Re-envisioning Library and Information Services in the Agile Era

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Chapter

15

Mapping and Visualizing Research of COVID-19 with Immunology: A Bibliometric Study

— S. K. Panda, Dr. Atul Bhatt & Dr. Aparna Satapathy

Abstract :

This paper aims to demonstrate the World's scientific contribution to COVID-19 and Immunology research for 2020–2022 and the emerging research pattern using various bibliometric parameters. The research publications were retrieved from the SCOPUS database and analyzed using MS Excel, R Studio, and VOS Viewer software. The VOS Viewer software is mainly used for networking and visualization to understand the research pattern better. A total of 2877 documents were retrieved from SCOPUS using the search topic COVID-19 and Immunology. The research found that DIAO B was a prolific author in COVID-19 and Immunology research, with 1247 publications. The most productive countries and institutions in this field were the USA (555 publications) and Huazhong university of science and technology (409 publications). The five hot author keywords are COVID-19, Sars-cov-2, Vaccine, Coronavirus and Antibody. The present study provides various networking map of research publications regarding the *immune* response during *COVID-19* infection. The results benefit researchers and practitioners in India and worldwide for understanding the pattern of research on COVID-19 and identifying the potential immune response against SARS-CoV-2.

Keywords: COVID-19, Bibliometrics, Immunology, Scientometrics, VOS Viewer

Introduction :

Coronavirus disease 2019, universally called COVID-19, is an infectious disease caused by the SARS-CoV-2 virus was first testified in December 2019 in Wuhan and then spread over all parts of China and has become a global pandemic worldwide now(Felsenstein et al., 2020). Symptoms like cognitive dysfunction, headaches, respiratory distress, anosmia, neurologic symptoms, and cerebrovascular disorders appear to be a combination of nonspecific complications reported in numerous studies(Akintunde et al., 2021; Zyoud et al., 2022)

Billions of people have died from COVID-19; at the same time, billions of people have been infected and even cured in the last three years(Abumalloh et al., 2022). It is evident that those who have a strong immune system fight the virus and get a second life. The immune system is an important component of the human body that protects from COVID-19 and other viruses (Xia, y, Zhou H-t, 2022).

The human immune system has evolved to include numerous cell types, communicating molecules and functional responses to deal with the above infectious disease. The immune system plays an active role in the human body and becomes vital once an individual is exposed to an infectious agent. (Calder, 2020). Whether physical and mental stresses, either acute or chronic, have a dramatic impact on the immune system, both innate and adaptive immune components are affected. Adaptive immunity provides pathogen-specific immunity, eradicating infection and providing long memory and recall of the immune responses(Gautam et al., 2022). Past research aslo says that a low immune system causes many diseases in the human body and animals. It is important to understand some immunological mechanisms; therefore, ongoing research can lead to breakthroughs in immunotherapy; for example, manipulating the immune system to treat cancer and developing vaccines for emerging pathogens, such as COVID-19(Fontanet & Cauchemez, 2020; Li et al., 2022). The pathophysiological features of SARS-CoV-2 infection involve microcirculationdysfunction,malfunctionof the immune response, viral invasion, endothelial cell injury and dysregulation of the renin-angiotensin-aldosterone system, in which the immune response is of paramount significance (Kalra et al., 2021). This paper tries to measure the research trends on this topic with bibliometrics analysis.

Bibliometrics comprises a set of methods to examine or measure books, articles and other publications. It is generally applied to scientific fields to quantitatively measure the various aspects of literature like subject, author, citations, affiliation, country, etc.(Zyoud et al., 2022) .This analysis helps monitorthe growth of literature and research patterns (JACOBS, 2001). Bibliometrics has been considered a standard science policy and research management tool in recent decades (Hossain et al., 2020). The science

indicators like authorship pattern, citation statistics, bibliographic coupling and bibliometric techniquesare also useful for decision-making and tracking the evolution of science and technology(Abumalloh et al., 2022; Mejia et al., 2021).

