The Impact of the COVID-19 Pandemic on Cardiovascular Disease Research: A Bibliometric Analysis

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Abstract. During the pandemic, the literature on the COVID-19 landscape has improved significantly. Cardiovascular disease is a significant risk factor for COVID-19 patients. In this paper, we will use bibliometric analysis to map the patterns in global COVID-19 on Cardiovascular research, allowing researchers to easily evaluate study areas and find extensive the focus of study. Scientific literature on COVID-19 and cardiovascular disease were found by searching the Scopus Core Collection database. Each selected paper's title, authors, contributing institute, nation, source journal, times cited, and extra data were extracted. For analysing the extracted data and exporting the bar charts and tables, Microsoft Excel 2019 was used. The R Studio/bibliophagy for bibliometric application and VOSviewer was used to execute and map global research trends and hotspots in this topic. A total of 1.313 papers were retrieved, with 151 countries, 5,371 organizations, 567 publications, and 5,128 keywords included. United States had the most overall citations, followed by China, United Kingdom, and Italy. United Stated had four of the top seven most referenced organizations, Saga University from Japan had the most documents. The paper by Guo T et al. (The Jama Cardiology, 2020) was the most frequent and popular quoted. The keywords were mostly concentrated on: cardiovascular disease, human, coronavirus disease 2019 are recent hotspots of concern. This study identified worldwide studies patterns in COVID-19 and cardiovascular disease, resulting in might aid scientists in finding relevant collaborators as well as identifying existing hotspots and potential research areas.

Keywords: Public Service; Integrated Governance; One Data Service; HomPIMPA; Health Service.

1 Introduction

COVID-19 is a new acute respiratory infectious disease induced by a new coronavirus (SARS-CoV-2) that spreads rapidly, has a wide range, and is very infectious. It has spread around the world and negatively impacted social and economic growth in big ways. It is thought that older people who get COVID-19 are at greater risk to get a deadly condition [1][2][3]. Cardiovascular disease is among one of the least prevalent types of chronic diseases in worldwide. Research show that people with cardiovascular

M. Setiyo et al. (eds.), *Proceedings of the 4th Borobudur International Symposium on Science and Technology 2022 (BIS-STE 2022)*, Advances in Engineering Research 225,
https://doi.org/10.2991/978-94-6463-284-2_80

disease are more likely to get serious health conditions and death than people without cardiovascular disease [4][5]. Covid-19 patients with recently diagnosed cardiovascular disease may have worse outcomes than those with history of cardiovascular disease [6]. It is important to give greater consideration to these infected patients with cardiovascular disease due to the worldwide incidence of cardiovascular disease among older adults. Global efforts are being made by researchers to stop and manage the COVID-19 epidemic as quickly as feasible. More research is being done on COVID-19 and cardiovascular disease. Scientists, however, lack a worldwide, thorough analysis to easily understand the viewpoint and identify associated research trends.

Bibliometric analysis is a statistical evaluation of publication that can both subjectively and quantitatively forecast future trends and reflect the status of the research at the time in question [7]. The technique is presently utilised on a large scale in the study of hot spots for a variety of diseases, and it serves as a resource for future studies on the prevention and management of diseases [8][9]. To address this, we used bibliometric techniques to perform an in-depth analysis of COVID-19 and cardiovascular disease studies, summarised existing literature, and identified potential areas of focus for future study utilising visualisation tools. This study aims to be used as a reference for future, additional studies on COVID-19 and cardiovascular disease by exposing study hotspots and trends.

2 Method

2.1 Data

Scopus was utilised to find documents regarding COVID-19 and cardiovascular disease published worldwide in all languages between January 1, 2020, and December 12, 2022. Scopus was commonly regarded as the main resource of bibliometric analysis out all over multiple disciplines [10][11][12][13]. The retrieval search phrase was "TITLE (("COVID-19 *" OR "SARS-CoV-2") AND ("cardiovascular*"))". The bibliometric analysis generated 1,131 articles. The file formats were downloaded as CSV files containing complete records and references, such as the titles, authors, abstracts, and key terms (Table 1).

Table 1. Document Types in the Collection.

DOCUMENT TYPES	number	%
Article	657	50.04
Book Chapter	5	0.38
Conference Paper	6	0.46
Editorial	79	6.02
Erratum	19	1.45
Letter	129	9.82
Note	58	4.42
Review	348	26.50
Short Survey	12	0.91
Total	1.313	

Articles are the most prevalent type of written document. Only a few of the 1,131 documents are book chapters, conference papers, or brief surveys. 7.31 is the average number of authors per document. The data set was subsequently utilised for bibliometric analysis.

