The Blockchain Technologies in Healthcare: Prospects, Obstacles, and Future Recommendations; Lessons Learned from Digitalization

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Abstract—For today's healthcare data management systems, fundamental problems are data transparency, traceability, immutability, audit, data provenance, flexible access, trust, privacy, and security. Blockchain is a promising technology that can help to optimise healthcare data management operations by increasing data efficiency and ensuring trust. The current study examined the usefulness of blockchain technology in healthcare and the barriers to adoption. Finally, we looked at the future of blockchain technology in healthcare. The current study reviewed 53 papers and utilised the PRISMA framework 2020 to include and exclude records from the Scopus database. The VOS Viewer software is used to categorize the published literature, and the prevalence of essential terms is often used to authenticate the main themes in classifications. The current study findings indicate that Blockchain offers a wide range of applications and functions in healthcare. By allowing the transfer of patient medical information, controlling the medication supply chain, and facilitating the safe transfer of patient medical records, blockchain technology assists healthcare researchers in discovering genetic codes. Because blockchain can support novel analytics, healthcare firms may notice changes in their data in real-time, allowing them to make swift choices without human involvement.

Keywords—blockchains technologies, electronic health records, healthcare, artificial intelligence, IoTs, PRISMA 2020

1 Introduction

The healthcare sector is vital in society since the issues it handles are directly involved with enhancing people's quality of life, which may be accomplished by resolving genuine health concerns [1]. As a result, healthcare remains one of the world's most pressing social and economic concerns, necessitating new and more complex scientific and technological solutions [2]. According to [3], in response to such demands, information and communication technologies (ICTs) have benefited the access, efficiency, and quality of nearly every healthcare procedure since the early 1990s. In addition, the development and success of the Internet have played a significant influence in enhancing access and the efficacy of any healthcare-related procedure [4]. The fast advancement of technology has substantially revitalised the healthcare sector. As a result, the idea of e-health, which may be generally described the use of ICTs in healthcare, has been widely accepted. In recent years, there has been a surge in public interest in the e-health industry and unprecedented levels of investment in terms of research effort and finance [5]. E-health provides significant opportunities for the users (doctors, patients, physicians, nurses, and social workers) to work in an environment that can improve patient care because healthcare records are better managed [6]. However, the electronic record security problem posed by e-health apps and sources in terms of patients' health reports and information is taken seriously. According to [7], privacy, security, and confidentiality are significant challenges that must be addressed in electronic medical record systems.

For today's healthcare data management systems, key challenges are data transparency, traceability, immutability, audit, data provenance, flexible access, trust, privacy, and security [8]. Blockchain is an exciting technology that can improve healthcare data management operations by enhancing data efficiency and assuring trust [9]. In addition, due to blockchain capabilities such as immutability, transparency, trustworthiness, and other considerations, the blockchain can alleviate concerns originating from the privacy and integrity of patient information [10]. The blockchain's immutability is a critical choice for healthcare data. It can protect health information, clinical trial outcomes, and regulatory compliance. Intelligent agreements show how blockchain may be utilised to assist patient surveillance and medical treatments [11]. However, blockchain-based healthcare systems continue to confront obstacles that must be solved [12]. One of these is that the channel's core characteristics are anonymous, and the anonymity of the nodes makes tracing the connections that allow the information to be made public impossible [13], [14]. According to [15], blockchain, with its secret safe, decentralised ledger, can provide security by keeping information across multiple computers rather than in a single source. Due to various blockchain technologies, storing records in numerous sources reduces the possibility of fraud and data theft. However, decentralized storing is a crucial aspect of blockchain technology and serves as the foundation for improved security and verification of information saved inside the system [16]. In addition, as a comparatively recent and immature technology, there is indeed a lack of standards, which impedes widespread acceptance and inhibits progress [17].

The current study aims to investigate blockchain technologies in healthcare—additionally, the prospects of employing blockchain technologies and the obstacles connected with blockchain technology adaption. The present study will make recommendations for the future of blockchain technology based on existing results for researchers and the industry.