Review of Literature :

The immune system protects against viruses and diseases and produces antibodies to kill pathogens(Asaduzzaman et al., 2020). The immune system becomes vital once exposed to an infectious agent.There isa different contagious agent. Our immune system produces different antibody molecules and lymphocytes to deal with various infectious agents. COVID-19 is known as a severe acute respiratory syndrome.It is caused by SARS-CoV-2(Liu et al., 2020). This airborne virus originated from bats and was transmitted to human lungs, creating various respiratory diseases like shortness of breath, severe cough, and chest tightness. Our immune system plays a crucial role in SARS-CoV-2 infection. Mainly theinnate immune system of our body act as the first line of immunological defence against this virus pathogenesis(Arslan Gulen et al., 2022;Felsenstein et al., 2020).

Mahmoud et al., 2021 reported that herbal products, micronutrients and probiotics improve our immunesystem and play a sign towards preventing and ameliorating COVID-19 infections(Alagawany et al., 2021). According to Shankar et al., 2022, "*Ayushkwath*' helps to boost our immunity against COVID-19 infection due to its immuno-modulatory, anti-oxidant, antiviral, anti-inflammatory, and anti-inflammatoryhepato-protective properties. In this study, we have attempted the bibliometric analysis mapping of COVID- 19 and immunology for scientific validation (Gautam et al., 2022).

For specific scientific research, bibliometric studies comprehensively assess and help to identify the number and distribution of publications related to authorship, co-authorship, most cited articles etc.In the past, in different areas,the bibliometric and scientometricapproaches have been adopted by several researchers to studying COVID-19 research,including a general overview of COVID-19 research and the comparative method followed by the vaccine distribution.Most bibliometric studies evidence that China and the United States have contributed the most significant scientific literature on COVID-19(Zhang et al., 2022). Most of the past workscomprehensively analyze the general literature on COVID-19 related to vaccine safety buthave not focused on the area of vaccine development, testing, and securitydespite the massive global attention (Akintunde et al., 2021).

The study aims to analyze the COVID-19 and its relationship with Immunology global research output between 2020 and 21. In order to undertake the study, several parameters such as year-wise growth of publication, authorship patterns, keywords used by various authors and citation received on published research is assessed(Majumder et al., 2021).

Thus, the following objectives are considered:

1. To study the type of research publications with respect to theiryear-wise growth.
2. To analyze the country-wise research trends globally in COVID-19 and Immunology research.
3. To identify author's productive life in COVID-19 and Immunology study.
4. To examine the mostfertile source titles and widely used keywords in COVID-19 and Immunology research.
5. To assess the international collaborations and top productive institutions of the World in COVID-19 and Immunology researchoutput.

Methodology :

The present study covers the literature published in 2020, 2021 and 2022on COVID-19 and Immunology retrieved from the SCOPUS database in the second week of December 2022.This search strategy yielded 2877publications (as of 15th December 2022).Subsequently, the data are analyzed using Excel and Bibliometrix (an R package)(Sources-for tabular data format. The graphical representationsare developed using VOSViewer(Dervis, 2019; García-Pascual et al., 2022).

Result and Discussion :

All theanalysis iscategorized into two parts: one is a Performance analysis and Scientific mapping between 2020- 2022 for COVID-19 and Immunology Research.

A) Performance Analysis :

A total of 2877 publications on COVID-19 and Immunology were retrieved from the Scopus database between 2020 and 2022, including 2842 (98.78%) original research articles. Among them, 653 (23%) papers were published in 2020, 1754 (61%) papers were published in 2021, and the other 470 (16%) were published in December 2022 (Figure 1). It is clearly shown that most of the articles were published in the year 2020,the beginning of the second wave of COVID-19.

The summary of the bibliometric findings (Table 1) shows that these articles were published in 210 sources and had a total of 5042 keywords. These documents were authored by 268886authors, whereas most of the articles had multiple authors (n = 26827), with about nine authors per document and a collaboration index(CI) of 9.53. The collaboration index is calculated as the total number of authors in collaborative articles divided by the total number of collaborativearticles(Elango & Rajendran, 2012;Koseoglu,

2016).

