

Bibliometric Analysis of the Coronavirus Research Publications Data Before and After the Outbreak of the COVID: A Comparison

Sainul Abideen P.

Indian Institute of Science Education and Research, Thiruvananthapuram - 695 551, India

E-mail: sainul@iisertvm.ac.in

ABSTRACT

This study analyses the research publications data about Coronavirus before and after the Covid-19 outbreak, to answer vital questions relevant to the Coronavirus research. The objectives of this study are to compare the Coronavirus research publications and tries to distinguish the pre and post Covid-19 outbreak trend in Coronavirus research, in the context of research areas, publications growth pattern, country and institutional contributions, funding agencies, language distribution, publishers and journal preferences, etc. It also tries to visualise the institutional and country-wide collaboration patterns in the Coronavirus research using the VOSviewer visualisation software. This study is based on the data retrieved from the Web of Science database for two time-frames, such as 1965 to 31st December 2019, and 1st January 2020 to 30th June 2021. This study reveals that, 89 per cent of the Coronavirus research publications were brought out after the Covid-19 outbreak, and research on Coronavirus has been undertaken in diversified areas in contrast to the prior period where it was mainly on virology, veterinary science, infectious diseases, microbiology, immunology, etc. It shows that USA and China continued to stand on top of the Coronavirus publications share, and the research collaboration between various countries and institutions has improved during 2020-21. It shows that over 97 per cent of the Coronavirus publications are in the English and the majority of the publications are in the journals published by Elsevier in both periods. During 2020-21 the Journal of Virology lost its upper hand in publishing the Coronavirus research publications.

Keywords: Coronavirus; COVID-19; Research data analysis; Bibliometric analysis; VOSviewer; Co-occurrence analysis; Collaboration studies

1. INTRODUCTION

The world is going through a dire pandemic situation due to the Coronavirus. According to the World Health Organisation (WHO)¹ 18,66,38,285 confirmed cases of the Coronavirus disease 2019 (COVID-19), including 40,35,037 deaths, were reported globally to the World Health Organisation as of 12th July 2021, 8:38 PM GMT+5:30.

Information overload during the COVID-19 pandemic has posed a set of challenges not encountered before. This pandemic was accompanied by the “infodemic” characterised by false news, conspiracy theories, magical cures, etc. These are being shared over the internet and social media². In this context, it is essential to know the current status of scientifically reliable information and act according to the scientifically proven research results. This study analyses the scientific and reliable content on the Coronavirus using reliable scientific literature before and after the Coronavirus disease was reported in Wuhan City in December 2019³.

Though the Coronavirus disease 2019 (COVID-19) was declared as a pandemic in 2020 by the World Health Organisation⁴, the history of human coronaviruses goes back to the 1960s. Tyrrell, D.A. & Bynoe, M.L.⁵ found that they could passage a virus named B814. The editorial material

published in 1968 by Almeida, J.D., *et al.*⁶ in the “*Nature*” journal had recognised this new group of viruses with the name ‘Coronavirus.’ According to the Centers for Disease Control and Prevention⁷ the seven coronaviruses that can infect people are 229E, NL63, OC43, HKU1, MERS-CoV, SARS-CoV, and SARS-CoV-2. The SARS-CoV-2 is the novel Coronavirus that causes COVID-19. Since the 1960s, the research information about various types of corona viruses has been published in various research journals.

This study analyses and compares various aspects of the Coronavirus research publications that are indexed in the Web of Science Core Collection Database produced by the Clarivate⁸. The Web of Science Core Collection is a “curated collection, contains over 21,100 peer-reviewed, high-quality scholarly journals published worldwide, in over 250 sciences, social sciences, and arts & humanities disciplines”⁸. This study is being undertaken for two time-frames. The first period starts from the initial stage of the Coronavirus research (1965) till the WHO was informed of cases of pneumonia of unknown cause in Wuhan City, China, i.e., 31st December 2019. The second period consists of the active COVID-19 pandemic period, i.e., 1st January 2020 to 30th June 2021.

2. LITERATURE REVIEW

Several studies are conducted with the objective of analysing the Coronavirus research publications, covering

different aspects of it, and for varying time-frame⁹⁻²² Ram, S., & Nisha, F⁹ analysed the highly cited articles in the Coronavirus research published from 1970 to 2019 and analysed the articles published up to March 2020, using the Scopus database. Singh, Kataria & Dey¹⁰ conducted a bibliometric study to analyse the research progress in Coronavirus, using the 4,917 articles published during 1989-2019 retrieved from the Web of Science database. Zhou & Chen¹¹ conducted a study to investigate the global trends of Coronavirus from 2000 to 2020, based on the articles published in English language indexed in the Web of Science.

