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THEORETICAL ARTICLE

Healthcare management and COVID-19: data-driven bibliometric analytics

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Abstract

Healthcare management and COVID-19 has been broadly studied during the recent few days, especially after declaration of the COVID-19 outbreak in almost all countries in the world. Therefore, the present research article aims to provide an extensive overview of the scientific literature about the study of healthcare management and COVID-19 for choosing the new topic of related research. It conducts four types of analyses where the first analysis is a trend analysis and other three analyses are related to network and density maps. The second analysis is analyzed decisively in order to produce all keywords, author keywords and index keywords co-occurrence network map and country co-authorship network map and tables summarizing the significant scientific trends under the present topics. The third analysis is analyzed purposefully in order to produce all documents, journals, authors and countries bibliographic coupling network maps and tables summarizing the significant scientific trends. The last analysis provides valuable approaching of the most significant used keywords on the research topic and the links among them using keyword co-occurrence network and density maps respectively.

Keywords Healthcare management · COVID-19 · VOSviewer · Network map · Density map

Abbreviations

COVID-19	Coronavirus disease-2019
TLS	Total link strength
Sars-Cov-2	Severe acute respiratory syndrome coronavirus 2
Cov	Coronavirus
US	United States
UK	United Kingdom

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1 Introduction

COVID-19 has amplified existing inequitable health outcomes. Five intersecting health and social conditions are correlated with poorer health outcomes namely physical health status, behavioral health challenges, unmet social needs, racial inequity and access to care. For physical health status, people with chronic conditions, the immune compromised, and the elderly make up most COVID-19 deaths. For example, obese patients, defined as those with a Body Mass Index above 35, are 2 times more likely to be hospitalized and 3.5 times as likely to be admitted to the intensive care unit due to COVID-19. For behavioral health challenges, individuals at an increased risk of developing severe COVID-19 symptoms are nearly twice as likely to have a behavioral health condition, including mental health and substance abuse disorders. For unmet social needs, people living in areas with significant unmet social needs (for example, food insecurity, housing insecurity) account for 15 percent of the population but 28 percent of COVID-19 deaths. In areas with high unemployment levels, COVID-19 deaths per 100,000 are 2.4 times higher than in areas with low unemployment. For racial inequity, compared with patients, the estimated age-adjusted COVID-19 mortality rate for other patients is 3.8 times, for American Indians 3.2 times, and for Hispanic/Latinx Americans 2.5 times. For access to care, challenges in access to care continue across the United States, with around 60 million Americans living in counties with low physical access to care. Furthermore, around 63 percent of all counties in the United States have a shortage of psychiatrists. Telehealth offers a great opportunity to expand access: inadequate physical access to care could be redressed for up to an additional 50 million Americans. However, 10 million Americans still do not have broadband access and live in areas with low physical access to care.

The present paper aims at contributing to this pathway by presenting an overview of extensive research in healthcare management and COVID-19 in the year 2020, through the use of the VOSviewer software. The supplementary value of this wide-ranging analysis is to show a very comprehensive and vital point of view of the literature evolution applying four different approaches. The first analysis is a trend analysis of the present research topics is presented. The second two aims are to analyse how the healthcare management and COVID-19 research has been studied by the different scientific journals through bibliometric analytics. The last approach, aims at exploring the evolution of the different research topics on healthcare management and COVID-19 using VOSviewer. The most extensively used keywords are collected and then analysed critically through network analysis.

This paper is organized as follows: In Sect. 2, the keyword research parameters and methodology to perform analysis are discussed. In Sect. 3, the analysis of results are presented and explained and finally, summary and conclusion are drawn in Sect. 4 providing the direction on how to use this tool to identify probable gaps in the existing literature and counter to the new research questions in healthcare management and COVID-19.

2 Research parameters and methodology

The literature research has been extracted from the Scopus database, on 28th of September 2020. The search parameters were defined as follows:

The keyword research parameters are summarized by this Boolean expression, *"HEALTHCARE AND MANAGEMENT AND COVID-19"*. Since many cases to have a more comprehensive view of the evolution of this literature, 2020 year was selected [1].

Through the application of these filters, 939 no. of papers was identified. Subsequently, the dataset was exported and analysed through the software package VOSviewer.

VOSviewer is a freely available software tool developed for building and displaying bibliometric maps. Unlike most of the other computer programs that are used for bibliometric mapping. VOSviewer gives particular attention to the graphical representation of the maps like network, density and overlay. The functionality of VOSviewer is in fact particularly useful for displaying large bibliometric maps, while providing a simple way to interpret such results [1, 5]. This software provides different models of visualization. In this present study, two bibliometric analyses are utilized like network and density.

The first two are the network and density visualizations of co-authorship and bibliographic coupling analysis which are discussed in the Sect. 3.1 and 3.2 respectively. The last is the density visualization of co-occurrence analysis of keywords and is discussed in Sect. 3.3 [1, 5]. All these bibliometric maps contain items and links.

2.1 Items

They are the object of interest of the map. In the present analysis, documents, journals, authors, organizations, countries and keywords are such objects. When reading the map, the higher the weight of an item, the larger the label and the circle of the item.

2.2 Links

Between a pair of items there may be link, which represents a connection between these two items. Each link has a weight, represented by a positive numerical value. The higher this value, the stronger is the link. Moreover, when looking at the map, the closer two items are located to each other, the stronger their relatedness. Also, the relatedness is represented by the thickness of the edges connecting the items [1, 2, 4, 6].

3 Results and analysis

The results of an initial quantitative analysis are presented as the trend analysis.

3.1 Trend analysis

The results of initial quantitative analysis are shown in Figs. 1, 2, 3, 4, 5, 6, 7 and 8. Figure 1 presents the documents by year. Figure 2 shows the documents per year by source. Figure 3 shows the documents by affiliation. It explains up to 15

