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Bibliometric analysis of coronavirus disease (COVID-19) literature published in Web of Science 2019–2020

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Abstract:

Coronavirus outbreak in Wuhan, China, turned into a pandemic in record time. Communication of disease presentation and mechanism of spread remain keys to getting ahead of the virus and limiting its spread beyond the capacity of management. Owing to huge academic focus and pandemic concern around the globe, this bibliometric analysis investigated research productivity related to coronavirus disease (COVID-19) pandemic using the Web of Science database. The relevant data were harvested, and search query was further refined by publication years (2020 OR 2019) and document types (article, book chapter, and proceedings paper). Finally, 6694 records were imported and downloaded in Plaintext and BibTeX formats on August 1, 2020. The data analysis was performed using MS Excel, VOS viewer, and Biblioshiny software. Of the 6694 publications that appeared in that period, the USA and Chinese research institutions topped the numbers. At the same time, the Journal of Medical Virology and CUREUS (Cureus Journal of Medical Science), remained favorite journals for publications. The pattern of multi-author publications has outstripped that of single-authors. Apart from COVID-19 and the novel coronavirus, the important keywords mentioned included pandemic, pneumonia, epidemiology, public health, outbreak, epidemic, China, infection, and treatment. The analysis shows a strong local research response from China, with large teams reporting on the disease outbreak. Subsequent studies will document a global response as the virus spreads worldwide. The initial research related to the current coronavirus outbreak was reported from within China. The data and patterns were supposed to alter as the virus spread globally.

Keywords:

2019-nCoV, bibliometric, bibliometric-coronavirus, COVID-19, health care, pandemic, China, severe acute respiratory syndrome-cov-2, research productivity, the World Health Organization

Introduction

In today's connected world, contagious and previously unknown pathogens have become a public health problem. In late December 2019, the health facilities of Wuhan city in China reported receiving patients with chest infection of an unknown cause. The clinical picture of these patients resembled viral chest infections and included fever, cough, and dyspnea. Initial laboratory investigations linked it with the Coronavirus family; however, no confirmatory links were established.[1] The World Health Organization (WHO) was alarmed about this outbreak. Within a month (January 30, 2020), the WHO had declared this outbreak a global health emergency. On March 11, 2020, they pronounced it a pandemic.[2] In the absence of a specific treatment or vaccine, minimizing human contact was the only way to slow its spread.[3]

The virus has been named a novel coronavirus and coded as COVID-19 and 2019-nCoV. Phylogenetic analyses have revealed its close similarity with the severe

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acute respiratory syndrome (SARS)-related coronavirus clade.[4] It is a single-stranded positive-sense ribonucleic acid (RNA) type virus, which bears 82% similarity to SARS-CoV. Predominantly, patients on presentation have respiratory symptoms, but may also involve intestines, liver, and brain.[5]

Initial studies on 2019-nCoV highlight its zoonotic origin designating bats as the carriers.[6] As much as 96% similarity was detected at the whole genome level between 2019-nCoV and a bat CoV. However, an intermediate host remains a mystery.[7] The reported mortality rate of COVID-19 remains close to 2%, lower than SARS reported in 2003 (>40%),[8] and MERS, reported in 2012 (30%).[9] As of August 1, 2020, 17,771,634 confirmed 2019-nCoV cases had been reported globally. There have been 683,278 deaths in 213 countries, areas, or territories globally.[10]

There was a surge in relevant publications after the SARS outbreak in 2003. As reviewed later,[11] the news features were the dominant type of publication (32%), while 25% editorials, 22% research articles, and 13% of letters were published. The US and Hong Kong contributed 30% and 24% of publications, respectively. The SARS publication pattern suggested immediate citation but low international collaboration.

The knowledge gaps on 2019-nCoV can only be filled if public health authorities continually update epidemiological data as China did. Early disease recognition and communication of the knowledge can minimize the spread by early implementation of public health measures. This study is intended to review bibliometric parameters of publication surge following the COVID-19 outbreak.

Research Questions

1. What are the most productive countries and organizations?
2. In what favorite sources would COVID-19 researchers like to publish their work?
3. What are the authorship and collaborative patterns of COVID-19 researchers?
4. What are the most frequently used keywords and co-occurrence network in COVID-19 research?
5. What kind of relationship is based on three-factor analysis (countries, keywords, and organizations)?
6. Which research papers are highly influential with respect to citation and usage count on COVID-19?