Mao, Guo, Fu, and Xiang¹² studied the Coronavirus literature by analysing 9,294 publications from 1st January 2003 to 6th February 2020 using the Web of Science database. However this study did not cover major part of the post Covid-19 outbreak period. Zhai¹³ *et al.* conducted a bibliographic study based on the publications retrieved from the Web of Science from 2003 to 2020 to explore the distribution of research capabilities of countries, institutions, and researchers and the hotspots. The study conducted by Lou *et al.*,¹⁴ was based on the publications in the PubMed database till 1st March 2020. Haghani *et al.*,¹⁵ conducted a scientometric analysis of 1,239 Coronavirus research publications. However, this study was specific to the safety-related publications indexed in the Scopus database, up to 9th April 2020. Dehghanbanadaki *et al.*,¹⁶ also conducted a bibliometric study on this topic with 923 items published from 1st December 2019 to 1st April 2020 using the Scopus database.

To understand the global scientific output of COVID-19 research during the early stage of the outbreak, Zyoud & Al-Jabi¹⁷ also conducted a study with 19,044 coronavirus research publications produced from December 2019 to 19th June 2020 from the Scopus database. A bibliometric analysis on the coronavirus research from 2019 to August 2020 was undertaken by Farooq *et al.*,¹⁸ using 6,694 items retrieved from the Web of Science database. Guleid¹⁹ *et al.* conducted a bibliographic study on Covid-19 literature with special reference to Africa using 1,296 articles published between 1st December 2019 and 3rd January 2021 retrieved from various databases including PubMed, African Journals Online, medRxiv, Collabovid, and Google. Similarly, country-specific studies were conducted by Ghosh²⁰ for India for the year 2020 and Akhter²¹ for China for the period 2011-2020. Soytaş²² conducted a bibliometric analysis on 784 documents retrieved from the Web of Science published between December 2019 and 17th March 2021. Soytaş²² identified the most relevant scientific research on coronavirus disease in older adults and identified the 50 most cited publications.

The above literature review shows that studies by Ram, S., & Nisha, F⁹; Singh, Kataria & Dey¹⁰; Zhou & Chen¹¹; Mao, Guo, Fu, and Xiang¹²; Zhai¹³ *et al.* and Lou *et al.*,¹⁴ were analysing the data pertaining to the pre Covid-19 outbreak or till the initial stage of the pandemic, when the research was minimal. Similarly, studies by Dehghanbanadaki *et al.*,¹⁶ Zyoud & Al-Jabi¹⁷; Farooq *et al.*,¹⁸ were also based on the data pertaining to the initial stage of the pandemic. While other studies were pertaining to specific countries¹⁹⁻²¹ the study by

Soytaş²² was for the most recent period, but was restricted to older adults.

The literature review reveals that an exhaustive comparative study between pre and post Covid-19 outbreak is lacking; this paper tries to fill this gap. Since the Covid-19 outbreak was one of the important turning points in the human kind, understanding the research dimension in this field is important. This study will also help in identifying the hot areas in this research fields and the areas where there is requirement for further attention.

3. SCOPE OF THIS STUDY

The data was retrieved from the Web of Science Core Collection⁸ based on the publications having the word 'COVID' or 'Coronavirus' in its title or keyword plus fields using the search query Coronavirus(Title) or COVID(Title) or Coronavirus(Keyword Plus) or COVID(Keyword Plus) during two specific periods such as 1965-01-01 to 2019-12-31 and for the period 2020-01-01 to 2021-06-30. The title and keyword plus fields are selected to obtain more relevant search results. The data consists of resources published in various resources, indexed in the database, irrespective of the language of publications. The datasets of articles, letters, editorial materials, and review articles are selected for this study. All other document types are excluded from the search result. The details of organisations are considered based on the research institution's standard 'organisation-enhanced' name as indexed by the Web of Science.

During the 1965-2019 period, 10,102 publications are retrieved, consisting of 8,638 articles, 903 review articles, 308 editorial materials, and 253 letters. During the 2020 to June 2021 period, 84,939 publications are retrieved, consisting of 46,231 articles, 8,816 review articles, 14,795 editorial materials, and 15,097 letters.