2.2 Analytical Tools

The following software was used to analyse and visualize the data: (i) R Studio 4.4.1, (ii) VOS viewer (Version 1.6.17), The R studio package "Bibliometric" [14] was used. The tool entitled Bibliometric is used to do analyses on bibliographic data. Both descriptive and network analysis are supported by this software. VOS viewer [15] is a different open resource application that relies on the VOS technique utilised to illustrate bibliographic networks and knowledge maps.

The files including these 1,131 publications on COVID-19 and cardiovascular diseases were imported into the VOS viewer (version 1.6.15) and R Studio application for bibliometric analysis, which included country/organization co-authorship, source/document citation, and keyword co-occurrence analysis. The overlay/network visualization map was created step by step using both VOS viewer's and R Studio's configuration settings.

2.3 Country/organization co-authorship analysis

Co-authorship analysis refers to the collaboration of multiple analytical targets (countries/regions, organisations) to publish any number of publications. Typically, the total link strength is utilised to quantify the relationship among each resource. As the total link strength rises, the correlation rises. In the present research, VOS viewer analysed country/organization co-authorship for the unit of countries/organizations. The map's nodes identified the country/organization components, and the larger the nodes, the greater the total number of documents. The various colours of the nodes represented the average citations of the documents. The thickness and distance of nodes of the connection curve lines represented the closeness and intensity of their authorship link, respectively.

2.4 Sources/documents citation analysis

Citation analysis (source, document) describes to the citation of many areas analysis objects. The larger the number of citations, the stronger their influence. VOS viewer performed resource and document citation in the respective citation analysis units of sources and documents. The overall number of documents/citations was used to determine the size of each node on the network visualisation map of sources/documents citation analysis. Various network colours indicated unique cluster classifications. The distance between nodes reflected their degree of relationship.

2.5 Keywords co-occurrence analysis

Co-occurrence analysis is a quantitative evaluation of the appropriate keywords that can use graphs to show important things like keyword frequency and the law of development and evolution. This helps researchers figure out the research state and development patterns of areas that are related [15]. We utilized "coronavirus disease 2019, coronavirus 2019, COVID 2019, COVID-19, nCoV-2019, nCoV2019, nCoV 2019" in this analysis.

The data from the CSV file was then imported to VOSviewer in order to conduct a co-occurrence analysis on all unit keywords. The size of every node from the map was determined by the frequency with which each keyword appeared. The close distance between nodes reflected their degree of relationship. In the network visualization map, various node colours indicated differentiated cluster types, whereas in the overlay visualization map, node colours indicated the average publication year of the keyword appearances.

2.6 Author's Co-Citation Analysis

Co-citation analysis has become one of the most widespread methods utilized for bibliometric analysis. While two publications are cited in the similar article, they are co-cited. If two documents are frequently cited together by other articles or documents, it is likely that they contain a similar theme [16].

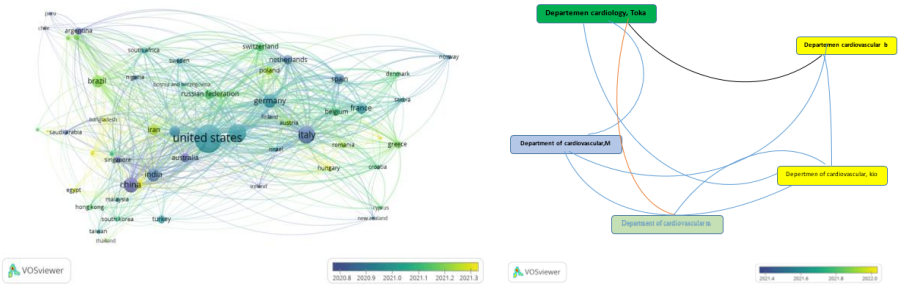
3 Result and Discussion

3.1 Country/organization co-authorship analysis

The authors of the 1,131 publications on COVID-19 and cardiovascular disease originated from 151 distinct nations. With the minimal number of documents set to 5 and the minimal number of citations set to 0, 57 countries (37.75%) met the minimum requirements.

