1.1.529) Variant	1262	420.667	67.2809	(17)
6	Waning immune humoral response to BNT162B2 COVID-19 vaccine over 6 months	1048	262	17.9167	(18)



**Figure 5:** Three-field plot of top keywords (middle), top authors (left), and top sources (right).

### 3.5. Trend Topics

As illustrated in Figure 6, the trending topics are identified based on a minimum frequency of the word occurring five times. The results presented in this figure indicate that terms such as peptides and capillary electrophoresis are trending topics in 2024. According to the time of collecting information from the Scopus database, the frequency of these terms is less than 1000. The most prevalent terms are "vaccination," "human," "coronavirus disease 2019," "Covid-19," and "article." The frequency of each of these terms was determined to be approximately 2000. The analysis of documents published in databases or scientific search databases determines the trend of topics from the past to the present. These results can be useful for researchers by illuminating areas of high interest and identifying scientific gaps (19). Bibliometric analyses have proven to be a valuable instrument in various domains of microbiology (20). Previous bibliometric reviews on the subject of the novel coronavirus (SARS-CoV-2) have been conducted by researchers (21-24). The analysis in these studies employed the VOSviewer software, a tool that facilitates the visualization of research networks and the identification of research trends. However, the current research is one of the most recent studies in terms of database, time period, and limitations applied in data extraction and analysis using R software. As this review was conducted at the beginning of 2024, the number of published documents is the lowest ( $n = 56$ ) compared to previous years. This observation should be considered when evaluating the trend topics identified in the 2024 review. The paucity of published books, as indicated by the number of articles and reviews, is particularly noteworthy. This paucity of published books may be explained by the temporal limitation of the review period. The keyword analysis reveals the presence of three distinct vaccines: Elasomeran, Covilo, and Tozinameran, all of which are

associated with the treatment of or prevention of the effects of the SARS-CoV-2 virus. Elasomeran is produced by Moderna, while Tozinameran is manufactured by Pfizer-BioNTech. A notable characteristic of both vaccines is their reliance on mRNA technology. Covilo, an inactivated virus vaccine, is produced by Sinopharm. The non-proprietary names assigned to Elasomeran, Tozinameran, and Covilo are mRNA-1273, BNT162b2, and BBIBP-CoV, respectively (7). The research article by Mohammadi et al. (25) and the review by Stefanik et al. (26) provide a comprehensive overview of the trend topics for 2024, including "peptides" and "capillary electrophoresis." These documents posit that viral peptides possess certain advantageous characteristics that render them suitable vaccine candidates, including hydrophilicity, flexibility, antigenicity, and charging characteristics (25). Additionally, the capillary electrophoresis technique is presented as a cost-effective alternative for investigating peptides (26-30).

### 4. Conclusion

In this study, no time limit was applied to the collection of documents. However, a review of the Scopus database revealed that documents pertaining to the manufacturing technology and effectiveness of the Corona vaccine were identified in the following four subject areas: 1) medicine, 2) immunology and microbiology, 3) biochemistry, genetics and molecular biology, and 4) pharmacology, toxicology, and pharmaceuticals, beginning in 2020. This is due to the fact that the development and testing of the vaccines for the novel strain of the virus, known as "Covid-19," had already been initiated prior to the onset of the pandemic. This issue will be addressed in the aforementioned areas following the conclusion of the coronavirus pandemic.

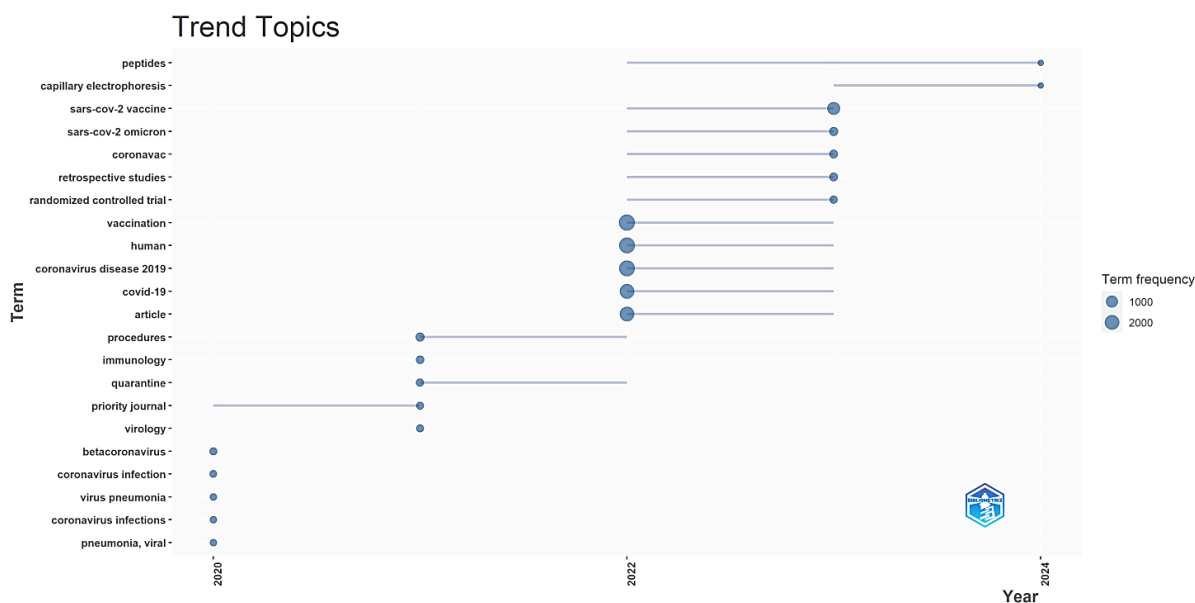


Figure 6: The trending topics of research by year in the field of corona vaccine.

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Not applicable

**Authors' Contribution**

Experimental work: R. Gh. & A. K.

Writing of manuscript: Kh. F. & H. S.

Statistical work: B. Z. & TM. M.

Supervisor the research: D. M. & H. M.

**Ethics**

All authors approve the ethics in this study

**Conflict of Interest**

The authors have not disclosed any conflicts of interest.

**Data Availability**

Data will be available after publication

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