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Bibliometric analysis of Blockchain in the healthcare domain

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Abstract: As an innovation, Blockchain has transformed numerous industries and sparked the interest of the research community due to its abundance of benefits, opening up diverse research routes in the healthcare sector in the last decade. With Health 4.0 becoming ubiquitous in the healthcare industry, end-user transactions are being carried out on a decentralized network, making Blockchain profitable to meet the demands of the modern healthcare sector. Therefore, a detailed analysis of Blockchain is very crucial. This study emphasizes the evolution of science and the preliminary research of Blockchain in healthcare through bibliometric analysis. All the data are extracted from the Scopus database, and the VOSviewer tool is used for analysis. A total of 1152 Scopus articles published between 2018 and 2022 are examined. Results reveal that in 2022, the field of Blockchain experienced a notable increment in the number of publications and a significant growth rate. *IEEE Access* became well known in this field and had a large number of citations. It is observed that China and India are the leading countries in terms of publications on Blockchain. This study offers a number of recommendations that amateur and professional researchers can use as a benchmark before commencing a Blockchain investigation in the future.

Key words: Blockchain; bibliometric; healthcare; VOSviewer

1 Introduction

Satoshi Nakamoto introduced Blockchain in the financial industry as "A peer-to-peer electronic cash system" and as a Bitcoin cryptocurrency[1]. Since then, scholars have become interested in Blockchain's sharing mechanism. The development of Blockchain has four stages: 1.0, 2.0, 3.0, and 4.0[2]. The frequently used Blockchain 1.0 is called Bitcoin for small-value payments and a system for exchanging currencies. Blockchain 2.0 introduces the concept of a set of small codes executed automatically whenever the given conditions are met; these codes are called smart contracts. Furthermore, Blockchain 2.0 deals with investments, intelligent properties, payment settlement, banking equipment, and many other financial fields. Blockchain 3.0 is primarily concerned with the governance and regulation of Blockchain applications in numerous domains, such as business, government, healthcare, agriculture, the Internet of Things, and information technology. Blockchain 4.0 facilitates business connectivity by redistributing and enabling systems for supply chain and financial and asset management. Blockchain is used in a wide range of sectors, such as education, government, finance, supply chain, food tracing, and healthcare[3]. This technology is most adapted for use in the healthcare industry. Traditional healthcare issues have increasingly worsened because the number of adult patients is higher than the amount of resources for them, and diseases are evolving. Blockhain addresses unusual difficulties regarding patient data management, including data fragmentation, storage, and distribution and maintenance of patients' sensitive data. It provides an opportunity to revolutionize several aspects of the healthcare industry and offers a secure and

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decentralized platform that can effectively manage electronic health records[4, 5]. It enables patients to manage their health data and healthcare providers tosecurely access and update the records in real time.

Blockchain ensures the transparency and traceability of pharmaceuticals across the entire supply chain, from manufacturers to patients. It provides an immutable record of every transaction, ensuring transparency, preventing the spread of counterfeit drugs, and improving drug safety. Blockchain can support telemedicine services by securely storing and sharing patient data, ensuring privacy and data integrity.

It enables remote patient monitoring devices to directly transmit data to healthcare providers, improving the accuracy and efficiency of remote healthcare services. Blockchain-based smart contracts can automate and streamline healthcare payments, reducing administrative costs and eliminating intermediaries. Blockchain can also facilitate real-time claims processing, reducing fraud and enhancing transparency in insurance transactions[6, 7].

Blockchain offers various key features, such as immutability, auditable, and decentralization, which can address existing problems in the healthcare sector[8, 9]. Therefore, a state-of-the-art analysis of this ledger technology in the healthcare domain is necessary.

This study presents a bibliometric analysis of the scholarly published literature on Blockchain in the healthcare sector as indexed by Scopus. Bibliometry is a scientific review process that can analyze all publications to find key authors or areas of research and their relationships. The findings from the bibliometric analysis in this study include the following:

- Co-authorship using authors and countries;
- Co-occurrence of author keywords;
- Trendiest research areas;
- Most popular publication venues.

The remaining sections of this study are structured as follows. Section 2 discloses the related works. Section 3 defines the steps for data retrieval and processing. Section 4 presents the outcome of bibliometric analysis. Section 5 presents the discussion on future research direction and limitations of this study. Finally, Section 6 concludes this study and identifies the future scope.