Materials and Methods

To examine the publishing trends and patterns on COVID-19 pandemic, bibliometric data were retrieved from the Web of Science (WOS), the most authentic indexing and abstracting database in the world. In the WOS core collection, the following search query was run in title and Author Keyword field.

> TI= (coronavirus OR covid19 OR covid-19 OR ncov2019 OR sars-cov-2 OR "SARS COV 2" OR orthocoronavirinae) OR AK = (coronavirus OR covid19 OR covid-19 OR ncov2019 OR sars-cov-2 OR "SARS COV 2" OR orthocoronavirinae).

The query was further refined by publication years (2020 OR 2019) and document types (article, or review article or book chapter or proceedings paper or early access). Letters, data paper, news items, and editorials were excluded. Finally, the 6694 records (articles = 3917, early access articles = 1487, review articles = 1023 review, early access review articles = 263, book chapters = 3, and proceeding paper = 1) were imported and downloaded in Plaintext and BibTeX formats on July 9–August 1, 2020.The citation impact (CI) used in this study was calculated by dividing the total number of citations by the total number of publications. This illustrates the average number of citations that a specific publication has received. Besides, some terminologies are defined by the WOS database, such as usage count U1 which refers to the usage count of the last 180 days. The data analysis was performed using MS Excel, MS Access, and various bibliometric softwares, including VOS viewer, Biblioshiny (RStudio), and BibExcel.

Results

In 2019, 324 publications obtained 2105 citations and a usage count of 2776 whereas from January to July 2020, i.e., 180 days, 6370 publications were recorded with 37,965 citations and a usage count of 46,885. This shows that the COVID-19 pandemic has had remarkable attention from researchers throughout the world.

Most Productive Countries and Organizations

Table 1 indicates top 10 countries and organizations that produced COVID-19 literature globally. All countries in the table produced over 100 publications from 2019 to July 1, 2020. Only four countries produced over 500 publications. The United States of America (USA) is at the top of the list with 1860 publications, 9468 citations followed by China with 1510, Italy with 782, and England with 592 publications. It has been observed that though the USA has a higher number of publications, the impact of publications by China is higher than any country. Of the top 10 organizations, Huazhong University Science and Technology produced 193 publications and 5484 citations, followed by Wuhan University with 133

Table 1: Top ten most influential countries and organizations on COVID-19 literature during 2019–2020

Rank	Country	TP	TC	Rank	Organizations	Country	TP	TC
1	USA	1860	9468	1	Huazhong University of Science and Technology	China	193	5484
2	China	1510	25797	2	Wuhan University	China	133	5752
3	Italy	782	2654	3	University of Milan	Italy	88	351
4	England	592	3219	4	Harvard Medical School	USA	87	416
5	India	370	752	5	University of Hong Kong	China	87	3114
6	Germany	369	2071	6	Fudan University	China	85	1237
7	Canada	328	1635	7	Chinese Academy of Science	China	82	4688
8	France	271	1428	8	Zhejiang University	China	76	939
9	Australia	243	1903	9	University of Toronto	Canada	61	370
10	Spain	231	882	10	The Chinese University of Hong Kong	China	60	477

TP=Total Publications, TC=Total Citations

publications and 5752 citations. The Chinese Academy of Sciences, China, ranks 7th with 82 publications.

Influential Research Journals

Table 2 presents the top 10 research journals that produce literature on COVID-19. Nine journals produced over 50 publications; two of those journals produced over 100 publications. Journal of Medical Virology (Quartile 4) emerged as a top source with 149 publications, 1631 citations, followed by CUREUS (Cureus Journal of Medical Science), a nonimpact factor journal with 142 publications and 92 citations. The source with the highest impact factor (6.551) "Science of the Total Environment" produced 77 publications and obtained 170 citations. Most of the journals belonged to the USA (3), the Netherlands (3), and Switzerland (2), while India, and France had one journal each.

Authorship Pattern

The analysis of authorship pattern shows that all top ten authorship patterns have a significant number of publications. The top three authorship patterns were two authors (830 publications), three authors (763 publications), and four authors (718 publications). It is noteworthy that a significant number of publications (712) have single authorship. There was a decline in number of studies for more than 5 authors with 519, 474, 370, 268, and 228 publications recorded for 6, 7, 8, 9, and 10 authors, respectively.