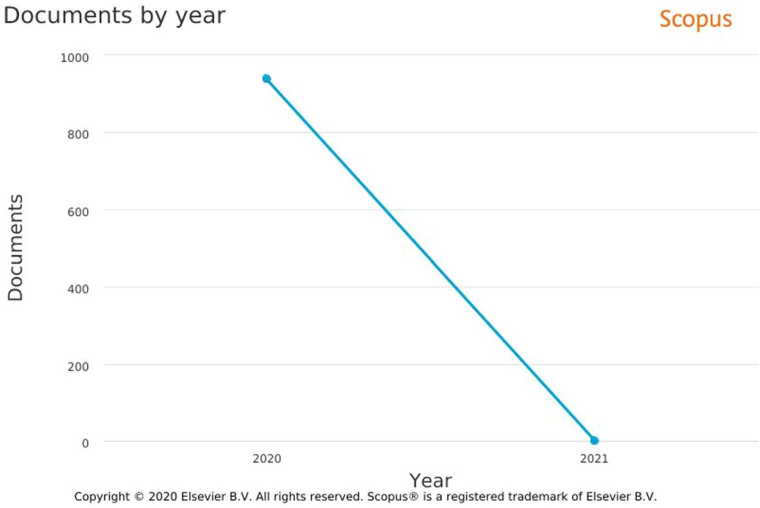

Fig. 1 Documents by year

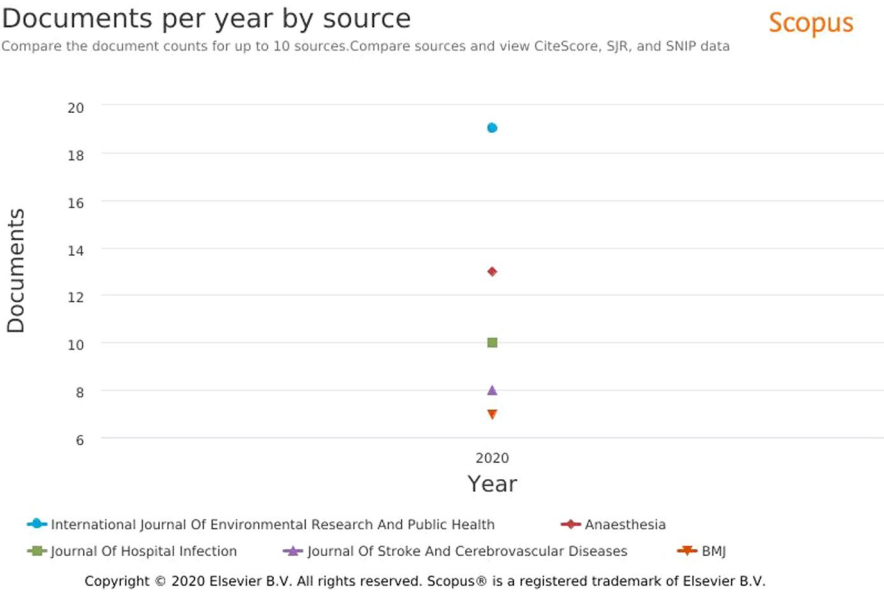

Fig. 2 Documents per year by source

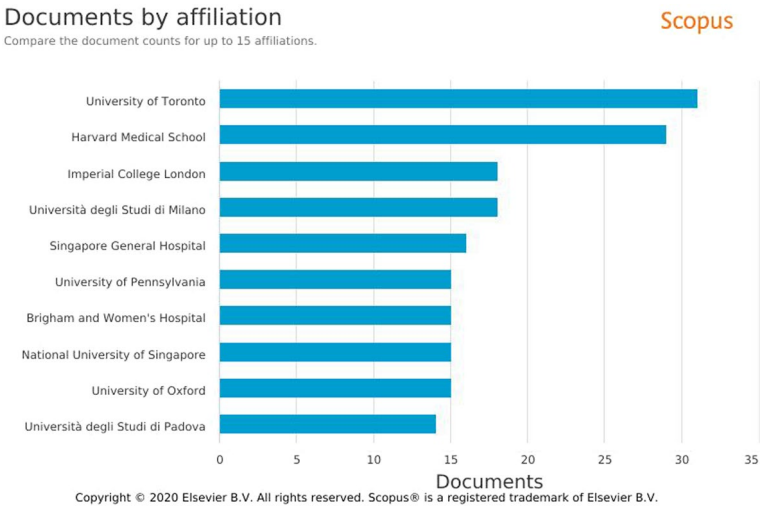

Fig. 3 Documents by affiliation

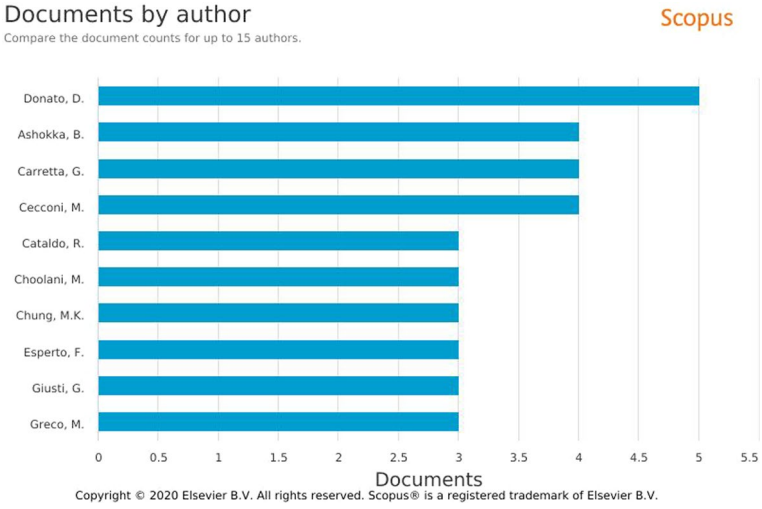

Fig. 4 Documents by author

documents from the top by comparing the documents by affiliation. The top three affiliations namely University of Torronto, Harvard Medical School and Imperial College of London published more than 30, within 25 to 30 and within 15 to 20

