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Original Research

Bibliometric Analysis of Worldwide Coronavirus Research based on Web of Science between 1970 and February 2020

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Abstract

Researchers worldwide are striving hard to find a solution for the coronavirus pandemic and reduce the fatalities from this severe outbreak. The purpose of this article is to evaluate and visualize the published documents about coronavirus research, based on extracted data from Web of Science (WoS) citation database. The study used a bibliometric method and social network analysis. Data were collected using the WoS database on February 23, 2020, with 13252 records being retrieved and used as the study sample. Descriptive statistics were used in the bibliometric method and network analysis. Text Statistics Analyzer and ISI.exe were used to compute the number of authors per document. VOSviewer and UCINET were used respectively for visualization and for measuring the centrality and the density of networks. Study findings indicate the top actors of the scientific society (authors, institutions, countries) that had the most publication on coronavirus. Similarly, the top keywords used by authors were identified. Also, the density and centrality measures of co-authorship networks (degree, closeness, betweenness) for the top 10 authors, institutions, countries, and keywords were identified. The Journal of Virology had the highest number of published papers on coronavirus research. The study revealed that the leading researchers and institutions were mostly from the United States of America, England, China, Germany, Netherlands, France, Canada, Japan, South Korea, and Saudi Arabia.

Keywords: Centrality Measures, Co-authorship, Coronavirus, Density, Social Network Analysis

Introduction

Human coronaviruses (HCoVs) were first observed in the 1960s among patients with the common cold (Su & et al., 2016). There are different kinds of HCoVs, out of which Van der Hoekand, et al. (2004) reported three types of human coronaviruses: coronavirus 229E (HCoV-229E), HCoV-OC43, and Severe Acute Respiratory Syndrome (SARS)-associated coronavirus (SARS-CoV). Also, Su & et al. (2016) reported two kinds of HCoVs, namely """"""Severe Acute Respiratory Syndrome (SARS) """""" and """"""Middle East Respiratory Syndrome (MERS)

"""""".The recent outbreak of human coronavirus disease (COVID-19) was first reported from Wuhan, in China, on December 31, 2019 (World health organization (WHO, 2020a). The outbreak was declared a public health emergency of international concern on January 30 2020 (WHO, 2020 b). Based on the latest data up to December 12 2020, there were 71,612,109 reported cases of COVID-19 globally and 1,604,565 deaths (Worldometers, 2020).

As the statistics indicate, the coronavirus disease has severely affected the lives of human beings in this decade, especially towards the end of 2019 and the start of 2020. The disease has started an outbreak in almost all countries around the world, and therefore massive global, national, institutional and individual efforts are required to control and conquer this pandemic. One of the important works to find solutions to this problem is to do research. Isaac Newton in 1676 had famously said, "If I have seen further, it is by standing on the shoulders of Giants" (Pu & et al., 2015). This metaphor is used for discovering the truth by building on prior discoveries, which has become a guiding principle for scientific progress and investigation. It also implies that researchers conduct their research projects based on previously published works. Moreover, the number of research publications produced worldwide are so enormous and ever increasing. This scenario demands the need to filter and distinguish the core actors of scientific society, to choose the best ones for their future research. Bibliometrics, the study of measuring and analyzing scientific literature, enables us to identify the essential works, researchers, institutions, countries, and concepts. Using this method, it is possible to systematically analyze the published documents on coronavirus and identify the leading authors, institutions, and countries in this area and throw light on what the authors had focused on what topics and which topics need attention.

Besides, actors in the scientific sector conduct research projects individually or collectively. Previous studies (Bharvi, Garg & Bali, 2003; Glanzel & Schubert, 2004; Kronegger, Ferligoj & Doreian, 2011) indicate an increasing trend for collaboration in conducting research. By applying the bibliometric method and network analysis, it is possible to study the collaboration between researchers, institutions, and countries by observing the co-authorship networks.

A network consists of connected nodes or actors (individuals, institutions, countries, etc). The connection between these actors is called ties or links; it should be noted that in mathematical literature on networks, """""actors""""" is called """""vertices""""" and """""ties""""" is called as """""edges""""" (Huisman, De Boer, Dill, & Souto-Otero, 2015). Degree, closeness and betweenness are three standard centrality measures (Borgatti, 2005; Freeman, 1979). In a co-authorship network, an author, institution, or country is considered the node, and their collaboration in publishing joint work with each other is considered the link. Furthermore, the density of a network indicates the sparseness of nodes in a dense network, while in a sparse network, such a relationship does not exist (Shekofteh, Karimi, Kazerani, Zayeri & Rahimi, 2017).

Though Web of Science (Wos), the world renowned indexing system has reported 13252 documents on Coronavirus research (as on the date of this study), it is observed that the number of papers on biliometrics studies and social network analysis are found to be very few. Table 1 indicates six previous bibliometric studies about coronavirus, based on Scopus, WoS, and PubMed.

