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Mapping Research Trends of Blockchain Technology in Healthcare

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ABSTRACT Disruptive technology, blockchain is propelling a technological intervention in healthcare due to its unique features and advantages. The healthcare industry is migrating to Health 4.0. Therefore, peer-to-peer (P2P) transactions in a decentralized and distributed manner makes blockchain more lucrative to serve the needs of the healthcare industry of today. The revolutionary system, blockchain has been discussed in the field of healthcare over the past five years. Hence, a systematic investigation of the existing body of knowledge concerning blockchain research in healthcare is essential. The motivation of this study is to support further studies based on the current research trend analysis via graphical visualization and bibliographic material analysis. Therefore, this study maps the expansion of scientific and academic research conducted concerning blockchain that is relevant to healthcare by utilizing a bibliometric analytic method to understand the state of the art. Bibliometric statistics were utilized to analyze current scientific articles published in the Scopus database from 2016 to 2019. In addition, an overview of the publication trends over the first three months of 2020 was undertaken to understand the research trend for the current year so far. The study serves the purpose of mapping research development trends in healthcare. The outcome discovered some beneficial insights such as the yearly trend of publications, top listed authors, institutes, countries, and publishers from around the world. Moreover, this article assists scholars in developing a theoretical framework to provide a primary source of reference for further studies regarding blockchain technology in the healthcare domain.

INDEX TERMS Blockchain, bibliometric analysis, health 4.0, healthcare, scopus database.

I. INTRODUCTION

Satoshi Nakamoto introduced blockchain as ''A Peer-to-Peer Electronic Cash System'' a decade ago in the financial sector as a cryptocurrency termed as bitcoin. Since then, the decentralized sharing mechanism of blockchain has attracted the attention of researchers [1]. Blockchain has gone through three stages of evolution known as Blockchain 1.0, 2.0, and 3.0. Blockchain 1.0 and 2.0 focused on finance (bitcoin, cryptocurrency) and transaction (register, confirmation, and contracts or property transfer) respectively. However, other than finance and goods transactions, the evolution of blockchain 3.0 also includes applications for education, government, science, and healthcare [2]. The revolution of blockchain 3.0 has conveyed hope for the healthcare industry [2], [3]. Therefore, health researchers have started looking forward to fully embark on discovering the advantages of blockchain technology (BcT) to combat existing issues in the healthcare industry.

The healthcare industry has started to shift from a conventional infrastructure to a health information technology (HIT) based infrastructure since the early 90s [4]. This push has continued to evolve as the world enters the era of the Industrial Revolution 4.0 (IR 4.0). The Health 4.0 concept is derived from IR 4.0. Health 4.0 aims to deliver patient-centric care through establishing trust among the stakeholders, facilitating

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improved data management, developing a sharing mechanism, and safeguarding trust and security issues [5]. This unique setting with various stakeholders such as doctors, nurses, researchers, patients, insurance providers, and suppliers makes the health care delivery process more complex [6]. The combination and unified communication among multiple stakeholders generate this complexity. Consequently, stakeholders of the healthcare industry end up carrying a double burden of conventional and non-conventional problems regarding the delivery of convenient patient-centric care services.

Conventional issues have increased due to the number of patients measured against constrained resources, the changing nature of diseases, and the high number of elderly patients. Unconventional issues on the other hand involved data management of patients including increased data fragmentation, data storage and sharing as well as maintenance of the privacy of medical data for patient-centric care delivery [7].

Blockchain as a decentralized distributed ledger technology has numerous advantages over the traditional internet-based system of the early 90s. Blockchain establishes a collective, encoded archive that is impossible to amend which holds a time-series in data, thus, ensuring transparency and irreversibility [8], [9]. Moreover, BcT makes the decision-making process seamless through allowing concurrent assessment by each stakeholder involved, which accordingly increases trust [8]. These features of BcT are believed to have the capability of solving current issues facing the healthcare industry [10]. Therefore, research trend analysis of BcT in healthcare is needed to understand the state of the art [6]. A minimal number of studies have recognized the systematic development of scholarly publications or historical assessments [11]. To the best knowledge of the authors, the only bibliometric study of BcT in healthcare was undertaken by Chukwu, E., & Garg, L. [6]. Presently, the literature showed that all chronological and growth patterns of an article in this field are available mostly in a narrative form [11]. The literature provides theoretical analysis without any statistical evaluation of the research trends. [11], [12].

Moreover, literature reviews are subjected to bias in terms of description and the expansion trend of a specific research area [11]. This gap motivates the current authors to proceed with further analysis by applying a bibliometric analytic approach to determine the existing literature gap and highlight other existing gaps. Thus, the current study employed a bibliometric analytic approach to fill this gap. Specifically, the motivation to peruse a bibliometric study on BcT in healthcare is to distinguish quantitative variances among its alternates and to specify a universal perspective of the state, scope, and effect of available research. The goal is also to propagate across the academic community with an empirical approach capable of complementing and extending research programs [13]. A bibliometric study will direct scholars in mapping research trends in a specific area of interest [14], [15]. Hence, this study illustrates an outline of the latest development in the body of knowledge of BcT in the healthcare domain. It also intends to highlight prominent institutions and authors including their affiliation as well as countries that are actively involved in BcT-based HIT research. Although a hybrid methodology of bibliometric analysis may also have been pursued, it is primarily held as bibliometric [14]. To this end, the study provides a bibliometric overview of the work results to date, presenting a graphical illustration of the bibliographic material extracted from the VOSviewer software [14]. Furthermore, this study highlights a few research gaps based on the analytic findings and suggests further research directions that can be insightful for future research.