VOSviewer provided an overlay visualization map of country co-authorship analysis, containing collaboration between countries, overall citations for each of them, and the average year the articles were published. Figure 1A depicted every level of close cooperation between these 57 nations. The United States possessed the largest amount of accumulate citations and documents. Moreover, fifty percent of the top 20 citation countries were from Europe (Table 1). In regards to citations and documents, the United Kingdom ranked first among these European nations, as indicated by the map.

Then, we conducted an organization co-authorship study on 5,371 organizations. When the minimal number of necessary documents for an organization was set at 5, all five organizations surpassed the requirement (Fig 1).



A B

Fig. 1. country/organization co-authorship. The overlay visualization map of nation (A)/and (B) co-authorship analysis showed country/organization parts as bigger nodes, indicating more documents. In relation to the color bar in the lower right corner, the nodes' colors represented the journals' average citations. The thickness and distance of linking curve line nodes indicated their interrelationship and authorship strength.

All seven listed institutions were from the United States and Japan, which includes the University of Maryland, which had the most citations, and Saga University, which had the most documents, based on the findings of the research. One organization alone received over one hundred citations (Table 2).

Table 2. Top 10 countries, institutions, authors with the most publications

No	Subject	documents	citations	total link strength
Country				
1	United States	380	12131	470
2	UK	166	3402	404
3	Italy	147	6072	294
4	China	113	9265	171
5	Germany	91	2960	263
6	India	81	961	170
7	Brazil	74	786	134
8	Canada	61	1496	175
9	France	58	1349	154
10	Spain	52	884	130
Institution				
1	Saga University	9	35	20
2	Cleveland Clinic	7	40	15
3	University of Maryland	5	103	0
4	Tokai University	5	15	17
5	Harvard Medical School	5	6	0
6	Keio University	5	5	17
7	Juntendo University	5	5	17
Authors				
1	jr.	11	393	3

No	Subject	documents	citations	total link strength
2	gupta a.	10	82	4
3	kohsaka s.	10	49	71
4	node k.	10	35	73
5	de lemos j.a.	9	219	8
6	wang x.	9	3615	2
7	kitai t.	8	32	71
8	kuroda s.	8	32	71
9	li y.	8	35	5
10	matsue y.	8	32	71

3.2 Analysis of authorship

During the COVID-19 pandemic, an overall of 7,074 authors made contributions to the retrieved articles on cardiovascular disease. The ten best-known authors contributed 91 papers, or 6.8% of total publications. (Table 1). The publication with the most citations was Cardiovascular Implications of Fatal Outcomes of Patients With Coronavirus Disease 2019 (COVID-19) by Guo T et al, published in the Jama Cardiology journal in 2020 (Table 3).

Table 3. 10 most-cited documents for COVID-19 and cardiovascular disease

No	Author/year	Total Citations	Journal
1	Guo T, 2020[17]	2324	Jama Cardiology
2	Zheng Y-Y, 2020[18]	1870	Nature Reviews Of Cardiology
3	Driggin E, 2020 [19]	1196	Journal Of The American College Of Cardiology
4	Li B, 2020[20]	1099	Clinical Research In Cardiology
5	Puntmann Vo, 2020[21]	1047	Jama Cardiology
6	Clerkin Kj, 2020, [22]	951	Circulationaha
7	Guzik Tj, 2020[23]	765	Cardiovascular Research
8	Mehra Mr, 2020[24]	704	The New England Journal of Medicine
9	Nishiga M, 2020[25]	625	Nature Reviews Of Cardiology
10	Liu Pp, 2020[26]	481	Circulationaha

3.3 Keywords co-occurrence analysis

By analysing keywords with a high frequency, we had the ability to show graphically clusters associated with COVID-19 and cardiovascular disease (Fig 2). In this research, a total of 6,293 keywords were identified, and 32 keywords that occurred more than 200 times were chosen (Table 4). The hotspot in the subject of COVID-19 and cardiovascular disease are illustrated by an overlay visualization map scaled by occurrences. The keyword cluster analysis revealed that these 32 keywords can be categorized into

four distinct categories. This research identified 32 top keywords, including cardiovascular disease, heart failure, hypertension, risk factor, and complication, among others.