Table 1

Summary of Literature Review

Researcher	Aim	Database	Period	Some analyzed parameters
Sa'ed (2016)	Assess the characteristics of publications involving MERS-CoV globally	Scopus	2012-2015	Year and type of publication, patterns of international collaboration, research institutions, journals, impact factor, h-index, language, and times cited
Ram (2020)	Identifying the trends of research associated with Coronavirus	Scopus	1970 to 2019	Annual growth, productive countries, institutes, authors, journals, highly cited papers, and research focus
Hossain (2020)	Identifying the leading research and analyzing the conceptual areas on COVID-19	WoS	Until April 1, 2020	Number of authors and citations per document, top ten articles, authors, and journals, major research areas
Zhou & Chen (2020)	Investigating the global research trends of coronavirus over the last twenty years	WoS	January 2000 to March 17 2020	Productive regions, institutions and journals, frequently-cited articles, hot keywords, year, collaboration
Lou et al. (2020)	Analyzing the publications about COVID-19	PubMed	From inception to March 1, 2020	Author country, number of publication, corresponding author, language, year and type of publication, research focus
Danesh, GhaviDel &, Piranfar (2020)	Co-word analysis of coronavirus publication	WoS	1970-2019	The highest frequent keyword was "Severe Acute Respiratory Syndrome (SARS)"

This study aims to analyze coronavirus publications' main characteristics based on bibliometrics and social network analysis to help researchers understand coronavirus research characteristics. To achieve the primary goal of the study, the following subsidiary objectives are presented.

Subsidiary Objectives

To identify the characteristics of published documents (published year, type, language, and WoS index) on coronavirus and its research

To identify the publishing pattern of authors on coronavirus published outputs

To study and visualize co-authorship patterns of research outputs published on coronavirus

To study and visualize co-authorship patterns of institutions on coronavirus

To study and visualize co-authorship patterns of countries on coronavirus

To study and visualize co-words on coronavirus

To measure the density and centrality analysis of networks (co-authorship of researchers, institutions and countries)

Methodology

Bibliometric method and social network analysis were used in the current study. Data were collected from WoS using a query on the topic """""Coronavirus""""" during 1900 to February 23 2020, and a total number of 13252 records were retrieved since 1970 and used as the sample of this study. Data gathering was carried out on February 23 2020. The retrieved data was saved as txt format in order to use in bibliometric software. Due to the limitation of saving only 500 records of WoS, the needed records were downloaded as 27 separate txt files; in the next stage, using a notepad and typing the order (copy/b """""*.txt""""""""" ""all txt""") and saving as .bat file, all the txt files therefore collectively were used in VOSviewer 1.6.13.

Co-authorship networks were also analyzed using density and centrality measures (degree, closeness, and betweenness). The number of lines present to the lines possible in a given ego network represents the density; the two measures of the study's density comprised the density for the non-valued relations (binary) and the valued relations (the number of ties for each association). The UCINET 6 software computes the average value, standard deviation, and average weight for matrices' density measures with valued relations (Embrey, 2012). Therefore, the present study with valued relations used mentioned descriptive statistics. The degree is defined as the number of direct connections that a given node has with other nodes without considering the strength of the connection. The current study recognizes each direct connection as a unique co-authorship. An author who has co-authored with many authors has a high degree of centrality (Otte & Rousseau, 2002). The average shortest distance by which a node is separated from all other nodes in the network is the Closeness (Lu & Feng, 2009). A node with the highest closeness centrality would spread in the whole network in minimum time (Freeman, 1979). The proportion of the shortest paths between all pairs of nodes that pass through a certain node in the networks is the Betweenness (Borgatti, 2005).

Recorded data were analyzed using descriptive statistics to study 'documents' features; also social networks analysis was carried out using descriptive statistics for centrality measures (degree, closeness and betweenness) and density of network. In addition, Text Statistics Analyzer and ISI.exe were used to compute the number of authors per documents. VOSviewer 1.6.13 was used for visualization, and UCINET 6 software (Borgatti, Everett & Freeman, 2002) was used for measuring the centrality and density of networks.

Results

Descriptive characteristics of documents

Publishing of documents on coronavirus began around the year 1970, with the first decade (1970-1979) amounting to only 131published documents. During the following decade (1980-1989), this number increased to 550 documents. Thereafter, year 2004 recorded the highest number of documents (793) published on this particular topic. A total number of 105 documents on coronavirus have published this year until February 23. The most common type of documents published on coronavirus were articles, meeting abstracts, reviews, proceeding papers, editorial material, book chapters, letters, and notes. Although the documents on

coronavirus were written in 16 languages, most of these documents were in the English language. The highest numbers of documents were indexed in the Science Citation Index Expanded. Whereas, The Journal of Virology recorded the highest number of published papers on coronavirus.

Publishing pattern of authors on coronavirus

Table 2 below indicates the number of authors per document. As data indicates, only 865 (6.53%) documents had one author, and the rest of the documents had more than one author. The collaboration of three authors (12.77%) and four authors (12.4%) per paper was more. In addition, a few papers had many authors; for instance, one document had 120 authors or other document had 74 authors.

