



Global Research Trends on COVID-19: A Bibliometric Analysis

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Abstract

Introduction: The emergence of the human coronavirus (SARS-CoV-2) in December 2019 caused a public health crisis. Knowing the progress of studies in the field of COVID-19 helps researchers a lot in summarizing the available information. Using a bibliometric analysis this study aims to assess the characteristics of the research publications involving COVID-19 globally.

Methods: To make the bibliometric indicators non-exhaustive, a bibliometric database is created where researchers can have immediate access and contribute to COVID-19 related bibliometric indicators. PubMed database was searched for COVID-19 publications published within 1st January up until 13th March 2020. An R package of Bibliometrix and VOSviewer for comprehensive science mapping analysis and visualization are utilized. Analysis parameters include publication type, pattern of international collaboration, leading journals, the most cited papers and the most productive countries. A total of 786 COVID-19 publications in 238 journals from 69 countries indicates the international spread of the research within short period.

Results: The Lancet (7.64%), Journal of Medical Virology (7.11%) and BMJ (6.08%) had the largest share of publications respectively. Manuscripts published in The New England Journal of Medicine (15 citations), Nature (10 citations), and The Lancet (10 citations) have received the highest citations. China was the largest contributor with 44.27% of total publications followed by the United States (4.58%) and Italy (2.67%).

Conclusions: Canada, Germany and United States had the greatest proportion of international research collaboration as per multiple country publication ratio. There is rapid increase in research activities related to COVID-19 in the initial 11 weeks of 2020.

INTRODUCTION

On 30 December 2019, ProMED-mail in an attempt published a post on atypical pneumonia in China (Hubei Province). Just a day after, on 31 December 2019 World Health Organization (WHO) Country Office in China received a report about sequential similar cases of pneumonia with an unknown aetiology in Wuhan city while some of the patients were severely ill [1]. Just a few days later, on 7 January 2020, a novel coronavirus which later was termed as SARS-CoV-2,

was identified as the causative agent for the mentioned pneumonia cases [2].

SARS-CoV-2 is transmitted quite efficiently with an exponential rate of increase worldwide. On the date of writing this article (based on Worldmeter data) coronavirus diseases designated as COVID-19 has spread to 126 countries with China, Italy, Iran and South Korea listed as the most hit countries [3]. Although the mechanism of transmission of SARS-CoV-2 remains

unknown [4], the rapid spread appears to have resulted from human-to-human interaction. As of 16 March 2020, 125,048 confirmed cases of infection are reported worldwide and death toll jumped to 4,613 [5] which led to declaration of Public Health Emergency of International Concern by WHO [6, 7].

All stakeholders around the globe have integrated to tackle this epidemic crisis. Country authorities have taken various measurements such as practice of lockdown of cities, suspensions of flight to and from hard-hit countries, prevention of community gatherings to control COVID-19. In labs the collaborative research teams are actively pursuing the clue for diagnostics, therapeutics, prevention, and vaccines. Governments and international institutions allocated huge budget to develop tools and resources to combat it. Some prestigious journals such as *The New England Journal of Medicine* and *The Lancet* have contributed to the fast spread of knowledge through providing free access on the new COVID-19 content including clinical reports, management guidelines and commentaries. Bibliometric analysis is a one of the well-established research methods to evaluate and quantify the growth of published research work in a particular subject. This method not only provides macroscopic overview of the amount of academic research on the specific field but also clearly identifies influential studies, authors, journals, and countries [8-10]. In this vein, bibliometric analysis seems a perfect match for the aims of the current study to identify the state of the research about COVID-19.

While the research on COVID-19 is growing fast globally, little is known about the progress of global scientific research production. Knowing the progress of studies in the field of Corona helps researchers a lot in summarizing the available information. Also, by knowing this information, the path of researchers and health policymakers will be brighter. In this regard, the current study endeavours to present the status of current knowledge and research trends in this context through conducting a bibliometric analysis.

METHODS

All the studies included in the present research were retrieved from PubMed on the 13th of March 2020. Our motivation for utilizing PubMed was twofold. Firstly, we expected the bulk of COVID-19 related research to be of biomedical relevance. In this regard, PubMed is widely regarded as the de facto biomedical literature data base in terms of its comprehensiveness [11]. Secondly, the use of PubMed data base allowed us to include studies that have been rapidly published in their online early versions. Given the amount and pace with which COVID-19 related research has been publishing since its outbreak, we expected a vast majority of this research to be available online in an early version. In

contrast, other widely utilized data bases, such as, Scopus and Web of Science, are only readily updated for printed literature and do not include online early versions [12].