Description	Results (frequency)
Timespan	2020:2022
Documents	2877
Article	2842
Sources (Journals, Books, etc)	210
Author's Keywords (DE)	5042
Authors	26886
Author Appearances	38524
Authors of multi-authored documents	26827
Authors per Document	9.35
Co-Authors per Documents	13.4
Collaboration Index	9.53

Table 1: Summary of the dataset

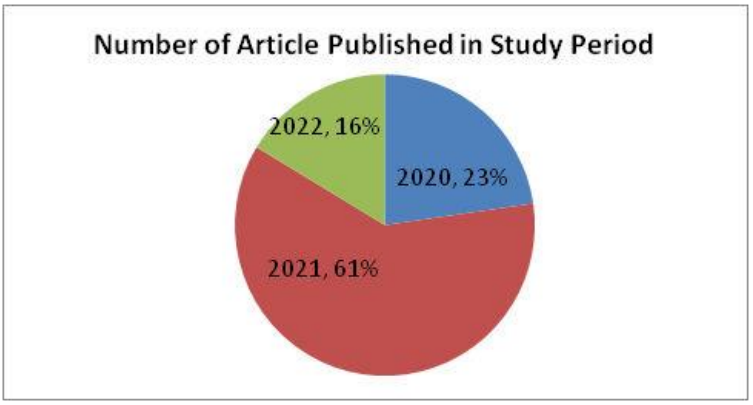


Figure 1: Publication trend duringthe study period 2020-2022

Table 2 and Figure 2 describe the ten most globally cited publications. The most highly cited article entitles,'Reduction and Functional Exhaustion of T Cells in Patients With Coronavirus Disease 2019 (COVID-19)' by ' DIAO B' published in 'Front Immunology' has a total of 1247 citations, followed by 416 total citations per year. The second article is 'Complex immune dysregulation in COVID-19 patients with severe respiratory failure' by 'EJ Giamarellos-Bourboulis' published in 'Cell host and Microbes', and it has a total of 1183 citations. A third-position article titled 'Coinfection with SARS?CoV?2 and other respiratory pathogens in patients with COVID?19 in Guangzhou, China' by'Zhengtu Li' published in 'Journal of Medical Virology'

has a total of 1084 citations. Out of these 2877 publications, the eight most locally cited publications are given in Table 3, compared to their global citations.It shows there is an enormous difference in citing the publications. The paper,' Detection of SARS-CoV-2-specific humoral and cellular immunity in COVID-19 convalescent individuals'authored by Ling Ni and published in 'Immunity', has a height of 118 local citations. In contrast, the article''Reduction and Functional Exhaustion of T Cells in Patients With Coronavirus Disease 2019 (COVID-19)' by ' DIAO B' was published in 'Front Immunology' having the highest global citation but had the second highest

Article	**Total Citations**	**TC per Year**
Diao B, 2020, Front Immunol	1247	415.667
Giamarellos-Bourboulis Ej, 2020, Cell Host and Microbe	1183	394.333
Li Z, 2020, J Med Virol	1084	361.333
Tai W, 2020, Cell Mol Immunol	887	295.667
Ahmed Sf, 2020, Viruses	718	239.333
Weisblum Y, 2020, Elife	695	231.667
Seow J, 2020, Nat Microbiol	664	221.333
Xiong Y, 2020, Emerg Microbes Infect	656	218.667
Ni L, 2020, Immunity	647	215.667
Middleton Ea, 2020, Blood	645	215

in terms of local citations (Figure 3).