Table 2
The Number of Author per Documents

N. of authors per paper	Occurrence	Percent	N. of authors per paper	Occurrence	Percent
1	865	6.53	26	20	0.15
2	1566	11.82	27	7	0.05
3	1691	12.77	28	9	0.07
4	1643	12.4	29	6	0.05
5	1463	11.05	30	9	0.07
6	1262	9.53	31	3	0.02
7	1044	7.88	32	2	0.02
8	811	6.12	33	2	0.02
9	653	4.93	34	3	0.02
10	540	4.08	35	2	0.02
11	388	2.93	36	3	0.02
12	305	2.3	37	2	0.02
13	218	1.65	38	1	0.01
14	168	1.27	42	2	0.02
15	119	0.9	45	2	0.02
16	93	0.7	47	1	0.01
17	68	0.51	53	1	0.01
18	64	0.48	59	2	0.02
19	58	0.44	62	1	0.01
20	43	0.32	66	1	0.01
21	28	0.21	67	1	0.01
22	24	0.18	68	1	0.01
23	12	0.09	74	1	0.01
24	16	0.12	120	1	0.01
25	19	0.14			

Visualizing co-authorship patterns of researchers

A total of 42501 authors had contributed to publishing 13252 documents on coronavirus. VOSviewer considered five as a default value; therefore, using this value as a cutoff point, 2600 authors had five or more than five documents. This network had 112 clusters, 20286 links, and its total link strength was 55949. The authors in the yellow area, especially with large font, are the authors who have the highest number of documents on the area (figure 1).

Kwok-Yung Yuen has published the highest number of documents (127) along with the most citations and the highest link strength. The total link strength indicates the total strength of a certain researcher's co-authorship links with other researchers (Waltman and van Eck, 2017, p.5). It should be noted that Luis Enjuanes, with 87 documents, seems to be the same person L. Enjuanes, who has published 82 documents on coronavirus and hence has the highest number of documents in the area of coronavirus research.

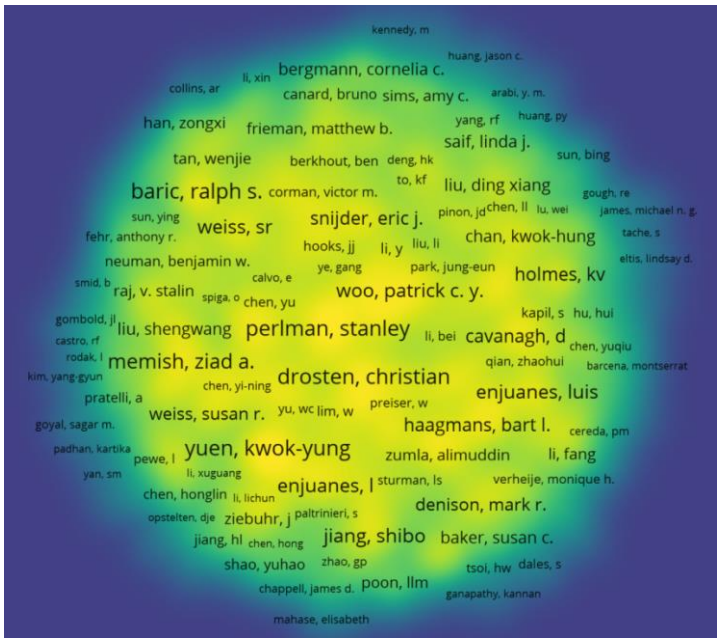

Figure 1. Co-authorship Networks of 2600 Authors

To know the authors who received more citations, the default value of VOSviewer rearranged (at least one document and 1000 or more citations for authors), and a totally of 364 authors had this condition. This network had 16 clusters, 4618 links with total link strength at 9771. Six clusters (inside red oval) are alone, apart from other network clusters; it means that 10 clusters of this network were connected (Figure 2).

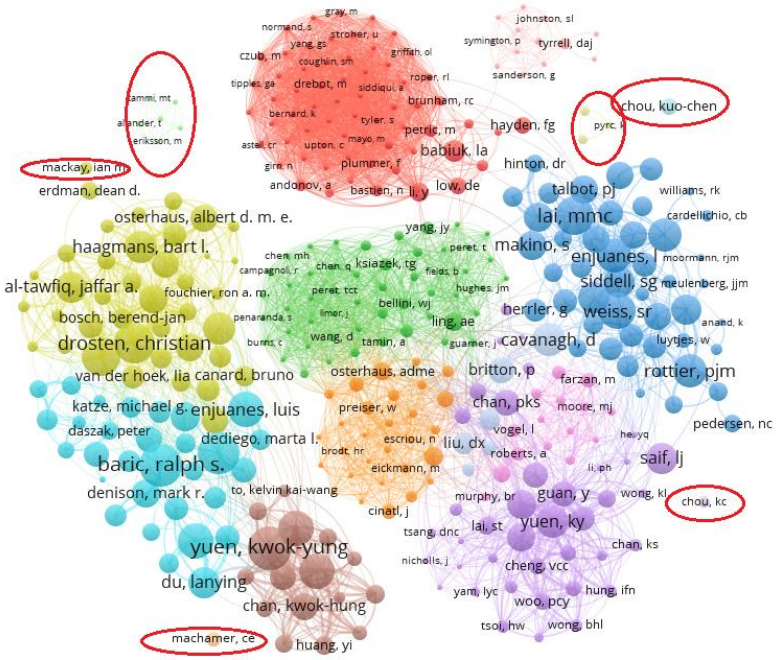

Figure 2. Authors with at least One Document and 1000 or more Citations

Visualizing co-authorship patterns of institutions on coronavirus

A total number of 6563 institutes collaborated to publish 13252 documents. Totally 947 institutes had five or more than five documents in this area; this network had 31 clusters, 9954 links with total link strength in 19418 (Figure 3). The University of Hong Kong ranked first, based on the number of published documents, number of received citations, and the total link strength followed by Chinese Academy of Sciences and University Utrecht (Netherlands). However, the University Utrecht has more citations than the Chinese Academy of Sciences.