4. OBJECTIVES OF THE STUDY

The objectives of this study are to distinguish the pre and post Covid-19 research trend and try to answer relevant questions in these two periods, like in which research area the coronavirus research are mainly undertaken and significant difference between the research areas during these periods? How fast are the scientific publications on Coronavirus growing? Which are the scientific institutions contributing to the Coronavirus research output? What is the country-wise share in the Coronavirus-related publications? Which are the primary agencies funding this critical research area? In which languages Coronavirus related resources are prominently published? Which preferred publishers and journals brought out more publications on this subject? It also tries to visualise the institutional and country-wide collaboration patterns using the VOSviewer²³.

5. GROWTH PATTERN OF THE CORONAVIRUS RESEARCH PUBLICATIONS

The study reveals that the first article on this topic, which was indexed in the Web of Science⁸, was published in the 1960s. The number of publications and growth of literature from 1965 to 2019 was plodding. Only 10.62 per cent of research literature

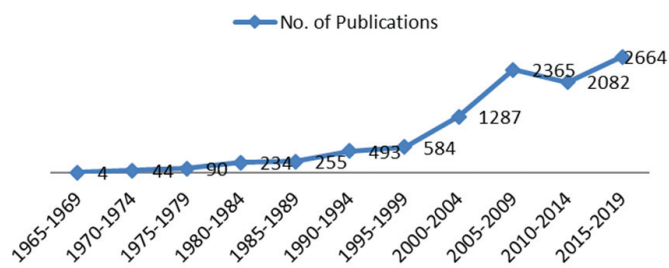


Figure 1. Growth pattern of the corona virus publications from the year 1965 to 2019.

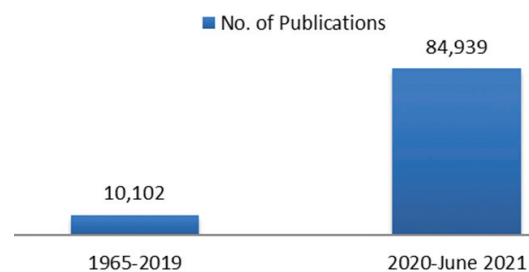


Figure 2. Number of the corona virus publications during 1965-2019 and 2020-June 2021.

Table 1. Major research areas and the corresponding number of publications during the 1965-2019 and 2020-June 2021 periods

1965-2019 Period			2020-June 2021 Period		
Research Areas	# of Publications	Per cent	Research Areas	# of Publications	Per cent
Virology	3404	33.696	General Internal Medicine	11818	13.914
Veterinary Sciences	1541	15.254	Public Environmental Occupational Health	8644	10.177
Infectious Diseases	1212	11.998	Infectious Diseases	5318	6.261
Microbiology	1119	11.077	Immunology	4022	4.735
Immunology	1118	11.067	Sci. Technology Other Topics	3959	4.661
Biochemistry Molecular Biology	1039	10.285	Cardiovascular System Cardiology	3853	4.536
Biotechnology Applied Microbiology	634	6.276	Environmental Sciences Ecology	3784	4.455
Science Technology Other Topics	491	4.86	Surgery	3596	4.234
Pharmacology Pharmacy	437	4.326	Neurosciences Neurology	3499	4.119
General Internal Medicine	391	3.871	Psychiatry	3318	3.906
Cell Biology	310	3.069	Pharmacology Pharmacy	3229	3.802
Public Envi. Occupational Health	288	2.851	Research Experimental Medicine	2876	3.386
Res. Exp. Medicine	279	2.762	Healthcare Sciences Services	2850	3.355
Biophysics	271	2.683	Psychology	2473	2.912
Chemistry	197	1.95	Pediatrics	2330	2.743
Genetics Heredity	179	1.772	Microbiology	2237	2.634
Pathology	146	1.445	Oncology	2106	2.479
Respiratory System	135	1.336	Respiratory System	2052	2.416
Pediatrics	114	1.128	Biochemistry Molecular Biology	1990	2.343
Life Sci. Biomedicine Other Topics	108	1.069	Virology	1879	2.212

on the corona virus was produced during this long period. Data shows that it took just 1.5 years to produce more than 89 per cent of research literature on Coronavirus during the 2020-2021 period due to the COVID-19 pandemic. Figure 1 shows the growth pattern of the publications from 1965 to 2019, and Figure 2 shows the growth of the Coronavirus publications during both periods.