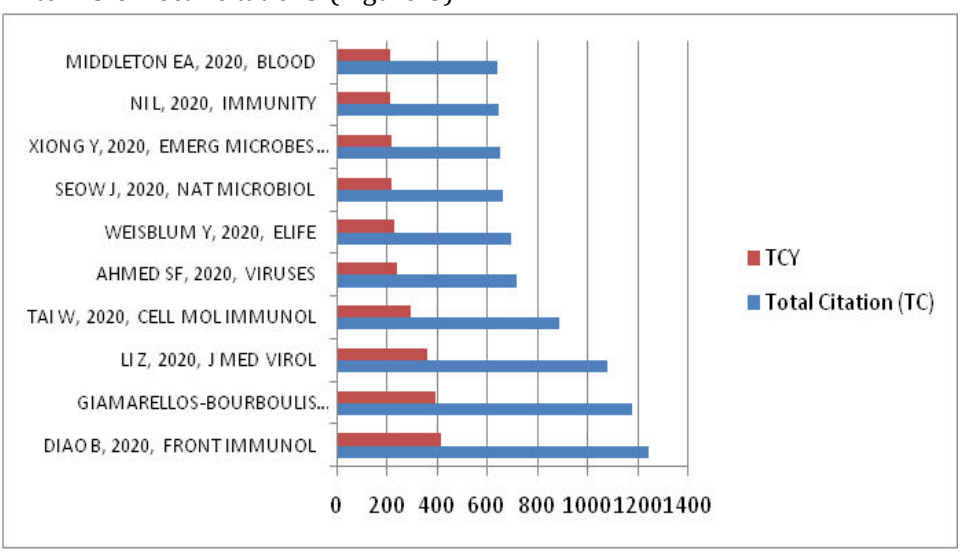


Table 2: Most Cited Publications

Article	Local Citations	Global Citations
Ni L, 2020, Immunity	118	647
Diao B, 2020, Front Immunol	112	1247
Giamarellos-Bourboulis Ej, 2020, Cell Host And Microbe	112	1183
Weiskopf D, 2020, Sci Immunol	95	513
Seow J, 2020, Nat Microbiol	75	664
Grifoni A, 2020, Cell Host And Microbe	71	554
Peng Y, 2020, Nat Immunol	71	578
Stadlbauer D, 2020, Curr Protoc Microbiol	59	363

Figure 2: Most Cited Publications

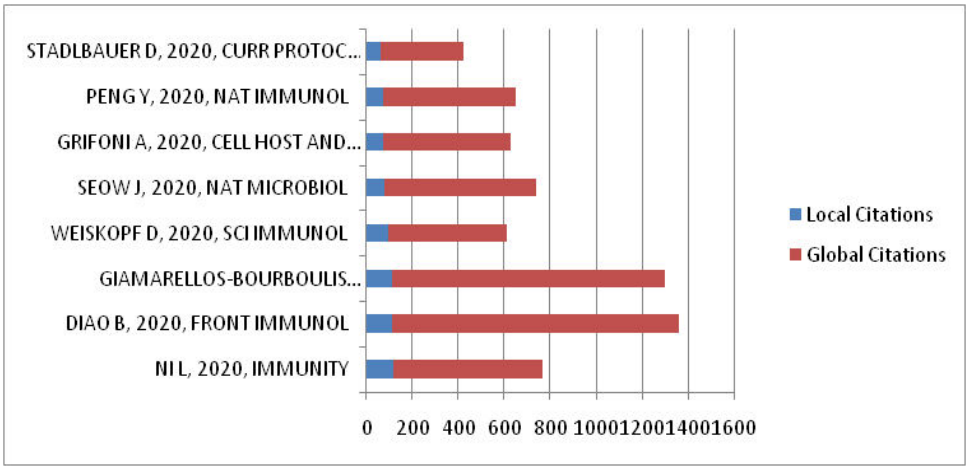


Table 3: Most Local versus Global Cited Publications

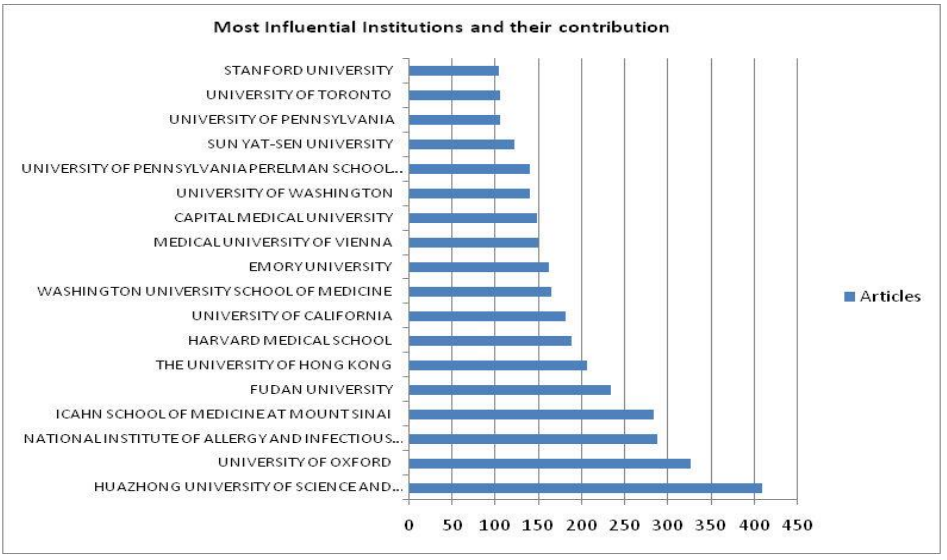
Figure 3: Most Local versus Global Cited Publications