We calibrated the search string such that potential combinations of the search terms related to COVID-19 were maximized so as to not miss out any relevant article. Additionally, we kept the search for relevant studies restricted to the year 2020. Consistent with our research objectives, this restriction allowed us to capture all the relevant studies between the first reported outbreak of COVID-19 on 31st December 2019 up until 13th March 2020 (our search date). That is, we queried the PubMed database considering the search string (((("2019-nCoV" [Title/Abstract] OR "2020-nCoV" [Title/Abstract] OR "2019-20 coronavirus*" [Title/Abstract] OR "2019-2020 coronavirus*" [Title/Abstract] OR "2019 coronavirus*" [Title/Abstract] OR "coronavirus*" 2019" [Title/Abstract] OR "2020 coronavirus*" [Title/Abstract] OR "coronavirus*" 2020" [Title/Abstract] OR "SARS-CoV-2" [Title/Abstract] OR "SARS coronavirus 2" [Title/Abstract] OR "COVID-19" [Title/Abstract] OR "COVID-2019" [Title/Abstract] OR "coronavirus disease 2019" [Title/Abstract] OR "coronavirus disease 2020"[Title/Abstract])) AND ("2020/01/01"[Date - Publication] : "3000"[Date - Publication])). Subsequently, the bibliometric analysis reflects metrics relating to the retrieved studies as at 13th March 2020.

Data was retrieved in RISmed (version 2.1.7), an R package for downloading content from NCBI databases. In order to perform the bibliometric analysis, we utilized Bibliometrix (version 2.3.2), an R package for comprehensive science mapping analysis [13]. Bibliometric analysis was undertaken to understand research trends in a particular field or subfield and to assess citation as a measure of impact. The Bibliometric analysis took place in two stages. First, we performed a descriptive analysis to provide an overview of the documents retrieved from our search. We generated co-occurrence network and density visualization of keywords by utilizing VOSviewer (version 1.6.14), a computer program for bibliometric mapping [14]. Next, we analyzed research output in terms of each corresponding author's respective country of affiliation. Corresponding author's country of affiliation further served as a proxy to analyze research output for the included countries. We then analyzed the scientific productivity of COVID-19 related research. Finally, we analyzed the amount of research collaboration by deriving a collaboration index. We further extended this to analyze country wise collaboration networks.

RESULTS

Overview of Documents

The search criteria yielded 786 documents. The largest share of document type was journal article (73.28%). Amongst these articles, 85 were English abstracts only, 46 were reviews, and 1 was retracted from publication. The second largest share of document type was letter (15.14%), amongst which, 7 were comments, and 1 was retracted from publication. The third largest document type was editorial (10.18%), amongst which 3 were comments. Other document types included in the analysis were, 6 case reports and 5 news documents. A total of 3,422 authors contributed to 786 studies.

Overall, the journals have addressed several related areas. The ten most relevant keywords, in terms of the number of documents in which the keywords occurred include, COVID-19 (154 documents), coronavirus (116 documents), SARS-CoV-2 (90 documents), 2019-nCoV (88 documents), China (35 documents), epidemiology (35 documents), pneumonia (37 documents), humans (26 documents), novel coronavirus (28 documents), and coronavirus infections (25 documents). The co-occurrence network of the keywords and their density visualization are available on www.decisionallab.com/covid19.

Research Output Details and Productivity

Journals

Table 1 summarizes the top ten most relevant sources of publication in the first eleven weeks of 2020, measured by the number of publications related to COVID-19. The weekly analysis showed an exponential increase in research publications related to COVID-19 from 1st January until 13th March 2020. In line with the spread of the virus globally, more journals started publishing related research. While in the first four weeks of 2020, only five journals published documents related to COVID-19, at the date of writing this paper, 238 journals have contributed to the publication of 786 documents which reveals how such research is widespread in the extant literature. In terms of journal relevance, The Lancet (7.64%) had the largest share of publications followed by, Journal of Medical Virology (7.11%), BMJ (6.08%) Chinese Journal of Tuberculosis and Respiratory Diseases (3.99%), Eurosurveillance (3.82%), The Lancet Infectious Diseases (3.30%), The New England Journal of Medicine (3.30%), Radiology (3.30%), Chinese Journal of Epidemiology (3.13%), and Journal of Clinical Medicine (2.78%). Making an early version of the submitted documents available online is recommended to expedite the research development.

