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Research Publications on SARS-CoV-2 (COVID-19): A Study of Publication Trends using the R Package

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Abstract

This study provides a bibliometric review of 1,027 documents published on COVID-19, extracted from the database of 'dimensions.ai' and published in 228 journals, authored by 3,436 authors. For the analysis, Bibliometrix R-Package was used through the biblioshiny interface. A topical query was conducted and 2,973 bibliographic literature from the online database of "Dimensions.ai" was downloaded using the search strategy "Text – 'Coronavirus OR COVID-19 OR SARS-CoV-2' in the title and abstract; Field of Research is Division code 08 Information and Computing Science". Documents from the earliest possible record to the current record of Bibliometric study revealed a sudden rise in the annual scientific production in the year 2019 with the advent of the COVID-19 pandemic. Further study revealed the most prolific authors, journals, and affiliations. Besides, we present research collaboration networks at the author level.

Keywords: COVID-19, SARS-CoV-2, Bibliometrix, R-Package, Dimensions.ai

Introduction

A novel coronavirus, designated as 2019-nCoV, emerged in Wuhan, China, at the end of 2019. Although many details of the emergence of this virus, such as its cause and capacity to spread among people, stay obscure, the number of cases seem to be on the rise because of human-to-human transmission. Given the Severe Acute Respiratory Syndrome coronavirus (SARS-CoV) outbreak in 2002 and the Middle East Respiratory Syndrome coronavirus (MERS-CoV) outbreak in 2012, the 2019-nCoV is the third COVID to develop in the human populace in the last 20 years – a rise that has put public health organisations worldwide on high alert (de Wit et al., 2020). In March 2020, the World Health Organization (WHO) declared COVID-19 to be a pandemic, with the virus infecting more than 150,000 people in 154 countries as of March 15 (Sohrabi et al., 2020).

The well-known indications of COVID-19 are fever, dry cough, and tiredness. Different side-effects that are more uncommon and experienced by a few patients include aches and pains, nasal blockage, migraine, conjunctivitis, sore throat, looseness of the bowels, loss of taste and smell, a rash on the skin, or the staining of fingers or toes. These indications are typically gentle and start slowly. A few people become contaminated, with mellow side-effects. Most people (about 80%) recuperate from the infection without requiring emergency clinical treatment. Around one in five individuals who get COVID-19 turn out to be extremely sick. More seasoned individuals, and those with fundamental clinical issues like hypertension, heart and lung issues, diabetes, or malignancy, are at a greater risk of falling severely ill ("Coronavirus disease (COVID-19) – World Health Organization", 2020).

Globally, as of October 7, 2020, there are 35,537,491 confirmed cases of COVID-19, including 1,042,798 deaths, reported to the WHO (Purcell & Charles, 2020).

Fig. 1 indicates the COVID-19 cases as of October 7, 2020, reported by WHO, with the United States of America having the highest number of cases, followed by the South-East Asian, European, Eastern Mediterranean, African, and Western Pacific regions.

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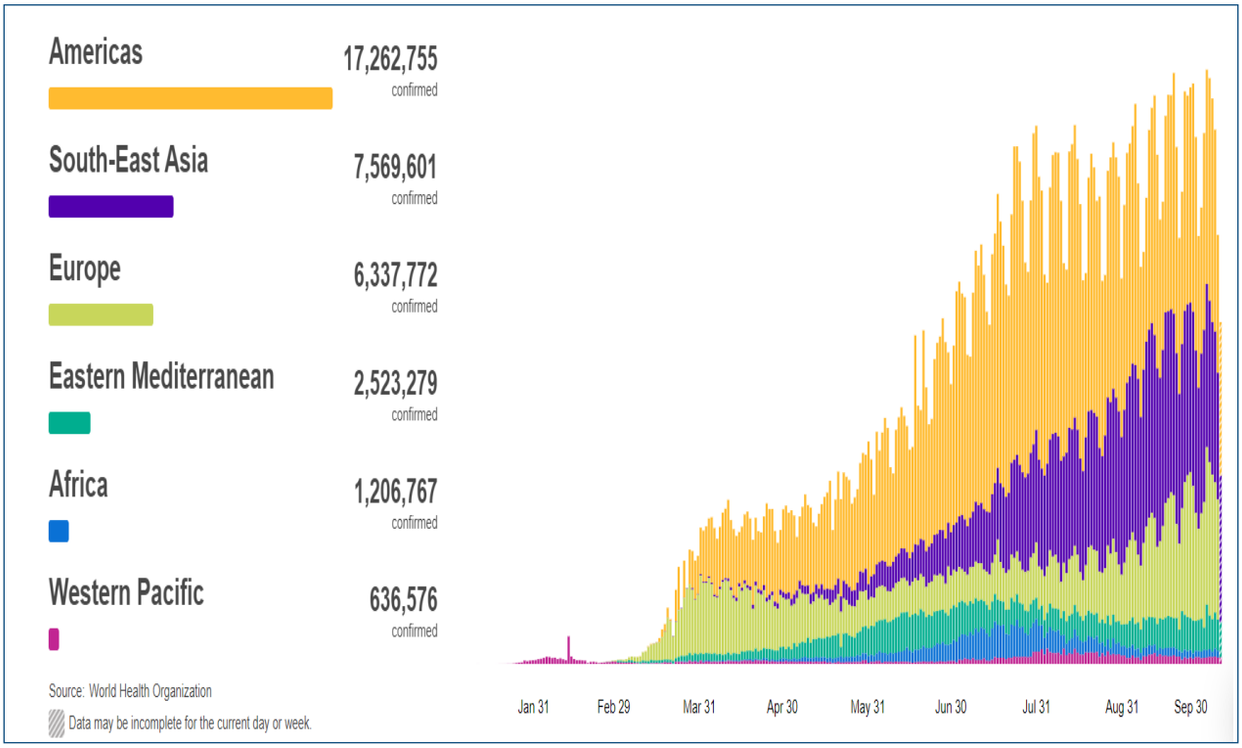


Fig. 1: COVID-19 Cases as of October 7, 2020

Further, research done on COVID-19 is vital to both control the spread and for the treatment of the patients (Purcell & Charles, 2020). Reports from nations with large numbers of confirmed cases outline hazard factors and clinical highlights from the treatment procedures for patients with COVID-19 (Xie et al., 2020). This paper aims at exploring the activity and trend of COVID-19 research worldwide since its outbreak in December 2019. For the study, data was extracted from Dimensions using the search strategy: Title and abstract "Coronavirus OR COVID-19 OR SARS-CoV-2".

Data was then analysed using bibliometric analysis software: Bibliometrix – R package.

Literature Review

Hossain (2020) in the investigation on 'the current status of global research on n-CoV through bibliometric analysis' considered bibliometric information on works distributed in *COVID-19* that was different from three significant data sets in *Web of Science*. According to the analysis, the number of authors and citations per document was 3.91 and 2.47, individually. For citation examination, top articles were considered. "Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China" was the leading article, with the recurrence of references at 124, trailed by "A novel coronavirus from patients with pneumonia in China, 2019", with 86 references, and "A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: A study of a family cluster", with 71 citations. Further, top authors, based on the number of published works on COVID-19, were Mahase, E. with 13 publications, followed by Akhmetzhanov, A. R. and Linton, N. M. with seven publications each. Top journals based on scientific publication were identified as the *British Medical Journal*, with a frequency of 49, *The Lancet*, with 37, and *Eurosurveillance*, with 22 publications.

