Healthcare blockchain-based Systems: A review

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Abstract

The increasing digitalization of healthcare systems has heightened the need for secure, transparent and interoperable mechanisms for managing sensitive medical data. Blockchain technology has emerged as a promising solution thanks to its decentralized architecture and robust cryptographic safeguards. This study presents a bibliometric analysis of scientific research into blockchain applications in the healthcare sector. Data were extracted from the Scopus scientific database and analyzed using VOSviewer and Bibliometrix. The results show growing research activity driven by interest in secure electronic health records, privacy preservation, smart contracts and decentralized analytics. Keyword co-occurrence patterns reveal emerging themes and the evolution of research clusters. This review provides a structured understanding of current work on blockchain in the healthcare sector and highlights strategic directions for the development of secure health information systems.

Keywords

Blockchain, Healthcare, Electronic health records, Data security, Privacy protection, Distributed ledger

1. Introduction

The digitalization of the healthcare sector has generated vast amounts of sensitive data, including electronic health records (EHRs), genomic data, diagnostic images and real-time physiological signals. Ensuring their integrity and confidentiality remains a major challenge. Traditional centralized infrastructures expose healthcare systems to risks of unauthorized access, single points of failure and data tampering [3], [4]. Blockchain technology, initially introduced for cryptocurrencies, enables decentralization, immutability and provides cryptographic data security, making it a suitable candidate for securing medical records and improving interoperability [3], [4]. A blockchain network validates transactions via distributed consensus, ensuring verifiable and tamper-resistant storage. Applications in healthcare include the secure management of EHRs [1], [2], data exchanges that preserve confidentiality [3], [4], monitoring of the medical supply chain [9], as well as patient-centered access mechanisms via smart contracts [6]. Emerging approaches integrate blockchain with artificial intelligence and federated learning to enhance privacy and distributed analytics [7], [8].

However, challenges remain regarding scalability, regulatory compliance, interoperability with existing systems, and computational cost [3], [4]. Given the rapid evolution of the field, a bibliometric analysis is required to map publication trends, identify key players and reveal thematic clusters [11], [12]. The aim of this study is to analyze the scientific landscape of blockchain research applied to the healthcare sector, focusing on publication growth, countries and collaboration networks, thematic structures and influential publications, in order to identify useful guidelines for future research.

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2. Brief overview of blockchain and health management-based systems

Blockchain is a distributed ledger technology designed to ensure the transparency, traceability, and immutability of transactions [3]. Public, private, and hybrid blockchains offer various privacy and governance models, tailored to different use cases in healthcare [4]. Applications in the medical field include:

- Secure storage of EHRs and access control [1], [2]
- Confidential data sharing using cryptographic protocols [3], [4]
- Automation of clinical workflows via smart contracts [6]
- Supply chain traceability to detect counterfeit drugs [9]
- Integration with AI and federated learning for distributed clinical analysis [7], [8]