II. METHOD

Bibliometric analysis is a study relating to the field of library and information sciences which investigates bibliographic content by employing quantitative techniques [12]. In 1969, Alan Pritchard initiated the concept of bibliometric analysis. In fact, this method of analysis in a certain field of study has existed since the 19th century [14]. Years back, researchers accomplished the data collection process manually for bibliometric analysis [13]. The advancement of information and communication technology has expedited and facilitated the growth of bibliometric analysis studies through faster access to scholarly materials in certain fields of interest to the researchers [13], [14].

A bibliometric investigation study is a systematic approach to determine research trends in a specific area of interest based on scholarly articles published in scientific databases [3], [11], [12], [14]. The analysis involves several methodologies to visualize the qualitative and quantitative changes in a specific field of research [3], [13]. Bibliometric analysis is a potential method that drafts previous studies, considers the development of the studies, and at the same time, supports the progression of prospective lines of study through its indicators [13], [14]. This analytic approach assists researchers to evaluate and critique the status of the scientific research in a subject area. The objective of bibliometric analysis is to identify the progress and the challenges of a current phenomenon of interest through an understanding of the characteristics of scientific publications [13], [14]. The above characteristics have encouraged the use of bibliometric techniques in various disciplines. Numerous business and management fields of research have been predominantly studied from this perspective such as economics, econometrics, innovation [12], sustainable transportation, city logistics, waste management [13], management, social entrepreneurship, international entrepreneurship, business incubator [13] corporate social responsibility, international scientific cooperation, knowledge management, education, and medicine [13], [14]. In addition, some publishers have recently accepted this approach to provide an outline of their publications. For example, the Journal of Business Research, the European Journal of Marketing, the International Journal of Physical

Distribution and Logistics Management, the International Journal of Uncertainty, Fuzziness and Knowledge Based Systems, or Information Sciences all use this method to analyze the characteristics of scholarly publications [13].

Nevertheless, the investigation of a specific research interest is not the sole aim of bibliometric analysis. This study uses the technique to investigate the consequences of a systematic method to recognize the interactions between the cause and effect of publication trends in BcT in healthcare [14].

A. DATA SOURCING STRATEGY

Elsevier declared Scopus as the main scientific database of multidisciplinary research literature and computational methods. According to the Scopus website, the archive includes more than 69 million publications and comprises 34, 346 peer-reviewed papers assessed and approved by the Content Selection and Advisory Board (CSAB) for acceptance or rejection in [3]. Data mining took place between March 31 and April 1 2020. The area of interest of the researchers was blockchain applications in healthcare. Therefore, the search central theme was (''Blockchain'' AND healthcare). The data search included two sections. In Section A, the search query string was: TITLE-ABS-KEY (''Blockchain'' AND healthcare) AND (EXCLUDE (PUBYEAR, 2020)) AND (LIMIT-TO (DOCTYPE, ''ar'')) AND (LIMIT-TO (LANGUAGE, ''English'')).

The oldest article found was from 2016 and the latest articles were from 2019. Articles published during the current year were excluded since 2020 has yet to be completed. This search resulted in a total of 127 documents. Reviews and a few other papers were excluded after evaluating the abstract, keywords, and full-text due to the terms mentioned such as editorial, highlights, interview, and systematic review. Some 38 documents were potentially found to be irrelevant to this study. To optimize the search outcomes, unpublished reports, working papers, and duplicates that could have more than a single combination of keywords were omitted in this phase [3]. Electronic Identification (EID) is a unique digital identifier used by Scopus. Therefore, 89 articles were retained for further analysis. The EIDs of the selected 38 articles were listed and inserted in the search string of Scopus to ensure exclusion of those documents from the CSV file as shown in Figure 1. For Section B, the data was collected from Scopus with same search string, but the search was limited to only 2020 to view the number of publications from January to March 2020.

B. BIBLIOMETRIC MAPS

The VOSviewer is a bibliometric analysis tool. This software was developed by the Centre for Science and Technology Studies, Leiden University, The Netherlands. Items such as author keywords and countries were used to create a map in VOSviewer for this study. This software collects bibliographic data and provides graphical maps in terms of bibliographic coupling, co-citations, co-authorship, and author keyword co-occurrences [12]. Therefore, the citation