Papers

Table 2 shows the top ten most cited manuscripts. Manuscripts published in The New England Journal of Medicine (15 citations), Nature (10 citations), and The Lancet (10 citations) have received the highest citations by 13 March 2020. Number of citations indicates the

relevance and impact of the paper in the development of the knowledge within the disciplines [15] though other factors such as authors' networks and reputation, being open access, and time of publication may impact a paper's number of citations too. The New England Journal of Medicine and The Lancet have contributed to the fast spread of knowledge through providing free access on the COVID-19 content. Four of the top ten most cited papers have been published in The Lancet (in total 32 citations) which indicates the salient role of this journal in developing the research.

Authors

In regard to the conformity of Lotka's Law [16, 17] to authorship distribution of COVID-19 related research, the estimation yielded a beta coefficient (β) of 2.54 and a constant coefficient (c) of 0.611 ($r^2 = .95$). Furthermore, the Kolmogorov-Smirnov test (K-S test) indicated that the author productivity distribution significantly differed from the theoretical distribution ($p < .05$). This suggests that COVID-19 related research has not conformed to Lotka's Law, and there were fewer highly productive authors than expected. Out of a total of 3,422 contributing authors, authors of single-authored documents were 99 (2.89%) and authors of multi-authored documents were 3,323 (97.11%). Furthermore, the theoretical and observed distribution of scientific productivity appear to be spatially proximate. However, if the true productivity distribution differs from the theoretical distribution, the large sample size of the number of documents and number of authors increases the likelihood of detecting this difference in terms of statistical significance of the Kolmogorov-Smirnov test.

Countries

The data set was a representation of 69 countries. The top ten contributing countries as measured by corresponding author's country and number of documents include China (44.27%), United States (4.58%), Italy (2.67%), Singapore (2.67%), Korea (2.42%), Canada (2.04%), Germany (1.53%), Japan (1.53%), France (1.40%), and Switzerland (1.40%). **Table 3** summarizes the top ten countries in terms of research output. The significant contribution of China is reflective of the state of emergency in this country due to the outbreak of a mysterious pandemic disease. The high rate of mortality in China (total deaths of 3,199 cases as of 13 March 2020) combined with non-existence of a specific treatment causing a 'wartime' situation in Wuhan city has urged Chinese scientists to embrace the research work related to COVID-19. Since the treatment for the COVID-19 so far has been limited to the kind of medication and care given for Influenza, many labs have turned their sights towards development of vaccine and specific medication which can rescue the

infected people. The US taking the second position in academic publications is not surprising.

Table 1. The most relevant sources of publication

Journals	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Week 10		Week 11	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
The BMJ															7	2.	1	2.	2	3.	3	4.
															23	4	99	5	69	5	45	
Cell Discovery	2	9.	2	9.	2	8.	2	7.	2	2.												
		09		09		70		14		53												
Eurosurveillance	5	22	5	22	5	21	5	17	1	21	1	11	1	8.	1	5.	1	3.	2	3.	2	2.
		.7		.7		.7		.8	7	.5	7	.7	7	21	7	41	7	63	2	25	2	79
		3		3		4		6		2		2										
Infectious Disease Modelling	2	9.	2	9.	2	8.	2	7.	2	2.												
		09		09		70		14		53												
Infection, Genetics and Evolution									2	2.												
									53													
International Journal of Infectious Diseases									2	2.												
									53													
Journal of Clinical Medicine									2	2.	4	2.	7	3.	1	3.	1	3.	1	2.	1	2.
									53		76		38	2	82	5	21	6	36	6	03	
Journal of Infection																			1	2.		
																			5	22		
Journal of Infection in Developing Countries									2	2.												
									53													
Journal of Medical Virology											7	4.	1	6.	1	4.	2	5.	3	5.	4	5.
											83	3	28	5	78	8	98	5	17	1	21	
Journal of Travel Medicine											3	1.										
												45										
The Lancet							2	7.	6	7.	1	9.	2	12	2	9.	3	7.	4	6.	4	5.
							14		59	4	66	5	.0	9	24	6	69	3	35	4	59	
													8									
The Lancet Infectious Diseases														8	2.	1	2.	1	2.	1	2.	
														55	4	99	9	81	9	41		
The New England Journal of Medicine							5	6.	5	3.	6	2.	9	2.	1	2.	1	2.	1	2.	1	2.
								33		45		90		87	3	78	4	07	9	41		
Osong Public Health and Research Perspectives								4	5.	4	2.	4	1.									
								06		76		93										
Radiology											7	4.	1	4.	1	4.	1	3.	1	2.	1	2.
											83	0	83	3	14	5	21	8	66	9	41	
Travel Med Infect Dis	5	22	5	22	5	21	5	17	5	6.	7	4.	7	3.	7	2.	1	2.				
		.7		.7		.7		.8		33		83		38		23	2	56				
		3		3		4		6														
Virologica Sinica												3	1.									
												45										
Chinese journal of contemporary pediatrics											3	2.	3	1.								
											07		45									
Chinese Journal of Tuberculosis and Respiratory Diseases											7	4.	9	4.	1	3.	1	2.	2	3.	2	2.
											83		35	2	82	4	99	1	10	3	92	
Chinese Journal of Epidemiology																			1	2.	1	2.
																			4	07	8	29
Others	8	36	8	36	9	39	1	42	3	37	7	48	1	48	1	58	2	61	4	64	5	67
		.3		.3		.1	2	.8	0	.9	0	.2	0	.3	8	.9	.9	3	.2	3	.4	
		6		6		3		6		8		8	0	1	5	2	0	7	5	5	0	3
Total	2		2		2		2		7		1		2		3		4		6		7	
	2		2		3		8		9		4		0		0		6		7		8	
											5		7		7		8		7		6	