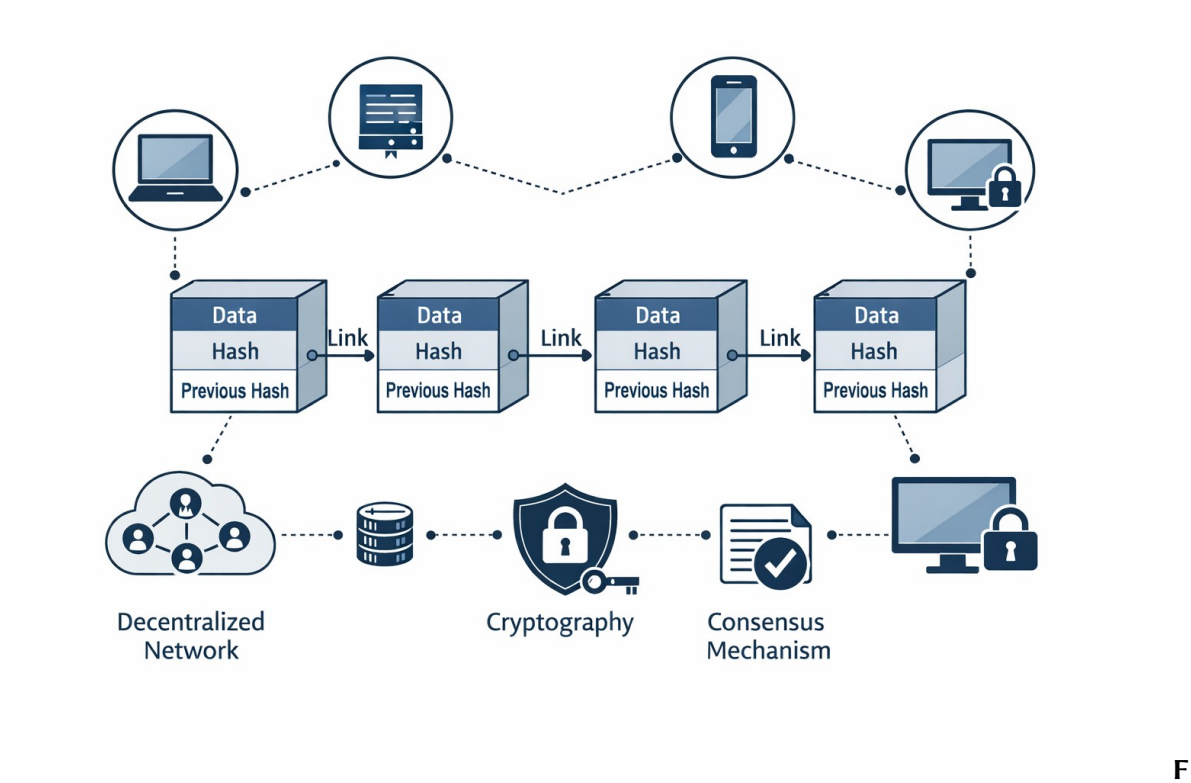

Figure 1: Blockchain system architecture

Figure 1 illustrates the general operation of a blockchain, which is based on a chain of interconnected blocks containing data, a cryptographic hash, and a reference to the previous block. The blocks are validated through a distributed consensus mechanism among multiple network nodes, ensuring the integrity and immutability of the information. This architecture enables decentralized, resilient, and transparent data storage.