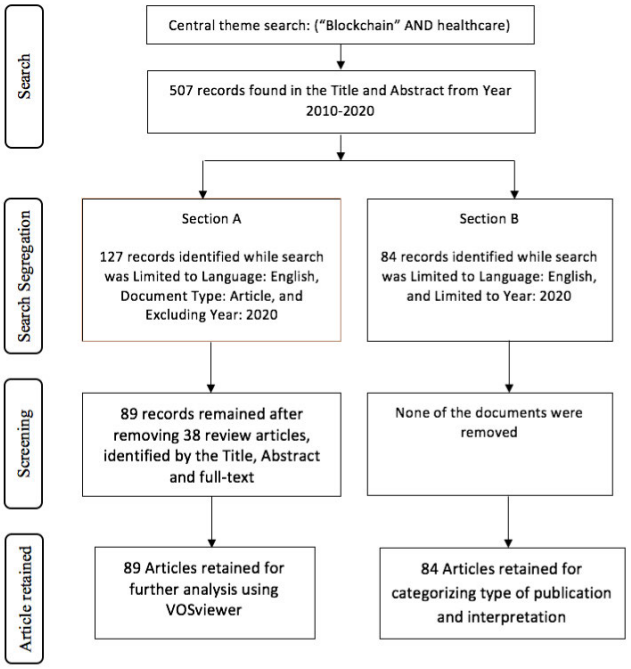

FIGURE 1. PRISMA flow diagram of data collection based on central search theme.

details, author keywords, and bibliographical data were extracted from the Scopus database for the creation and visualization of the bibliometric maps. Information of the 89 Articles in the CSV file format was transferred to the ''VOSviewer'' Software version 1.6.14. The items are also known as an object of interest. Any two items may be interlinked, which have a strength (a curved line represents an interlink in the VOSviewer). A positive arithmetic value denotes the strength of the link. A high value indicates a high link strength. Co-authorship refers to the number of journals published by two countries with affiliations and co-authors. Link strength designates the overall strength between the two countries. Link strength in co-occurrence analysis means the number of journals in which two keywords appear together [16].

C. ANALYSIS OF CO-AUTHORSHIP

Co-authorship measures the most efficient set of documents and those with a maximum degree of mutual publications [12]. In co-authorship analysis, a bibliometric network reflects the links among scholars, research organizations, and countries grounded on the quantity of journals they have authored conjointly. The bibliometric map of co-authorship from the VOSviewer using author names showed three clusters, as indicated in Figure 2. ''A cluster is a set of closely related nodes. Each node in a network is assigned to exactly one cluster. The number of clusters is determined by a resolution parameter'' [17]. An example of the interpretation of Figure 2 is that author Ouyang I. (as mentioned in the overly visualization view of the VOSviewer) belonging to cluster 1 has 9 links, 12 strengths, and 2 documents with

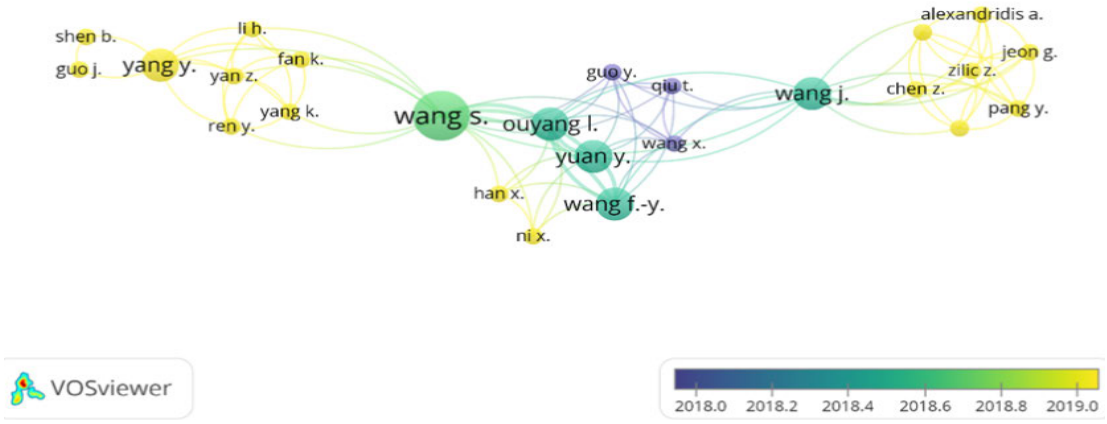

FIGURE 2. Bibliometric map of co-authorship from VOSviewer using author names.

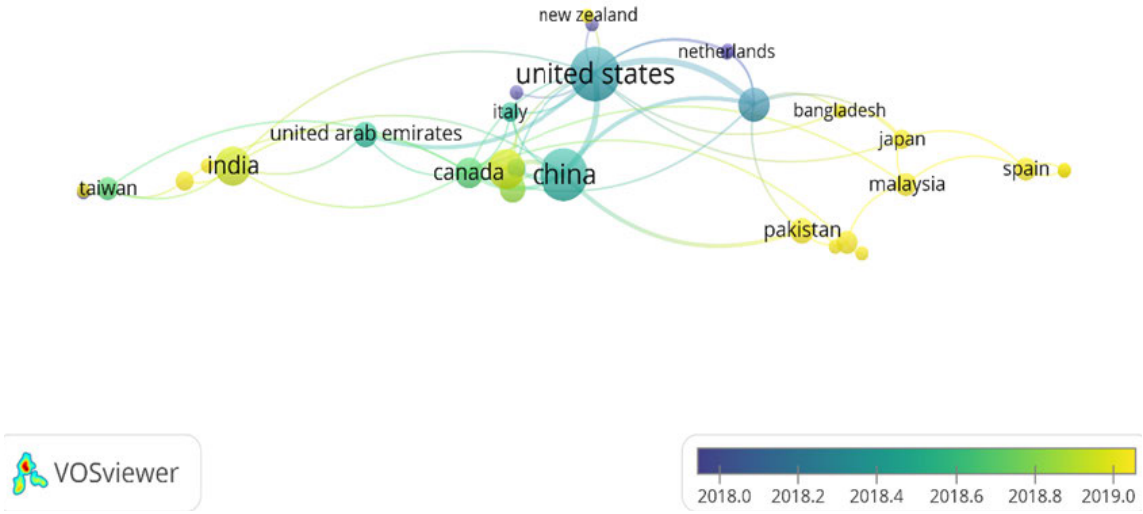

FIGURE 3. Bibliometric map of co-authorship from VOSviewer using country.