Note: Journals with less than one paper have been excluded

Not only has the US always been the most prolific country for scientific research in general [18], It has allocated a huge budget of \$8.3 billion emergency spending bill to fight against coronavirus for instance in making the vaccine and other therapeutic development that are affordable for all [19]. Besides, private funders in the US have donated huge amounts to speed up the development of Coronavirus treatment. While in the country the situation of 'National Emergency' is declared and US struggles to 'catch up' in the fight against coronavirus, it seems an urge to contribute to this unprecedented national action.

Although China has the highest research output (measured by the corresponding author's country),

China's multiple country publication ratio (0.236) is lower than that of Canada (0.563), Germany (0.500), United States (0.389), France (0.364), Italy (0.286), and Switzerland (0.273). Relative to the absolute number of publications, China appears to be lagging in terms of inclusivity of foreign researchers within their research output. Nonetheless, research output from China has received the highest number of citations (61 citations) so far. Nonetheless, this is not surprising given that the total number of documents emerging out of China is substantially higher than any other contributing country. Table 4 summarizes total citations per country. However, taking into account average document

citations received per country (Table 4), Hong Kong is leading with an average document citation of 3.00.

Table 2. Top manuscripts per citations.

Document reference	Total Citations
Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., ... & Xing, X. (2020). Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. <i>The New England Journal of Medicine</i> .	15
Zhou, P., Yang, X. L., Wang, X. G., Hu, B., Zhang, L., Zhang, W., ... & Chen, H. D. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. <i>Nature</i> , 1-4.	10
Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., ... & Cheng, Z. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. <i>The Lancet</i> , 395(10223), 497-506.	10
Wu, J. T., Leung, K., & Leung, G. M. (2020). Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. <i>The Lancet</i> , 395(10225), 689-697.	9
Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., ... & Niu, P. (2020). A novel coronavirus from patients with pneumonia in China, 2019. <i>The New England Journal of Medicine</i> .	8
Lu, R., Zhao, X., Li, J., Niu, P., Yang, B., Wu, H., ... & Bi, Y. (2020). Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. <i>The Lancet</i> , 395(10224), 565-574.	7
Kim, J. Y., Choe, P. G., Oh, Y., Oh, K. J., Kim, J., Park, S. J., ... & Oh, M. D. (2020). The first case of 2019 novel coronavirus pneumonia imported into Korea from Wuhan, China: implication for infection prevention and control measures. <i>Journal of Korean Medical Science</i> , 35(5).	6
Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., ... & Yu, T. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. <i>The Lancet</i> , 395(10223), 507-513.	6
Roth, C., Schunk, M., Sothmann, P., Bretzel, G., Froeschl, G., Wallrauch, C., ... & Seilmaier, M. (2020). Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. <i>The New England Journal of Medicine</i> .	5
Corman, V. M., Landt, O., Kaiser, M., Molenkamp, R., Meijer, A., Chu, D. K., ... & Mulders, D. G. (2020). Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. <i>Eurosurveillance</i> , 25(3).	5

Note: Total citations is based on citations recorded by PubMed and not any other source. The number of citations may therefore differ on google scholar and other data bases.