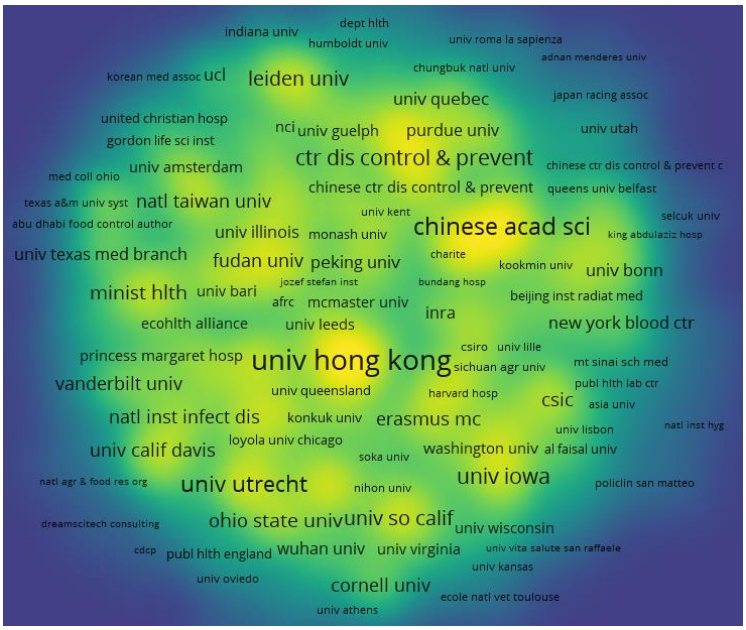

Figure 3. Co-authorship Networks of 947 Institutions

Visualizing co-authorship patterns of countries on coronavirus

A total of 138 countries had participated in publishing 13252 documents. This network had 23 clusters, 1266 links with total link strength at 7103. In addition, the largest connected network consisted of 132 countries. In addition, out of the 138 countries, 85 had five or more than five documents. This network with 85 countries had nine clusters, 1017 links with total link strength at 6786. The United States of America (USA) had the highest number of documents (4514) and participated in eight clusters; the USA had 78 links with total link strength in 2335. China had 2632 documents in this network, 4 clusters, 57 links, and total link strength in 1278. Germany with 828 documents, 6 clusters, 67 links, and total link strength of 1298, was the third country based on the number of documents (Figure 4). Furthermore, based on the number of received citations, USA with 5777.22 citations, China with 2712.49 citations, and the Netherlands with 1298.56 citations were the top three countries. In the top 10 countries in terms of the number of documents, the citation and link strength, USA, China and Germany are in the first to third position, respectively. Based on continents, four countries from Asia, four from Europe, and two from America are in the top 10.

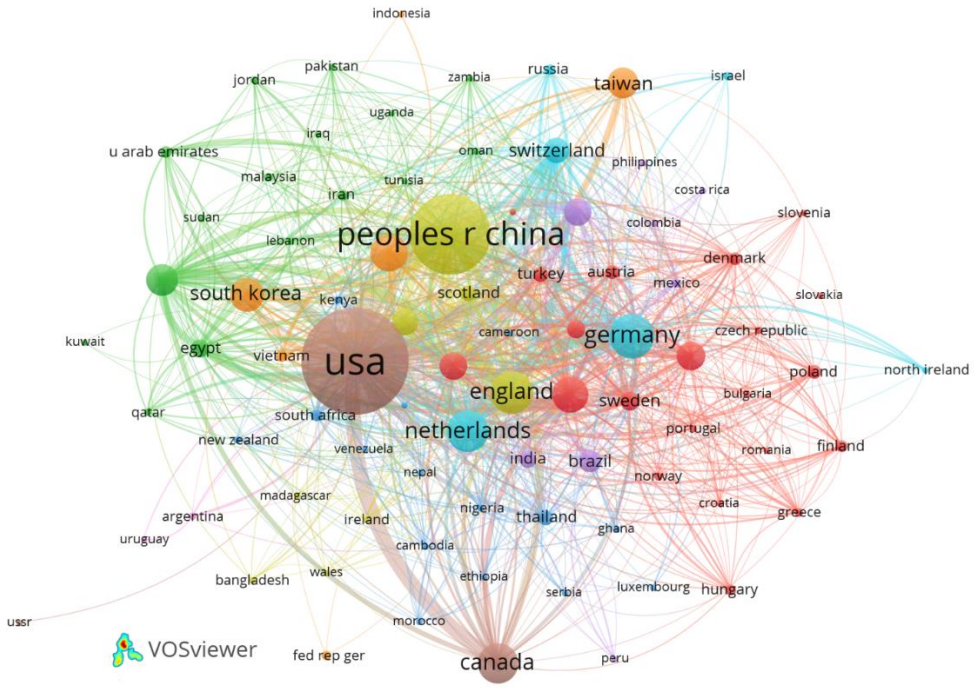

Figure 4. Co-authorship Networks of 85 Countries

Visualizing co-words on coronavirus

In the current study author keywords was considered as the unit of analysis for presenting concepts represented by the document. Authors had assigned 11523 keywords for 13252 documents that were published on coronavirus. Out of the 11523 keywords, 979 keywords had repeated five or more than five times. This network had 14 clusters, 15661 links with the total link strength at 26140 (Figure 5).