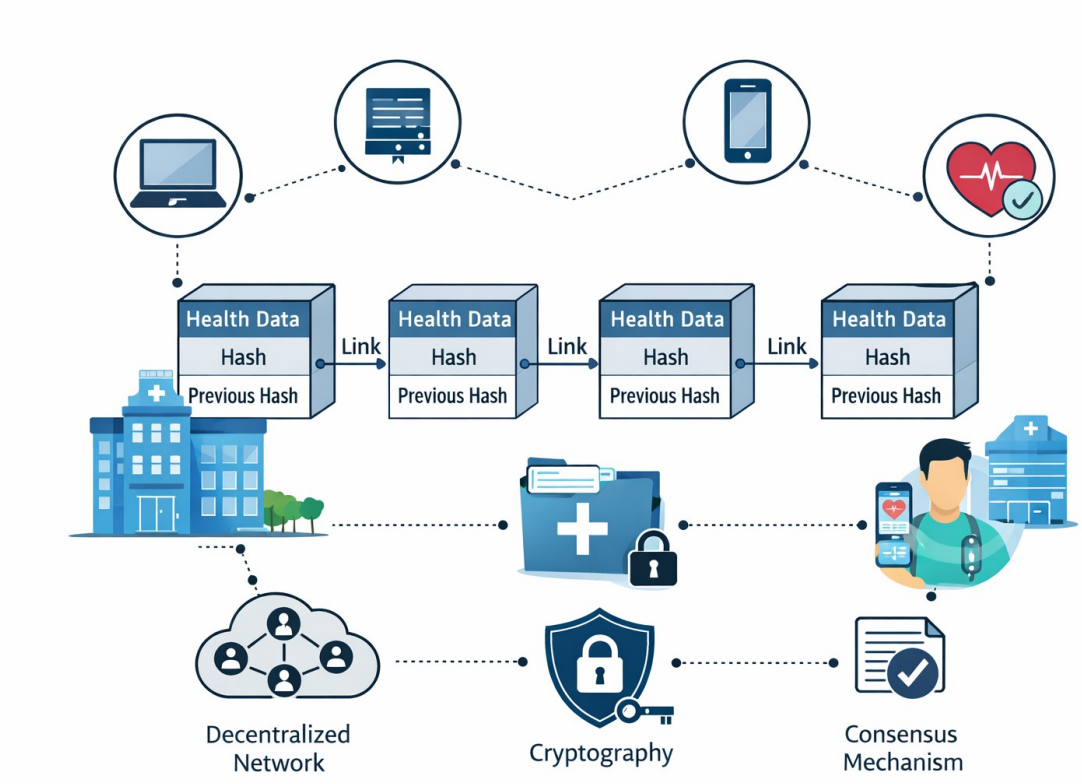

Figure 2: Health based blockchain system architecture

Figure 2 illustrates the use of blockchain for the secure management of health data between hospitals, patients, and digital systems. Medical information is recorded in the form of linked blocks, ensuring traceability, confidentiality, and enhanced access control. As the data are packed on the decentralized network through a consensus mechanisms, several encryptions techniques are applied along to provides data's integrity. This model facilitates the reliable sharing of medical data while meeting security and governance requirements. Despite its potential, the adoption of blockchain faces challenges such as limited scalability, difficulties integrating with existing hospital systems, and compliance with regulations such as the GDPR and HIPAA [3], [4]. These constraints underscore the need for complementary security mechanisms (encryption, off-chain storage, access control). Given the growing scientific interest and the diversity of applications, a bibliometric review is essential to structure the field, identify emerging themes, and highlight gaps in current research [11], [12].

3. Literature review

The integration of blockchain technology into the healthcare sector has sparked growing scientific interest over the past decade, primarily due to challenges related to the security, privacy, and interoperability of medical data. Numerous studies have examined the conceptual foundations, technical architectures, and practical applications of blockchain in digital health systems [3], [4], [5]. Azaria et al. (2016) proposed MedRec, one of the first blockchain-based systems for managing access to medical records [1]. Their approach aims to give patients back control over their health data while ensuring the traceability of access. The authors demonstrate that blockchain can improve interoperability among different healthcare providers, although challenges remain regarding performance and large-scale deployment. Kuo et al. (2017) conducted an in-depth analysis of distributed ledger technologies and their applicability to biomedical fields and healthcare systems [3]. Their study highlights blockchain's potential to enhance security, transparency, and the management of patient consent. However, the authors note that the majority of proposed solutions remain at a conceptual stage and still require empirical validation.

Dubovitskaya et al. (2018) developed a system for the secure sharing of electronic health records based on blockchain technology and advanced cryptographic techniques [2]. This solution ensures data confidentiality while facilitating controlled access for healthcare professionals. The results highlight a significant improvement in trust and traceability in the exchange of medical data. Esposito et al. (2018) questioned whether blockchain is truly a "panacea" for the security and confidentiality of health data hosted in the cloud [4]. Their study emphasizes that, although blockchain improves data integrity and transparency, it must be combined with other mechanisms such as encryption and off-chain storage. The authors thus emphasize the need for hybrid approaches to address regulatory constraints. Agbo et al. (2019) conducted a systematic review of blockchain applications in the healthcare sector [5]. They identify several major use cases, including medical record management, the pharmaceutical supply chain, and clinical research. Their analysis nevertheless reveals significant limitations related to scalability, energy costs, and the absence of clearly defined regulatory frameworks. Casino et al. (2019) proposed a comprehensive taxonomy of blockchain applications across various sectors, including healthcare [13]. Their work highlights several technical limitations, such as latency, resource consumption, and scalability issues. Despite these constraints, the authors emphasize blockchain's strong potential to improve governance and transparency in healthcare systems. Dwivedi et al. (2019) presented a secure blockchain architecture designed for sharing medical data from connected devices (IoT) [15]. Their model relies on advanced cryptographic mechanisms aimed at ensuring patient anonymity and confidentiality. Theoretical results suggest improved resistance to attacks, although large-scale implementation remains limited. Rieke et al. (2020) explored the integration of blockchain with federated learning in the context of digital health [7]. Their study demonstrates that this combination enables distributed analysis while preserving the confidentiality of medical data. This approach appears particularly promising for environments subject to strict ethical and regulatory constraints.