2 Materials and methods

The current study applied the PRISMA statement 2020 to include and exclude records for the current study. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement, or PRISMA Statement, is the most generally used reporting guidelines for systematic reviews including the literature search component [18]. The current analysis incorporates content from Scopus, a well-known database utilised by academics worldwide. We used the search terms "blockchain technologies" AND "healthcare" for our literature survey. Initially, 419 records were retrieved, and subjects such as computer science, engineering, business management and accounting, environmental science, social sciences, mathematics, and health professions were chosen. The selection of subjects narrows down the number of records to 408. In addition, we picked articles, review papers, and book chapters when deciding on document types. In the following phases, the published papers in the English language were chosen to consider the relevant literature and the number of articles was limited to 57. A detailed selection was made for each found classification to assess related papers, and duplicate records, irrelevant materials, and missing documents were deleted. Only 53 papers were selected for inclusion in the assessment to synthesise it. Figure 1 depicts the current study's complete PRISMA 2020 statement selection and rejection procedure.

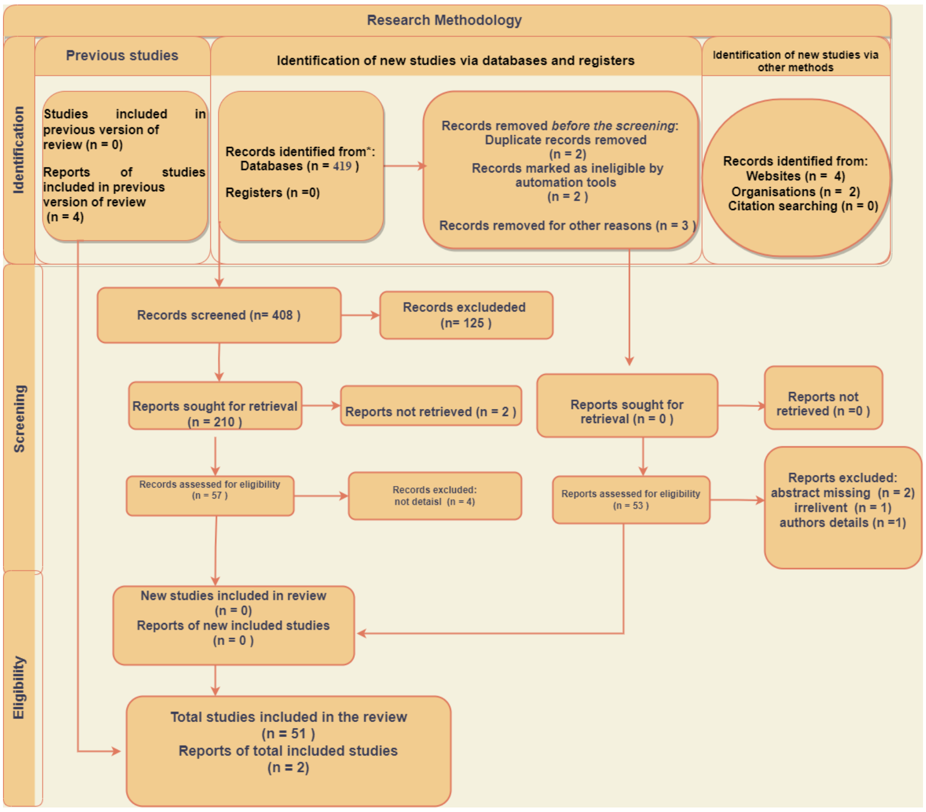

Fig. 1. PRISMA statement 2020 inclusion and exclusion process

3 Results

The distribution of subjects is depicted in Figure 2, and the major contributor to the current study is computer science subject with 17% articles included. The engineering discipline studies percentage is 15%, with 12% from business, management, accounting, and medicine records. In addition to this, social science and health professions subject of 10% per cent of each subject record were included. The other significant contributions are from chemistry and environmental science, shown in Figure 2 below.