an average year of publication of 2018.50 (mid of 2018). Similarly, author Wang S., from cluster 1 has 15 links, 18 strengths, and 3 documents with an average year of publication of 2018.67 [18]. Again, the link strength between the authors is 2.

Figure 3 illustrates that 30 out of 52 countries have 62 links with a total link strength of 73. Therefore, in terms of co-authorship analysis, this study included 30 countries with affiliation. The link strength between the United States and the United Kingdom is 3. In the case of Malaysia and Japan, the link strength is 1. The higher the link value, the higher the link strength.

2) ANALYSIS OF CO-OCCURRENCE OF AUTHOR KEYWORDS

Co-occurrence of author keywords analyzes keywords that appear in articles more often, typically below the introduction, and keywords that exist in the same documents [12]. This study analyzed 294 author keywords from 89 articles. It is noteworthy to mention that this study considered author keywords, not index keywords. The VOSviewer recorded 294 author keywords, while the minimum number of co-occurrences of a keyword was set to 5, only 8 keywords (3%) met the threshold of the 294 keywords. Additionally, with the minimum number of co-occurrence of a keyword set to 4 and 3, 16 (5%) and 29 (9%) of the keywords met the threshold, respectively. Figure 4 illustrates the overlay visualization mode of author keywords where the least number of occurrences was set to two, which met the threshold of the 51 keywords.

A few keywords represented the same thing. For example, EHR or ehr is the short form of Electronic Health Record. Again, IOT refers to the Internet of Things. Therefore, during analysis, the researchers removed a few keywords with the same meaning. Other than blockchain (65 times), the 10 most frequently used author keywords were: healthcare (12 times), smart contacts (10 times), internet of things (9 times), security (9 times), decentralization (7 times), privacy (7 times), and e-health (4 times).

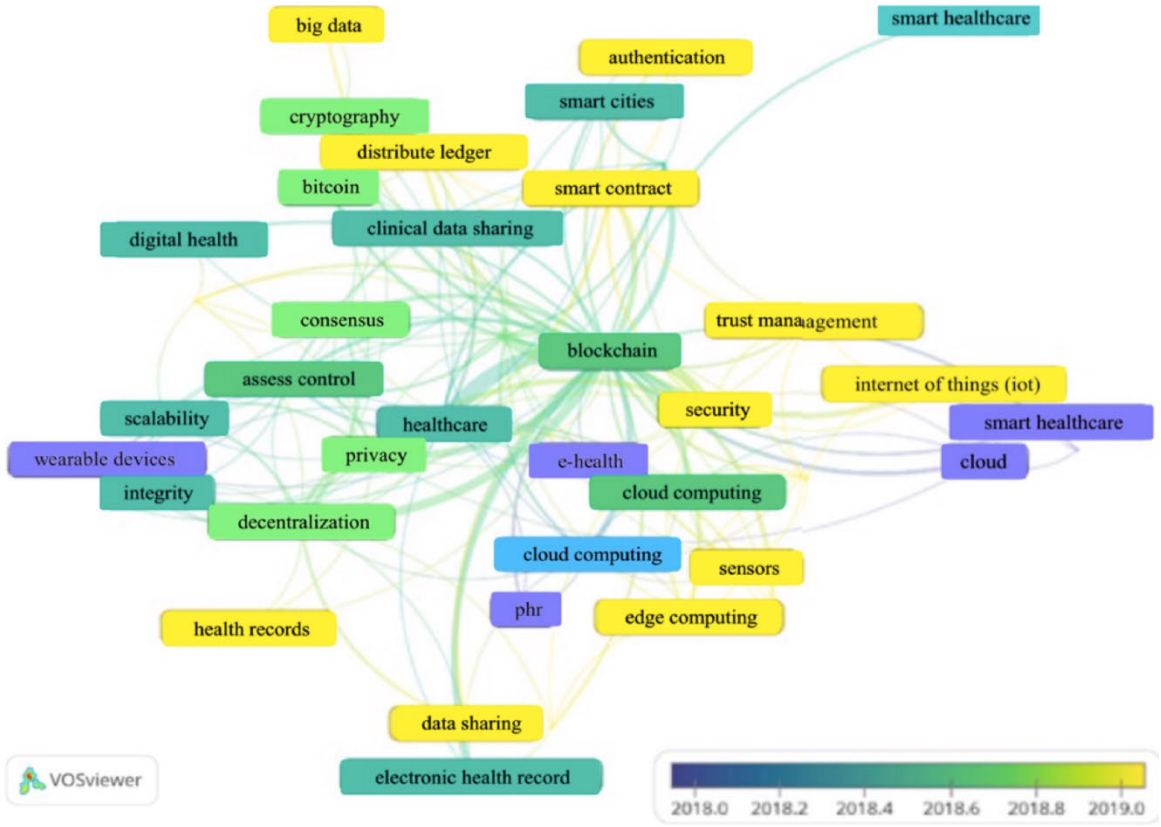

FIGURE 4. Bibliometric map of author keywords from VOSviewer.