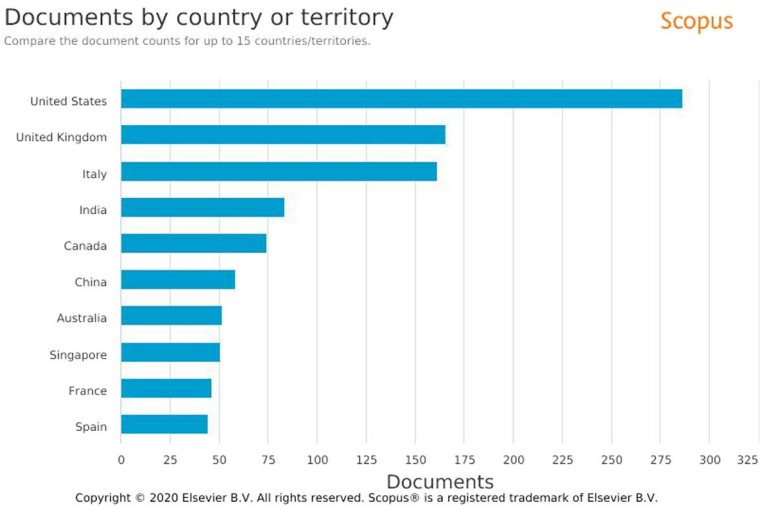

Fig. 5 Documents by country or territory

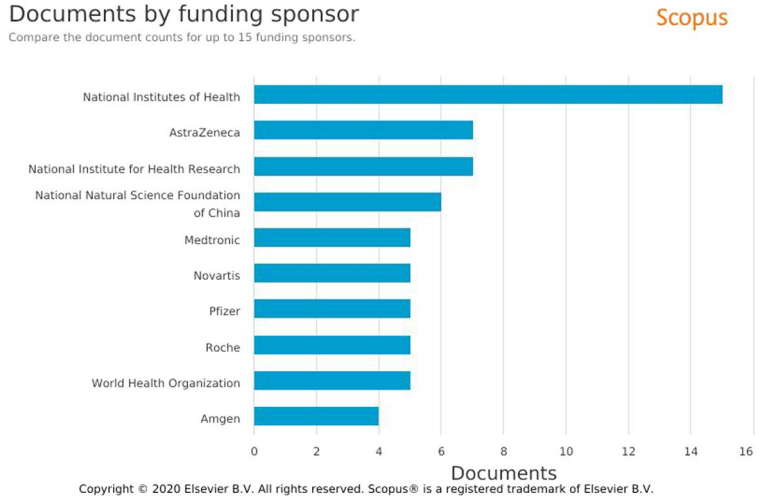

Fig. 6 Documents by funding sponsor

documents respectively. Figure 4 shows the documents by author. It explains up to 15 documents from the top by comparing the documents per year by source. The top three sources namely D. Donato, B. Ashokka and G. Carretta published 5, 4 and 4 documents per year respectively. Figure 5 shows the documents by country. It explains up to 15 documents from the top by comparing the documents by country/territory. The top three countries namely United States, United Kingdom and Italy published within 275 to 300, within 160 to 175 and within 150 to 175 documents respectively. Figure 6 shows the documents by types. The

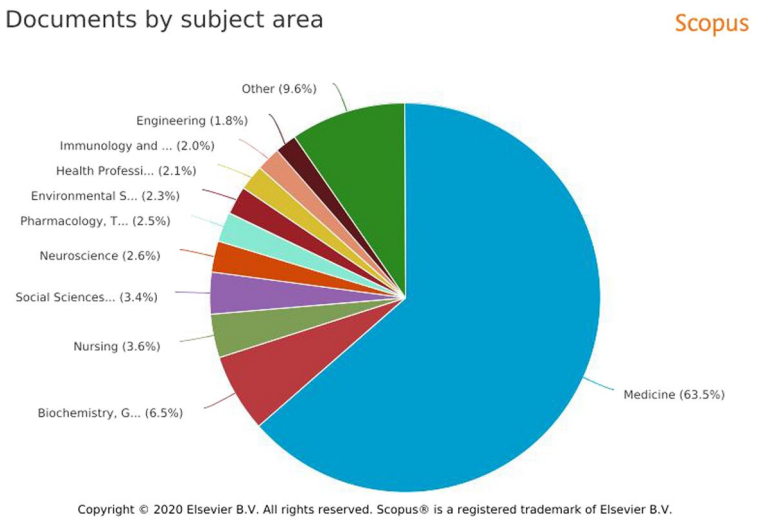

Fig. 7 Documents by subject area

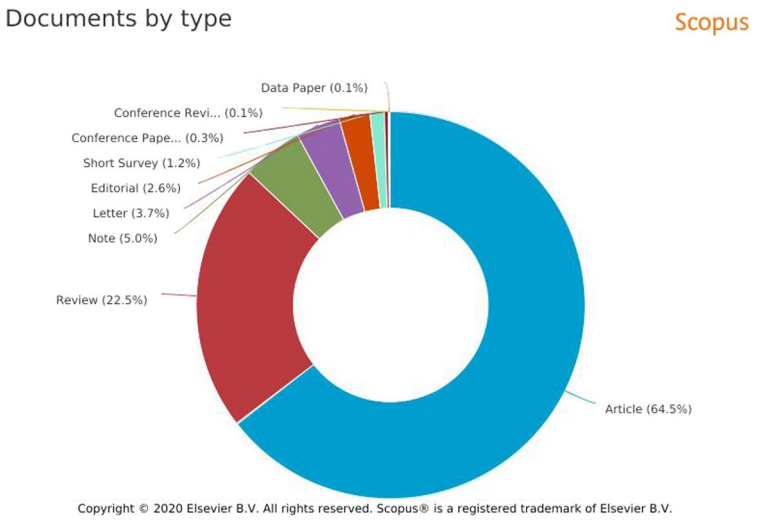

Fig. 8 Documents by type

top three types namely article, review and notes published 64.5%, 22.5% and 5% documents respectively. Figure 7 shows the documents by subject type. The top three subject types namely Medicine, other and Biochemistry published 63.5%, 9.6% and 6.5% respectively. Figure 8 shows the documents by funding sponsorship. It explains up to 15 documents from the top by comparing the documents by funding sponsorship. The top three funding sponsorship namely National Institute

of Health, AstraZeneca and National Institute for Health Research sponsored for 14 to 16, 6 to 8 and 6 to 8 documents respectively.

In Sect. 3.2, three type of co-occurrence network and one type of co-authorship network visualizations are discussed. In Sect. 3.3, four types of bibliographic coupling network visualizations are discussed. Both network and density visualizations of co-occurrence of keywords are discussed in Sect. 3.4.

3.2 Co-occurrence and co-authorship network visualizations

This section shows the co-occurrence network maps in which the relatedness of the occurrence of items namely all keywords, author keywords and index keywords is determined, based on the number of co- occurrence they have. Table 1 shows the top 10 co- occurrence all keywords, author keywords and index keywords respectively. The minimum number of occurrences of the keywords for co- occurrence network map was set to 5. Of the 5831 keywords, 856 met the threshold. For each of the 856 keywords the total link strength (TLS) of the co- occurrence links with other keywords was calculated. The authors with the greatest TLS were selected and it was 856. So this network map has 856 keywords, 8 clusters, 91,367 links and 325,555 total link strengths. The results are shown in Fig. 9 and Table 1. "Human", "Pandemic" and "Coronavirus disease 2019" can found at the top of the table, with 700, 568 and 565 occurrences of all keywords co- occurrence network map respectively. The author keywords co-occurrence network map shown in Fig. 10 and Table 1 where, the minimum number of occurrences of author keywords in the co-occurrence network maps was set to 5. Of the 1933 keywords, 83 met the threshold. For each of the 83 keywords the total link strength (TLS) of the co- occurrence links with other author keywords was calculated. The author keywords with the greatest TLS were selected and it was 83. So this network map has 83 author keywords, 9 clusters, 566 links and 1633 total link strengths. "COVID-19", "Sars-Cov-2" and "Coronavirus" are found on the top, with 520, 137 and 136 occurrences of author keywords in co-occurrence network map respectively. The index keyword co- occurrence network map shown in Fig. 11 and Table 1 where, the minimum numbers of occurrences of the index keywords in the co- occurrence network map was set to 5. Of the 4446 index keywords, 792 met the threshold. For each of the 792 index keywords the total link strength (TLS) of the co- occurrence links with other keywords was calculated. The index keywords with the greatest TLS were selected and it was 792. So this network map has 792 index keywords, 7 clusters, 81,290 links and 291,222 total link strengths. "Human", "Virus Pneumonia" and "Humans" are found on the top, with 700, 569 and 565 index keywords of co-occurrence network map respectively. The country co-authorship network map shown in Fig. 12 and Table 1 where, the minimum numbers of documents of a country and minimum number of citations of a country in the co-authorship network map were set to 5 and 5 respectively. Of the 184 countries, 50 met the threshold. For each of the 184 countries the total link strength (TLS) of the co-authorship links with other countries was calculated. The countries with the greatest TLS were selected and it was 50. So this network map has 50 countries, 5 clusters, 693 links and 2486 total link strengths. "United States",