The keywords Coronavirus, SARS and MERS-CoV, respectively, had the highest frequency and link strength. The total link strength indicates the number of publications in which two keywords occurred together. A number of documents (1324) had used coronavirus

as the keyword. The keywords """Severe Acute Respiratory Syndrome""", and """SARS," ""; were used 290 and 427 times, respectively in their researches. Researchers had also used the SARS-CoV keyword 345 times.

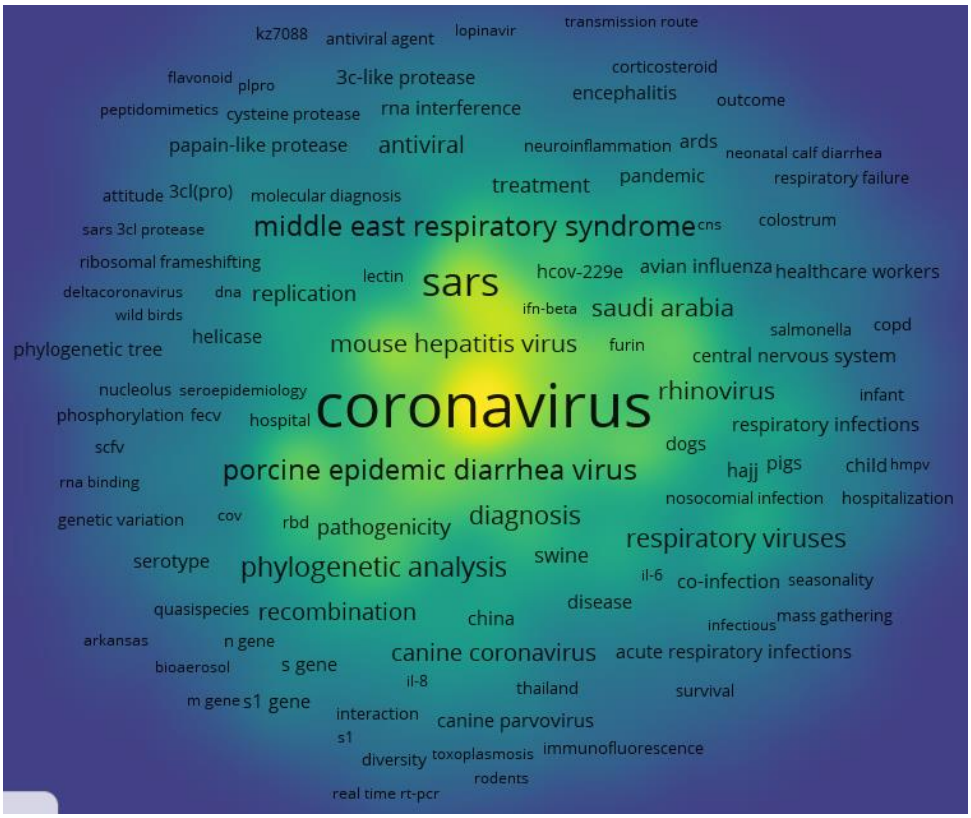

Figure 5. Co-word Occurrence Network

Density and centrality analysis of networks (co-authorship of researchers, institutions and countries)

The density of network was measured by UCINET 6 software. The average of density for co-authorship networks of authors and institutions are respectively 0.017 and 0.043, which indicate low density of these networks; while the average value for density of countries was 1.901, which is a sign of high density of network. In addition, density of keywords network with value of 0.055 was low. Reported density is for nodes (authors, institutions, countries and keywords) with five or more than five frequencies. It should be noted that the average values for country density for the whole 138 countries and the whole 6563 institutions respectively were 0.75 and 0.002; while obtaining the density of all authors (42501) and keywords (11523) by software, due to volume of data, was not possible (table 3).

The low standard deviation (near to zero) indicates that the values tend to be close to the mean, while a high standard deviation, for example for country in present study (11.800) indicates that the values have spread out over a wider range. It means that the co-authorship density for some countries is higher than other countries (table 3). Average Weighted Degree is the average sum of weights of the edges of nodes. The weight of an edge represents that a certain edge how many times has traversed between a pair of nodes. If weight of node was higher, it means it has been visited many times than any other low weight degree node (Ayyappan Nalini & Kumaravel, 2016).