Table 4and Figure 4shows the top twenty institutes/organizationsin terms of publication.The analysis says thatthemost productive institute/ organization is 'Huazhong University of Science and Technology' with a total of 409 publications, at the second rank 'University of Oxford' with total of 326 publications and 'The National Institute of Allergy And Infectious

Diseases' stands in third position having 287 publications. Table 4 also

Institutions	**Articles**
Huazhong University Of Science And Technology	409
University Of Oxford	326
National Institute Of Allergy And Infectious Diseases	287
Icahn School Of Medicine At Mount Sinai	283
Fudan University	234
The University Of Hong Kong	206
Harvard Medical School	189
University Of California	181
Washington University School Of Medicine	165
Emory University	162
Medical University Of Vienna	150
Capital Medical University	149
University Of Washington	141
University Of Pennsylvania Perelman School Of Medicine	140
Sun Yat-Sen University	123
University Of Pennsylvania	106
University Of Toronto	106
Stanford University	105

indicates that the USA organization arefairly contributing to COVID-19



research(Koseoglu, 2016).

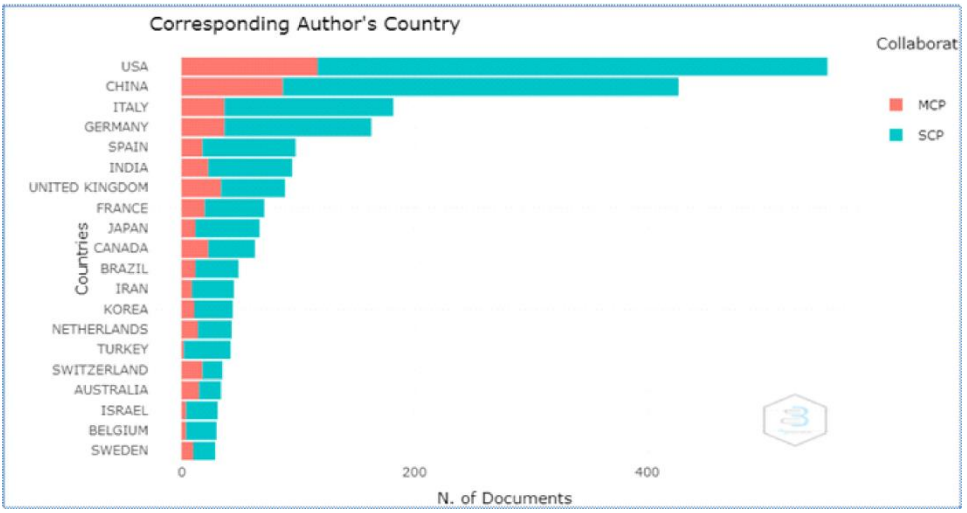
Table 4: Most Influential Institutions and contibutions

Figure 4: Most Influential Institutions and contributions

Table 5 shows the 20 most influential counties by corresponding authors. USA was the country with the most scientific papers published on COVID-19 and Immunology (555 publications), followed by China (427), Italy (182), Germany (163), Spain (98), India(95), UK(89), France (71). It shows that Indian authors have submitted a good chuck of publications. Viewing **Figure 5**, most of the publications were from single-country publications. The USA is at the top in terms of both single-authored and multiple-authored publications.Whereas India has significantly contributed a good number of