Authors' Keyword Analysis

Figure 1 presents the authors' keyword analysis on COVID-19 literature from VOS viewer software. The minimum occurrence of 30 was selected; hence, 75 keywords met this criterion consisting of seven clusters. The size of the bubble indicates the number of occurrence and total strength links with other items/keywords. The top five keywords were COVID-19, coronavirus, sars-cov-2, pandemic, and pneumonia, which occurred 3409, 1201, 1266, 492, and 189 times, respectively.

Highly Cited Articles

Table 3 highlights the top ten highly cited articles on COVID-19. It is interesting that all the top ten articles were published in 2020. Half of those articles were published in *Lancet*, three in *The New England Journal of Medicine*, and one in *The Journal of American Medical Association* and *Nature* each. Half of the articles got over 1000 citations. The article entitled "Clinical Features of Patients Infected with 2019 Novel Coronavirus in Wuhan, China" by "Huang CL" published in *Lancet* got the highest citations (2264), U1 score (997), Z9 score (2396), and TR (37). The article at the bottom of the list by 'Lu RJ' received 639 citations.

Three-Factor Analyses of Major Aspects of the Data

Countries, keywords, and organizations

Figure 2 presents the three-factor analysis of the relationship among countries (left), keywords (middle), and authors' affiliated organizations (right). It shows that six countries (China, USA, Italy, United Kingdom, India, France, and Germany) published COVID-19 literature mostly using four main keywords (COVID-19, coronavirus, sars-cov-19, pandemic). These countries and keywords have a strong relationship with five organizations (Huazhong university science and technology China, Wuhan University China, Fudan University China, Tehran University of Medical Sciences, and the University of Hong Kong).

Country Collaboration Map on COVID-19 Literature

Figure 3 presents the country collaboration map on COVID-19 literature around the world. There are 1817 entries of collaborations among various countries

Table 2: Top ten most highly influential research journals on COVID-19 literature all over the world during 2019–2020

Source	TP	TC	H_index	Impact factor	Quartile	Publisher	Country
Journal of Medical Virology	149	1631	24	2.021	4	Wiley-Blackwell	USA
Cureus (Cureus Journal of Medical Science)	142	92	5	N/A	N/A	Cureus	USA
Head and Neck	85	135	5	2.538	1	Wiley	USA
Science of the Total Environment	77	170	7	6.551	1	Elsevier	Netherlands
Journal of Clinical Virology	62	63	4	2.777	3	Elsevier	Netherlands
Eurosurveillance	60	641	10	6.454	1	ECDC	France
International Journal of Infectious Diseases	54	563	12	3.202	2	Elsevier	Netherlands
International Journal of Environmental Research and Public Health	53	174	6	2.468	2	MDPI	Switzerland
Viruses-Basel	52	520	13	3.816	2	MDPI	Switzerland
Journal of Pure and Applied Microbiology	48	10	3	N/A	N/A	Journal of Pure and Applied Microbiology	India

NA=Not available, ECDC=European Centre for Disease Prevention and Control, MDPI=Multidisciplinary Digital Publishing Institute, TP=Total Publications TC=Total Citations

Table 3: Top ten most highly cited articles by researchers in the world during 2019–2020

Title	Author	Year	Source	TC	U1	TC per year
Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China	Huang Cl	2020	Lancet	2264	997	2264
Clinical characteristics of 138 hospitalized Patients with 2019 novel coronavirus-infected Pneumonia in Wuhan, China	Wang DW	2020	JAMA: The Journal of the American Medical Association	1343	230	1343
Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus Pneumonia in Wuhan, China: A descriptive study	Chen NS	2020	Lancet	1234	392	1234
Clinical characteristics of coronavirus disease 2019 In China	Guan W	2020	The New England Journal of Medicine	1226	50	1226
A novel coronavirus from patients with pneumonia in China, 2019	Zhu N	2020	The New England Journal of Medicine	1198	631	1198
A pneumonia outbreak associated with a new coronavirus of probable bat origin	Zhou P	2020	Nature	871	12	871
Early transmission dynamics in Wuhan, China, of Novel coronavirus-infected pneumonia	Li Q	2020	The New England Journal of Medicine	841	34	841
Clinical course and risk factors for mortality of adult inpatients with covid-19 in Wuhan, China: A retrospective cohort study	Zhou F	2020	Lancet	790	281	790
A familial cluster of Pneumonia associated with the 2019 Novel coronavirus indicating person-to-person transmission: A study of a family cluster	Chan JFW	2020	Lancet	744	428	744
Genomic characterization and epidemiology of 2019 Novel coronavirus: Implications for virus origins and receptor binding	Lu RJ	2020	Lancet	639	412	639