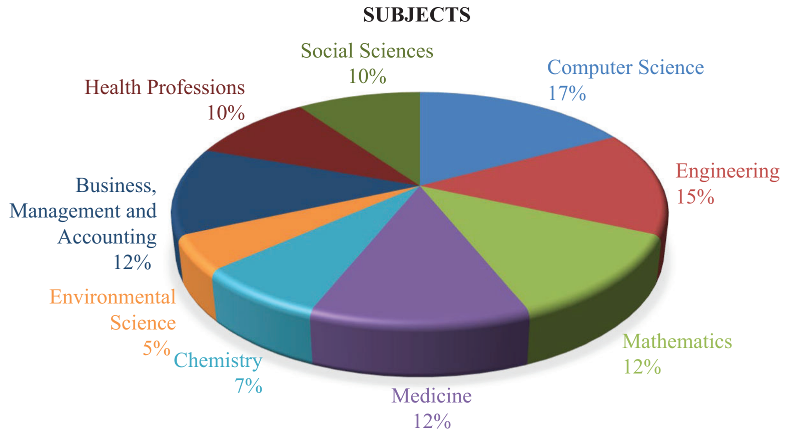

Fig. 2. Distribution of subject's area

In addition, the year base distribution of results shows that year of records chosen for the current study is a significant difference from the year 2016 to the year 2021. The year 2021 is the major contributor with 15 documents selected, following the year 2020 with 13 articles. In addition, the year 2019 has contributed eight articles and the year 2018 with seven records. The number of articles is narrowed down in 2017 and 2016 with four records, respectively. Figure 3 illustrates the distribution of records from the year base.

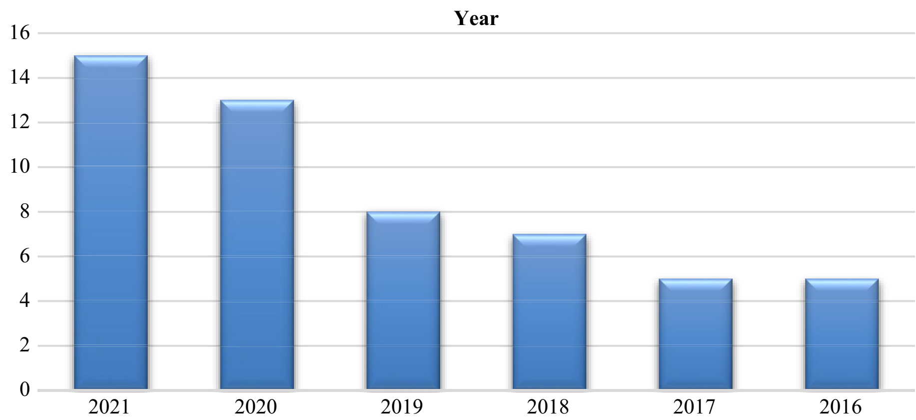

Fig. 3. Distributions of records on year base

Furthermore, the record chosen from the country is explained in this section; the significant records in the current study are included from India with 11 articles. The other significant articles were on Saudi Arabia only 9 with documents. In addition, records included from China are seven and shown on the map. The six articles were selected from South Kore and represented in the orange colour in the map below. Figure 4 Map illustrates the selection of articles from each country.