Country	Articles	SCP	MCP	MCP_Ratio
USA	555	438	117	0.2108
CHINA	427	340	87	0.2037
ITALY	182	145	37	0.2033
GERMANY	163	126	37	0.227
SPAIN	98	80	18	0.1837
INDIA	95	72	23	0.2421
UNITED KINGDOM	89	55	34	0.382
FRANCE	71	51	20	0.2817
JAPAN	67	55	12	0.1791
CANADA	63	40	23	0.3651
BRAZIL	49	37	12	0.2449
IRAN	45	36	9	0.2
KOREA	44	33	11	0.25
NETHERLANDS	43	29	14	0.3256
TURKEY	42	40	2	0.0476
SWITZERLAND	35	17	18	0.5143
AUSTRALIA	34	19	15	0.4412
ISRAEL	31	27	4	0.129
BELGIUM	30	26	4	0.1333
SWEDEN	29	19	10	0.3448

publications and, regarding the corresponding author's, 72 are single-authed



publications, and 23 are multiple-country publications.

Table 5: Mot Influential Countries

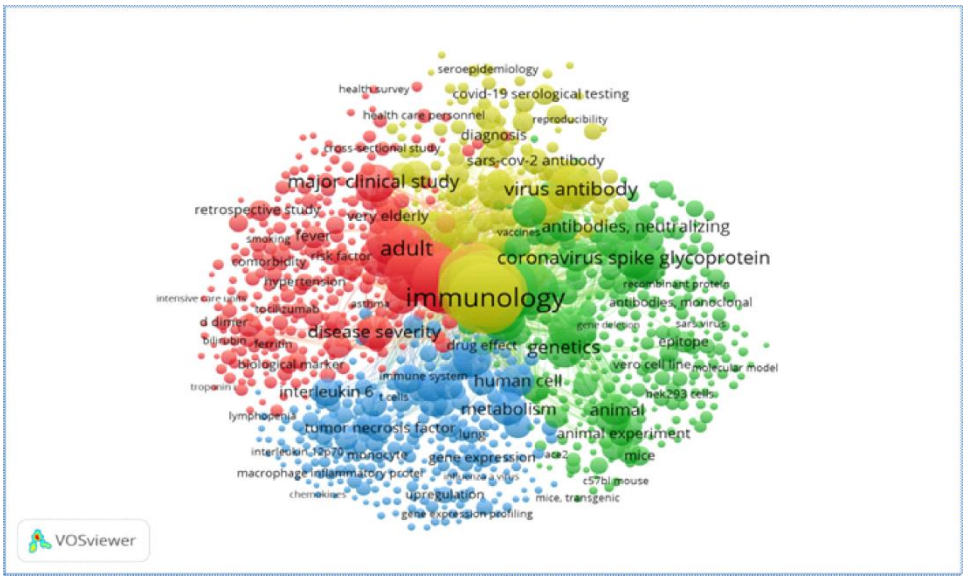
Figure 5: Analysis of Country Collaboration

B) Bibliometric analysis based on scientific mapping

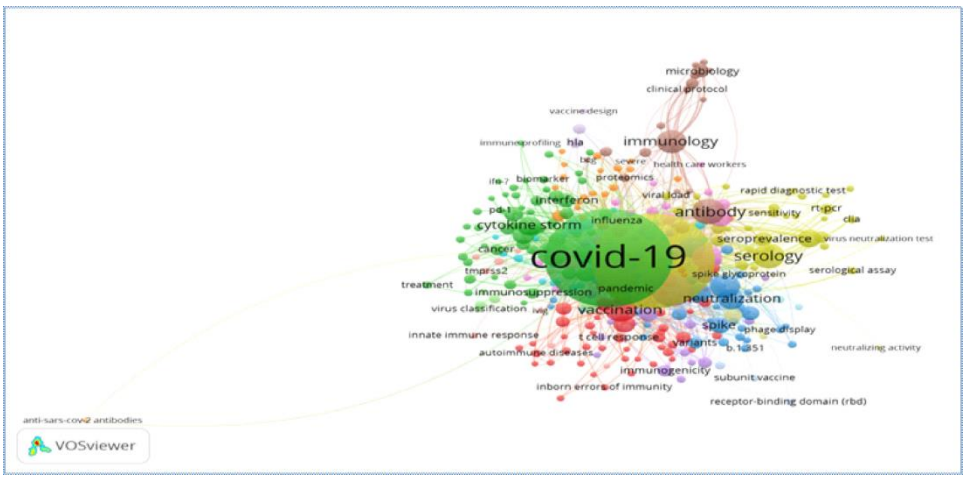
1. Network Analysis of Co-occurrences :