2 Literature study

Researchers have shown interest in the outcomes, functionality, benefits, and issues that firms encounter when using new technology. The use of Blockchain could lead to exceptionally high levels of innovation. A Blockchain consists of time-stamped blocks that are securely and irreversibly sealed. The connection between each subsequent new block and the preceding block is established by generating a hash code using the SHA256 algorithm[10]. The participants of a Blockchain are also known as the nodes.

Only very few studies have recognized the systematic evolution of Blockchain. The authors in Ref. [11] presented a systemic literature review for Blockchain in the health domain and discussed several of its shortcomings in improving healthcare operations. According to Ref. [12], Blockchain has revolutionized commercial and lifestyle practices. Some authors cited the banking crisis of the past as the cause of its extensive use. Another systematic review[13, 14] examines the applications of Blockchain and related research subjects. Most researchers reviewed Blockchain and discovered that the majority of the analyzed papers lacked technical information regarding the Blockchain components[15, 16]. The authors in Ref. [17] disclosed the current state of Blockchain for Internet of Things (IoT) and cloud in the contexts of electronic health, intelligent buildings, and traffic monitoring. Various research gaps with possible solutions were also presented. The authors in Ref. [18] analyzed Blockchain for education and presented the pros and cons of adopting this ledger technology. In the framework of interdisciplinary research, a bibliometric analysis for implementing artificial intelligence, Blockchain, and IoT was presented[19]. Other authors explored healthcare compliances and reviewed Blockchain for the healthcare industry[20].

3 Methodology

Researchers used various tools to conduct bibliometric

analyses. Some authors employed Gephi to perform citation and cocitation analysis on articles related to Blockchain[21]. Other studies use R to examine the current state, potential, and constraints of Blockchain[22, 23]. In another work, the coword and cluster analysis of Blockchain-related publications from 2014 to 2020 were studied using SciMAT[24]. This study uses VOSviewer to analyze the future trends and conducts a bibliometric analysis to evaluate the current trends and define the connections amongregions, organizations, research fields, and author collaboration. VOSviewer is a tool designed by the Centre for Science and Technology Studies at Leiden University in the Netherlands for quantitatively analyzing scientific publications. In the present study, all the related data were gathered from the Scopus database using an advanced query string:

TITLE-ABS-KEY (blockchain AND healthcare) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p")) AND (LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2022)) AND (LIMIT-TO (LANGUAGE, "English")).

This search retrieves a total of 1952 articles. After the abstract, keywords, and entire texts are analyzed, reviews and a few other papers are eliminated because of using the terms editorial, spotlight, interview, and comprehensive review. 48 documents are deemed possibly unrelated to this investigation. Unpublished reports, working papers, and duplicates that might contain several keyword combinations are also excluded to improve the search results. Finally, a total of 1152 articles are received, and the CSV file for these documents is obtained from the Scopus database and imported into VOSviewer for further analysis, as shown in Fig. 1.

4 Result

Coauthorship is used as a measure to determine the most effective set of documents and identify those with the highest number of mutual publications[12]. In this analysis, a statistical network is used to visualize the connections among academics, research institutions, and nations by determining the number of publications they have collaborated on. Figure 2 depicts the network visualization of authorship using researcher names in nine clusters.

A group of nodes that are closely linked together is called a cluster. One cluster is given to each node in a network. Figure 2 illustrates that author Tanwar Kumar is associated with cluster 3 and has 8 links, 38

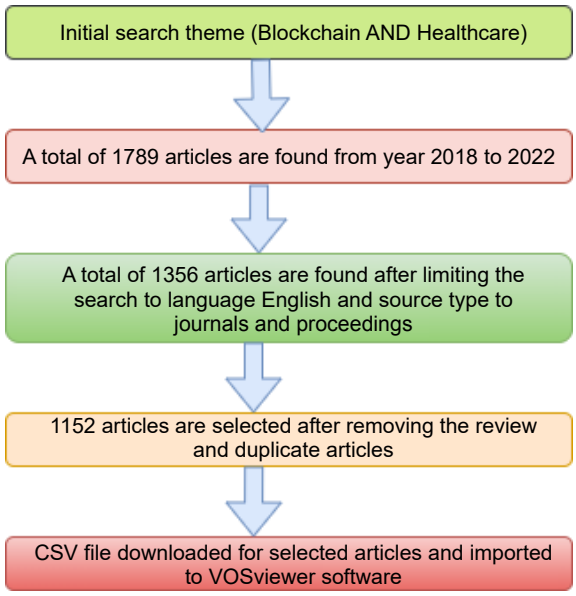

Fig. 1 Steps for abstraction.