Table 3
Density of Co-authorship Networks

Network Name	N	Ave. Value	Std. Dev	Ave. Wt. Degree
Authors	2600	0.017	0.326	43.038
Institutions	6563	0.002	0.078	12.471
Institutions	947	0.043	0.485	41.010
Countries	138	0.751	7.310	102.942
Countries	85	1.901	11.800	159.671
Keywords	979	0.055	0.538	53.401

Based on findings of the present study the top 10 authors with the highest centrality measures were identified. The first column indicates the top 10 authors based on degree centrality; these authors have the highest numbers of links with other authors. The second column shows closeness centrality of top 10 authors; these authors have the shortest distance with other authors in the networks. It should be noted that closeness values for 29 authors was 0.664 and for 82 authors was 0.663; however due to high number, only first the 10 is reported. The third column indicates the betweenness centrality; these authors play a hub role in the network (table 4).

Table 4
Centrality Measures for Top 10 Authors

Rank	Degree		Closeness		Betweennes	
1	Drosten, Christian	7.503	Tien, Po	.665	Tien, Po	41.379
2	Perlman, Stanley	6.310	Gao, George F.	.665	Zhang, X	23.147
3	Baric, Ralph S.	5.848	Enjuanes, Luis	.665	Li, Y.	15.755
4	Yuen, Kwok-Yung	4.810	Guo, Deyin	.665	Gao, George F.	8.212
5	Enjuanes, Luis	4.733	Perlman, Stanley	.665	Enjuanes, Luis	6.292
6	Thiel, Volker	4.540	Wu, Ying	.665	Guo, Deyin	6.203
7	Mueller, Marcel A.	4.425	Chen, Yu	.665	Perlman, Stanley	5.871
8	Memish, ZiadA.	4.155	Zhang, X	.664	Wu, Ying	5.796
9	Zhao, Jincun	3.925	Snijder, Eric J.	.664	Drosten, Christian	5.148
10	Jiang, Shibo	3.617	Zhang, Yan	.664	Peiris, Jsm	4.498

In current study, the top 10 institutions with the highest centrality measures were identified. The first column indicates the top 10 institutions based on degree centrality; these institutions had the highest numbers of links with other institutions. The second column shows closeness

centrality of institutions; these institutions had the shortest distance with other institutions in the networks. The third column indicates the betweenness centrality; these institutions had a hub role in the network (table 5).

Table 5
Centrality Measures for Top 10 Institutions

Rank	Degree		Closeness		Betweennes	
1	University Hong Kong	22.304	University Hong Kong	8.452	University Hong Kong	7.860
2	Chinese academic science	19.133	Chinese academic science	8.397	Chinese academic science	6.479
3	Center for Disease Control & prevent	18.288	University Utrecht	8.395	Center for Disease Control & prevent	5.088
4	University Utrecht	16.490	Center for Disease Control & prevent	8.389	University Utrecht	4.805
5	Ministry health*	14.693	NIAID	8.359	University N. Carolina	2.713
6	University Bonn	14.693	University Bonn	8.348	NIAID	2.620
7	National Institute of Allergy and Infectious Diseases (NIAID)USA	14.482	University N. Carolina	8.344	University Bonn	2.614
8	University oxford	13.848	Leiden university	8.341	Ministry health	2.447
9	Erasmus Mc	12.896	University Iowa	8.336	University Sao Paulo	2.441
10	University N. Carolina	12.791	Ministry health	8.327	University Oxford	2.366

* """"Ministry health"""" in downloaded txt file of WoS mainly was associated to Saudi Arabia

In the present study, the top 10 countries with the highest centrality measures were identified. The first column indicates the top 10 countries based on degree centrality; which had the highest numbers of links with other countries. The second column shows closeness centrality of countries; and their shortest distance with other countries in the networks. The third column indicates the betweenness centrality; these countries had a hub role in the network. The USA and England were in the first and second rank based of centrality measures (table 6).

Table 6
Centrality Measures for Top 10 Countries

Rank	Degree		Closeness		Betweennes	
1	USA	72.2630	USA	13.8100	USA	18.9600
2	England	58.3940	England	13.5640	England	7.9500
3	Germany	56.2040	Germany	13.5110	China	6.4210
4	France	51.0950	France	13.4180	France	6.1510
5	China	50.3650	China	13.4050	Italy	5.2380
6	Netherlands	47.4450	Netherlands	13.3530	Germany	5.1610
7	Switzerland	44.5260	Switzerland	13.2880	Canada	3.5170

Rank	Degree		Closeness		Betweennes	
8	Saudi Arabia	42.3360	Saudi Arabia	13.2110	Switzerland	3.3940
9	Italy	39.4160	Italy	13.1980	Saudi Arabia	3.2430
10	Sweden	37.9560	Sweden	13.1730	Netherlands	3.0170

The network of 85 countries is visualized using UCINET 6; as the graph indicates, the top 10 countries are in the middle of network with most links with other countries. Centrality measures are considered in visualizing (figure 6).