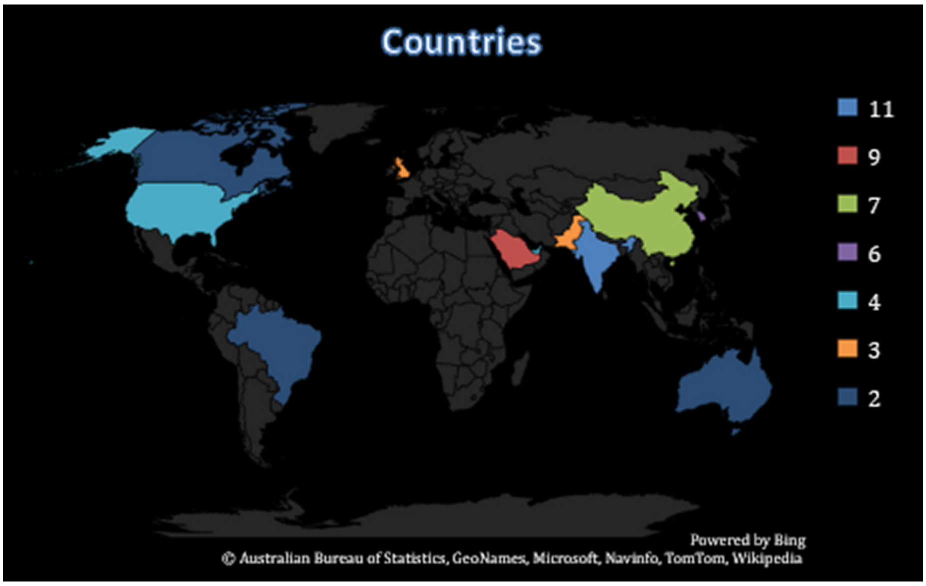

Fig. 4. Map distribution of articles from countries

Moreover, the journal-based publication analysis is conducted for the current study and finds that the IEEE Access contributes the highest number of articles with nine records. Second, most articles are selected from the International Journal of Advanced Computer Science and Applications. Gradually, the name of the studies is going down for the current study, and the Sensors have contributed articles. Figure 5 shows the details of source titles in detail below.

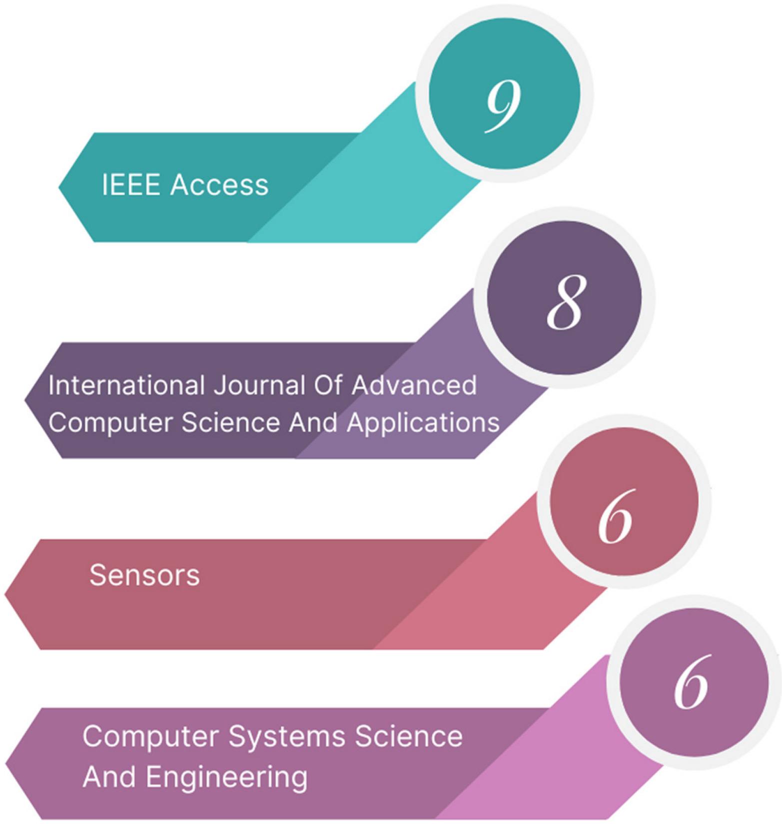

Fig. 5. Number of articles included in sources

3.1 Reviewing the literature

Furthermore, we employed key terms occurrences analysis to identify the significant themes in the review literature. The VOS Viewer emphasized the number of keywords and key phrases used in the published articles. Fifty-three articles were selected to analyze the critical occurrence, with 42 essential terms appearing more than four times. Electronic health records, blockchain, and AI are the three critical areas of data streams. In addition, we provide the relevance score of each phrase and the average score. Table 1 below illustrates the details of important phrase categorization.