For their study, 'Coronavirus: A scientometric study with special reference to *Web of Science*', Radha (2020) retrieved data from the *Web of Science* for the years 2018, 2019, and 2020 (till March). This study is an attempt to know the publication pattern, year-wise growth of publications, country-wise research output, and the top-cited paper. Additionally, this paper focuses on the research output of China and Wuhan University in the publications, and Wuhan University's interest in this research publication during the period.

Nasab and Rahim (2020) performed qualitative and quantitative analysis of the publications of research on COVID-19 from 2019 to 2020. According to the results, China represented the highest proportion of published research (44 papers, 40.48%), trailed by the United States (21 papers, 19.32%), and Canada (seven papers, 6.44%). Altogether, the top ten journals published 47 articles, which represented 51.08% of all published articles in this field. A total of six studies (5.52%) were upheld by the National Natural Science Foundation of China. The Chinese Academy of Sciences placed second (2.76%).

One of the studies retrieved 883 MERS-CoV-related publications. According to the results, "Nine publications were published in 2012, 155 in 2013, 318 in 2014, and 401 in 2015. Around 60% of the total share was published as original articles, 13.3% as reviews, 9.5% as editorial materials, 7.5% as letters, and the remaining being note, erratum, and conference paper. Among these articles, 829 (93.9%) were written in English, 18 (2.04%) were in Korean, 12 (1.4%) were in Chinese, 10 (1.1%) were in German, and the remainder of articles were in a variety of other languages such as French, Czech, Dutch, Greek, Polish, and Hungarian. The MERS-CoV-associated publications originated from 92 countries/territories, indicating the international spread of MERS-CoV research. Out of 883 publications, the USA was the largest contributor, with 319 (36.1%) articles published in over four years; this was followed by KSA (113, 12.8%), China (103, 11.7%), and the UK (93, 10.5%). The total number of citations for these publications is 8,015, with an average of 9.01 citations per each publication. The h-index for MERS-CoV-associated publications was 48. The USA also has the highest h-index (32), followed by KSA (26), and the UK (22). The Netherlands produced the greatest proportion of publications with international research collaboration (72.7%), followed by the UK (71%) and Germany (69.1%) out of the total number of publications for each country" (Zyoud, 2016).

Objectives of the Study

- The primary objective of this study is to focus on the current bibliometric status of global publications on coronavirus.
- To study the annual scientific production of publications on COVID.
- To identify the most prolific sources in the field.
- To identify authors' productivity in the field.
- To identify the most prolific author in the field.
- To validate Lotka's Law for the dataset.
- To identify the trending topics in the field.

Scope of the Study

The examination covers writing, as indexed by dimensions.ai, encompassing a period from the earliest record till October 2, 2020. The study covers the following four areas of bibliometric studies:

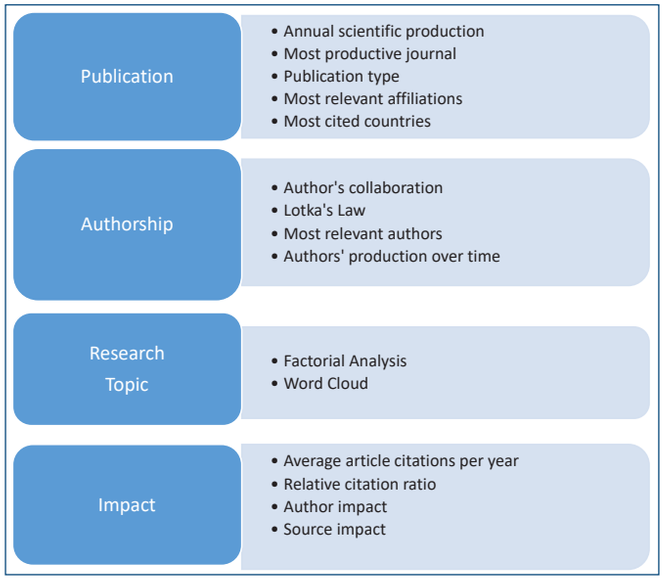
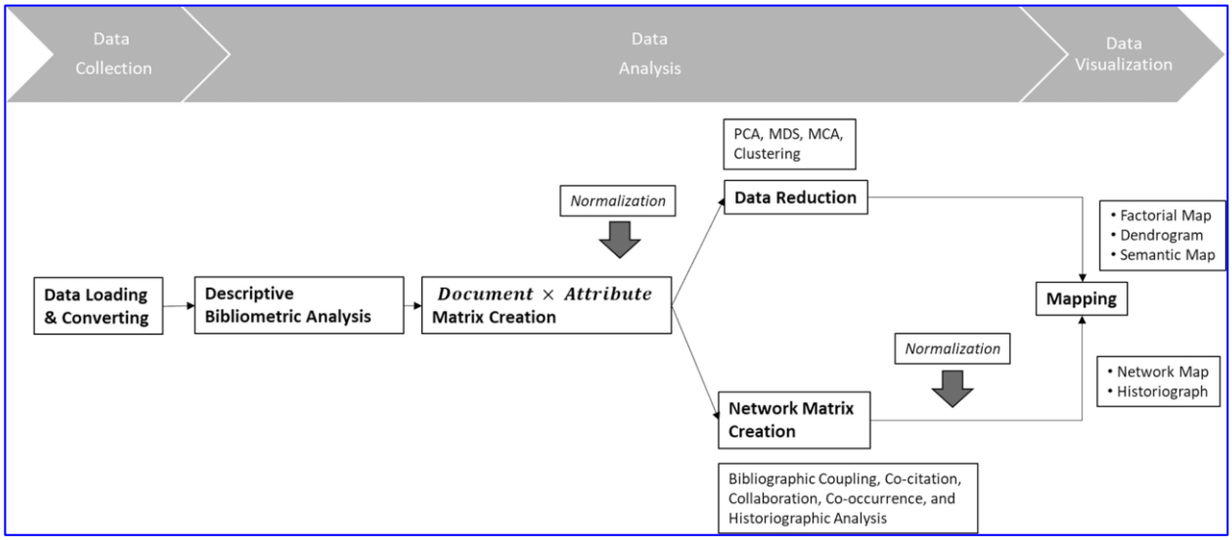


Fig. 2: Four Areas of the Bibliometric Study

Research Methodology

A topical query was conducted and 2,973 bibliographic literature from the online database of "Dimensions.ai" was downloaded using the search strategy "Text – 'Coronavirus OR COVID-19 OR SARS-CoV-2' in the title and abstract; Field of Research is Division 08 Information and Computing Science"; documents from the earliest possible record to the current record were taken into consideration. While we downloaded 2,973 records, the number of files might change as more articles are published. Document types: articles, proceeding papers, and chapters were included. We installed the

latest version of R Studio in Windows 10; established the bibliometrix package within the R environment to analyse and map the bibliographic data if it has not been install yet. Then, we used bibliometrix's functions to create a descriptive and co-citation network, respectively. Eventually, the function biblioanalysis generates descriptive data from bibliographic data. The results can be drawn by the generic function (plot) in R. Bibliometrix supports the main stages of the recommended science mapping workflow:



Source: The biblioshiny web interface

Fig. 3: Workflow

This article aims to conduct a bibliometric and co-citation analysis to answer the following research questions:

- What is the annual scientific production in the field of COVID-19?
- What are the most productive journals, types of publications, most relevant affiliations, and most cited countries?
- What are the current authorship patterns in the field?
- What are the average article citations per year, relative citation ratio, author impact, and source impact?
- Is Lotka's law verified for the dataset?