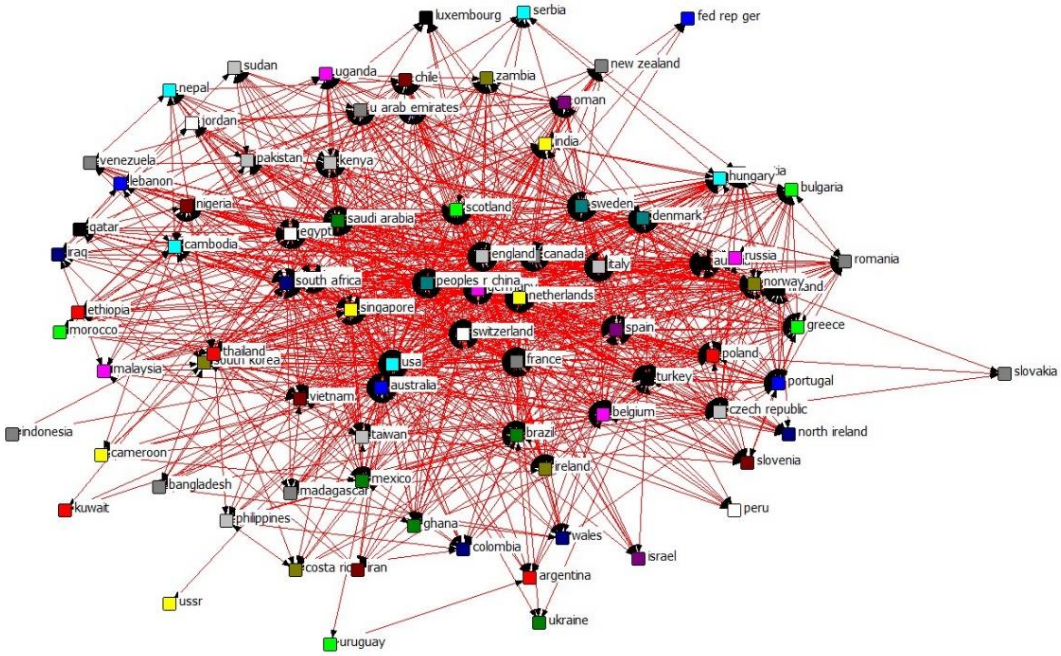

Figure 6. The network of 85 Countries

In the present study, the top 10 keywords with the highest centrality measures were identified. The first column indicates the top 10 keywords based on degree centrality; these keywords had the highest numbers of links with other keywords. The second column shows the keywords' closeness centrality; these keywords had the shortest distance with other keywords in the networks. The third column indicates the betweenness centrality; these keywords had a hub role in the network. The three keywords: Coronavirus, SARS, and SARS-CoV, were the top three in centrality measures (table 7).

Table 7
Centrality Measures for Top 10 Keywords

Rank	Degree		Closeness		Betweenness	
1	Coronavirus	78.119	Coronavirus	82.047	Coronavirus	34.520
2	SARS	39.162	SARS	62.135	SARS	6.171
3	SARS-CoV	35.072	SARS-CoV	60.482	SARS-CoV	4.650
4	MERS-CoV	34.151	MERS-CoV	60.148	MERS-CoV	4.345
5	Severe Acute Respiratory Syndrome	29.550	Severe Acute Respiratory Syndrome	58.598	Virus	3.704

Rank	Degree		Closeness		Betweenness	
6	Virus	28.732	Virus	58.318	Severe Acute Respiratory Syndrome	3.348
7	Epidemiology	24.744	Epidemiology	56.860	Epidemiology	1.924
8	Infectious Bronchitis Virus	20.552	Vaccine	55.600	Infectious Bronchitis Virus	1.661
9	Vaccine	20.552	Spike Protein	55.317	Spike Protein	1.347
10	Influenza	19.836	Influenza	55.285	Vaccine	1.328

The study is limited to data collected from the WoS database during 1970 and 2020 and has limitations due to methodological problems such as the variations in the rendering of names (authors and institutions). Authors have also used keywords without vocabulary control or controlled language, resulting in synonymous words existing in the vocabulary set. Furthermore, the software had limitations in giving outputs for extensive data.

Discussion

The coronavirus disease COVID-19 though first reported in Wuhan city in China during December 2019, rapidly engulfed the globe with varying degrees of irrecoverable damage (economic a public health) and mortality rate. Whereas the world's most fatal pandemics (in several cycles of attacks) plague and smallpox took well over hundreds of years to reach out to the world, COVID-19 needed only less than a month, owing to the seamless airline connectivity in 'today's globalized world. Perhaps the disease's severity was less known to the world at large or that it was thoroughly ignored and underestimated. For instance, the paper published by Cheng, Lau, Woo & Yuen (2007) in Clinical Microbiology Reviews warned this in lucid terms to the world as back as 2007; the revelations also point to the huge research gap existing in worldwide coronavirus research. Though the quantum of world research on coronavirus that was carried out during the past 50 years shows reasonably good in numbers, it certainly is not good enough, considering the impact of these researches on its immunization, rapid diagnosis, treatment, control, and management.

This paper evaluated the global research trends in coronavirus publications indexed in WoS from 1970 to February 2020. Research on coronavirus based on current study findings was initiated in 1970, which was moving at a slow pace during the initial two decades. Even post-1990, the number of documents in this area of research was not substantial. It is only in 2003 and 2013, with the SARS and MERS outbreak, which the research community was alerted, and the number of publications registered an increase. The eventual control of the infection afterward again led to a downfall in the number of publications. It implies that with the outbreak of this disease, some researchers tend to investigate in this area, and when this area loses its primacy, they may tend to switch to other research areas. However, it is worth mentioning that some core researchers continued working on coronavirus; and this group is possibly the most productive researcher in this area.