Table 1. Distribution of occurrences of terms, classification, relevance score

Classification	Term	Occurrences	Relevance Score
Blockchain and AI	artificial intelligence	7	2.1131
	blockchain	11	1.1866
	blockchain technology	7	1.1109
	cloud	8	0.7311
	decentralization	6	0.4854
	health data	7	0.3533
	healthcare system	7	0.8125
	hospital	7	1.5405
	integration	8	0.7529
	internet	19	1.2098
	iot	14	1.623
	lack	7	0.9062
	ledger	11	0.6547
	need	11	0.8528
	number	5	3.1144
	performance	10	0.916
	sharing	10	0.7716
	survey	6	1.108
	transaction	10	0.9211
	transparency	7	0.5821
	trust	7	1.2099
	user	11	0.6038
	work	8	0.9198
Electronic health record	approach	12	0.4615
	benefit	6	0.5279
	covid	8	1.364
	device	13	0.6747
	doctor	6	0.8754
	EHR	7	1.734
	electronic health record	10	1.3226
	entity	7	0.6998
	healthcare stakeholder	5	1.3024
	implementation	6	0.9465
	integrity	6	0.5963
	literature	7	1.0418
	management	16	0.7072
	medical data	9	1.2804
	record	20	0.5432
	technique	12	0.9038
	thing	16	1.3128
	time	10	1.1273
	use	9	0.4798

Additionally, the papers were subjected to content analysis to identify the study's classification. The VOS Viewer software explores the content of published literature—data clusters formed on the text to group related concepts. According to the current study, researchers' keywords and keywords in the journals' indexing method stated in the databases are equally appropriate for bibliometric analysis meant to discover the structures of the investigating field. Hence, we involved both classes of keywords for the co-occurrence analysis within the study area associated with blockchain technologies in healthcare. The research contained fifty-three records, and the data delivered 43 keywords. We have thoroughly established and selected only the most numerous 43 keywords repetitive in a minimum of 5 records. Figure 6 illustrates the content analysis results—the group showed two major clusters, described in different colours in Figure 5. The cluster is represented by orange displays blockchain, blockchain technology, and performance. The cluster in blue is primarily ascribed to the blockchain and Artificial Intelligence (AI). The green cluster signifies prevention, technology intervention, and effectiveness. Ultimately, the purple cluster indicates electronic health records and healthcare systems. Each cluster is further examined in the next section.