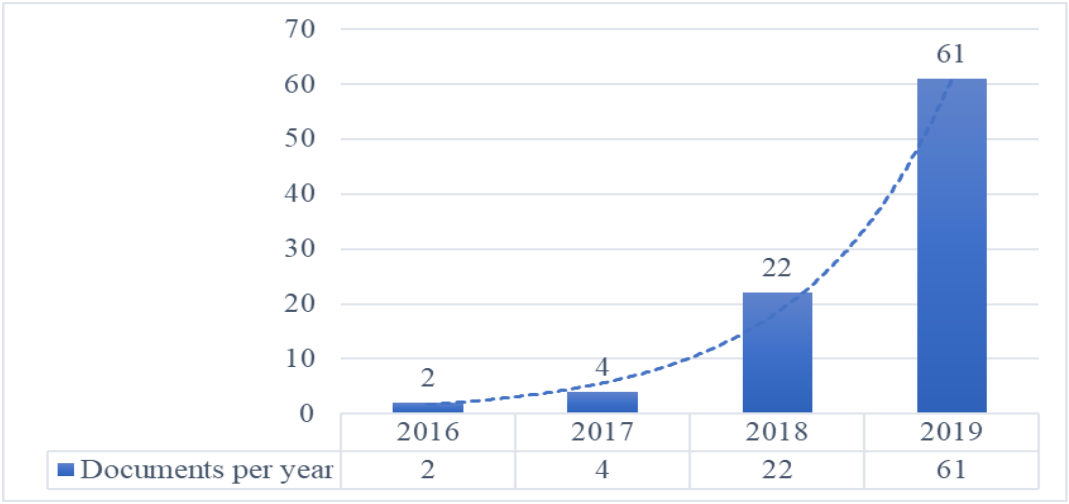

FIGURE 5. Research articles published on Scopus from 2016 to 2019.

According to [19], "keyword analysis of publications provides an effective way not only to investigate the knowledge structure of research domains, but also to explore the developing trends within domains". The findings from the author keyword analysis concluded that privacy, security, and decentralization are a significant part of the study of blockchain in healthcare. Moreover, diverse literature reflects different subtopics of blockchain technology and offers room for further research in this field.

III. FINDINGS AND ANALYSIS

A. DATA SOURCING STRATEGY

Figure 5 presents the number of scholarly articles concerning BcT in healthcare that have been published per year on

TABLE 1. The top 5 journals and publishers and the number of publications published from 2016 to 2019.

No	Source title	Publisher	Number of publications	CiteScore (2018)
1	IEEE Access	IEEE	13	4.96
2	Journal of Medical Systems	Springer Nature	5	3.31
3	Applied Sciences Switzerland	Multidisciplinary Digital Publishing Institute (MDPI)	4	2.52
4	Electronics Switzerland	Multidisciplinary Digital Publishing Institute (MDPI)	4	2.49
5	Future Generation Computer Systems	Elsevier	4	6.3

Scopus from 2016 to 2019. The Blockchain concept was first introduced in 2008 [16], [18]. Researchers have started exploring the potential of BcT beyond the financial sector since 2010. Consequently, the application of BcT for data management has evolved from the field of finance to other fields [19]. Research articles (Qualitative, Quantitative, and case study) on the Scopus database specific to BcT in the healthcare domain can be found from 2016. The number of publications in 2016 and 2017 was negligible. However, the number swiftly increased from 2018 onwards. This increase in the trend of BcT research indicates that this technology is going to remain relevant in the future. BcT is still at the infancy level. Therefore, it has research gaps that need to be addressed and studied specifically in the healthcare domain since technology is emerging in Health 4.0.

The analysis showed that most of the articles applied a qualitative approach and focused on architecture or model development. The findings of this current study highlighted two major gaps: quantitative study was lacking and acceptance or readiness with respect to this disruptive technology has yet to be addressed.

Several BcT-based architecture formats should utilize the unique advantages of the technology. Blockchain-based medical data sharing projects such as GuardTime, MedRec, Carechain, MedicalChain, and Dovetail have already been tested using prototypes [10]. It can be concluded that qualitative studies are progressing accordingly, and further studies can look for potential solutions to implement cost [22], scalability, and security issues of BcT [9] from the technical or technological perspective.

Most of the articles were qualitative and based on novel architecture development proposing models and prototypes. Healthcare researchers have developed several BcT-based architecture formats to utilize the unique advantages of the technology. At the same time, other than the technological or technical aspects, issues related to environmental support and human elements need to be dealt. End-users will ultimately utilize any novel system in the end. Therefore, the successful implementation and sustainability of HIT depends on the end-users. The novelty of a system needs to be accepted, understood, and appreciated by the end-users. The authors in [23] claimed that a conceptual approach to assess user acceptance of technology-based healthcare services would be insufficient. Technologies in the healthcare domain may be technically moving faster, but due to the gap between the technological features and the expectations of end-users, the expected outcome remains unachieved.