Table 4. Top 32 keywords Analysis For COVID-19 And Cardiovascular

No	keyword	occur-rences	TLS	No	keyword	occur-rences	TLS
1	human	1146	34524	17	complication	272	9933
2	covid-19	991	28008	18	review	271	9516
	coronavirus	984	31971		coronavirus infec-	256	9555
3	disease 2019			19	tion		
	cardiovascu-	938	29223			255	9667
4	lar disease			20	myocarditis		
5	humans	859	27433	21	virus pneumonia	255	9622
	cardiovascu-	635	20945		coronavirus infec-	254	9523
6	lar diseases			22	tions		
7	pandemic	600	19057	23	mortality	251	9435
8	sars-cov-2	506	15167	24	pneumonia, viral	245	9272
		485	16477		major clinical	242	9421
9	article			25	study		
		454	15216		severe acute respir-	241	9117
					atory syndrome		
10	pandemics			26	coronavirus 2		
11	male	346	13025	27	comorbidity	238	9240
12	female	344	12854	28	hospitalization	225	8551
13	hypertension	309	12463	29	heart arrhythmia	224	9289
14	adult	298	11095	30	priority journal	218	8138
15	heart failure	297	11574	31	betacoronavirus	211	7735
16	risk factor	293	10738	32	aged	205	7830

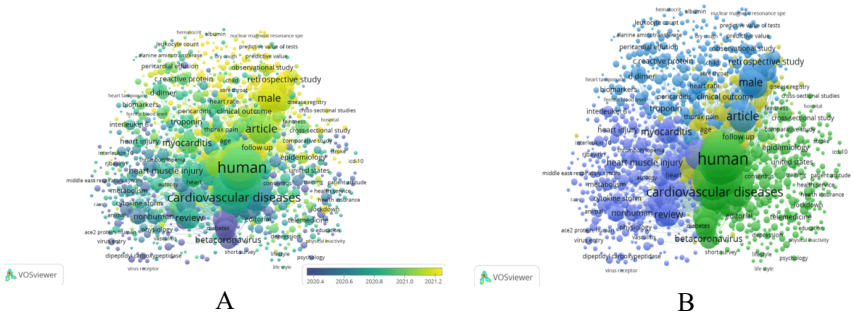


Fig. 2. Analysis of keyword co-occurrence. The size of each node in the map was decided by the number of occurrences of each keyword. The length between nodes indicated how closely they were related. (A) The colours of the nodes in the overlay visualization map of keyword co-occurrence analysis indicated the average year of the keyword occurrences. (B) Distinct colours of nodes in the network visualization map of keywords co-occurrence analysis assumed various clusters split by keywords co-occurrence.

3.4 Discussion

Over eighty-five percent of the publications in the current study consist of articles, reviews, letters, and other forms of research that produced substantial advancements in this field. The result is comparable to the research that was conducted by Milad Haghani [27].

On the other hand, pandemic isolation could restrict the collecting of article data. According to the results of earlier research, however, news, editorials, reviews, and letters were among the most common types of content on Twitter and other social networking networks [28].

There were 151 countries represented among the 1131 research publications that were provided. According to the findings of this study, a number of countries, including the United States, the United Kingdom, Italy, Germany, and China, play important roles in the studies about the COVID-19 epidemic of cardiovascular disease. Around sixty percent of the publications came from these five nations, with the United States and China accounting for more than half of the overall citations.

After January 2021, Europe and North America will account for 16% of the total population of the world but will be responsible for 64% of the daily new cases of the disease. In contrast, although Asia is home to 58% of the world's population, it is responsible for only 11% of the confirmed new cases of the disease a day. Findings are noticeably better in Asian countries [29]. In contradiction to the fact that the United States of America, the United Kingdom, and many other nations of other European countries are usually among the leading countries in scientific study [30]. It is important to point out to to the attention the fact that the United States of America, the United Kingdom, Italy, India, and Spain are also among the top countries in regard to the overall number of confirmed cases at this time [31]. This trend indicates that the number of publications released at the time COVID-19 is proportional to the seriousness of the situation with the pandemic.

According to the findings of organizations, colleges and universities are the predominant key pillars of scientific research. There are noticeable geographical features in the cooperation between organizations.

With 2324 and 1870 citations, respectively, the most-cited journals were Jama Cardiology and Nature Reviews of Cardiology. During the COVID-19 pandemic, each of the above- mentioned journals helped to make cardiovascular-related studies more suitable and promoted the dissemination of information regarding scientific studies. Due to the fact that journals have to deal with the dual challenge of balancing timeliness and scientific methodology, it is essential that information be disseminated in a precise and trustworthy method. For instance, in a paper titled Cardiovascular Implications of Fatal Outcomes of Patients With Coronavirus Disease During the COVID-19 Pandemic, Jama cardiology overturned one of the major comorbidity and mortality issues regarding cardiovascular and COVID-19 [17].