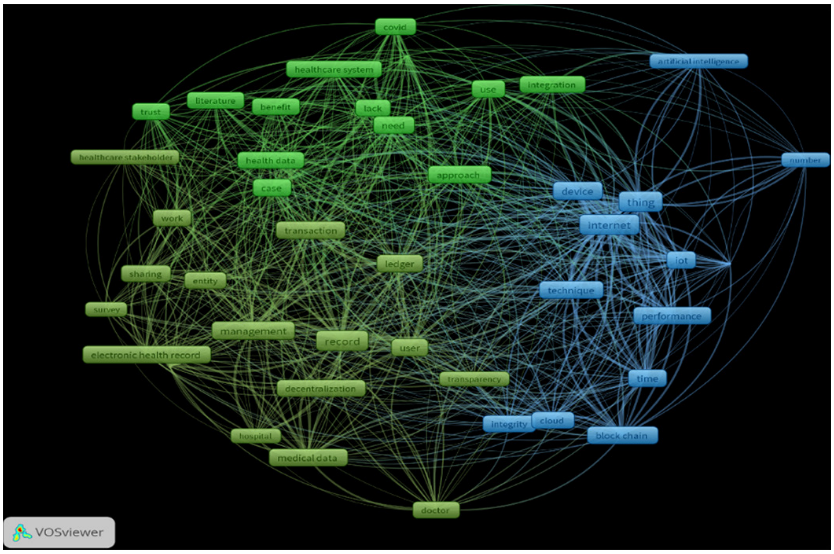

Fig. 6. The classification of literature using the VOS viewer

3.2 Electronic health records

Electronic Health Records (EHRs) offer a handy health record storage system that encourages traditional paper patient medical records to be electronically accessible on the web. This system was created to provide people authority over the generation, management, and sharing of EHRs with family, friends, healthcare professionals, and other approved data users [19]. Compatibility in EHR strives to create agreements regarding approach, access, and storage that are secure, private, and trustworthy [20]. In addition, the vast scale influences of health-related technologies, such as e-health and m-health digital technologies, and electronic health records are significant [21], [22]. However, security and privacy were significant concerns in digital technology in the healthcare business [23]. According to [24], cybersecurity vulnerabilities in many electronic health apps and individual healthcare records are not safe. The authentication and trust associated with electronic health records are a significant barrier for patients and healthcare personnel to prevent security issues with digital health sources [25]. Many efforts have been made to balance data privacy and the requirement for patients and clinicians to use this sensitive data for various objectives to secure electronic health records. Consider the sensitive information in EHRs as an example of data that requires more excellent protection [26]. In addition, medical institutions are currently facing an upsurge in demand for real-time data from industrial and research companies. At the same time, unlawful exchanges, highly publicised cyberattacks, and data thievery continue to erode public faith in healthcare facilities. The other issue is that abuses in the healthcare ecosystem share the same trust (e.g., problems with fake drugs, procedures, skills, and patients) [27], [28]. Table 2 below shows the details of the authors, year of publication, citation records, segment and settings in the research conducted.

Table 2. Authors, year, citation, segment, and settings

Authors	Year	Cited by	Segment	Settings
Bharimalla P.K., Choudhury H., Parida S., Mallick D.K., Dash S.R.	2021		transfer, and storage of patient's medical records	Blockchain
Chen W., Zhu S., Li J., Wu J., Chen C.-L., Deng Y.-Y.	2021	1	diagnostic accuracy	system security
Guo R., Shi H., Zhao Q., Zheng D.	2018	218	healthcare and restore management	patient-related data
Hameed K., Bajwa I.S., Sarwar N., Anwar W., Mushtaq Z., Rashid T.	2021	9	Internet of Health Thing	clinical decision support system
Indumathi J., Shankar A., Ghalib M.R., Gitanjali J., Hua Q., Wen Z., Qi X.	2020	6	Health Records,	Internet of Medical Things
John J., Varkey M.S., Selvi M.	2019	7	E-health care monitoring system	Intelligent Wireless Body Area Networks
Kim H., Lee S., Kwon H., Kim E.	2021		personal health records	blockchain-based PHR platform
Lee D., Song M.	2021		Health information exchange (HIE)	privacy issues
Majdoubi D.E., Bakkali H.E., Sadki S.	2021	1	Internet of Things	Medical IoT data and Electronic Health Records
Mijoska M., Ristevski B.	2021		electronic health records	big data
Murugan A., Chechare T., Muruganantham B., Ganesh Kumar S.	2020	11	Health Information Exchange	wearable IOT device
Rao K.R., Naganjaneyulu S.	2021		lack of privacy and security	system security
Roehrs A., da Costa C.A., da Rosa Righi R.	2017	161	Personal Health Records	Information and Communications Technology (ICT)
Senbekov M., Saliev T., Bukeyeva Z., Almabayeva A., Zhanaliyeva M., Aitenova N., Toishibekov Y., Fakhradiyev I.	2020	13	telemedicine and blockchain technologies	medical digital technologies

Furthermore, various healthcare entities, such as doctors, pharmacists, medical lab directors, and insurance companies, may be required to report transactions in the Healthcare Information Exchange System, which may result in changes to the contents of Electronic Medical Records (EMR) [29]. These EMRs include vital and sensitive patient medical information that must be kept safe. It necessitates that the persons carrying out transactions be known and trusted by the other participants [30]. However, the use of blockchain technology in healthcare systems, on the other hand, drastically reduces data security in electronic health records [31]. The advantages of blockchain in healthcare are divided into three categories: integrity, availability, and trust. To fabricate data on the blockchain, attackers change all of the data between the earliest and most recent blocks; hence, manipulating data in the blockchain is impossible [32]. According to [33], reduced cost, speed, automation, immutability, near-impossible data loss, permanence, removal of intermediaries, decentralisation of consensus, legitimate access to health data, data safekeeping, accrual-based reimbursement mechanisms, and medical supply chain efficacy are all benefits of the blockchain. In addition, blockchain technology can improve data integrity, decentralise data, aid in delivering precision medicine, improve patient care and results, and connect medical records throughout a country [34], [35]. In conclusion, data security and personal records privacy have been a significant worry with electronic health records worldwide, and blockchain technologies have considerably reduced the risks of security and trust with electronic records for individuals and masses in recent years.