Another interesting finding of this study was that a large number of published documents was journal papers. The journals on the virology area were the core source of publishing, with the 'Journal of 'Virology' had the highest number of published papers on coronavirus, outscoring the second leading journal by almost three times. Furthermore, the journals on infectious

diseases, veterinary microbiology, experimental medicine, and biology were the other publishing vehicle. The top journals' impact factor is around two and seven, which is approximately a good score. Majority of published records had been indexed in """Science Citation Index Expanded""", with English as the main language.

The number of authors per document in coronavirus research was high, whereas only 6.53 percentage of documents had one author and on the other hand, about 13 percent of documents had 10 authors or more. It seems the structures of research in this area need more collaboration and co-authorship among different expertise. It also implies that collaborative writing is prominent in coronavirus research. This finding is in line with the previous studies (Bharvi, Garg & Bali, 2003; Glanzel & Schubert, 2004; Kronegger, Ferligoj & Doreian, 2011).

Besides researchers and institutions from USA and some European countries like England, Germany, the Netherlands, and France that had done the most investigation on coronavirus, countries like China and Saudi Arabia been involved with a different kind of coronavirus in prior years, had considerable research on this topic. Authors, namely Enjuanes, Luis, and Perlman, Stanley, based on three centrality measures, were among the top 10; it means that these researchers had much connection with other researchers, they were close to other researchers, and they act as a hub in co-authorship network.

Although three institutions from China were among the top four institutions based on the number of documents, as far as citation and total link strength are concerned, as evidenced by country data, USA had the highest number of documents. A justification for the above could be that in China, most coronavirus research has been concentrated to a few research centers, such as University of Hong Kong, Chinese Academy of Sciences and the Chinese University of Hong Kong; therefore these centers are among top institutions on coronavirus researches. These three institutions were respectively in the first, second and fourth rank in terms of the number of documents, citations and total link strength. In addition, these three institutions from China were in a good position based on centrality measures.

Although our analysis showed the coronavirus research was from multiple countries, some countries became more productive than the rest. An explanation for concentrating South East Asian (China, Japan and South Korea) researchers on coronavirus could be the outbreak of this infection in China and the MERS in Saudi Arabia. However, researchers from USA, Canada, and some European countries (Germany, England, France and the Netherlands) had paid more attention to this problem; which could be due to the financial support researchers get in developed countries acting as an important motive.

Based on three centrality measures USA was in the first rank. The USA had the highest number of links with other countries; this means USA had co-authorship with most of countries. The USA based on betweenness was in the position of shortest path between every pair of countries. Although England, based on number of documents was in the fourth rank, in terms of centrality measures was in second position; it means that England, like USA, has a key role in co-authorship between countries. In addition, Germany, in degree and closeness was in third rank and China, based on betweenness, was in the third position. However, China in terms of citation and document numbers was in better position than England and Germany, based on centrality measures, was not in the same position. As Li, Liao & Yen (2013) explained if actors of scientific community (researchers, institutions, and countries) can analyze their structural situations in the network, they can shift into mediator positions (like high betweenness) via collaboration from different research group and then will get more citation. The researchers,

institutions and countries that have network centrality position are considered core nodes (actors) of the coronavirus area. The nodes with degree centrality have a number of links with other nodes. Information can quickly flow to the nodes with closeness centrality. The nodes with betweenness centrality have the potential to act as brokerage or gatekeeping.

The low average value of density for co-authorship network of researchers and institution means that members have low tendency to form different clusters and indicate a great sparseness of co-authorship network. On the other hand, the density of co-authorship between countries indicates high collaborations between nations and continents. However, a majority of documents were found to be published by top 10 countries that enjoyed a central and key role in network.

Based on findings of this study it can be concluded that researchers had focused on topics such as Coronavirus, SARS, MERS-CoV and SARS-CoV. In addition, new research hotspot mainly concentrated on infectious bronchitis virus, virus, epidemiology, spike protein and vaccine.

Conclusion

Coronavirus is a major global threat, which has emerged as biggest health-related challenges in the form of SARS, MERS, and COVID-19 during recent two decades. However, COVID-19 due to its high rate of infectivity quickly evolved into a pandemic and spread worldwide. It is only a global effort from multiple sectors that will eventually help in overcoming this infection. In this regard, a fifty-year bibliometric study on coronavirus based on WoS in order to integrate the key actors has been attempted in this study. The number of researches on coronavirus with outbreak of SARS and MERS increased at first and thereafter showed reduction post control over the outbreak. Co-authorship in coronavirus researches was common behavior due to necessity of collaboration among different expertise in this area. Productive and core authors and institutions were from some developed countries as well as the countries affected the most with coronaviruses during recent two decades. The new research hotspot mainly concentrated on infectious bronchitis virus, virus, epidemiology, spike protein and vaccine. The study also emphasizes the urgent need for intensive research interventions in terms of development of vaccines, rapid diagnosis, management and spread control.

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