Results and Discussions

Table 1 gives the concise data extracted from the information by the Bibliometrix Package. As observed from the table we can presume that documents were extracted from a total of 228 sources with 1,027 reports. Average years from publication is 0.643, average citations per document is 3.664, whereas average citations per year per document is 2.271.

Table 1: Information Analysed by Bibliometrix Software

Description	*Results*
Timespan	1986:2020
Sources (Journals, Books, etc.)	228
Documents	1,027
Average years from publication	0.643
Average citations per document	3.664
Average citations per year per document	2.271
References	1

Publications

Annual Scientific Production

Fig. 4 indicates the annual scientific production, i.e. articles published per year on coronavirus. The first publication on coronavirus appeared in the year 1986. To begin with, only a few papers were noted, but with the emergence of the novel coronavirus in 2019, a sudden jump in the literature was observed in the year 2020, with the highest publications in the year {n=959}.

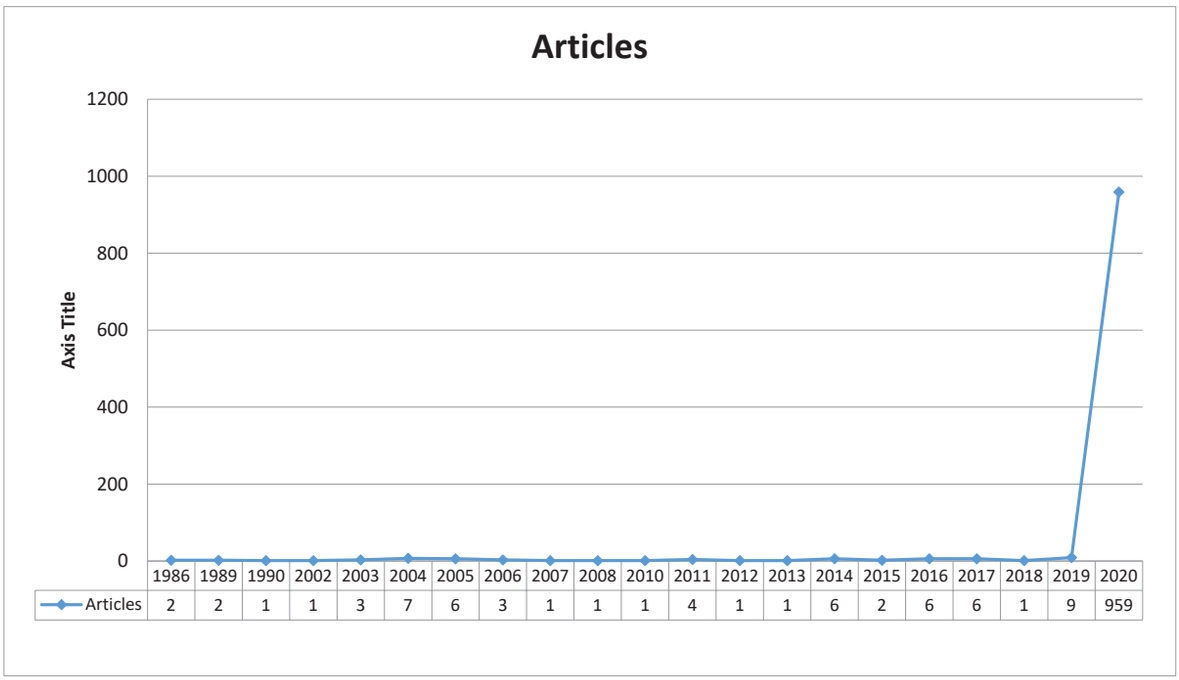


Fig. 4: Annual Scientific Production of Documents on Coronavirus

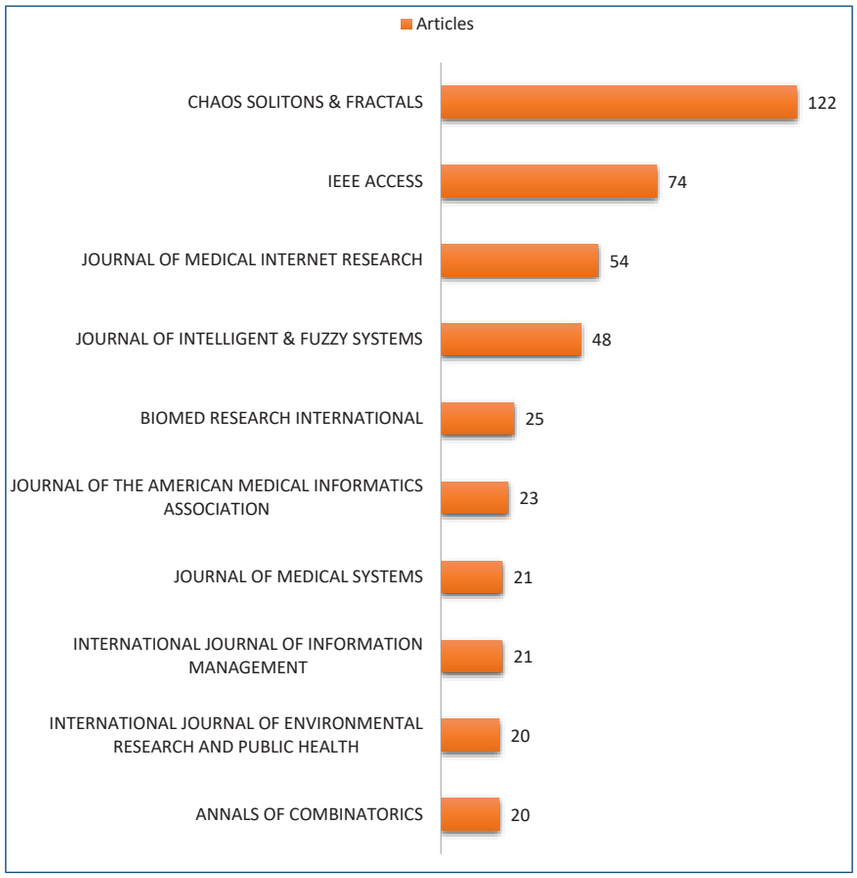


Fig. 5: Most Productive Journals

Most Productive Journals

Fig. 5 reveals the top ten productive journals that published maximum articles on coronavirus. With 997 articles, these ten journals account for 42.92% of the total article production. The top ten journals, based on the maximum number of articles published by the journals, are *Chaos Solitons & Fractals*, which published 122 articles in the field, followed by *IEEE Access* (74), *Journal of Medical Internet Research* (54), *Journal of Intelligent & Fuzzy Systems* (48), *Biomed Research International* (25), *Journal of the American Medical Association* (23), *Journal of Medical Systems* (21), *International Journal of Information Management* (21), *International Journal of Environmental Research* (20), and *Annals of Combinatorics* (20).

Type of Publication

Fig. 6 shows the type of publications that have been preferred by the authors. It is clear from the pie chart that 98% of the publications are in the form of articles, while merely 2% are in the form of chapters. Proceedings have a negligible contribution in the publications {n=2}.

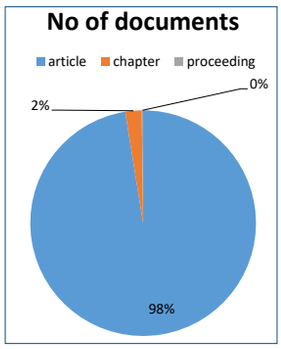


Fig. 6: Distribution of Types of Documents

Most Relevant Affiliations

Fig. 7 illustrates the most pertinent affiliations that have been working in the field of SARS-COVID-19. Predicated on the number of documents, these affiliations have been ranked in descending order of their document count. While a maximum number of articles' affiliations {n=130} have not been reported, it was observed that the highest number of articles have been affiliated with Harvard University {n=10}. Sorting the most germane affiliations would avail a researcher to assist which institutes have been working actively in the field, thereby narrowing down their search for literature review.