3.3 Blockchain technologies and Artificial Intelligence (AI)

Blockchain is a new area that operates on the premise of a digitally distributed ledger and a consensus method that eliminates any intermediary risks [36]. Every node in the Blockchain system will keep a record of all interactions, and these transactions will keep the status of the data maintained on the Blockchain network, and the ledger frequently consists of two types of data structures. The initial data structure is Blockchain itself, which is an append-only log of all transactions that have occurred; it is comparable to a linked list of blocks, and a block is a collection of transactions [37]. Its initial applications were in the finance industry, but this idea has already been expanded to practically all essential fields of study, including education, IoT, banking, supply chain, military, governance, and healthcare [38]. Blockchain technology's modern decentralisation mechanism offers solid answers to healthcare system safety and dependability challenges [39]. Another compelling component of blockchain technology is eliminating the need for intermediaries [40]. In addition, the healthcare industry has established the capability of transforming the blockchain revolution. It is a forerunner in the industry [41]. Patients are the health ecosystem's priority, and their mission is to increase the security, privacy, and interoperability of health data [42]. Blockchain solutions provide immutability in EHR storage. Thanks to the decentralised ledger, dispersed healthcare stakeholders may easily access their records. It provides a platform for the trust-based exchange of health transactions, which authorities may authorise and audit to provide record provenance [43]. Besides this the blockchain-based Internet of Medical Things (IoMT) is gaining traction in the healthcare industry because it improves treatment quality through real-time and continuous monitoring and reduces healthcare costs [44]. According to [45], the IoMT's open and pervasive environment, which provides high-end digital benefits while involving human lives, causes enormous hurdles in protecting data from emerging cyber threats, assaults, and vulnerabilities. Table 3 below shows the details of the authors, year of publication, citation records, segment and settings in research conducted.

Table 3. Authors, year, citation, segment, and settings

Authors	Year	Cited by	Segment	Settings
Adavoudi Jolfaei A., Aghili S.F., Singelee D.	2021		Internet of Medical Things (IoMT)	scalable blockchain system
Ahmad M.S., Shah S.M.	2021		researchers	healthcare
Alotaibi A.S.	2021		Internet of Medical Things (IoMT)	machine-learning techniques and blockchain
Christo M.S., Jesi V.E., Priyadarsini U., Anbarasu V., Venugopal H., Karuppiah M.	2021		Electronic Medical Card (EMC)	data authentication and data confidentiality
Ferrag M.A., Friha O., Maglaras L., Janicke H., Shu L.	2021	2	internet of Healthcare Things	deep learning approaches
Khatri S., Alzahrani F.A., Ansari M.T.J., Agrawal A., Kumar R., Khan R.A.	2021	2	blockchain-based health systems	adopting blockchain
Kumar S., Kumar A.	2021		ledger deal	health insurance
Musamih A., Jayaraman R., Salah K., Hasan H.R., Yaqoob I., Al-Hammadi Y.	2021	2	controlled drugs misuse	healthcare supply chain
Sonkamble R.G., Phansalkar S.P., Potdar V.M., Bongale A.M.	2021		healthcare stakeholders	EHR management
Vaiyapuri T., Binbusayyis A., Varadarajan V.	2021	4	smart healthcare system	Internet of medicals things
Wazid M., Das A.K., Park Y.	2021		Artificial Intelligence of Things (IoT)	healthcare monitoring
Yaqoob S., Khan M.M., Talib R., Butt A.D., Saleem S., Arif F., Nadeem A.	2019	15	digitally distributed ledger	reduced systematic fraud

In recent years, technological advancement has resulted in incorporating blockchain technology that is not restricted to healthcare data privacy and security. The usage of blockchain is heavily collaborating with other digital media such as IOTs, big data, and artificial intelligence [46]. According to [47], the blockchain technology safe authentication framework for AI is a conglomeration of AI, IoT, and blockchain-related tools and technology. That is accomplished using many complex algorithms, such as consensus, deep learning, and IoT communication algorithms. Furthermore, IoTs and AI-based programmes in healthcare are not only beneficial in ensuring privacy and maintaining health data; the programmes use the algorithm to communicate the patients' medical history and medication supply chain operations [35]. Blockchain technologies are proliferating in the healthcare sector by integrating other digital technologies.