Table 3. Top ten countries in terms of research output.

Country	Number of documents	Frequency	SCP	MCP	MCP ratio
China	348	.585	266	82	.236
United States	36	.061	22	14	.389
Italy	21	.035	15	6	.286
Singapore	21	.035	19	2	.095
Korea	19	.032	18	1	.053
Canada	16	.027	7	9	.563
Germany	12	.020	6	6	.500
Japan	12	.020	10	2	.167
France	11	.019	7	4	.364
Switzerland	11	.019	8	3	.273

Note: SCP = Single country publications; MCP = Multiple country publications; MCP ratio = Multiple country publication ratio (number of documents / MCP)

Table 4. Total citations per country

Country	Total citations	Average document citations
China	61	0.175
Hong Kong	15	3.000
Germany	10	0.833
Korea	9	0.474
Switzerland	4	0.367
Netherlands	2	0.500
United States	2	0.056
France	1	0.091
Japan	1	0.083
Sweden	1	0.143

Note: Corresponding author's country serves as a proxy for measuring citation metrics regarding each respective country.

Research Collaboration

The collaboration index amongst authors was 5.25 (4.35 authors per document and 6.64 co-authors per document). Figure 1 shows the country collaboration network. The bigger nodes of, China, United States, and Hong Kong represent greater inter country collaboration. The density of networks around South American and African countries suggests a greater

collaboration within the mentioned regions. For China, the collaboration appears to be vaster and spread out globally. However, it appears that documents relating to COVID-19 are more frequently published by local research clusters (higher single country publications relative to multiple country publications).