TP=Total Publications TC=Total Citations

worldwide with a maximum of 272 to one collaboration. The United States of America and China are top collaborating countries with 272 collaborations, followed by the USA and UK with 140 collaborations, Italy and the USA with 136 collaborations, the USA and Canada with 133 collaborations, and Italy and the UK with 130 collaborations.

Discussion

Bibliometric analysis is increasingly being used for the review of trends and progress in different fields and areas of research. The current analysis of data represents different dimensions of COVID-19 research, which includes the top countries, organizations, and journals producing publications on COVID-19. Of these countries, the USA stands as the number one country in terms of research on COVID-19 closely followed by China and distantly by such countries as Italy, England, and India. Although China has produced relatively fewer publications than the top producing country, its publications have obtained significantly higher CI than any other country listed. It is also notable that despite being ranked 5th in terms of the number of publications, India is ranked outside the top 10 countries with a CI 2.03. This puts a huge responsibility on Indian policymakers and scientists to fund more meaningful and citable research. Our results are in line with the findings of Tao, Zhou,[12] who reported the USA as the most productive country. This recent trend outstrips the statistics noted by

Bonilla-Aldana, Quintero-Rada[13] who used the Science Citation Index (SCI), Scopus, and PubMed databases with the term "Coronavirus" as the main operator from January 1951–January 2020. The study identified 18,158 articles from Scopus (31.3% from the USA, China 13.6%, and the United Kingdom 7.4%) followed by PubMed with 14,455 (20.1% the USA, China 18.6%, and Germany 4.2%), and SCI with 11,775 articles (34.9% from the USA, 22.4% China, and 6.8% Germany). This study also contradicts the findings of Chahrour *et al.*,[14] Hamidah *et al.*,[15] and Dehghanbanadaki *et al.*,[16] who ranked China as the top country that has produced research on COVID-19. This may be because COVID-19 was initially a public health problem in China.

Keeping in view the country-wise contribution on the subject, it is not surprising that out of the top 10 organizations listed, eight including the top two belong to China, followed by the USA with one organization.

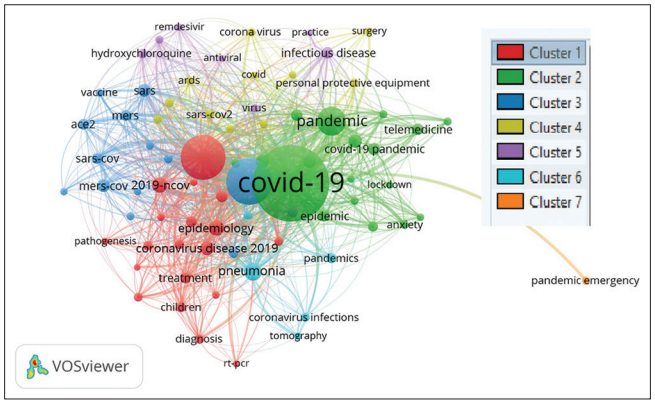


Figure 1: Authors' keyword analysis on COVID-19 literature from VOS viewer software

Although Chinese Academy of Science produced a smaller number of publications, it secured the highest CI than all other organizations. Dehghanbanadaki *et al.*,[16] have ranked the University of Hong Kong and Huazhong University of Science and Technology the first in producing documents on the topic. This study contradicts the findings of Hossain,[17] who reported China as the top country and the University of Hong Kong as a top organization. This trend of CI indicates that people around the world are reading the original research produced by the organizations working at the epicenter of the disease. This also highlights the epidemiological/public health significance of sharing the data in addition to treating patients. Instant access to news and research has created a solid foundation for epidemiological debate, presenting some idea of the size of the problem, and encouraging preventive measures.