6. PROMINENT AREAS IN THE CORONAVIRUS RESEARCH

This study identified significant Web of Science research

areas on which more research items are published. The Coronavirus-related publications are indexed in the Web of Science⁸ under various research areas. It varies from the medical field like virology, medicine, infectious diseases to diversified areas like social issues, sociology, psychology, environmental engineering, management, public administration, etc. It indicates the breadth and depth of the research activities revolving around various aspects of the Coronavirus and its consequences in society.

This study shows that till the outbreak of the Covid-19 in 2019, the Coronavirus research mainly concentrated in the

Virology domain with 33.696 per cent publications. Other areas like Veterinary Sciences (15.254 %), Infectious Diseases (11.998 %), Microbiology (11.077 %), Immunology (11.067 %), etc., were also prominent research areas during this period. However, during 2020-2021 the research areas have been widely diversified due to the COVID-19 pandemic, as shown in Table 1.

7. COUNTRY-WISE CONTRIBUTION IN THE CORONAVIRUS RESEARCH PUBLICATIONS

The Web of Science⁸ data reveals that many countries across the globe have been involved in contributing publications related to the Coronavirus. During the 1965-2019 period, countries such as the USA (3,604 publications) and China (2,265 publications) were the leaders in the Coronavirus research, having more than 58 per cent share in the publications portfolio. Countries such as Germany, England, Netherlands,

Canada, Japan, France, Saudi Arabia, South Korea, Taiwan, and Italy have published more than 300 publications each in this field.

During the 2020-June 2021 period, though the USA and China continued to stand on top of the Coronavirus publications, their cumulative share percentage has reduced to 43.96 per cent from 58 per cent. It also shows that countries like England (9,040 publications), Italy (8,777), and India (4,434) have well performed in the Coronavirus research publications during this period, with an increase in the number of publications by 4.2 per cent, 7.36 per cent, and 4.32 per cent respectively than that of 1965-2019 period.

Table 2 shows the comparison of research publications share of the countries that contributed more publications in the Coronavirus research area during these two periods. During the 1965-2019 period, India was in the 22nd rank based on the total number of publications (90) on Coronavirus. During the 2020-June 2021 period, India produced 4,434 publications and reached the fifth rank.

Table 2. Comparison of Coronavirus research publications shares of major countries during 1965-2019 and 2020-2021 (June)

1965-2019 Period				2020-June 2021 Period			
Rank	Country	# of Publications	Per cent	Rank	Country	# of Publications	Per cent
1	USA	3604	35.676	1	USA	25453	29.958
2	China	2265	22.421	2	China	11898	14.004
3	Germany	696	6.89	3	England	9040	10.64
4	England	650	6.434	4	Italy	8777	10.331
5	Netherlands	609	6.029	5	India	4434	5.219
6	Canada	565	5.593	6	Spain	4116	4.845
7	Japan	503	4.979	7	Canada	4086	4.809
8	France	451	4.464	8	Germany	3820	4.496
9	Saudi Arabia	353	3.494	9	France	3710	4.367
10	South Korea	334	3.306	10	Australia	3576	4.209
11	Taiwan	329	3.257	11	Brazil	2762	3.251
12	Italy	300	2.97	12	Turkey	1936	2.279
13	Singapore	268	2.653	13	Iran	1917	2.256
14	Australia	266	2.633	14	Switzerland	1910	2.248
15	Spain	256	2.534	15	Netherlands	1850	2.177
16	Switzerland	213	2.108	16	Japan	1690	1.989
17	Brazil	156	1.544	17	Saudi Arabia	1485	1.748
18	Belgium	134	1.326	18	South Korea	1420	1.671
19	Sweden	132	1.307	19	Singapore	1312	1.544
20	Egypt	113	1.119	20	Belgium	1307	1.538
21	Scotland	92	0.911	21	South Africa	1048	1.234
22	India	90	0.891	22	Sweden	1017	1.197
23	Thailand	77	0.762	23	Scotland	1015	1.195
24	Austria	74	0.733	24	Poland	1004	1.182
25	Poland	68	0.673	25	Pakistan	998	1.175

7.1 Coronavirus Research Collaboration between Countries

This study analysed the strength of collaboration between various countries by analysing the strength of co-authorship with higher relatedness of countries, using the VOSviewer software²³. The VOSviewer is intended primarily for analysing the bibliometric networks.