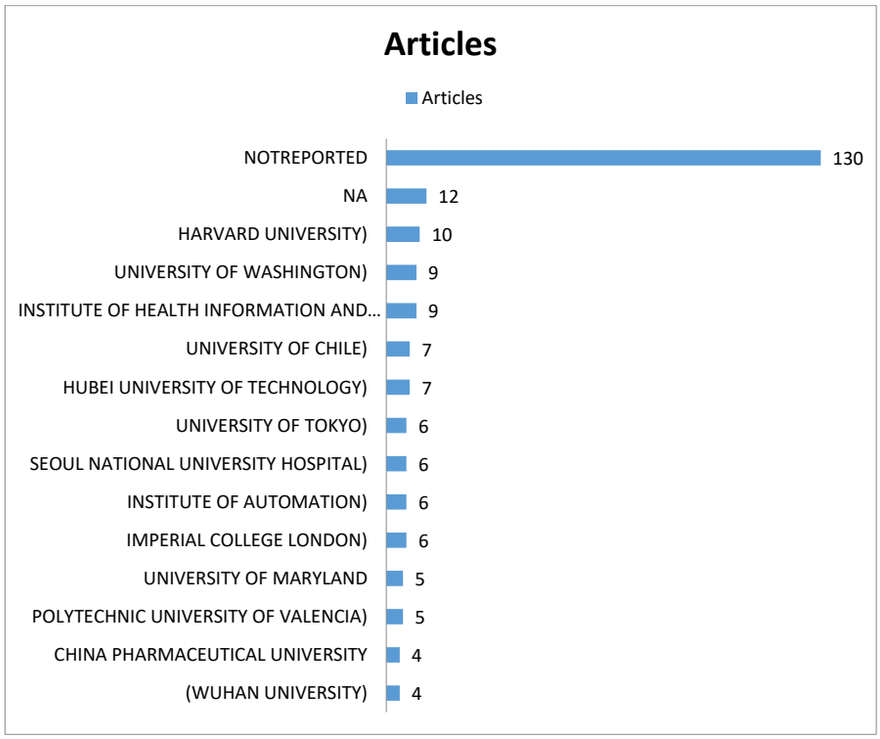


Fig. 7: Most Relevant Affiliations

Most Cited Countries

With the advent of SARS-COVID 19, literature in the field has increased sharply in the past few months. With the vigilance of the countries actively taking part, it is easy for the researchers to grasp which country is publishing the maximum work in the field to obtain better results. This would assist in identifying a community of scholars in the field. Fig. 8 represents the most cited countries in the field, predicated on the maximum number of citations received by the papers, thereby indicating their importance. As denoted by the figure, Denmark has the highest number of citations received {n=37}, trailed by Korea, China, Hong Kong, Bangladesh, Chile, South Africa, Singapore, Azerbaijan, the USA, Malaysia, Qatar, Australia, Mexico, and Kuwait.

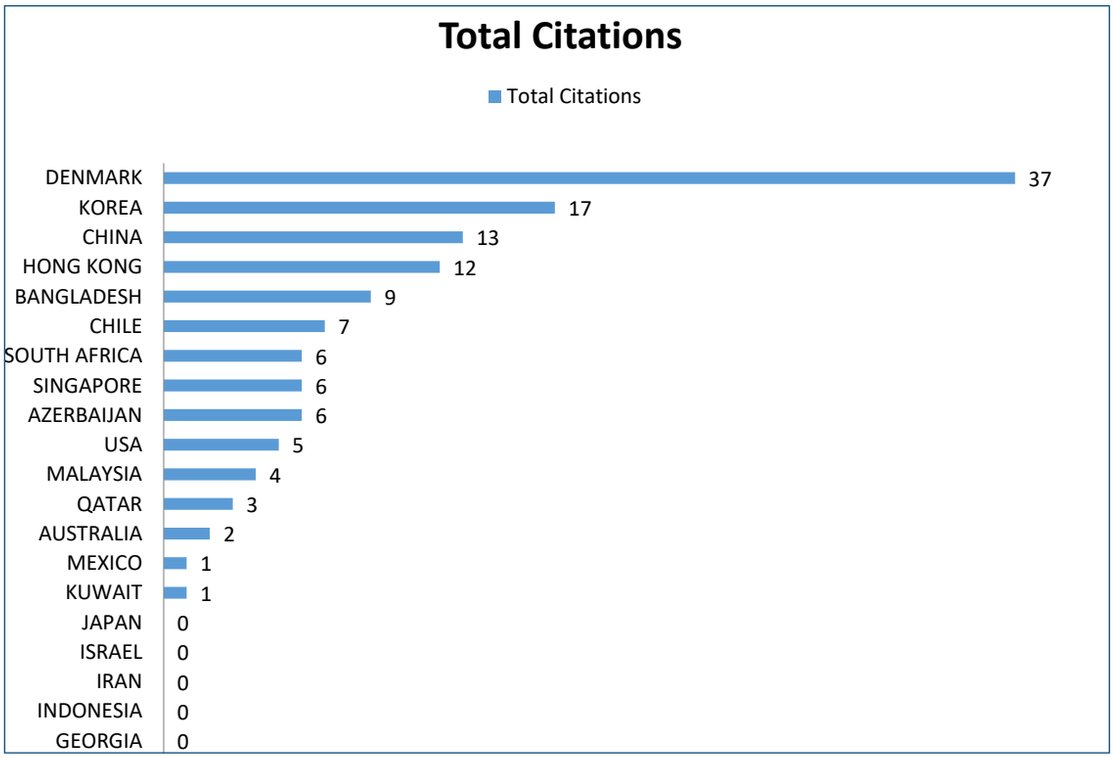


Fig. 8: Most Cited Countries

Authorship

Author Collaboration

From Table 2, we observe that 3,436 authors have worked in the field. Author appearances {n-4129} indicate the high rate of author collaborations. Further, we can observe that there are more authors of multi-authored documents {n=3262} than single-authored documents {n=174}, where the number of single-authored documents is 188, which indicates the authorship trend towards collaboration. As per the Bibliometrix package analysis, average documents per author is 0.299, average authors per document is 3.35, while average co-authors per document is 4.02.

The collaboration index for the given data is 3.97.

The Collaboration index gives the mean number of authors per paper. It has no upper limit and cannot be expressed as a percentage. The collaboration index (CI) is the simplest tool, presently used to explore the literature, which interprets the mean number of authors per paper (4.9); the formula is $\frac{\sum_{j=1}^{A} jf_j}{N}$:

Hence, j is the number of co-authored papers appearing in a discipline; N is the total number of papers in the discipline over the same time interval, and k is the greatest number of authors per paper in a discipline (Venkatesan, 2020).

Table 2: Author Collaboration

Verification of Lotka's Law

Authors	
Authors	3436
Author Appearances	4129
Authors of single-authored documents	174
Authors of multi-authored documents	3262
Author Collaboration	
Single-authored documents	188
Documents per Author	0.299
Authors per Document	3.35
Co-Authors per Documents	4.02
Collaboration Index	3.97

'The frequency distribution of scientific productivity', an article published by Alfred L. Lotka, an American scientist, in 1926, stated the 'law of scientific productivity', which is an inverse power function describing the rate of productivity of published scientific articles over time.