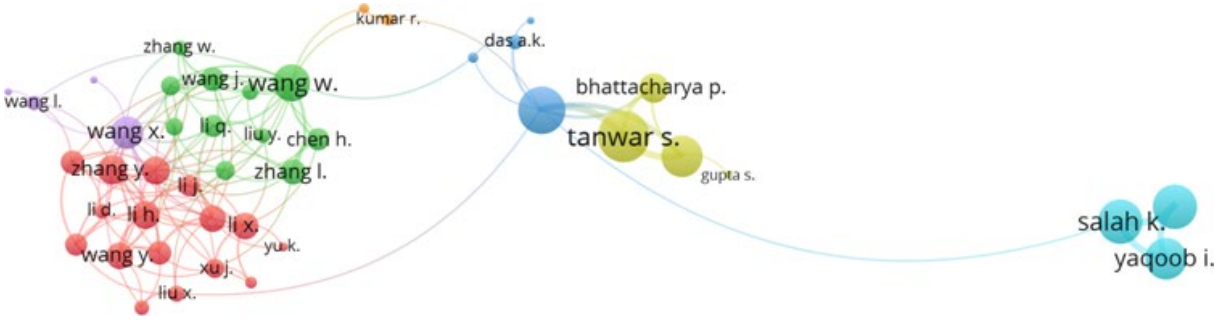

Fig. 2 Network visualization of authorship.

strengths, 35 documents, and 530 citations. It is also noted that 25 countries are included in the co-authorship analysis. China has 20 links, and India has 22 links.

4.1 Keyword-based analysis

Keyword analysis of articles offers a valuable tool for exploring the knowledge within research fields. By examining the cooccurrence of author keywords, this study can identify the keywords that occur frequently in the papers. In this study, the software records 2322 author keywords from 1152 articles. During this analysis, the least number of occurrences of a keyword is set to 10, and a maximum of 72 keywords meet this threshold value. Figure 3 illustrates the network visualization diagram of author keywords, and Fig. 4 plots the tree diagram of the top 30 author keywords. The majority of the studies are with the keywords Blockchain (20%), followed by healthcare (10%) and Internet of Things (6%).

4.2 Articles published per year

Table 1 illustrates the number of articles published per year and the growth rate. Figure 5 shows the number of publications per year. An increase in the publication of materials is observed from 2016 to 2023. This huge rise in publications is attributed to the great interest among businesses in using Blockchain. Although the yearly increaserate has stabilized at around 35%, it still shows a tendency to increase.

Research trends related to the Blockchain are expected to grow in 2023. Figure 6 summarizes the number of publications on Blockchain in five different sources, and Table 2 lists the publication sources in terms of the total number of citations. Table 3 presents the top 10 documents with the highest citations.

Compared with other sources, *IEEE Access* exhibited a sharp increase until 2022. Figures 7 and 8 depict the percentage of subject areas in the healthcare sector and of published documents classified by type, such as articles, conference papers, reviews, book chapters, notes, and short surveys.

5 Future scope and limitation

On the basis of the bibliometric analysis, this study provides a concise description of the issues that require attention in the future:

• To solve the security- and performance-related issues, researchers must adopt a wide perspective on Blockchain adoption. This step is essential for developing robust data protection and identity