The network visualisation map created using VOSviewer²³ includes items and links. Items are objects of interest like organisation, country, author, keywords, etc., generally shown as circles or frames along with its label. Items with higher

weight are shown in a bigger size than those with a lower weight. The items are interconnected with lines called links to represent the relationship between them. Generally, one map contains only one type of item. The thickness of a link shows the strength of the items connected with it. For example, the number of publications in which two terms occur together (in case of the co-occurrence links) the number of publications two researchers have co-authored (in case of co-authorship links). Items may be grouped into clusters. A cluster is a set of items grouped in a visualisation map. The clusters are labeled using cluster numbers, and items in different clusters are shown in

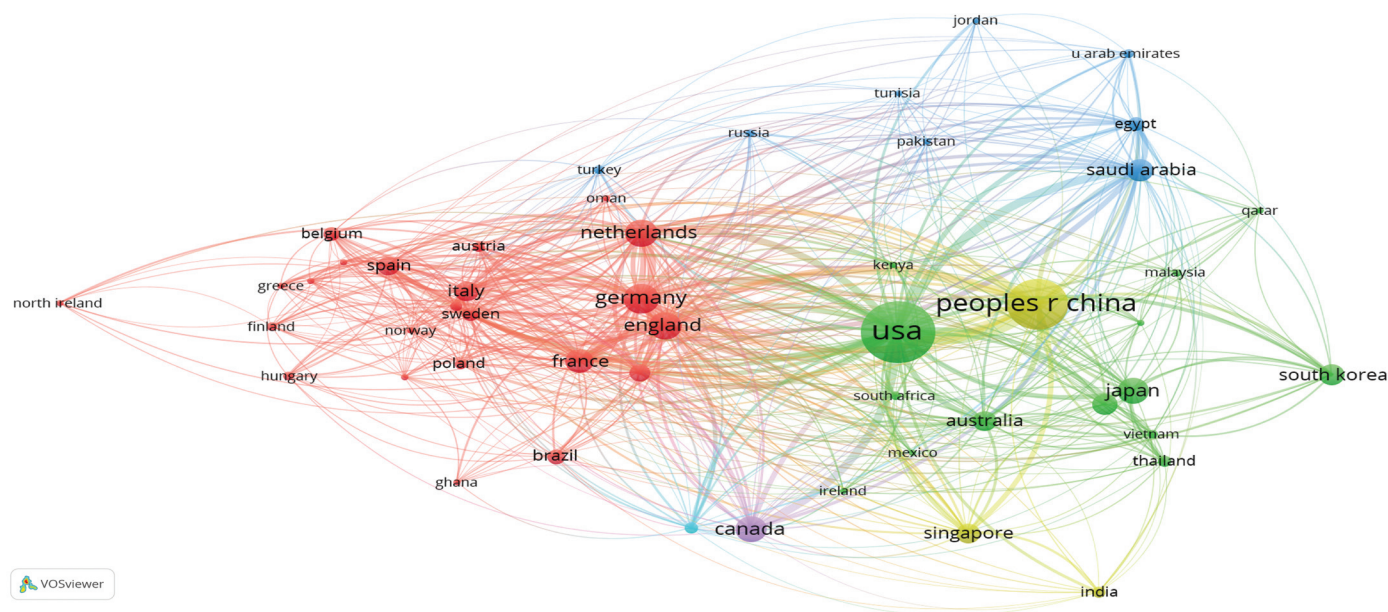


Figure 3. Network map of co-authorship with collaborating countries (1965-2019).