Consequently, the authors in [23] highlighted that the lack of willingness on the part of end-users to adopt technology as the main obstruction towards successful HIT implementation. The findings concerning user acceptance would be expected to be as generalized as possible. Therefore, quantitative research of BcT in the healthcare domain is necessary [23] to address the intention of end-users with respect to BcT adaptation [24].

B. JOURNALS AND PUBLISHERS

Healthcare journals that publish BcT-related papers can be identified through this analysis. Furthermore, it enables researchers to understand the motivation of each journal. Table 1 presents the 5 most prominent journal names that publish papers concerning BcT. The analysis demonstrated that IEEE Access was leading the list with 13 publications in this area. The Journal of Medical Systems published 5 articles since 2016. Applied Sciences Switzerland, Electronics Switzerland, and Future Generation Computer Systems each published 4 documents up to 2019.

C. LEADING INSTITUTIONS AND TERRITORIES

Figure 6 shows the top ten institutions affiliated with BcT in healthcare study. A total of 160 institutions were identified as having contributions in this field. Based on the number of publications, Figure 6 demonstrates that the University of Electronic Science and Technology of China published 4 articles followed by the Electronics and Telecommunications Research Institute, the Chinese Academy of Sciences,

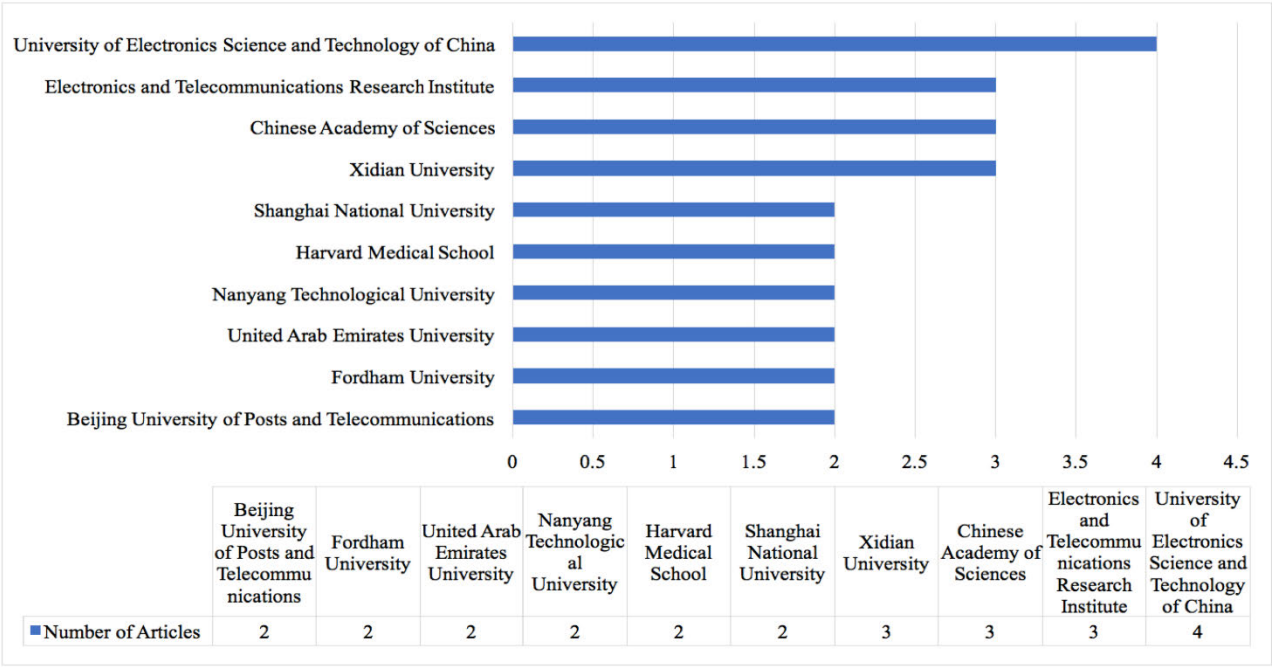

FIGURE 6. Number of publications by top 10 institutions around the world.

and Xidian University, each with 3 publications. The remaining 6 institutes each had 2 publications. The publication result calculation method differed from institution to institution. Therefore, the number of publications may differ between institutions.

Additionally, institutional and expenditure support may vary among universities. Consequently, several high impact journal publications were found to be affiliated with institutions that provide appropriate reward and human resource-related support. In other words, institutions with many high impact journal publications were nurturing research activities through providing comparatively better financial research assistance or reward mechanisms than the others.

Figure 7 represents the number of publications by the top 10 countries. The United States of America published 25 journals concerning BcT in healthcare since 2016. China ranked 2nd with 20 publications followed by South Korea, ranked 3rd with 12 published journals. The publication activity of other countries in this area is as follows: India (11 publications), United Kingdom (8 publications), Canada (6 publications), Australia (5 publications), and Pakistan and the United Arab Emirates each published 4 journals. Malaysia ranked 10th with 3 published journals. Most of the publications were from the United States and China since the majority of the Scimago Journal & Country Rank (SJR) journals originated from those two countries.