The bibliometric data regarding the most productive journal publishing research on COVID-19 discloses some interesting results. The Journal of Medical Virology (Wiley-Blackwell) has the most publications closely followed by CUREUS (Cureus Journal of Medical Science), which is the publication of Cureus, USA, and "Head and Neck" being published by Wiley, USA. The Dehghanbanadaki *et al.*,[16] reported that The Lancet and BMJ Clinical Research Ed were the most prolific in publishing documents on the topic. Lou *et al*.[18] conducted a PubMed based bibliometric analysis of COVID-19 literature and found that the Journal of Medical Virology was the most productive journal on the topic. These results also contradict the findings of Hossain,[17] who reported Viruses-Basel, Journal of Virology, and Transboundary and Emerging Diseases to be in the first, second, and third positions,

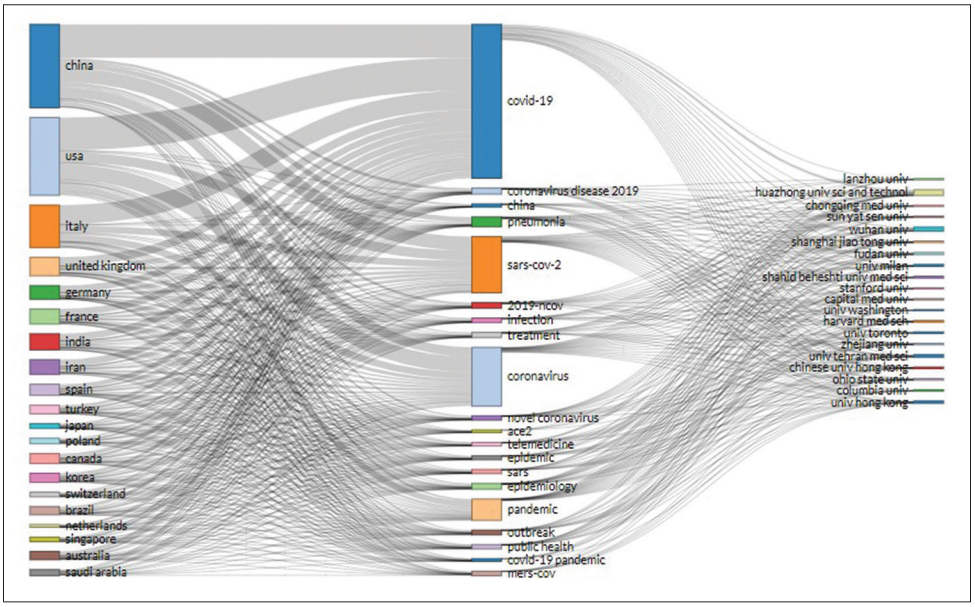
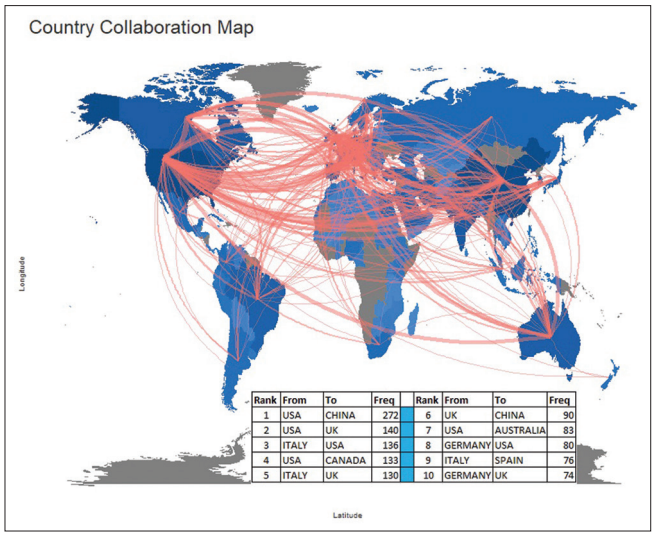


Figure 2: Three-factor analysis of the relationship among countries (left), keywords (middle), and authors' affiliated organizations (right)



Rank	From	To	Freq	Rank	From	To	Freq
1	USA	CHINA	272	6	UK	CHINA	90
2	USA	UK	140	7	USA	AUSTRALIA	83
3	ITALY	USA	136	8	GERMANY	USA	80
4	USA	CANADA	133	9	ITALY	SPAIN	76
5	ITALY	UK	130	10	GERMANY	UK	74

Figure 3: Country collaboration map on COVID-19 literature around the world

respectively in terms of their productivity. The Journal of Medical Virology has also attained the highest citations of 1631 while of the rest, only three journals *Eurosurveillance*, *International Journal of Infectious Diseases*, and *Viruses-Basel*, got over 500 citations. However, though CUREUS is in the second position on the list it has received only 92 citations so far. It is encouraging that the most relevant and authentic publication sources are getting more attention and referral. It is also evident that initial articles were prepared entirely locally with international attention and collaboration arriving later.