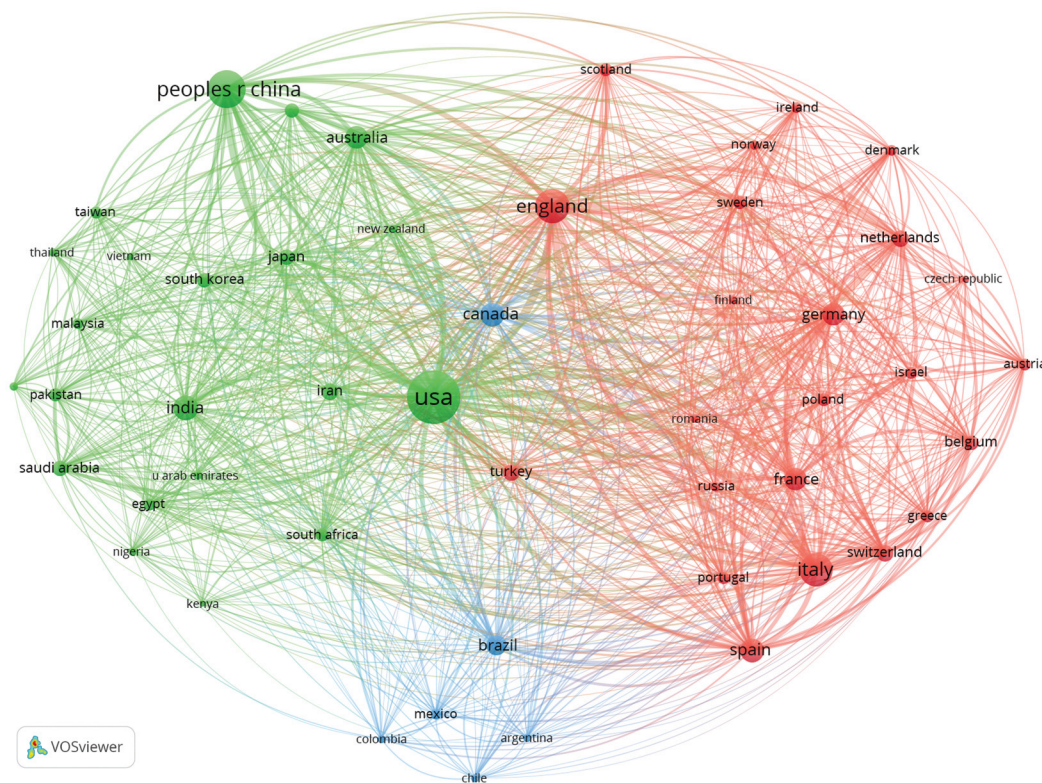


Figure 4. Network map of the 50 co-authorship with collaborating countries (2020-June 2021).

different colors. The distance between items in a visualisation map shows its closeness. If the items are nearer, they are more related than those items that are far away on the map.

This analysis considered only those publications were having less than 25 collaborating countries. Further, this study considered only those countries that have published a minimum of 10 papers and have received a minimum of 10 citations for its Coronavirus research publications during the period in consideration.

During the period 1965-2019, out of 129 countries, 57 countries qualified above parameters. During the 2020-2021 (June) period, out of 200 countries, 146 countries qualified above parameters. From each group, the top 50 countries are considered based on their strength of collaboration (greatest link strength, as identified by the VOSviewer software) for this analysis.

This analysis for 1965-2019 shows that the top 50 countries are collaborating with each other in 6 collaborating clusters with 618 links, i.e., whose scholars work together on research related to the Coronavirus. These clusters have formed with the collaboration of varying numbers of institutions such as cluster 1 (23 institutions), cluster 2 (14), cluster 3 (8), cluster 4 (3), cluster 5 (1), and cluster 6 (1). These clusters of fifty collaborating countries are shown in different colors in the network map of the co-authorship of the collaborating countries, created using VOSviewer, as shown in Fig. 3.

Similarly, during 2020-June 2021, the scholars of the top 50 institutions work together in 3 prominent collaborating clusters, with 1,216 links as shown in the network map of the co-authorship of the collaborating countries (Fig. 4). These clusters have formed with varying numbers of institutions such as cluster 1 (23 institutions), cluster 2 (21), and cluster 3 (6).

It shows that institutional collaboration has significantly improved during 2020-2021 (June) than in the previous period.

8. PROMINENT INSTITUTIONS CONTRIBUTING TO THE CORONAVIRUS RESEARCH PUBLICATIONS

This study identified the major research organisations contributing to the Coronavirus-related research publications. Table 3. enlists prominent 15 organisations that contributed with more Coronavirus-related publications in both periods.

Until 2020, only two institutions, namely, the University of Hong Kong and the Chinese Academy of Sciences had more than 300 publications in this research area⁸. The covid-19 pandemic caused a steep increase in the research publications during 2020 and 2021.

During 2020-2021 (June), institutions like Harvard University, the University of London, and the University of California System became the top 3 institutions that produced more Coronavirus-related publications. All top 13 institutions have produced more than 1000 publications on this critical research area during this short time.