The United States, China, South Korea, the United Kingdom, Canada, Australia, and the United Arab Emirates are developed countries. India and Pakistan, being middle income developing countries were ranked 4th and 8th. On the other hand, considering the economic perspective, Malaysia may be a high-income developing country positioned before India and Pakistan. The country is striving towards Vision 2020 that aims to enter the ''Information Age'' which ends by this year. Since the 6th Malaysia plan, the government has been pushing technology to reform healthcare service delivery. The initiative includes the establishment of a Health Information System (HIS) for Health Information Exchange (HIE) since 1993 followed by a telehealth project originating in 1996 [25]. The current focus is to implement Electronic Medical Records (EMR) in all public hospitals (government-owned) in the country. Despite the Hospitals Information Technology (HIT) initiative, Malaysia was ranked 10th in this study for research activity in BcT in healthcare. In line with the country's Vision 2020, Malaysia should fast forward research activity in the HIT field. Malaysian institutes and researchers should collaborate with other countries and institutes that have been listed in this study for better research outcomes.

D. LEADING AUTHORS

Some 15 of the most prominent authors of BcT in the healthcare area were affiliated to 10 countries around the world. The affiliations were as follows: China (6 authors), South Korea and Australia (2 authors for each country), and Qatar, Australia, Pakistan, South Korea, United States, South Korea, Singapore, Canada (1 author for each country). The first journals of the authors were published from 1989 to 2019. Author Niyato, D. from Singapore, ranked number 1 according to this study with 502 publications since 2005, 66 *h*-index, and 17,855 citations. The 2nd and 3rd leading authors, Guo, R. and Ouyang, L., are affiliated with Edith Cowan University, Australia and the University of Chinese Academy of Sciences, China, respectively. Based on the

Rank	Country	Number of publication		Rank	Country	Number of publication
1	United States	25		6	Canada	6
2	China	20		7	Australia	5
3	South Korea	12		8	Pakistan	4
4	India	11		9	United Arab Emirates	4
5	United Kingdom	8		10	Malaysia	3

FIGURE 7. Number of publications by top 10 countries around the world.

information provided by the Scopus database, this analysis lists the top 15 Authors, as shown in Table 2.

E. BcT RESEARCH SUBJECT AREAS UNDER THE HEALTHCARE DOMAIN

This study only considered publications related to blockchain and healthcare. Figure 8 demonstrates the subject areas (in percentages) of this study under the healthcare domain. The highest number of publications of BcT were from the Engineering field such as computer science, engineering, material science, chemical engineering, physics, and astronomy, which occupied 70%. Publications from medical subject areas, including biochemistry, genetics, and molecular biology as well as medicine, encompassed 13%. Other subject areas covered 5% of the publications. The social sciences consisting of health professions, social science, and business management and accounting were mostly conducted as a quantitative study and only made up 12% of the total publications which analyzes user's acceptance factors. This analysis validated the findings from Section A that there is a la in quantitative study and the acceptance factors of an individual in terms of human element and environmental support.

F. RESEARCH TRENDS IN BcT FROM JANUARY TO MARCH 2020 IN THE HEALTHCARE DOMAIN

Section B of the data search retained data from January to March 2020. A total of 84 papers were published in the English language over this time span. The highest number of publications was research articles (32 publications). Other categories of publication included reviews and conference papers (13 publications in each category), followed by book chapters and conference reviews (10 publications in each category) as shown in Figure 9.

The study found 89 articles within a four-year time frame from 2016 to 2019 in Section A, while 32 articles were published within the first three months of 2020 (Section B). This comparison of the volume of publications proved that BcT is a hot topic of research in the healthcare domain.

G. LIMITATIONS OF THE STUDY

The study only considered ýthe Scopus database to map out the research trends in BcT for healthcare. Since the interest of the researchers was to only look for BcT research trends in the healthcare domain, BcT studies conducted in other areas such as banking and finance, agriculture, and computer science were disregarded. A confined search of ''Blockchain'' AND healthcare within titles and abstracts made the search so narrow that the result may have overlooked potential studies from other fields regarding BcT study. It is possible that some papers did not appear in the search result due to the use of different terms such as distributed ledger technology instead of Blockchain and EMR, HER, HIS, or ICT as an alternative for healthcare. During the data search, the authors limited

TABLE 2. List of top 15 authors.