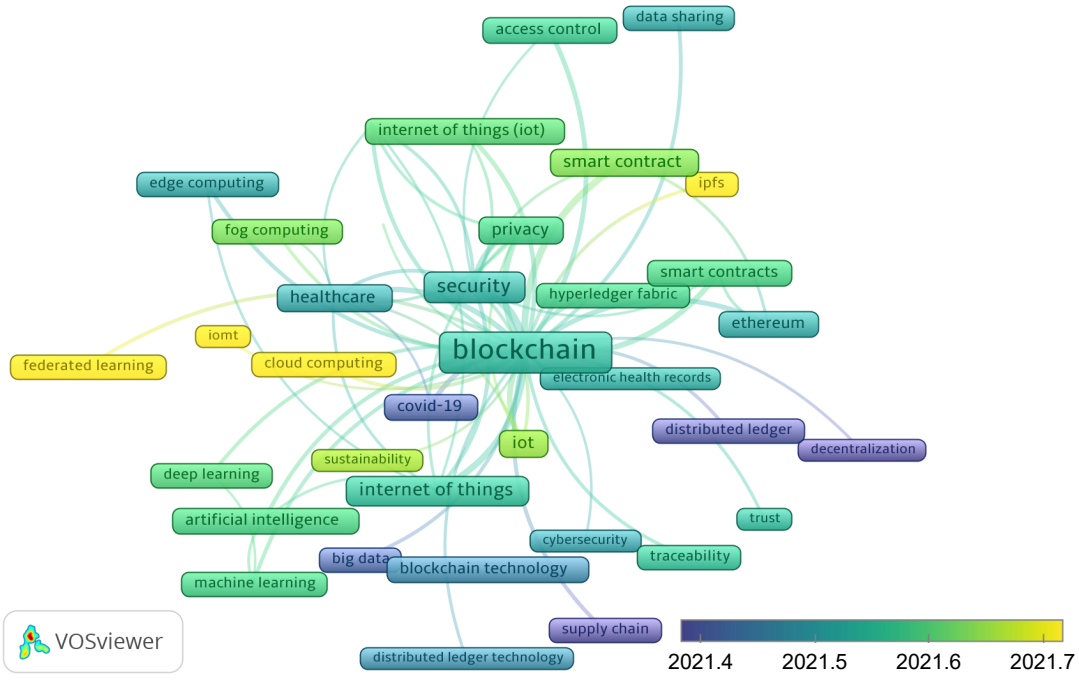

Fig. 3 Network visualization of author keywords.

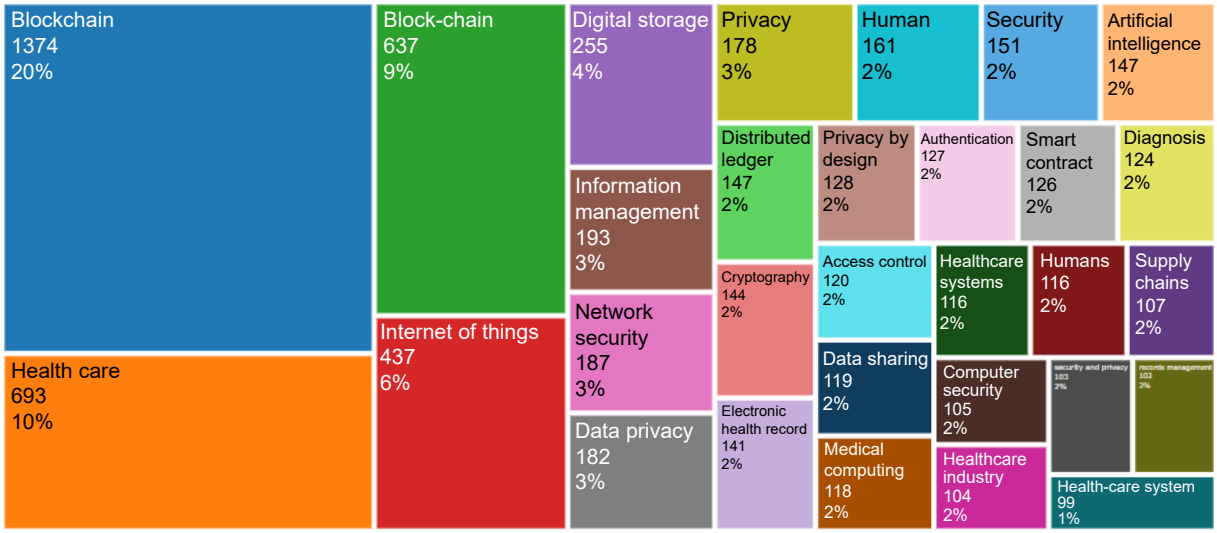

Fig. 4 Tree plot for widely used author keywords.

Table 1 Documents published per year

Year	Number of publications	Growth rate (%)
2018	131	0
2019	345	163
2020	536	55
2021	793	48
2022	1154	45

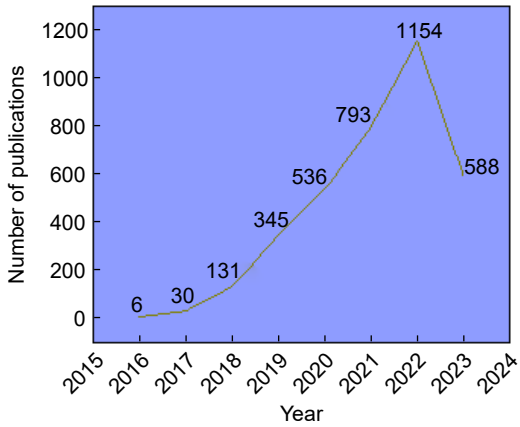

Fig. 5 Document publications per year.

management in e-health ecosystems that are comprehensive, legal, and ethical[32].