Table 1 Top 10 co-occurrence all keywords, author keywords and index keywords and co-authorship country

Sl. No	Co-occurrence all keywords	Cluster	Link	Total link strength	Occurrence
1	Human	2	854	19,462	700
2	Pandemics	4	853	16,761	568
3	Coronavirus disease 2019	2	854	16,749	565
4	Organisation & management	4	853	16,780	563
5	Coronavirus infection	4	791	7985	277
6	Severe acute respiratory syndrome coronavirus	1	785	6821	205
7	Practice guidelines	5	728	4592	147
8	Female	8	715	4753	143
9	Sars-Cov-2	1	660	3371	137
10	Health care delivery	4	684	4031	135
Sl. No	Co-occurrence author keywords	Cluster	Link	Total Link Strength	Occurrence
1	Covid-19	1	82	800	520
2	Sars-Cov-2	2	62	307	137
3	Coronavirus	1	67	314	136
4	Pandemic	9	58	266	119
5	Telemedicine	6	24	65	36
6	Management	7	26	61	26
7	Persona protective equipment	8	28	71	24
8	Surgery	5	27	60	21
9	Healthcare workers	2	11	32	15
10	Tele health	6	13	27	12
Sl. No	Co-occurrence index keywords	Cluster	Link	Total link strength	Occurrence
1	Human	2	790	18,306	700
2	Virus pneumonia	7	790	16,049	569
3	Humans	7	790	15,933	565
4	Coronavirus infection	7	790	15,920	563
5	Pneumonia and viral	7	790	15,920	563
6	Pandemics	7	790	15,807	560
7	Beta coronavirus	7	788	12,952	450
8	Organisation and management	7	737	7628	277
9	Severe acute respiratory syndrome coronavirus 2	1	726	6338	203
10	Practice guideline	3	673	4282	146
Sl. No	Co-authorship country	Cluster	Link	Total link strength	Documents
1	US	3	47	414	294
2	UK	3	47	391	165
3	Italy	1	45	373	162
4	India	5	38	120	83
5	Canada	2	41	220	75

Table 1 (continued)

Sl. No	Co-authorship country	Cluster	Link	Total link strength	Documents
6	China	2	39	179	58
7	Australia	3	40	184	50
8	Singapore	2	33	120	50
9	Spain	1	32	185	49
10	France	1	35	192	47

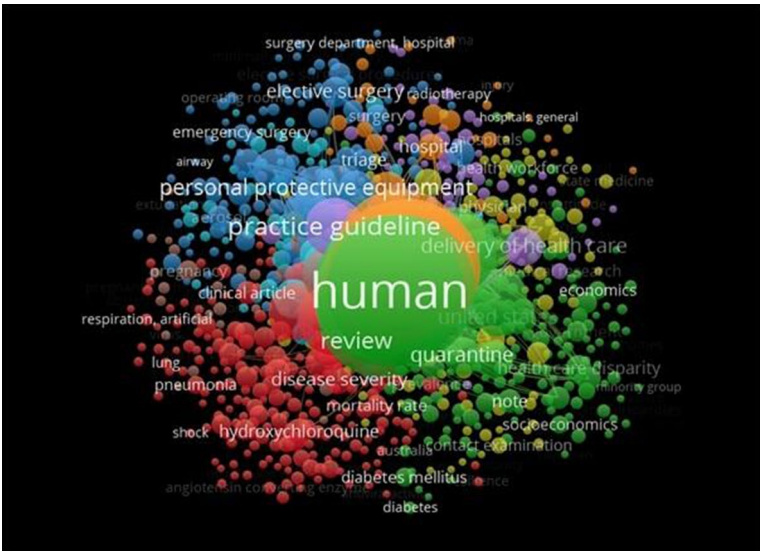

Fig. 9 Co-occurrence all keywords network map

"United Kingdom" and "Italy" are found on the top, with 294, 165 and 162 countries of co-authorship network map respectively.

3.3 Bibliographic coupling network visualizations

This section shows the bibliographic coupling network map, in which the relatedness of the items namely documents, journals, authors, and countries is determined based on the number of references they share. Table 2 shows top 10 bibliographic coupled documents, journals, authors, and countries respectively. The document bibliographic coupling network map shown in Fig. 13. The minimum number of documents and citations of a document in the bibliographic coupling network map were set to 5 and 5 respectively. Of the 939 documents, 169 met the threshold. For each of the 139 documents the total link strength (TLS) of the bibliographic coupling links with other documents was calculated. The