Table 3. The top 15 organizations contributed more Coronavirus-related publications during 1965-2019 and 2019-June 2021

1965-2019 Period			2020-June 2021 Period		
Institutions	# of Publications	Per cent	Institutions	# of Publications	Per cent
University of Hong Kong	464	4.593	Harvard University	2847	3.352
Chinese Academy of Sciences	352	3.484	University of London	2755	3.244
Utrecht University	267	2.643	University of California System	2131	2.509
National Institutes of Health NIH, USA	252	2.495	Harvard Medical School	1742	2.051
University of California System	246	2.435	Huazhong University of Science Technology	1473	1.734
University of North Carolina	218	2.158	Institut National De La Sante et De La Recherche Medicale	1369	1.612
Centers for Disease Control Prevention USA	204	2.019	University of Toronto	1251	1.473
Chinese University of Hong Kong	199	1.97	University College London	1241	1.461
University of North Carolina Chapel Hill	185	1.831	Johns Hopkins University	1165	1.372
University of Texas System	171	1.693	Assistance Publique Hopitaux Paris	1157	1.362
University of Iowa	169	1.673	University of Texas System	1075	1.266
NIH National Institute of Allergy Infectious Diseases	154	1.524	Imperial College London	1003	1.181
Consejo Superior De Investigaciones Cientificas	153	1.515	University of Oxford	1001	1.178
Leiden University	152	1.505	University of Milan	931	1.096
University of Southern California	151	1.495	University of Pennsylvania	907	1.068

clusters, as shown in different colors in the network map (Fig. 6) of the co-authorship of the collaborating institutions created using VOSviewer. These clusters have formed with varying numbers of institutions such as cluster 1 (76 institutions), cluster 2(58), cluster 3(33), cluster 4(25), cluster 5(24), cluster 6(16), cluster 7(15), and the cluster 8(3). It shows that institutional collaboration has improved during 2020-June 2021 by joining more institutions to the clusters than in the previous period.

9. PROMINENT FUNDING AGENCIES FOR THE CORONAVIRUS RESEARCH

Analysis of the Web of Science⁸ data shows that the United States Department of Health Human Services, National Institutes of Health USA, and National Institute of Allergy Infectious Diseases were prominent funding agencies, which has resulted in 2,040, 1,971, and 1,449 publications, respectively, during 1965-2019. Other prominent funding agencies during this period include the National Natural Science Foundation of China (507 publications), European Commission (411), National Institute of Neurological Disorders Stroke (349), and the National Institute of General Medical Sciences (265).

During the 2020-2021 (June), the United States Department of Health Human Services (4,427 publications) and National Institutes of Health, USA (4,254) continued to be the major funding agencies in Coronavirus research. National Natural Science Foundation of China (3,332) and the European Commission (1,789) have become the top funding agencies with third and fourth positions during this time span.

10. LANGUAGE BREAKUP OF THE CORONAVIRUS RESEARCH PUBLICATIONS

This study reveals that during the 1965-2019 and 2020-2021 (June), English remained the preferred language of publication with more than 97 per cent share of publications. Table 4 shows the share of major languages in which Coronavirus resources are published.

Table 4. Share of major languages in the corona virus research publications

Language	1965-2019 (%)	2020-June 2021 (%)
English	97.357	97.427
Spanish	0.208	1.078
German	0.683	0.669
French	0.752	0.339
Portuguese	0.089	0.174
Chinese	0.297	0.014

11. PUBLISHER BREAKUP OF THE CORONAVIRUS RESEARCH PUBLICATIONS

This study shows that a major share of the coronavirus research output has been published in the journals published by *Elsevier* in both periods⁸. It shows that the American Society for Microbiology was the second preferred publisher during 1965-2019. However, it lost its priority during the 2020-June 2021 period by a reduction of 13.29 per cent share of publications. Elsevier also showed a reduction by 1.73 per cent share of publications during this period.

12. SOURCES OF PUBLICATION OF THE CORONAVIRUS RESEARCH PUBLICATIONS

This study identifies that during 1965-2019 the *Journal of Virology* was the topmost journal publishing 10.711 per cent of the Coronavirus research publications. Based on the number of publications in the Coronavirus research, this study ranked top 10 journals. It is noticed that most of the items published during 1965-2019 were in virology-related journals.