Chamola et al. (2020) analyzed the combined role of blockchain, artificial intelligence, and the Internet of Things in managing the COVID-19 pandemic [14]. The authors highlight blockchain's contribution to traceability, combating misinformation, and securing health data. However, their study remains largely descriptive and calls for more in-depth experimental validation. Hasselgren et al. (2021) conducted a comprehensive review of blockchain applications in the fields of health and medical sciences [16]. The authors show that blockchain primarily contributes to improving traceability and trust in health data management. However, their analysis highlights that the majority of solutions rely on hybrid architectures and that the effectiveness of blockchain depends heavily on complementary security and governance mechanisms. Zhang et al. (2022) proposed an architecture combining blockchain and interoperability standards for the secure and traceable sharing of clinical data [17]. The results suggest that this approach improves the auditability and reliability of data used in medical decision support systems. However, performance and scalability constraints remain significant limitations. Al Omar et al. (2023) critically reviewed blockchain solutions applied to healthcare that have been published over the past decade [18]. Their analysis shows that, despite sustained growth in scientific research, the majority of systems remain at an experimental stage. The authors therefore call for more in-depth empirical evaluations under real-world conditions. Also, Siyal et al. (2024) provided a comprehensive review of blockchain applications in the healthcare sector [19]. Titus-Okpanachi et al (2025) explores work related to the integration of blockchain technology to enhance the efficiency, traceability, and security of blood supply chain management [20]. P, Kiran et al (2026) proposed a framework with two key features: a doctor verification system that ensures only authorized practitioners can access sensitive records, and a patient-centered reminder module to support timely management of appointments and medications. Their study highlights a growing diversification of use cases, particularly in medical record management and clinical research.

4. Methodology

This study was conducted in three (3) phases. Bibliographic data were collected from the Scopus database, totaling 12,817 publications between 2016 and 2026 including journals and conference papers. Data extraction was performed on 31st January 2026, using the following query: (("blockchain" OR "distributed ledger") AND ("health" OR "healthcare" OR "medical records" OR

'EHR' OR "electronic health records")). A preprocessing step was conducted on the retrieved data, where duplicate records are removed, bibliographic completeness are verified and authors names are normalized. The cleaned dataset was then analyzed using VOSviewer for network visualization [12] and RStudio with the Bibliometrix package in order to obtain quantitative overview about data for scientometric analysis and public performance evaluation [11]. These tools are chosen in review process as they provide a broader information about topic involved and enabled the exploration of publication trends, collaboration structures, and thematic clusters.

5. Results and discussion

5.1. Annual Research Output

The number of publications has been steadily increasing since 2018, reflecting the growing recognition of blockchain as a solution for securing healthcare systems and improving interoperability [3], [4].