The formula of Lotka's states that the number of authors producing x publications is about $1/x^a$ of those making one publication, or:

$$Y = C/x^a$$

Where, Y is the relative frequency (or relative or proportional number) of authors with x publications, and C and the exponent a are constants, depending on the specific domain.

Using R-programming, the following data has been generated ("LOTKA's Law of Productivity – Venus Iconography," 2020).

Table 3: Lotka's Law

Sr. No.	*Documents Written (x)*	*No. of Authors (y)*	*Proportion of Authors*	*X = Log x*	*Y = Log y*	*XY*	*XX*
1.	1	2997	0.872	0	3.476	0	0
2.	2	304	0.088	0.301	2.482	0.747	0.090
3.	3	87	0.025	0.477	1.939	0.925	0.227
4.	4	26	0.008	0.602	1.414	0.851	0.362
5.	5	7	0.002	0.699	0.845	0.591	0.489
6.	6	3	0.001	0.778	0.477	0.371	0.605
7.	7	3	0.001	0.845	0.477	0.403	0.714
8.	8	5	0.001	0.903	0.699	0.631	0.815
9.	9	1	0	0.954	0	0	0.910
10.	10	2	0.001	1	0.301	0.301	1
11.	16	1	0	1.204	0	0	1.450
				7.763	12.11	4.82	6.662

Calculations:

For the given data set,

$$\mathbf{a} = \frac{\mathbf{N}\sum\mathbf{XY} - \sum\mathbf{X}\sum\mathbf{Y}}{\mathbf{N}\sum\mathbf{X}^2 - (\sum\mathbf{X})^2}$$

$$a = \frac{\mathbf{53.02-94.01}}{\mathbf{73.28-60.26}}$$

$$a = \frac{40.99}{13.02} = 3.14$$

Since the value of 'a' is not equal to 2, Lotka's law could not be verified for the data.

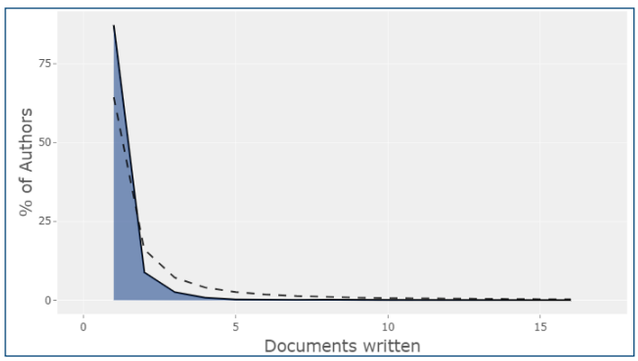


Fig. 9: Frequency of Authors Publishing Corresponding Articles

Most Prolific Authors

Fig. 10 lists the most prolific authors who have published literature in the field. As shown, Wang J published 16 articles, followed by Liu S, Li Y, Li L, Zahang X, Wang Z, Liu H, Li J, Li H, Wang Y, Wang H, Chen J, Zhang Y, Liu J, Liu D, Xu Z, Xu H, Wang X, Liu X, and Elaziz MA. Further, Fig. 11 represents the productivity of these authors over the years.