Figure6 depicts a network map of all keywords within the research article selected for the study in the area of COVID-19 and Immunology. The minimum number of occurrences ofa keyword is considered to be 5.The results show out of a total of 16941 keywords,only 3284 keywords met the threshold. For each of the 3284 keywords, the total strength of the co-occurrence links with other keywords is calculated. Keywords with the greatest total link strength of up to 1000 has been selected. The keywords that appeared most were 'Immunology' (total link strength 1,21,690) and 'COVID-19' (total link strength 1,11,306), which had a strong link to 'virus antibody' and 'immune response'. As comparisons of COVID-19, COVID-19 Vaccines and Coronavirus spike glycoprotein, another two keywords and the total link strength of each were more than 5000. There are multiple clusters of keywords plotted in Figure 6, out of which there are 15 most frequently usedare Immunoglobulin g, Human, Adult, Women, Clinical Study, Animal Cell, Neutralizing, Viral, Article, betacoronavirus, blood, C reactive proteins, CD4+ lymphocytes, Cohort analysis, Coronavirus infection and Drug effect. The width of the lines of the network reflects the intra-relationship among the keywords, i.e., the thicker the network line, the stronger the association.Whreas in **Figure 7** plot the networking of only author keywords.

Out of a total of 5042 keywords, only 327 keywords met the threshold.The



keyword 'COVID-19' appeared most with the highest 1492 occurrences,



andthe total link strength is 3559 followed by 'Sars-cov-2' with 1387occurrences (total link strength 3682) then Vaccine, Coronavirus and Antibody.

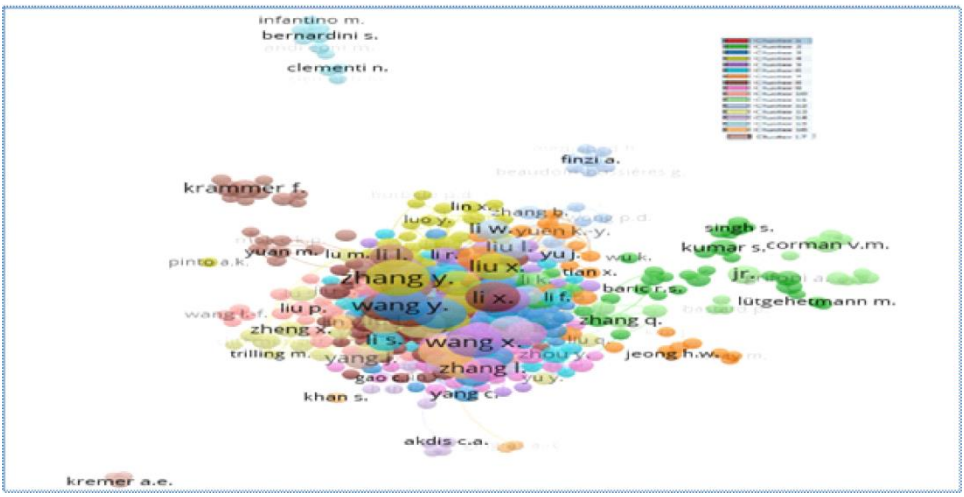
Figure 6: Co-occurrence Analysis in Terms of All Keyword

Figure 7: Co-occurrence Analysis in Terms of Author Keyword

2. Co-authorship Network Visualization :

Figure 8 shows the network map of co-authorship among authors.