COVID-19 is a new virus that is causing a lot of infections and deaths. Based on the results of the study, many COVID-19 people had heart problems [32][33]. People with heart disease were a greater probability of need to be hospitalized and death than people

without heart disease [34][4]. Another studies indicate that COVID-19 may cause both acute and chronic cardiovascular disease [35][6][36].

The correlation between COVID-19 and cardiovascular disease is significant and complicated in the context of causality. Even though relevant research is continuous there is no comprehensive analysis of Current and future studies areas. We identified the current condition and patterns of COVID-19 worldwide and cardiovascular disease research using bibliometric analysis. The findings indicated that the United States, the United Kingdom, Italy, China, and Germany were publication and citation hotspots in this field. University of Maryland had the most citations, while Saga University had the most documents. The article by Guo T et al. entitled "Cardiovascular Implications of Fatal Outcomes of Patients with Coronavirus Disease 2019 (COVID-19)" (Jama Cardiology) was the most credible and cited.

The co-occurrence of keywords in a field of study can disclose research topics and hotspots[37].The specific top 16 mentioned keywords were cardiovascular disease, hypertension, male, female (gender), adult (age, risk factors as well as heart failure. The relationship between hypertension and cardiovascular disease, as well as fatal and life-threatening COVID-19, has been described in several countries.[38] According to an Iranian study, the percentage of patients with COVID-19 infection was highest with hypertension, Diabetes Mellitus, and Cardiovascular Disease [39] In a Chinese study, COVID-19- associated anxiety was correlated to a temporary elevate in morning Systolic Blood Pressure between many older patients, instead of improvements risk of cardiovascular events[40]. The effect of COVID-19 on blood pressure control and cardiovascular risk profile requires accurate clinical assessment due to the implications of a possible impact on many aspects [41].

Many studies suggest gender associated with cardiovascular disease. Lengthy COVID complications, including depression, decreased regular activity, and poor lifestyle choices, which may raise Cardiovascular risk, tend to be worse for women than for men [42]. Mortality in patients with ischemic stroke are significantly higher in men compared to women with COVID-19 [43]. Recent study with a history of taking ACEi and ARB therapies for cardiovascular disease indicates that females over the age of 65 were protective toward in-hospital mortality among COVID-19 patients [44]. Compared the incidence of cardiovascular disease among both genders in COVID-19 patients, women had a higher prevalence than men [45]. According to the findings of a study conducted on COVID-19 patients who experienced from cardiovascular disease, men had a greater rate of in-hospital mortality than women, especially among elderly patients [46].

Patients who are obese, particularly those who are younger than 50 years old, are considerably more likely to be hospitalized with COVID-19, and they are at a higher risk of death while they are in the in-hospital or requiring mechanical ventilation [47]. Patients with COVID-19 and heart failure disease who were elderly, had a 8% more likely of death [4].

Correlations Risk factors of cardiovascular disease with severity, complication and mortality in COVID-19 patients describe in many researches. Patients' elevated cardiovascular risk was closely correlated with how severe COVID-19 was [48]. Newly developing cardiovascular complications linked to long COVID-19, including postural

tachycardia syndrome (POTS)[49]. In hospitalized COVID-19 patients, cardiovascular events were frequent and linked to worse outcomes[50].

4 Conclusion

Bibliometric analysis was utilized in this research to map out the research themes related to COVID-19 and cardiovascular disease on globally. Additionally, co-authorship analysis was conducted to found the countries and organizations involved in the research, while source/document citation analysis and keyword co-occurrence analysis were utilized to further explore the research landscape. Subsequent to the outcomes of these investigations, we proceeded to examine the areas of focused study effort in the domains of COVID-19 and cardiovascular disease.

Further research into the correlation between COVID-19 and cardiovascular disease will provide patients with an alternative viewpoint on how to diagnose and treat their conditions. In conclusion, we believe that the findings of our study have the potential to provide researchers with a substantial new viewpoint on the current situation and fields of research related to COVID-19 and cardiovascular disease, which may in the future result in significant breakthroughs in science.

Acknowledgement. This research is funded by LPPM Universitas Muhammadiyah Gombong.

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