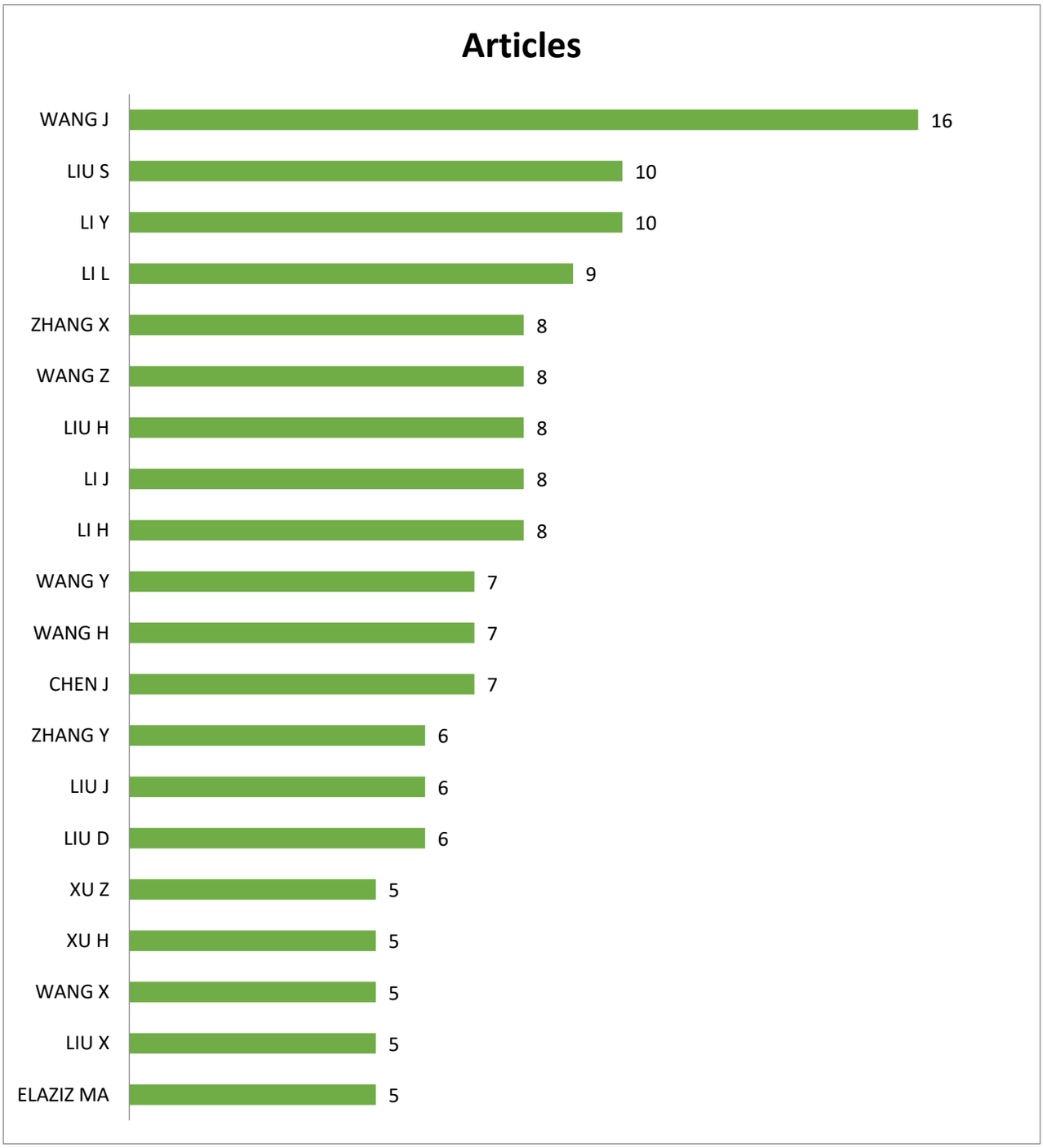


Fig. 10: Most Prolific Authors

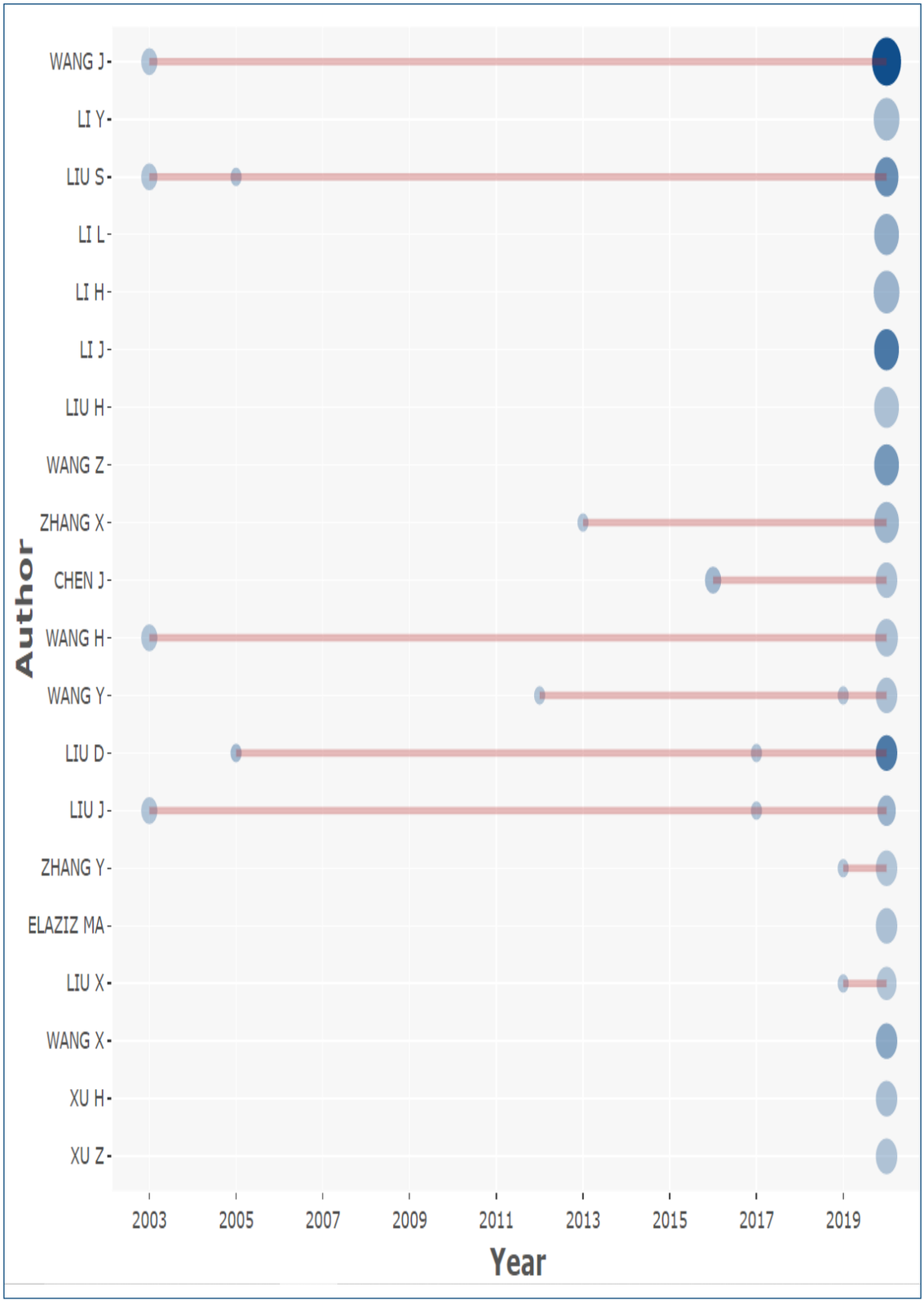


Fig. 11: Authors' Productivity over Time

Research Topic

Factor Analysis

There are many forms of data analysis used to report on and study survey data. Factor analysis is used to simplify complex data sets with many variables.

Factor analysis is a way to condense data in many variables into just a few variables. For this reason, it is also sometimes called 'dimension reduction'. You can reduce the 'dimensions' of your data into one or more 'super-variables' ("Qualtrics XM – Experience Management Software", 2020).

Fig. 12 is a dendrogram created by the bibliometrix software based on the titles of the literature in the field. Multiple correspondence analysis methods have been adopted for the analysis. It indicates the research topics that correlate with the research on SARS-COVID 19. As evident from the figure, we can conclude how research has been related to artificial intelligence.

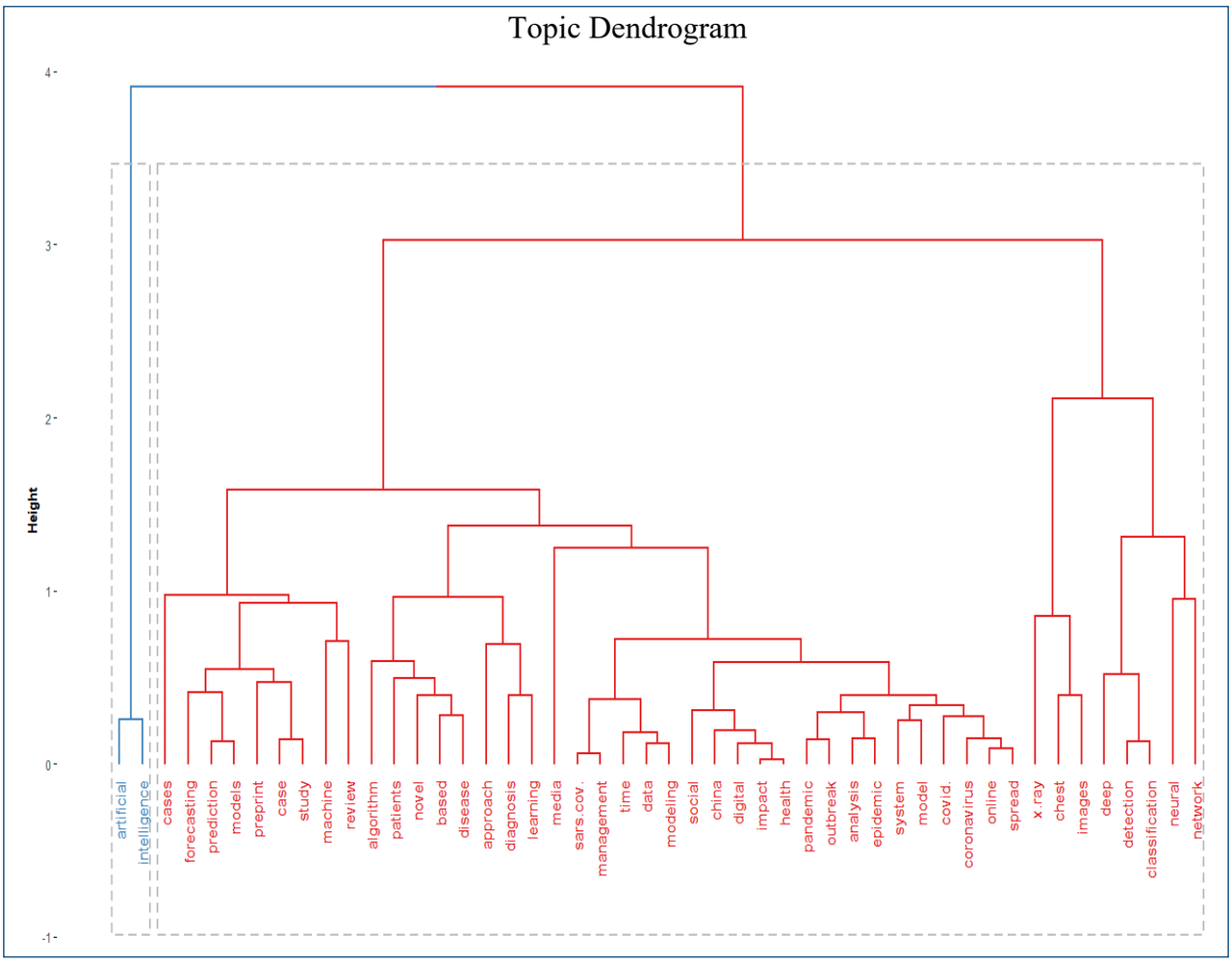


Fig. 12: Factor Analysis

Word Cloud

A word cloud for the dataset was generated using the 'biblioshiny app' and the bibliometrix software. To generate the word cloud, the graphical parameters selected were:

Field: Author's Keywords, where the number of keywords was restricted to 50.