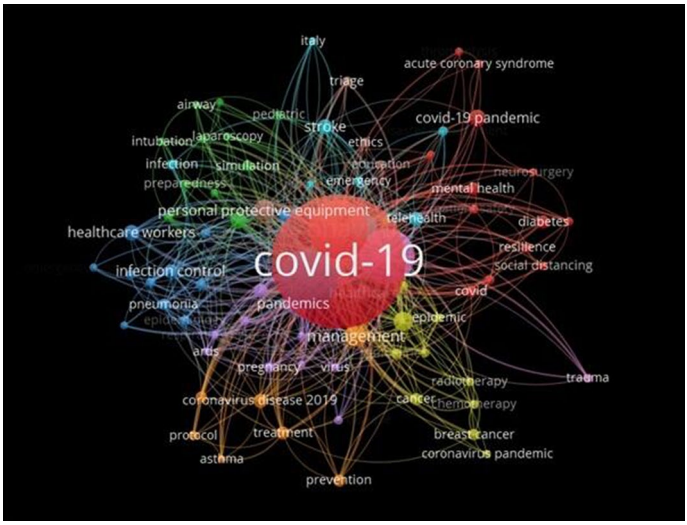

Fig. 10 Co-occurrence author keywords network map

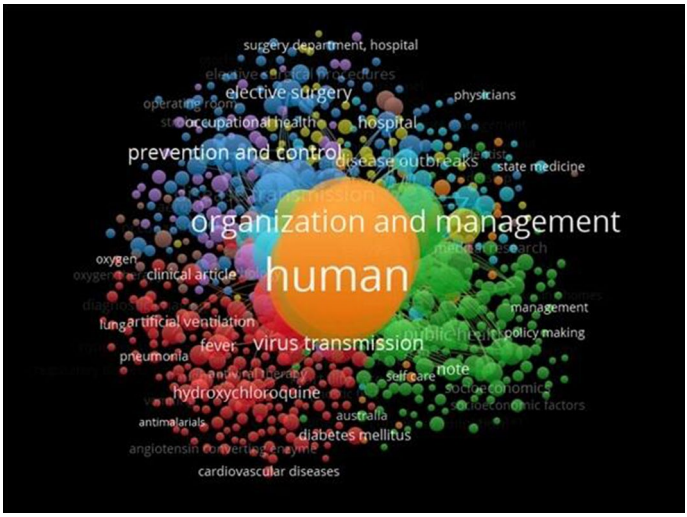

Fig. 11 Co-occurrence index keywords network map

documents with the greatest TLS were selected and it was 139. So this network map has 139 documents, 10 clusters, 2280 links and 4403 total link strengths. "Lin Y.H. (2020)", "Alhazzani W. (2020)" and "Wang J. (2020)" are found on the top, with 370, 256 and 155 citations of the documents by bibliographic coupling network map respectively. The journal bibliographic coupling network

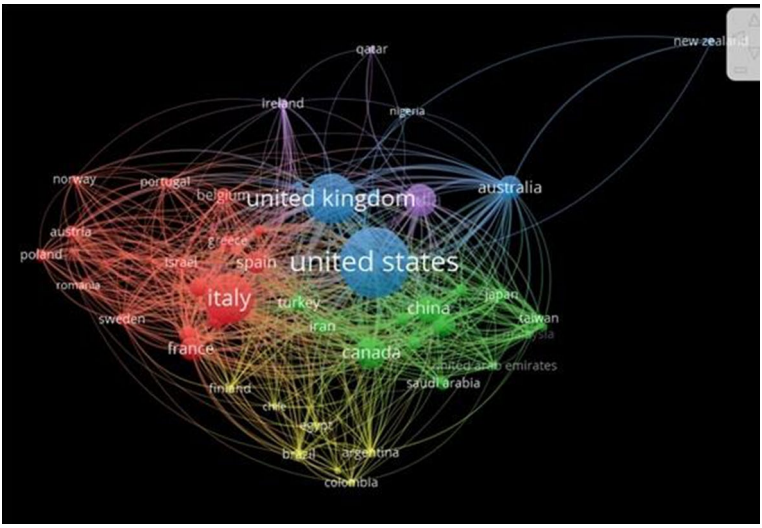

Fig. 12 Country co-authorship network map

map shown in Fig. 14 and Table 2 where the minimum number of documents and citation of a journal in the bibliographic coupling network map were set to 2 and 2 respectively. Of the 605 documents, 106 met the threshold. For each of the 106 journals the total link strength (TLS) of the bibliographic coupling links with other journals was calculated. The journals with the greatest TLS were selected and it was 99. So this network map has 99 journals, 12 clusters, 2037 links and 6552 total link strengths. "International Journal of Environmental Research & Public Health", "Anaesthesia" and "Journal of Hospital Infection" are found on the top, with 19, 13 and 10 journals of bibliographic coupling network map respectively. The author bibliographic coupling network map shown in Fig. 15 and Table 2 where the minimum number of documents and citation of an author in the bibliographic coupling density map were set to 2 and 2 respectively. Of the 5558 authors, 243 met the threshold. For each of the 243 authors 237 the total link strength (TLS) of the bibliographic coupling links with other authors was calculated. The authors with the greatest TLS were selected and it was 237. So this network map has 237 authors, 12 clusters, 10,930 links and 75,787 total link strengths. "Li Y.", "Donato D." and "Ashokka B." are found on the top, with 6, 5 and 4 authors of bibliographic coupling network map respectively. The country bibliographic coupling network map shown in Fig. 16 and Table 2 where the minimum number of documents and citation of a country in the bibliographic coupling network map were set to 5 and 5 respectively. Of the 184 countries, 50 met the threshold. For each of the 50 countries the total link strength (TLS) of the bibliographic coupling links with other countries was calculated. The countries with the greatest TLS were selected and it was 50. So this network map has 50 countries, 4 clusters, 1200 links and 283,671 total link strengths. "United States", "United Kingdom" and "Italy" are found on the top,

Table 2 Top 10 bibliographic coupled documents, journals, authors, and countries

Sl. No	Bibliographic coupled documents	Cluster	Link	Total link strength	Citations
1	Lin Y.H. (2020)	5	9	16	370
2	Alhazzani W. (2020)	5	77	419	256
3	Wong J. (2020)	6	57	122	155
4	Cook T.M. (2020)	8	32	54	139
5	Alhazzarni W. (2020a)	5	85	482	91
6	Dashraath P. (2020)	9	61	151	86
7	Vukkadala (2020)	8	71	130	85
8	Sorbello M. (2020)	2	61	108	73
9	Chen X. (2020)	4	48	67	69
10	Simpson S. (2020)	3	38	73	53
Sl. No	Bibliographic coupled journals	Cluster	Link	Total link strength	Documents
1	International Jour. Of Environmental Public Health	4	82	482	19
2	Anaesthesia	3	78	661	13
3	Jour. Of hospital infection	3	63	247	10
4	Jour. Of stroke & cerebrovascular disease	4	72	255	8
5	International jour. Of infectious diseases	3	71	299	7
6	International jour of surgery	7	51	105	7
7	The BMJ	1	5	5	7
8	Jour. of general internal medicine	2	23	32	6
9	Acta biometrica	1	51	137	6
10	Diabetes & metabolic syndrome, clinical research reviews	1	39	53	6
Sl. No	Bibliographic coupled authors	Cluster	Link	Total link strength	Documents
1	Li Y	1	150	591	6
2	Donato D	6	131	523	5
3	Ashokka B	1	137	1132	4
4	Li Z	2	70	179	4
5	Papalia R	5	159	430	4
6	Kumar S	2	166	586	4
7	Liu J	2	105	359	4
8	Chung M.K	3	115	1689	3
9	Giusti G	5	28	286	3
10	Lie S.A	1	125	764	3
Sl. No	Bibliographic coupled counties	Cluster	Link	Total link strength	Documents
1	US	2	49	63,263	294
2	UK	1	49	47,122	165
3	Italy	1	49	47,642	162
4	India	2	49	18,210	83
5	Canada	3	49	30,577	75
6	China	3	48	30,122	58