Authorshaving minimum 5 articles published selected. The study found that total 19538 authors, out of which 384 authors meet thresholds. The circle size represents the number of articles in which each author collaborates with authors based on the number of co-authors. In general, the larger size of a

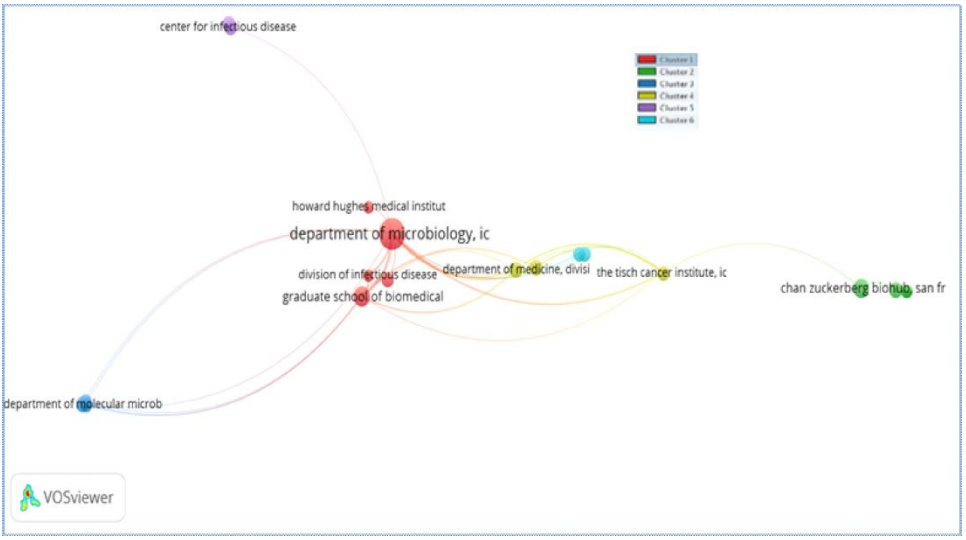


circle, the more often vital co-authors seem. The author 'Zhang y' published the highest number of articles(58) with top link strength 414 followed by wang x. and wang y. and each having the same documents (48) but nearer in total link strength. There are seventeen main clusters that are characterizedby different zones of 'COVID-19 and Immunology research.

Figure 8: Co-authorship Network

Figure 9 shows the network map of co-authorship and organization. The organization that published a mimimum number of 5 articles is considered. Of the 14253 organizations, only 49 met the thresholds. The'Department of Microbiology, Icahn School of Medicine at Mount Sinai, New York, United

States has the highest number of articles(29) with total link strength is 44



followed by 'The Graduate School of Biomedical Sciences, Icahn School of Medicine at Mount Sinai, New York, United States' having 11 articles with link strength 26. This analysis aslo shows that the maximum number of the organization from the United States have contributed papers with co-authorship. There are 6 clusters generated for this analysis, and out of 49 items in this network, the largest set of connected items consistsof 19 only.

Figure 9: The organization's co-authorship network

CONCLUSION :

Using bibliometric tools, one can measure the various parameters related to publications. This study is undertaken to understand the research trends and contribution of researchers for COVID-19 and Immunology research. The study findsthat almost all published documents are articles (2842), and the most prolific author in the COVID-19 and Immunology research is ZHANG Y (71), who is from china. The study also finds that most of the first 20 prolific authors belong to China, which has contributed the largest paper. Even a china based organization called 'Huazhong University of Science and Technology' contributed the largest number of articles, but in the constant, the country USAhasthe most scientific papers published on COVID-19 and Immunology (555 publications). The research also reveals that an article written by DIAO B, 2020 from the journal FRONT IMMUNOL has received highest number of citations. A single author from USA has contributed the highest number of publications. The authored keyword 'COVID-19' appeared most followed by 'Sars-cov-2' 'Vaccine', 'Coronavirs' and 'Antibody'. Although the study hasbeen undertaken in a small timespan, it has a great

scope for further studies in future because the pandemic has a greater effect on society. Because of this, only within a few months, thousands of publications have been published on this topic. Researchers are doing their best irrespective of their country's locations and how this pandemic affected their country. India is also not behind in these contributions. Therefore, a bibliometric study is the most preferred way to measure the productivity of the specific topic, organizations, authors, etc. We antedate that this study will aid future researchers who wish to undertake bibliometric visualizations on the topics selected.

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