No	Author	Scorpus author ID	Authors 1st Journal	Total publication	h-index	Total citations	Current affiliation	Country
1	Ahmed, M.	57206975377	2013	25	7	474	Edith Cowan University	Australia
2	Guizani, M.	7004750176	1989	784	52	13721	Qatar University, Department of Computer Science	Qatar
3	Guo, R.	57194510020	2013	21	6	129	Edith Cowan University	Australia
4	Hang, L.	57196461072	2018	12	5	59	Virtual University of Pakistan	Pakistan
5	Kim, D.H.	44361167000	2009	148	11	529	Jeju National University	South Korea
6	Kuo, T.T.	36483066900	2006	29	10	351	University of California	United States
7	Lee, S.Y.	57191039558	2019	14	1	2	Namseoul University	South Korea
8	Niyato, D.	8919714700	2005	502	66	17855	School of Computer Science and Engineering	Singapore
9	Ouyang, L.	57201860874	2018	8	4	68	University of Chinese Academy of Sciences	China
10	Shi, H.	55448205700	2012	17	6	121	Shaanxi Normal University	China
11	Wang, F.Y.	55615075400	1989	642	55	14180	Chinese Academy of Sciences	China
12	Wang, P.	56508546500	2006	286	42	8378	York University	Canada
13	Wang, S.	57188814458	2012	36	10	454	University of Chinese Academy of Sciences	China
14	Yuan, Y.	55041229900	2008	91	16	1172	Institute of Automation Chinese Academy of Sciences	China
15	Zheng, D.	7202567251	2004	107	14	793	Xi'an Institute of Posts and Telecommunications	China

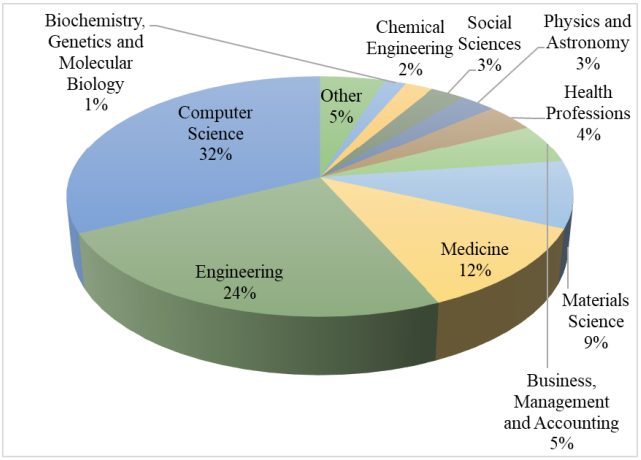

FIGURE 8. Diverse nature of BcT research subject areas under the healthcare domain.

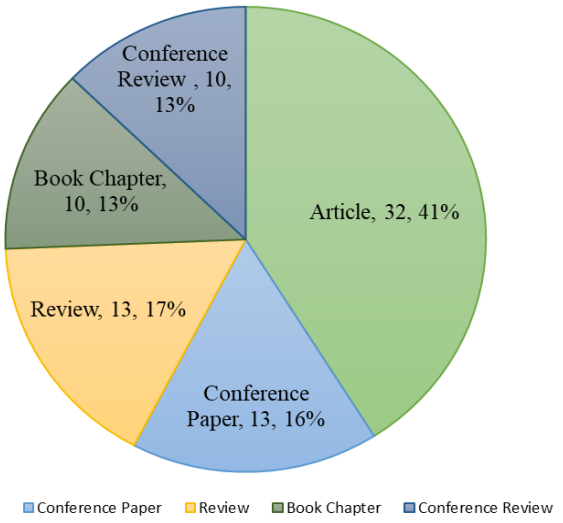

FIGURE 9. Documents published in Scopus from January to March 2020.

the papers to only select the ones that are written in the English language. For optimum global visibility and attention, research with significant results would have undoubtedly been sent to English-language journals – the logic behind such a choice. Moreover, only the first author of each paper was taken into consideration [26]. Thus, English language bias and first author bias can be considered as limitations. A fundamental limitation of this study is that it focused only on scholarly articles extracted from the Scopus database.

Co-occurrence analysis of author keywords revealed only 87% of 89 articles because of missing author keyword information provided by journals [16]. The researchers in [6] mentioned the potential of non-scholarly publications such as blockchain implementation at the ''Estonia national level,'' where the data was available only on the project website. Those researchers argued that scientific publication trend analysis overlooks such project reports, which may be considered a limitation of the analysis since non-scholarly yet, upcoming practical projects were not counted. It is noteworthy to mention that the outcomes of the bibliometric analysis are very vigorous and changes periodically with the entry of new articles in scholarly databases [12]. Consequently, future studies are very much appreciated after a while due to the nature of the analysis method. Furthermore, future studies may consider a comparison of the results from different scholarly databases such as Web of Sciences and Scopus. It is recommended to redesign the search strategy for an in-depth insight into the research trends in this field. Due to the nature of the database itself, the outcome may be different. Therefore, the data search strategy can be redefined by utilizing the multi-method approach of the search strategy for a more comprehensive study.

IV. CONCLUSION

The study investigated the growth of scientific and academic publications of BcT in healthcare based on the articles published in Scopus. Analysis of the author's keyword co-occurrence was conducted using the analytic tool, VOSviewer. Moreover, the study illustrated an overview of research development that demonstrates to what extent BcT has been propelling publication trends in the healthcare domain since 2016. The rapid growth of scholarly studies can be anticipated to increase. The study has identified a few countries and institutions that are actively involved in research in this field. Authors or institutions from other countries can extend their collaborative links with their colleagues in various institutes that are active in this field. Due to the characteristics and potential of BcT, it can become a hot topic for future research. Constant exertion to search is required for adequate, affordable, and available healthcare facilities to guarantee quality in healthcare.

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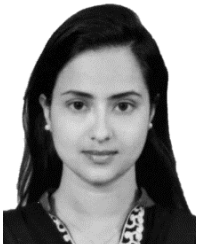

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