Table 2 (continued)

Sl. No	Bibliographic coupled counties	Cluster	Link	Total link strength	Documents
7	Australia	3	48	27,411	50
8	Singapore	2	48	15,722	50
9	France	1	49	17,468	47
10	Spain	1	49	19,548	44

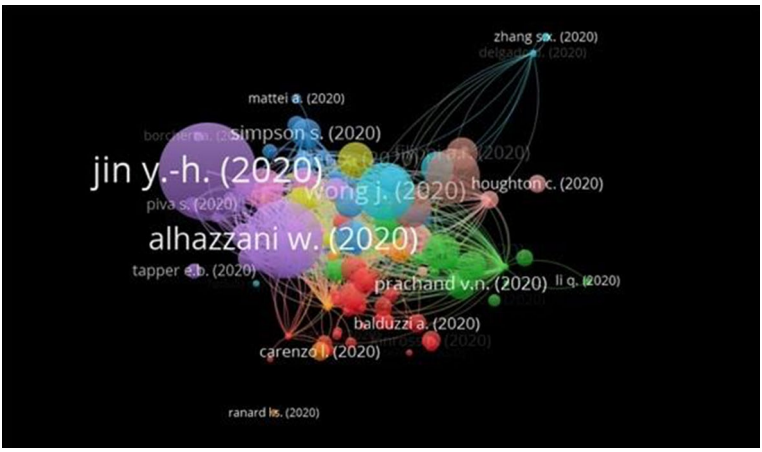

Fig. 13 Document bibliographic coupling network map

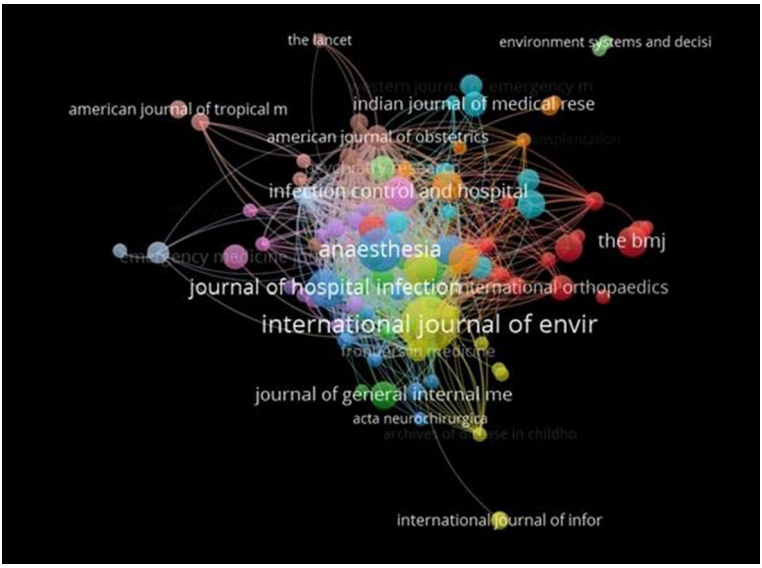

Fig. 14 Journal/ Source bibliographic coupling network map

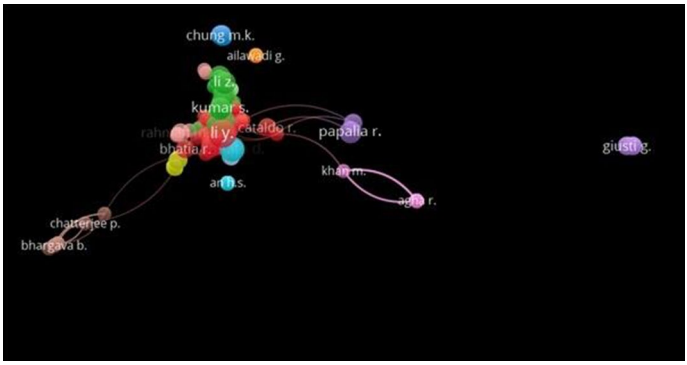

Fig. 15 Author bibliographic coupling network map

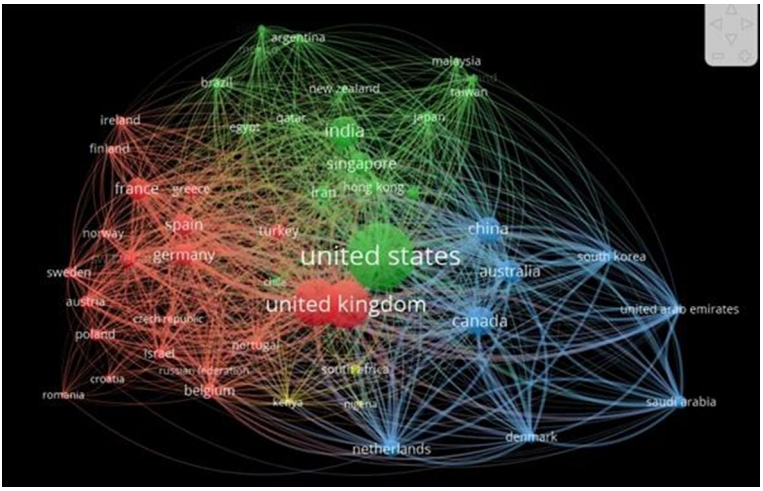

Fig. 16 Country bibliographic coupling network map

with 294, 165 and 162 documents in the countries of bibliographic coupling network map respectively. These items are the key point of reference for the present research subjects.

4 Keywords co-occurence network and density visualizations

In this section the keywords co-occurrence using both bibliometric network and density analyses are examplified. In this paper, keywords co-occurrences network and density maps were created, for the year 2020 (939 papers). In these maps the