The analysis of data regarding authorship and collaborative research patterns shows that most publications are by two-author collaboration, closely followed by three, four, and single authors. Interestingly, the remaining collaborative patterns also have a good number of publications in their credit. This denotes the importance of multidisciplinary teams of scientists working on the virus-related research. These findings are different from those of Hossain,[17] who reported very few single-authored entries on the topic. The review of published literature reveals that more than 10 authors for a single article is not unusual in medical research. This may be due to multiparty collaboration where researchers at the epicenter of the disease outbreak may be seeking outside collaboration. It is important to note here that the WHO made essential recommendations for international cooperation following the Ebola epidemic to avoid failure of therapeutic trials.[19-21] The research institutions at the forefront of an infectious outbreak must be consulted to obtain the benefit of their experience. Of the keywords, COVID-19 was the most frequently used, followed by coronavirus, SARS-CoV-2, pandemic, and pneumonia, as indicated by the findings of Hossain[17] and Hamidah *et al*.[15]

In order to see the impact of individual articles, a list of the top ten articles was prepared on the basis of their citation count. "Clinical Features of Patients Infected with 2019 Novel Coronavirus in Wuhan, China," published by Lancet, achieved the highest number of citations whereas "Genomic characterization and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding" was at the bottom of the list. Dehghanbanadaki *et al*.,[16] reported "Genomic characterization and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding" as the most cited. Further analysis identified the five articles that obtained more than 1000 citations each, presumably helping accelerate research on COVID-19. The three-factor analysis provides the most productive countries such as China, the USA, and Italy, focusing on the four main keywords including COVID-19, coronavirus, sars-cov-19, and pandemic. The analysis focusing on the map of country collaboration discloses a significant number of publications resulting from collaborative research between the USA and China, which is in agreement with the findings of Hossain.[17] The USA also did much collaborative research with the UK and Canada.

The data summarized in this bibliometric analysis signifies immediate response to an outbreak, both from research and clinical perspective, and its communication. High priority publication of findings would give other countries hints about a possible pandemic and provide them with reaction time to prepare for it. The standard operating procedures of the WHO regarding infectious disease cases also demand communication of such cases as quickly as possible.[22] The same strategy of reporting noteworthy diseases has been followed to successfully combat polio and tuberculosis in most parts of the world.[23]

Another important aspect highlighted by our results is the indigenous nature of the response. Had it been a third world country, we may have seen a delay in reporting, communication, and response to the pandemic. Other possible different outcomes could have been a foreign base of research. For example, two bibliometric reviews published after the Ebola outbreak in West Africa concluded that most of the research, funding agencies, and highly cited articles were based outside Africa.[24,25] While bibliometric analyses are by no means a way of quantifying the actual adequacy of the response on the ground, the apparent effect on limiting the spread and flattening the curve can be correlated with the rapid publication and communication of the data that lead to the formulation of preventive and treatment guidelines.

Limitations and future research directions

This study was limited to WOS publications indexed on the subject area of COVID-19 during 2019–2020. Since our focus was on bibliometric aspects, it was not within the scope of our study to determine whether the incorporated research work was conducted in relevant countries or not. Databases such as PubMed, EMBASE, Google Scholar, Dimension, and Scopus may give different sets of records on searching, but a comparison is out of the scope of this analysis. Future work in this domain would have to verify the present findings with data after the pandemic is over. The studies might also look at the economic and public health impact of individual studies on a thorough quantification of CI and collaboration.

Conclusion

The results of this bibliometric review document are that most of the initial research related to the current coronavirus pandemic was carried out and reported from within the USA and China, with The Journal of Medical Virology and CUREUS being the favorite sources of publications. The research was mostly carried out by large teams. This is an analysis of research done from 2019 to July 2020, so the data and patterns would undoubtedly alter as the virus spreads worldwide. Future studies will provide updates on these dynamics.

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Conflicts of interest

There are no conflicts of interest.

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