Shape, Font & Text Colours: Circle, Impact, & Random Dark colour, respectively.

Ellipticity & Padding: 0.65 & 1, respectively.

The main advantage of selecting author keywords is that it provides insight into main topics and research trends.

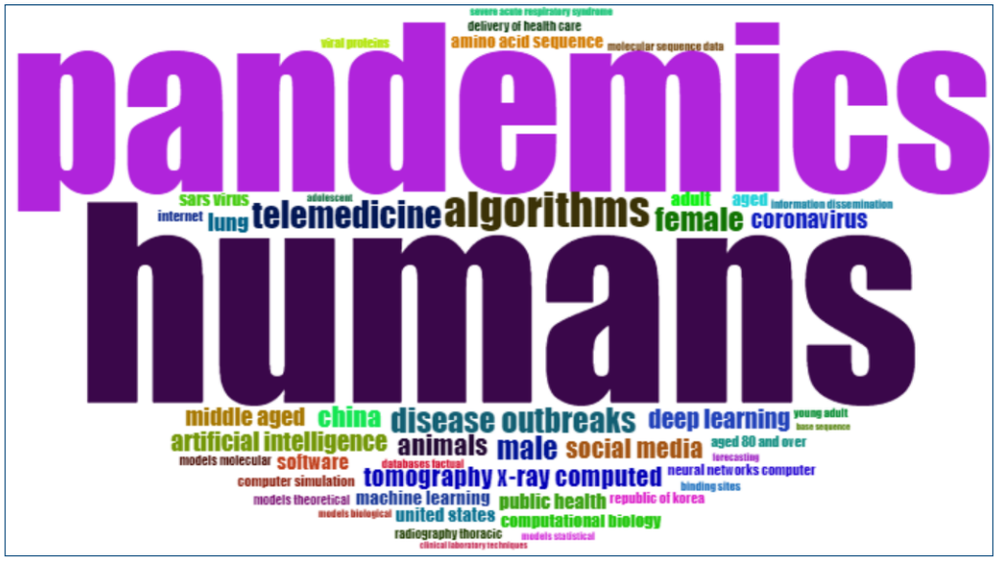


Fig. 13: Word Cloud (Author's Keywords)

Impact

Relative Citation Ratio

The relative citation ratio (RCR) is a metric endorsed by the National Institutes of Health. RCR indicates the relative citation performance of a publication when comparing its citation rate to that of other publications in its area of research. A value of more than 1.0 shows a citation rate above average. The article's area of research is defined by the articles that have been cited alongside it. The RCR is calculated for all PubMed publications which are at least two years old. As indicated by Fig. 14, RCR for publications in the years 2015 and 2016 had citation rates above average ("Dimensions – The next evolution in linked scholarly information", 2020).

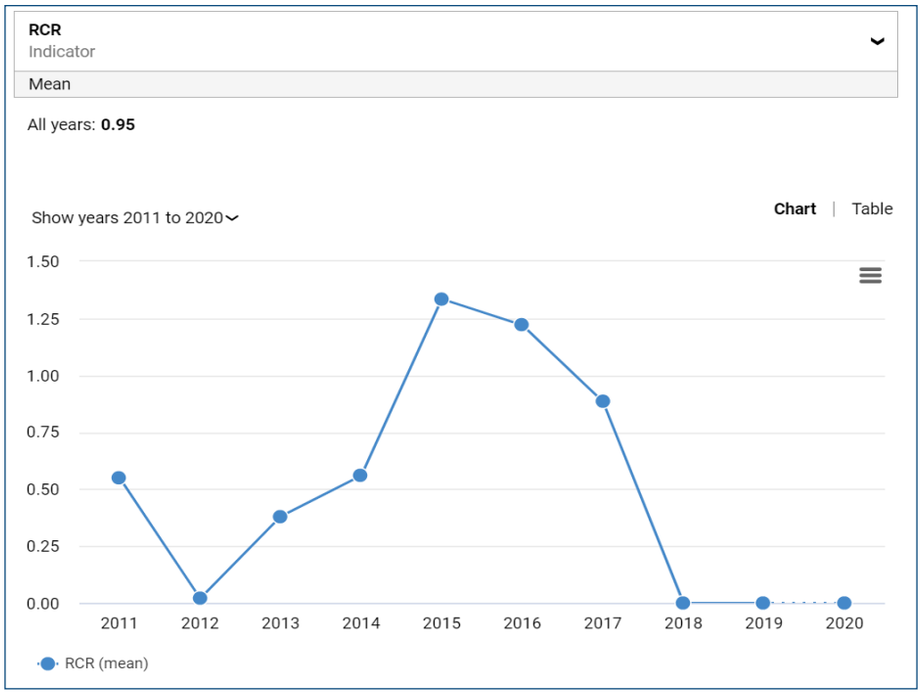


Fig. 14: Relative Citation Ratio

Average Article Citations per Year

As stated by the Initiative for Open Citations (I4OC), "Citations are the connections that weave together our scientific and cultural knowledge. They are the essential information that gives both provenance and clarification for how we know facts. They permit us to ascribe and credit logical commitments, and they empower the assessment of examination and its effects. In aggregate, the citations are the main vehicle for discovery, dissemination, and evaluation of all the scholarly knowledge. The present scholarly communication system inadequately exposes the knowledge network that already exists within our literature. Citation data are not usually freely available to access, they are often subject to inconsistent, hard-to-parse-licenses, and they are not usually machine readable".

Table 4 gives the Average Citations per Article [ACPA], Average Citations per Year [ACPY], total citable years, and total number of articles published in the respective years [N].

Fig. 15 illustrates the average article citations received per year. Average citations for the articles are calculated based on citable year calculated from the year the article was published to the current year.

Table 4: Average Citations

Year	N	ACPA	ACPY	Citable Years
1986	2	13.5	0.39	34
1987	0	0	0	0
1988	0	0	0	0
1989	2	125.5	4.05	31
1990	1	7	0.23	30
1991	0	0	0	0
1992	0	0	0	0
1993	0	0	0	0
1994	0	0	0	0
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	1	18	1	18
2003	3	5.3	0.31	17
2004	7	54.28	3.39	16
2005	6	26.83	1.78	15
2006	3	34.33	2.45	14
2007	1	150	11.54	13
2008	1	4	0.33	12
2009	0	0	0	0
2010	1	10	1	10
2011	4	13.25	1.47	9
2012	1	3	0.37	8
2013	1	9	1.28	7
2014	6	18.66	3.11	6
2015	2	33.5	6.7	5
2016	6	22.66	5.66	4
2017	6	8.16	2.72	3
2018	1	0	0	2
2019	9	4.22	4.22	1
2020	959	2.26		0

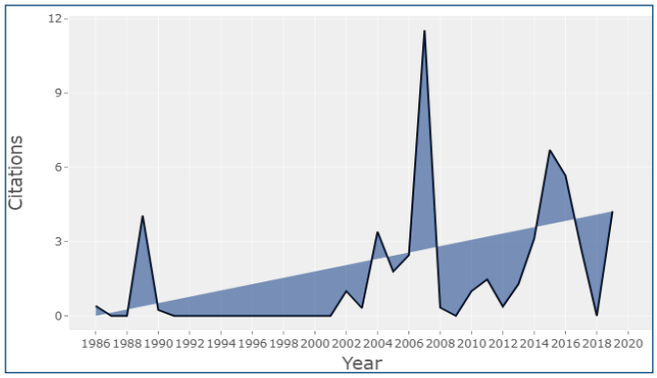


Fig. 15: Average Citation of Articles

Source Impact

Table 5 lists the source title-wise distribution of total research output on SARS CoV-19 literature. A journal's impact would assist the researchers in comparing the relative impact of journals within a discipline, as measured by citations.