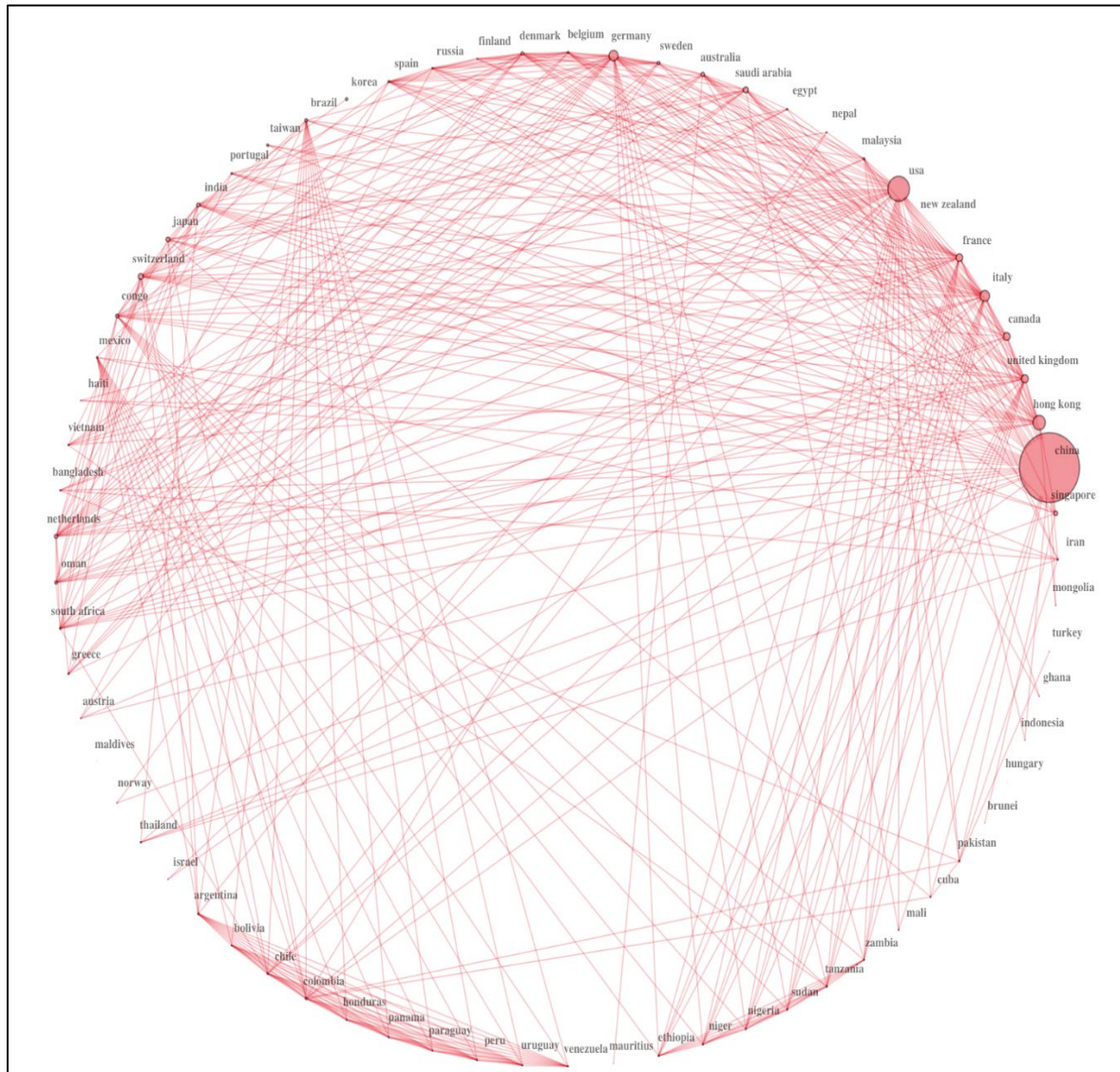


Figure 1. Country Collaboration Network

DISCUSSION

The current study contributes to the fast-growing body of research in two main ways. First, this study shows the current state of research on COVID-19 by determining the leading journals, the most impactful papers, the most productive authors and countries, and the state of collaboration in research on COVID-19. Second, while a bibliometric analysis on such studies provide valuable information, the rapid pace of COVID-19 related research publications makes a static bibliometric analysis become inherently outdated. To make the bibliometric indicators non-exhaustive and up to date, we have created a bibliometric database where researchers can have immediate access to various COVID-19 related bibliometric indicators. This bibliometric analysis would aid in the rapid dissemination of COVID-19 related research developments in a more meaningful manner. To

summarize, the current study not only presents a bibliometric analysis of COVID-19 research of the first eleven weeks of 2020 but also provides a venue for other researchers to contribute.

One of the lessons learnt from the 2003 SARS outbreak was the need to keep track of related research in a timely and meaningful way. The exponential growth in studies relating to the COVID-19 outbreak pose a major challenge to researchers in keeping track of existing research developments. While a bibliometric analysis on such studies has its obvious benefits, the rapid pace of COVID-19 related research publications makes a one-off bibliometric analysis inherently out of date. Additionally, researchers may not always have access to relevant data bases which poses a threat to the timely dissemination of potentially life-saving research findings. To address these challenges, we have created a webpage as a 'collaborative' platform where researchers

not only can have immediate access to various COVID-19 related bibliometric indicators but also can contribute to it via inclusion of new metrics. Researchers can manually upload metrics which would constantly improve the bibliometric indicators. We aim to make these bibliometric indicators non-exhaustive and up to date. To summarise, this timely study endeavours to provide a venue for other researchers to contribute to the project until a new development can extinguish the public health crisis.

Based on the main results, in terms of journal relevance, The Lancet had the largest share of publications. In another study [20] The Journal of Medical Virology (Wiley-Blackwell) had 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. In line with our study Dehghanbanadaki [21] reported that The Lancet was the most prolific in publishing documents on the topic. Also, in present study The New England Journal of Medicine was contain the top cited papers and the article entitled "Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia" that was published in The New England Journal of Medicine was the top cited paper. In another study "Clinical Features of Patients Infected with 2019 Novel Coronavirus in Wuhan, China," published by Lancet, achieved the highest number of citations [20]. Dehghanbanadaki et al. reported "Genomic characterization and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding" as the most cited [21].

Another main result was authors of multi-authored documents were 97.11%. Results of another study showed that most publications are by two-author collaboration, closely followed by three, four, and single authors [20]. These findings are similar to those of Hossain [22], 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 [20]. In present study, the top contributing country as measured by corresponding author's country and number of documents was China (44.27%). The result was the same with Farooq [20]. This study is in line with the findings of Hossain, who reported China as the top country and the University of Hong Kong as a top organization [22].

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 China, with The Lancet being the favorite source of publications. The research was mostly carried out by large teams. Future studies will provide updates on these dynamics.

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CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICAL APPROVAL

Ethic committee approval did not applicable for this study.

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AUTHORS' CONTRIBUTIONS

HSN, SPSh, and NN contributed to intellectual content and study design. SPSh, HW, and HSH contributed to data collection. HSH and SPSh run the data analysis. AHG, SPSh, HSH, HW, and NN wrote the first draft. HSN, AHG, and HW contributed to critical revision of manuscript. All of the authors accepted the final version of manuscript.

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