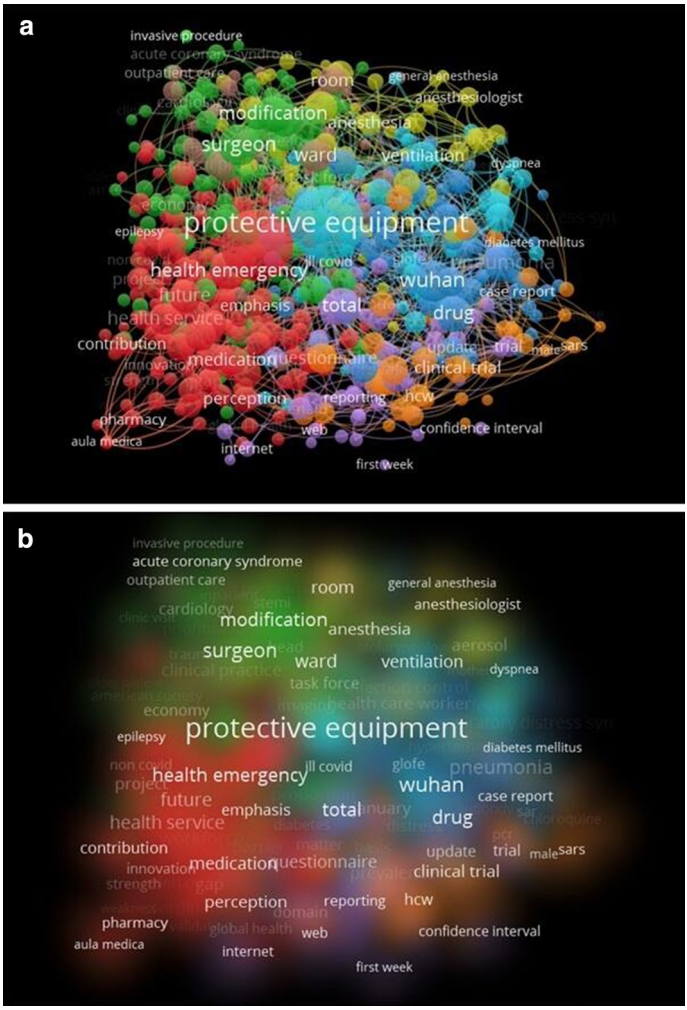

Fig. 17 Keyword co-occurrence **a** network and **b** density map (minimum no. of occurrence of an item is 5 with binary counting)

relatedness of the items (keywords) is determined based on the number of documents (papers) in which they occur together, while the strength of the links indicates the number of publications in which two keywords occur together. In the network and density maps from Fig. 17a, b and Fig. 18a, b respectively, the minimum number of occurrences of a given keyword, in order to be relevant for the analysis, 5 and 10 were set respectively applying binary counting. In the network and density maps from Fig. 19a, b and 20a, b respectively, the minimum number of occurrences of a given keyword, in order to be relevant for the analysis, 5 and 10 were set respectively applying full counting. This choice has been adopted in order to obtain an optimal swapping between readability and completeness of the bibliometric density

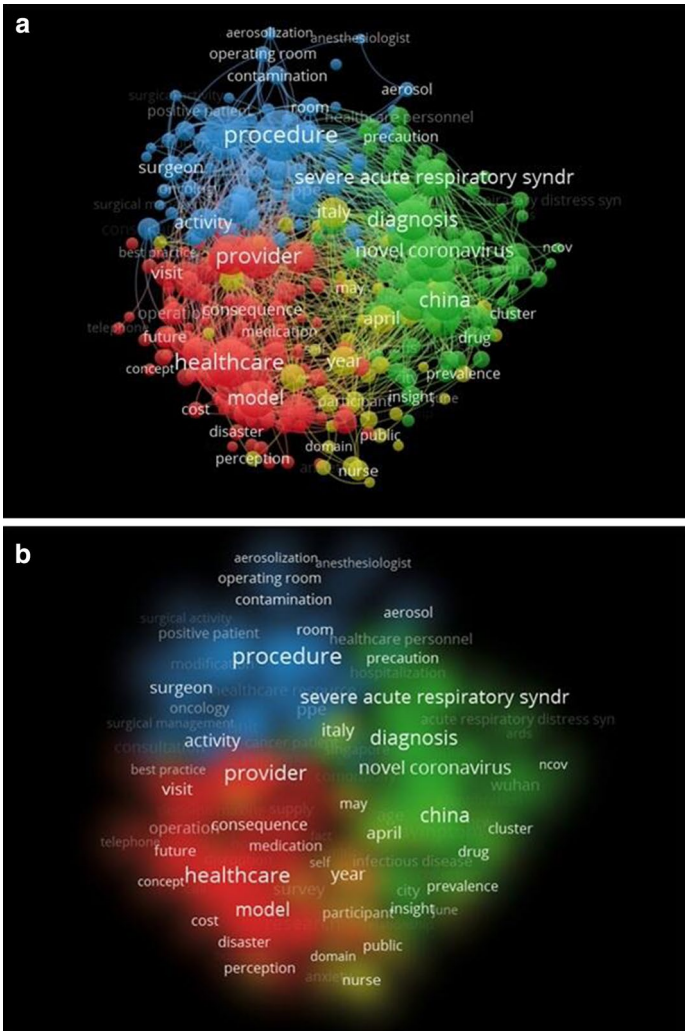

Fig. 18 Keyword co-occurrence **a** network and **b** density map (minimum no. of occurrence of an item is 10 with binary counting);

maps. Tables 3, 4, 5 and 6 exemplify the results of each of the four bibliometric network and four density map analyses respectively.

Figures 17a, b and 18a, b show the keyword co-occurrence bibliometric network and density maps respectively with minimum no. of occurrences of an item is 5 and 10 applying binary counting for the year 2020. Figures 19a, b and 20a, b show the keyword co-occurrence bibliometric network and density maps respectively with minimum no. of occurrences of an item is 5 and 10 applying full counting for the year 2020. Examining Tables 3 and 4, it can be noted that the top 10 keywords related to its relevance are chosen with the relatedness

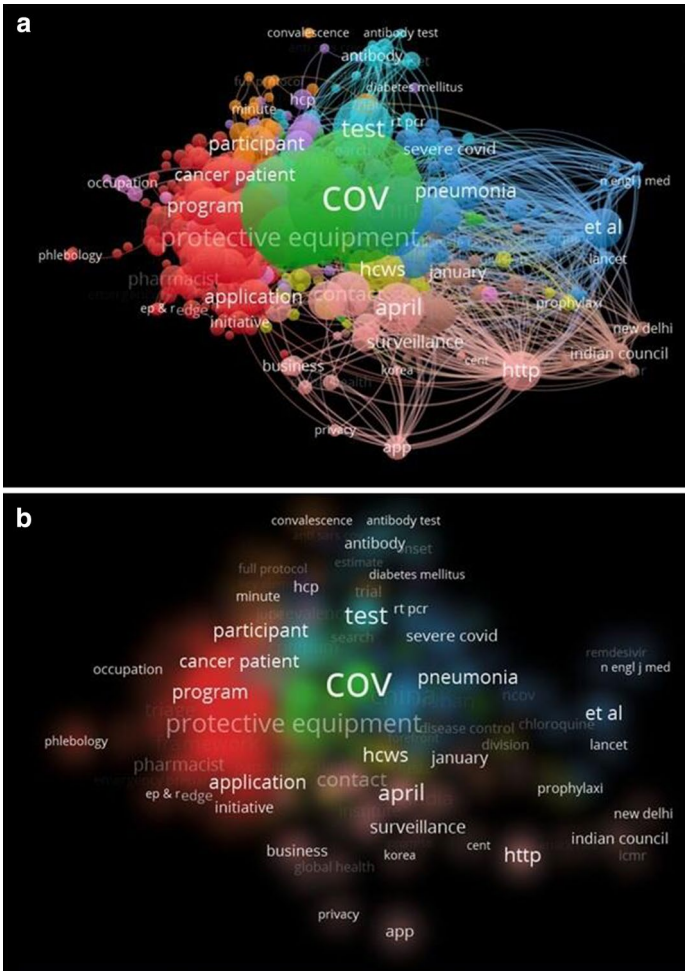

Fig. 19 Keyword co-occurrence **a** network and **b** density map (minimum no. of occurrence of an item is 5 with full counting)