Chaos Solitons & Fractals is the first journal with the highest number of publications (NP), i.e. 122 (h-index = 10 & TC = 496). IEEE Access has the second-highest number of publications – 74 (h-index = 5 & TC = 111), followed by the Journal of Medical Internet Research, with 54 publications (h-index = 6 & TC = 137).

h-index: It is a means for determining quantity and resonance beyond the citation rate and impact factor. It is a combination of the number of publications and publication frequency.

Table 5: Source Title-Wise Distribution of Publications and Indexes

Source	*h_index*	*Total Citations (TC)*	*NP*	*PY_start*
CHAOS SOLITONS & FRACTALS	10	496	122	2008
IEEE ACCESS	5	111	74	2020
JOURNAL OF MEDICAL INTERNET RESEARCH	6	137	54	2020
JOURNAL OF INTELLIGENT & FUZZY SYSTEMS	1	1	48	2019
BIOMED RESEARCH INTERNATIONAL	5	77	25	2014
JOURNAL OF THE AMERICAN MEDICAL INFORMATICS ASSOCIATION	4	107	23	2020
INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	4	60	21	2020
JOURNAL OF MEDICAL SYSTEMS	5	102	21	2020
ANNALS OF COMBINATORICS	1	2	20	2020
INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH	3	42	20	2020

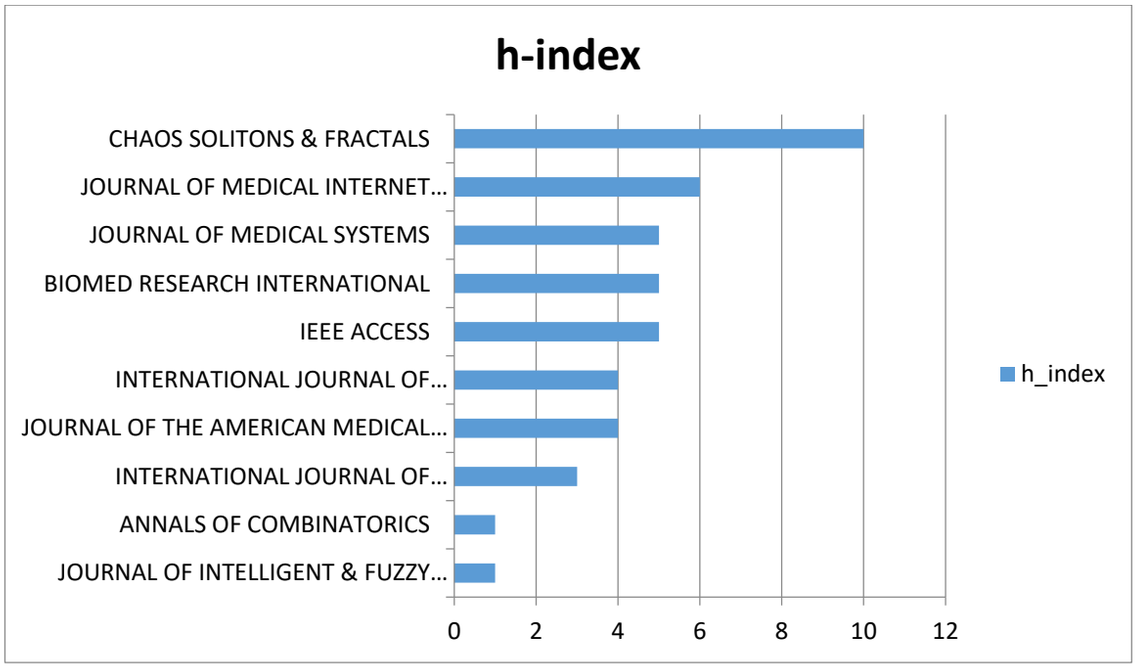


Fig. 16: Journal's Impact Based on the h-Index

Author Impact Analysis

The h-index, or Hirsch index, measures the impact of a particular scientist. "It is defined as the highest number of publications of a scientist that received h or more citations, each while the other publications have not more than h citations each." (Schreiber, 2008).

Table 6 indicates the author's impact, based on the number of publications and total citations received by them. As evident from the table, Wang has the highest number of publications {N=15} on SARS CoV-19, with 64 citations and h-index 5. LIU S ranked second with a total of ten publications, but a higher number of citations, i.e., 76, giving the same h-index 5. It was also observed that LI

Y has nine publications, while LI J has eight, and LIU D has six; however, total citations received from them are 4, 31, and 36, respectively, thereby giving them a similar h-index of 2.

Table 6: Author-Wise Distribution of Publications and Indexes

Author	*h_index*	*TC*	*NP*	*PY_start*
WANG J	5	64	15	2003
LI Y	2	4	9	2020
LIU S	5	76	10	2003
LI L	2	10	8	2020
LI H	1	6	7	2020
LI J	2	31	8	2020
LIU H	1	2	8	2020
WANG Z	2	18	8	2020
ZHANG X	1	6	8	2020
CHEN J	2	28	7	2016
WANG H	2	18	7	2003
WANG Y	1	6	7	2012
LIU D	2	36	6	2017
LIU J	4	29	6	2003
ZHANG Y	1	1	6	2019
ELAZIZ MA	1	2	5	2020
LIU X	1	1	5	2019
WANG X	2	12	5	2020
XU H	1	3	5	2020
XU Z	1	1	5	2020

Conclusion

Bibliometrics is defined as the "quantification of scholarly output examining its creation, quantity resonance, impact, significance, influence" (Librarians, 2020). An extensive bibliometric study on 'Research publications on SARS-CoV-2 (COVID-19): A study of publication trends using the R package' has been performed. To document the literature growth, authorship patterns, gender patterns, citation patterns, and related bibliometric phenomena, the necessary data were collected from the Dimensions.ai database with a time of all years. To perform the analysis, Bibliometrix package on the biblioshiny app written in R was used. It was observed that the publications had a sudden rise in the year 2019 with the advent of the Covid-19 pandemic. With 997 articles, the top ten journals account for 42.92% of the total article production, with *Chaos Solitons & Fractals* leading with 122 published articles, while the highest number of articles have been affiliated to the Harvard University {n=10}. It was also observed that multi-authored documents {n=3262} are more in number than single-authored documents {n=174}, where the number of single-authored documents is 188; this indicates that the authorship trend leans towards collaboration. As per the analysis by the Bibliometrix package, average documents per author is 0.299, average authors per document is 3.35, while average co-authors per document is 4.02.

The collaboration index for the given data is 3.97. Denmark has received the highest citations for its publications. By considering the bibliometric parameters viz. publications count, citations, and h-index, Wang was the most prolific author in the field. The study also revealed that the data did not verify Lotka's Law. It is suggested that developing countries in the world should increase qualitative publications in the field.

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