4 Conclusion

The potential of blockchain to maintain an incorruptible, decentralised, and transparent log of all patient data makes it a technology ripe for security applications. Additionally, while blockchain is visible, it is also private, concealing any individual's identity using complicated and secure codes capable of protecting the sensitivity of medical data [48]. Blockchain technologies significantly contribute to the healthcare industry by developing the patients' trust related to Electronic Health Record security. The current study findings indicate that Blockchain offers a wide range of applications and functions in healthcare. By allowing the transfer of patient medical information, controlling the medication supply chain, and facilitating the safe transfer of patient medical records, blockchain technology assists healthcare researchers in discovering genetic codes [49]. Blockchain has made inroads into the healthcare field, gaining traction.

Furthermore, people in the health ecosystem are favourable to innovations in the early phases. The overall vision of Blockchain to revolutionise the healthcare business in the following years will be to solve challenges impacting the current structure. It enables physicians, patients, and pharmacists to access all accessible information at any time quickly. Figure 7 is illustrating the outcomes of literature in current study.

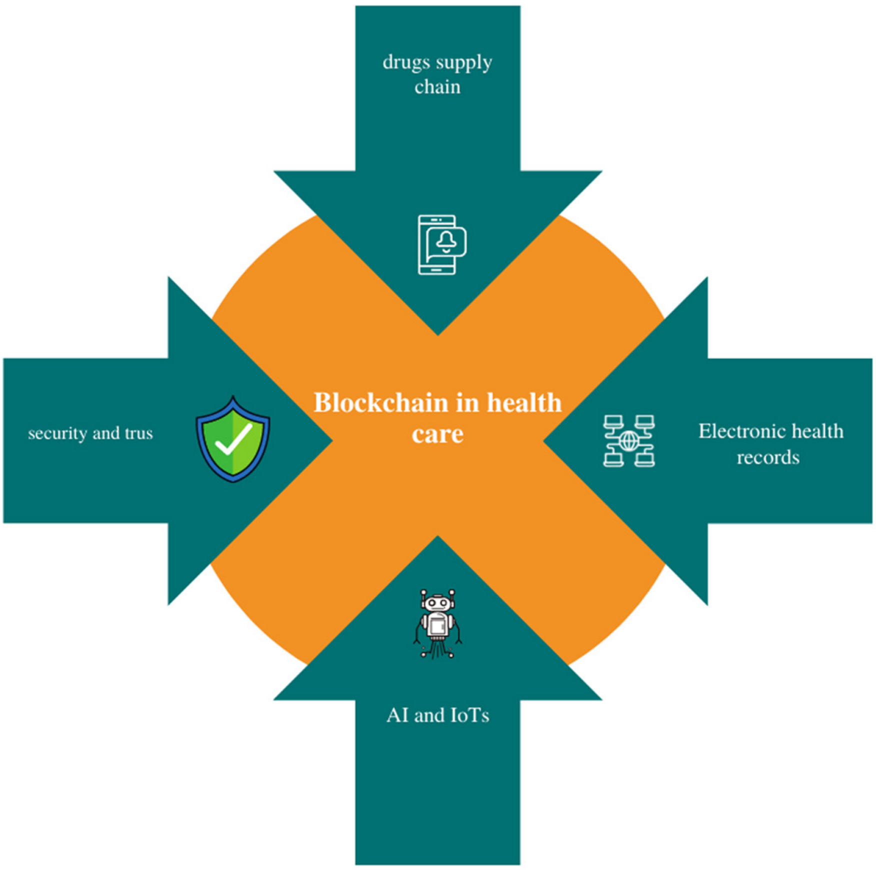

Fig. 7. The literature findings blockchain technologies in healthcare

Despite the enormous prospects and benefits of blockchain technology, the current study results indicate some barriers to blockchain technologies in the healthcare industry. The most significant impediment to adopting blockchain technology is the high cost of innovative technologies, which makes it difficult for governments in developing nations to embrace them [50]. The other reason is the skills gap in most healthcare sector industry users who are unfamiliar with advanced digital technologies.

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