between healthcare and management and COVID-19 for 5 and 10 as the minimum no. of occurrences of an item applying binary counting respectively. Similarly, in Tables 5 and 6, it can be noted that the top 10 keywords related to the relevance are chosen with the relatedness between healthcare and management and COVID-19 for 5 and 10 as the minimum no. of occurrences of an item applying full counting respectively. It is clear from the above analyses that some of the keywords like *protective equipment, professional, Wuhan, Procedure, Healthcare, Provider, Cov, Worker, China, Sars Cov, Service, Surgery* may be added in healthcare management and COVID-19 research for the policy makers and government officials to develop the decision making strategies.

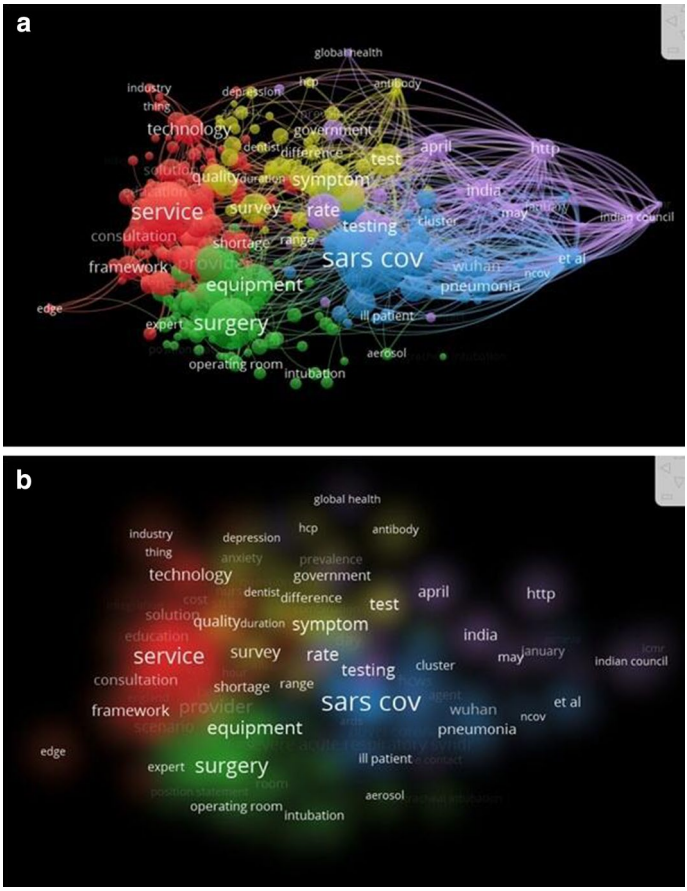

Fig. 20 Keyword co-occurrence **a** network and **b** density map (minimum no. of occurrence of an item is 10 with full counting);

Table 3 Top 10 keywords occurrences with minimum no. of occurrence of an item is 5(Binary counting)

Sl. No	Keywords	Cluster	Link	Total link strength	Occurrences
1	Protective equipment	5	465	1012	112
2	Professional	3	440	852	105
3	Wuhan	2	290	461	42
4	Surgeon	5	227	383	41
5	Pneumonia	2	263	445	37
6	Health emergency	3	240	324	35
7	Total	1	242	352	34
8	Drug	2	248	387	33
9	Modification	4	191	301	33
10	Medication	3	169	232	25

Table 4 Top 10 keywords occurrences with minimum no. of occurrence of an item is 10(Binary counting)

Sl. No	Keywords	Cluster	Link	Total link strength	Occurrences
1	Procedure	3	287	1598	148
2	Healthcare	1	280	1146	130
3	Provider	1	281	1131	117
4	Surgery	3	288	1171	110
5	Diagnosis	2	258	985	96
6	Professional	1	261	853	96
7	China	2	280	1230	94
8	Symptom	2	268	1071	90
9	Model	1	257	878	87
10	Symptom	2	268	1040	87

Table 5 Top 10 keywords occurrences with minimum no. of occurrence of an item is 5(Full counting)

Sl. No	Keywords	Cluster	Link	Total link strength	Occurrences
1	Cov	2	666	10,621	431
2	Worker	2	643	6247	332
3	China	3	481	4545	132
4	Protective equipment	2	501	2149	129
5	Professional	1	451	1735	119
6	Test	6	412	3963	112
7	Novel coronavirus	3	393	2644	84
8	April	9	421	4957	83
9	Framework	1	316	1349	72
10	India	8	314	4111	71

Table 6 Top 10 keywords occurrences with minimum no. of occurrence of an item is 10(Full counting)

Sl. No	Keywords	Cluster	Link	Total link strength	Occurrences
1	Sars Cov	3	355	10,234	428
2	Service	1	340	4527	258
3	Surgery	2	284	3715	240
4	Crisis	1	320	2975	190
5	Model	1	299	3006	160
6	Provider	1	319	2603	158
7	China	3	317	4352	132
8	Symptom	4	301	2963	130
9	Safety	2	304	2045	125
10	Testing	5	312	2889	108

5 Conclusion

This paper extends to provide an overview of the existing literature on healthcare management and COVID-19 research fields by applying VOSviewer software package. It creates automatically bibliometric maps and tables from a large number of data (939 records) for the year 2020.

The methodology of creating bibliometric network [1] maps allows me to have a macroscopic and all-inclusive view of the state of the art of the literature. It results to observe the presence of the significant keywords which create the relationships between them. It shows the findings of research gaps in the existing research of healthcare management and COVID-19 for further research scope. The research trends can be directly identified in Figs. 17a, b, 18a, b, 19a, b and 20a, b by indicating the presence and strength of certain links between research topics or keywords. Through these analyses namely keyword co-occurrence bibliometric network and density analysis, the researchers will be able to determine the keywords which are more common, or to discover if there is a trend into the practice of certain methodologies in healthcare management and COVID-19. Anyway, for future research scope, it is investigated to apply the present methodology to build specific comparisons and to find more useful insights in healthcare management and COVID-19.

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