• Researchers may concentrate on boosting the efficiency and performance of the designed systems by improving the transaction speeds. This goal may be achieved by dealing with congestion control, scalability, throughput, and bandwidth.

• Future studies must concentrate heavily on the issues of data, user privacy, and legality. These issues

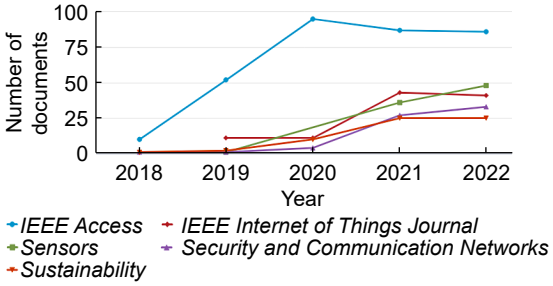

Fig. 6 Documents published by different sources.

Table 2 Publication citation by source.

Rank	Source	Number of citations
1	*IEEE Access*	226 182
2	*IEEE Internet of Things Journal*	42 380
3	*Sensors*	147 968
4	*Security and Communication network*	5526
5	*Sustainability*	141 654

Table 3 Total citation (TC) of top 10 documents.

Reference	TC	TC per year	Normalized TC
[25]	503	125.75	29.15
[9]	317	79.25	18.37
[26]	256	64.00	14.84
[27]	229	76.33	40.62
[28]	191	47.75	11.07
[29]	189	47.25	10.95
[14]	172	43.00	9.97
[6]	147	36.75	8.52
[30]	144	36.00	8.34
[31]	141	35.25	8.17

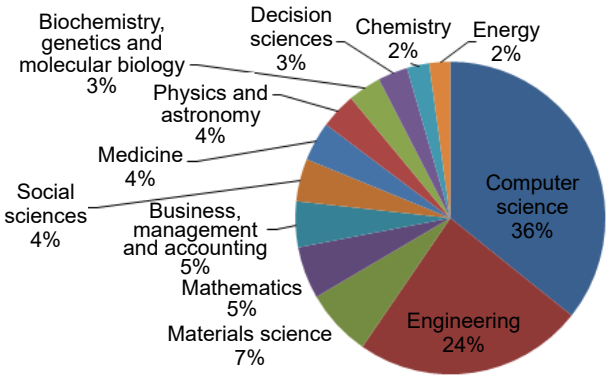

Fig. 7 Publication under different subject areas.

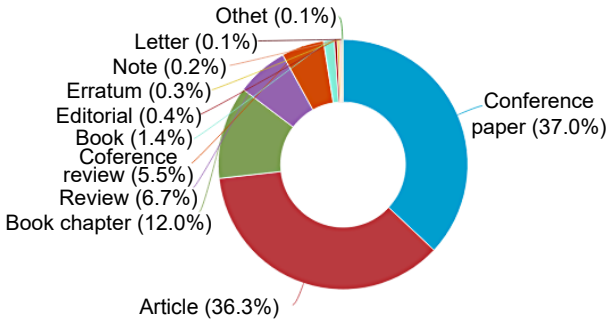

Fig. 8 Percentage of published documents by type.

can be directly addressed by designing a Blockchain protocol to manage health records that are verifiable through smart contracts and are in compliance with data and privacy protection legislation, such as the HIPPA Act.

• Blockchain may improve the services in the healthcare domain. For instance, researchers might concentrate on enhancing the interface of IoT using Blockchain-based health care platforms to deliver individualized medical care and diagnoses[33]. To ensure access, home automation, and emergency personnel, researchers may also concentrate on connecting IoT-based sensors with Blockchain.

This research has certain limitations. First, the scope is only limited to the studies published in the Scopus database. Some other international databases, such as PubMed, CSCD, CSSCI, and Web of Science (WoS), should have been considered for a comprehensive analysis.

6 Conclusion

This study conducted a bibliometric analysis of the utilization of Blockchain in the healthcare sector from 2018 to 2022. The data are obtained from the Scopus database, which poses a research restriction. Therefore, different data sources, such as WoS, will be used in the next investigation. A total of 1152 documents are analyzed, and an overview of various factors, including the changes in the publishing rate throughout the study period, published documents in different categories, different publication sources, and VOSviewer-referenced research, is presented. Blockchain is connected to many fields. According to the analysis, a few keywords are recognized as significant topic areas for further investigation in the healthcare industry because they do not form a network with other terms. This work also identifies the research gaps and presents alternative insights based on the analytical results, which may serve as a valuable guide for future studies.

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