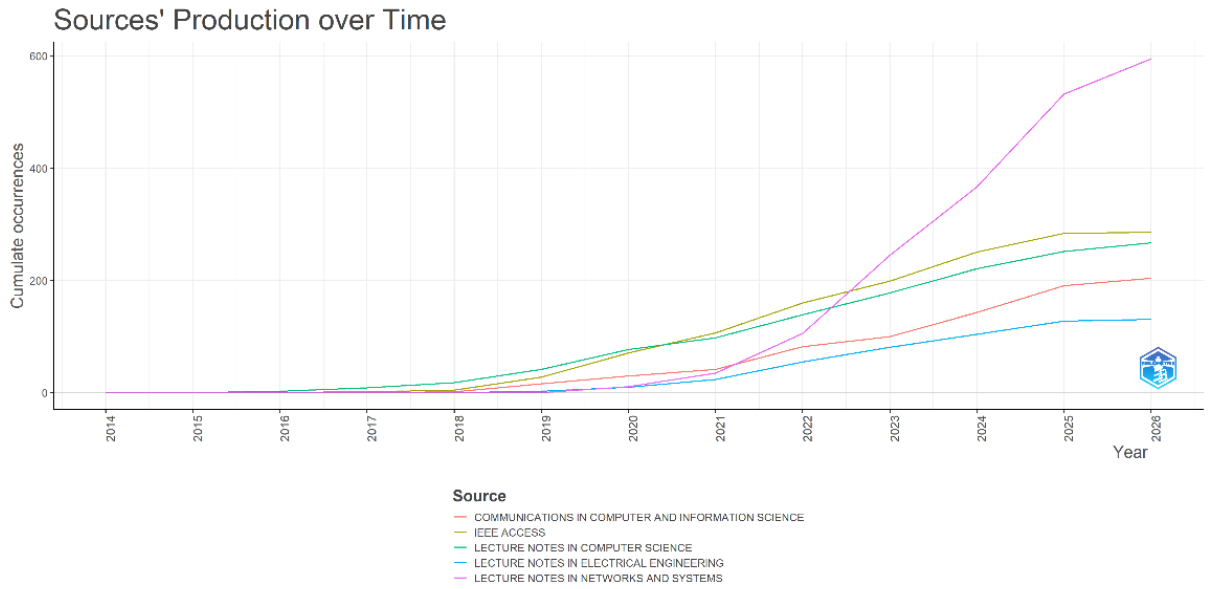

Figure 3: Annual Research production

Figure 3 illustrates the temporal evolution of cumulative scientific output from the main publication sources in the field under study. Moderate growth is observed through 2018, followed by a marked acceleration beginning in 2020, reflecting growing scientific interest in the topic. The journal IEEE Access stands out for its particularly rapid growth in recent years, confirming its central role as a channel for disseminating emerging research, while the Lecture Notes and Communications in Computer and Information Science series show more gradual but steady growth, reflecting a diversification of publication platforms.

5.2. Countries contributions and co-authorship

The countries contributions reveal the engagement of countries with respect to impacting the sector through scientific research and the collaborations existing between them.

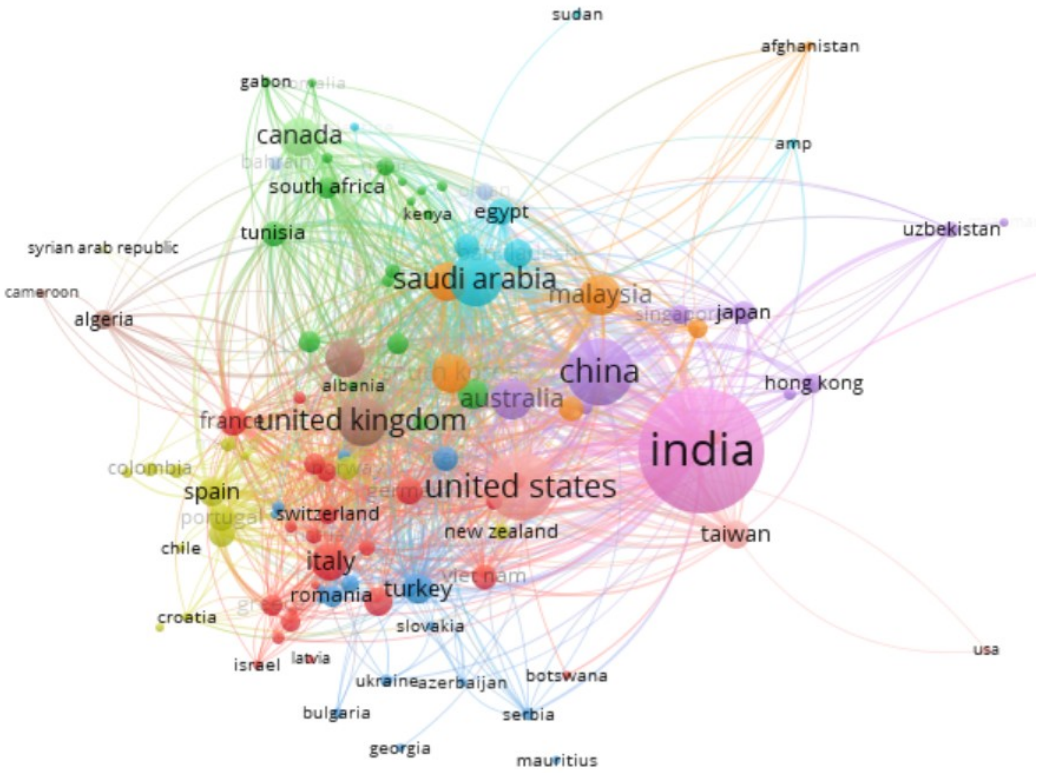

Figure 4: countries contributions and co-authorship

From figure 4, we can see that some countries have seriously taking the lead. India, United States and China are the most producing countries respectively while establishing relationship all over the word. Other countries such as Saudi Arabia, United-kingdom and Australia are followed. There is a densification around European countries which has established several collaborations. African countries show interest as several countries such as Tunisia, Algeria, Egypt, South Africa, Kenya and Cameroun have partnered with leading countries indicating African countries devotion to move forward in the field though there is still a lot to cover to improve upon the actual research achievement.

5.3. Author productivity and collaboration networks

The author productivity emphasizes the researchers that are really impacting the sector with their work and how they collaborate with each other to further improve upon the existing work. This is illustrated in figure 5.