Interestingly, the same ranking for the period 2020-June 2021 shows that Coronavirus research publications are not concentrated in any specific journal. Moreover, those ten highly ranked journals during 1965-2019 did not get a place in

Table 5. Top 10 journals that published more publications on Coronavirus

1965-2019				2020-2021 (June)			
Rank	Journal	# of Publications	Per cent	Rank	Journal	# of Publications	Per cent
1	Journal of Virology	1082	10.711	1	International Journal of Environmental Research & Public Health	1491	1.753
2	Virology	444	4.395	2	Plos One	1083	1.274
3	Journal of General Virology	293	2.900	3	Journal of Medical Virology	813	0.956
4	Virus Research	233	2.306	4	British Medical Journal- BMJ	810	0.953
5	Emerging Infectious Diseases	226	2.237	5	Frontiers in Psychology	638	0.750
6	Archives of Virology	224	2.217	6	Frontiers in Public Health	581	0.683
7	Plos One	188	1.861	7	Lancet	561	0.660
8	Veterinary Microbiology	172	1.703	8	Sustainability	543	0.639
9	Viruses Basel	152	1.505	9	International Journal of Infectious Diseases	523	0.615
10	Journal of Virological Methods	141	1.396	10	Scientific Reports	508	0.597

the top 10 journals during the 2020-June 2021 period. Table 5 lists journals where more publications on coronavirus research are published⁸ during these two time-frame.

13. FINDINGS AND CONCLUSIONS

This study reveals that a large number of research activities across the globe are taking place in the Coronavirus and allied areas. This study shows that Coronavirus-related research publications were minimal until Covid-19 became a pandemic, and 89 per cent of the publications were published after the Covid-19 outbreak. The studies by Zhou & Chen¹¹; Mao, Guo, Fu, and Xiang¹² and Haghani *et al.*,¹⁵ shows that there were two sharp increases in publications after the severe acute respiratory syndrome (SARS) and the Middle East respiratory syndrome (MERS) outbreaks. Similar sharp increase is seen during the Covid-19 outbreak also.

The study shows that the Coronavirus-related publications were mainly on research areas like virology, veterinary science, infectious diseases, microbiology, immunology, etc., till 2019. However, after the Covid-19 outbreak, the research was undertaken on diversified areas. The study reveals that USA and China continued to stand on top of the Coronavirus publications-based ranking. They together had 58 per cent of the publications share till 2019, and it was reduced to 43.99 per cent during 2020-21 as other countries also progressed in the Coronavirus research.

The studies by Ram, S., & Nisha, F⁹; Zhou & Chen¹¹; Mao, Guo, Fu, and Xiang¹²; Zhai¹³, *et al.* show that USA is highly productive country prior to spread of Covid-19 and Zyoud & Al-Jabi¹⁷ and Farooq, *et al.*,¹⁸ also shows that USA is continuing as highly productive country after the Covid-19 outbreak.

India also produced a good number of research publications in this domain and reached the fifth position during the 2020-21 period. The collaboration between countries and institutions also has improved significantly during 2020-21.

This study reveals that the University of Hong Kong and the Chinese Academy of Sciences were toppers who produced more publications until the Covid-19 outbreak. The studies by Ram, S., & Nisha, F⁹; Singh, Kataria & Dey¹⁰ and Mao, Guo, Fu, and Xiang¹² and Zhai¹³, *et al.* also shows that the University of Hongkong was the highly productive institution prior to spread of Covid-19.

Harvard University, the University of London, and the University of California Systems were toppers during 2020-21. The United States Department of Health Human Services and National Institutes of Health, USA, continued to be the primary funding agencies in both periods. The study shows that over 97 per cent of items are published in the English language, and a significant share of the Coronavirus research output has been published in the journals published by *Elsevier* in both periods. The study shows that the Journal of Virology was the topmost journal publishing 10.711 per cent of the Coronavirus research publications till 2019. The studies by Ram, S., & Nisha, F⁹; Singh, Kataria & Dey¹⁰; Zhou & Chen¹¹; Mao, Guo, Fu, and Xiang¹²; Zhai¹³ *et al.*; and Haghani *et al.*,¹⁵ also shows that the Journal of Virology was the highly productive journal prior to spread of Covid-19.

The top ten journals published Coronavirus publications were mainly in the virology field till 2019, but virology related journals lost their top positions during 2020-21. This study also shows that around 86 per cent of the Coronavirus-related publications are made available in the open-access domain⁸.

This study was limited to the publications on Coronavirus, indexed in the Web of Science. Further study may be conducted based on other prominent databases. Since the pandemic is continuing and the number of publications is proliferating, there is scope for further studies in the years to come.

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CONTRIBUTORS

Dr Sainul Abideen is currently heading the Library of the Indian Institute of Science Education & Research (IISER) Thiruvananthapuram. He is VLIR Scholar in Scientific and Technological Information Management offered by Flemish Inter-University Council, Belgium.