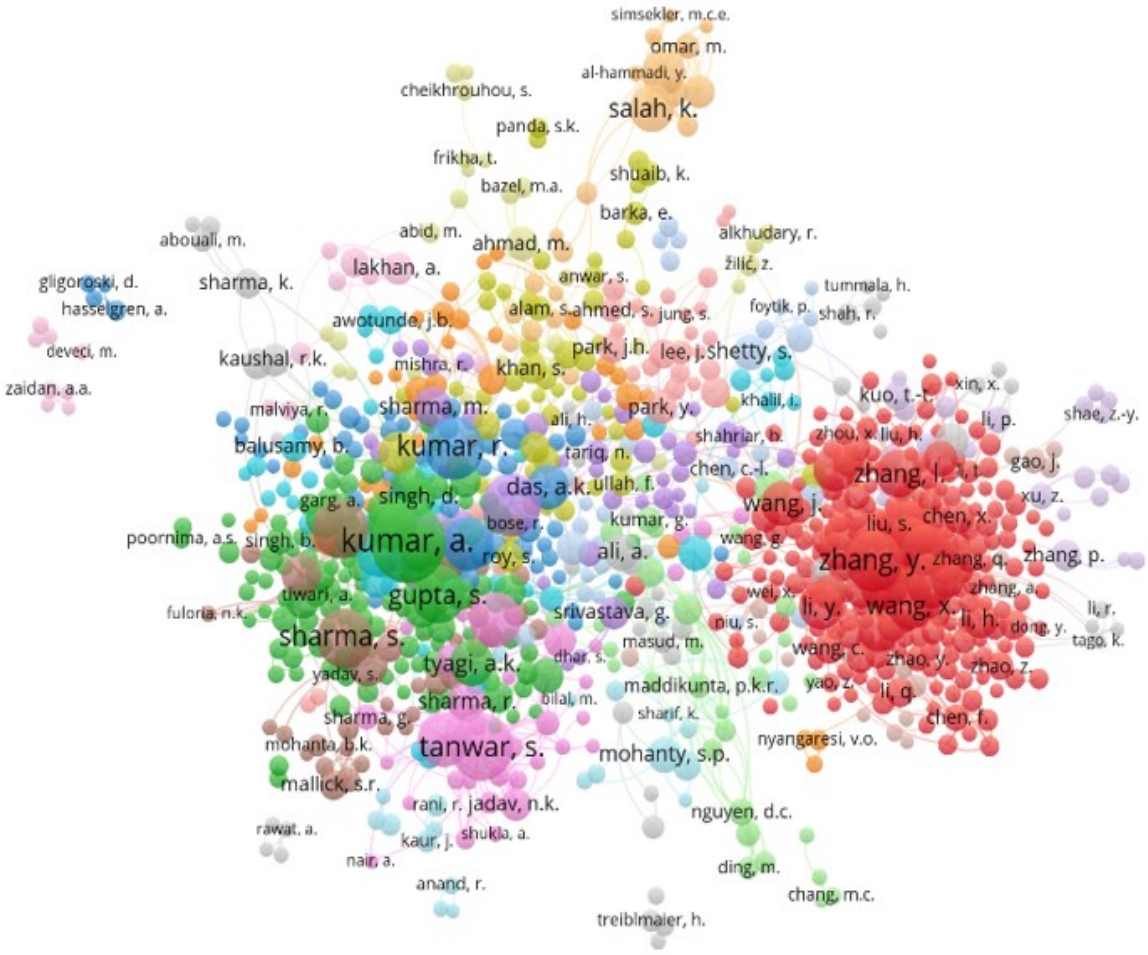

Figure 5: Author productivity importance and collaboration network

Figure 5 shows the authors of scientific papers and the network of collaboration among them in the field under study. Each node represents an author, while the links between these authors represent scientific collaborations through co-authored papers. The size of the nodes reflects the author's level of productivity in the field, and the different colors correspond to the various existing research communities. Upon closer inspection of the network, we can see that authors such as Kumar A, Wang X, Gupta S, Zhang Y, and Tanwar S are represented by large nodes, indicating high productivity and active collaboration with researchers. The red cluster is one of the densest and most active in the network. It is dominated by the Chinese researchers Zhang, Y and Wang, X and indicates intense output and sustained scientific collaboration. It is followed by the green cluster, dominated by Kumar A and Gupta S, which also demonstrates strong collaboration with other researchers through an influential scientific community. Note that we also have isolated and limited collaborations with few connections to the central network, which thus demonstrate a certain degree of scientific fragmentation.

5.4. Co-occurrence of keywords and thematic clusters

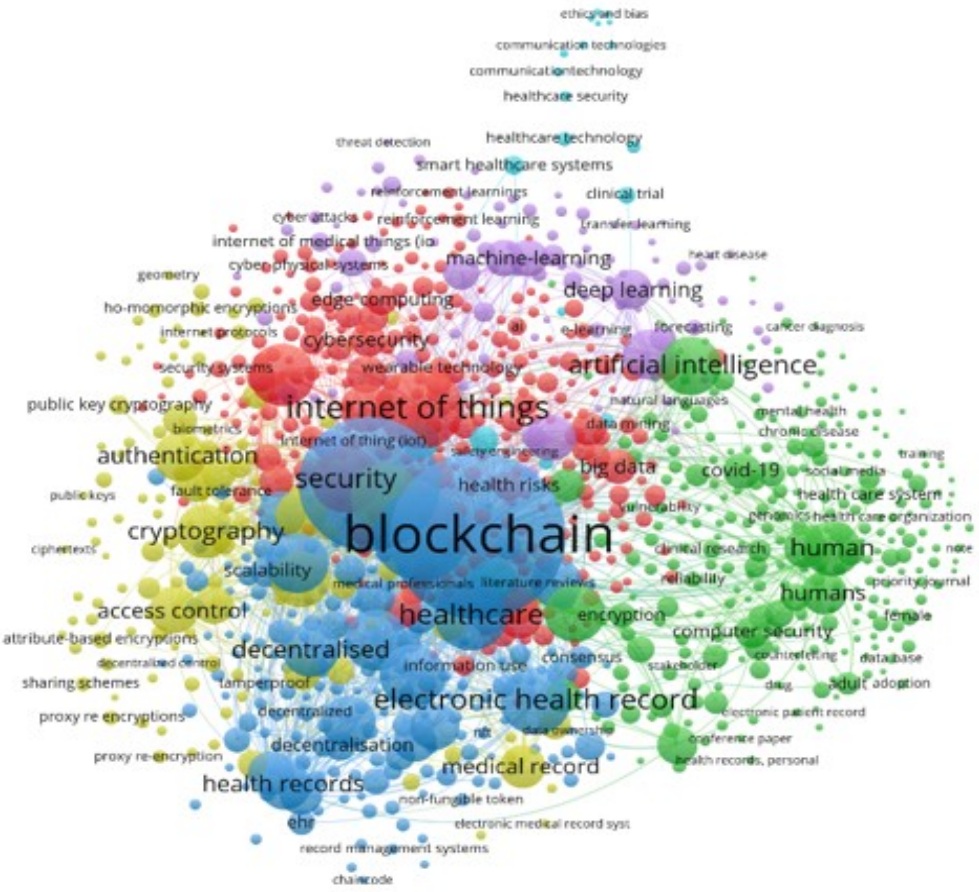

Figure 6: keywords and thematic clusters

Figure 6 highlights the thematic structure of the corpus under study through a co-occurrence map. The term "blockchain," positioned at the center and represented by a large node, emerges as the central concept around which the main research themes revolve. Concepts such as "healthcare," "electronic health record," "security," "Internet of Things," and "data protection" also occupy a central position, suggesting that they constitute major and well-established areas of focus within the field. Several colored clusters reveal key subthemes. The red cluster, dominated by security-related terms (authentication, cryptography, IoT security), underscores the importance of protection mechanisms in digital health systems. The blue cluster, focused on privacy and medical data management (health record, data privacy, trust), highlights growing concerns regarding the protection of sensitive data. The yellow cluster, focused on direct blockchain applications (smart contracts, distributed ledger), demonstrates the rise of decentralized solutions in the sector. Finally, the green cluster encompasses concepts associated with artificial intelligence (machine learning, deep learning, predictive analytics), illustrating the growing integration of advanced analytics technologies into the digital health ecosystem. Overall, this mapping reveals a landscape structured around four major areas: security, data protection, blockchain applications, and artificial intelligence. These themes are central to current scientific discourse, although they still require further exploration to reach full maturity, particularly with regard to their operational integration into healthcare systems.

5.4. The 10 Most Relevant Publications

Figure 7 below ranks the ten most-cited authors in the field, highlighting those who contribute most to the scientific literature on blockchain technology applied to healthcare. The most-cited author occupies a dominant position in the ranking.

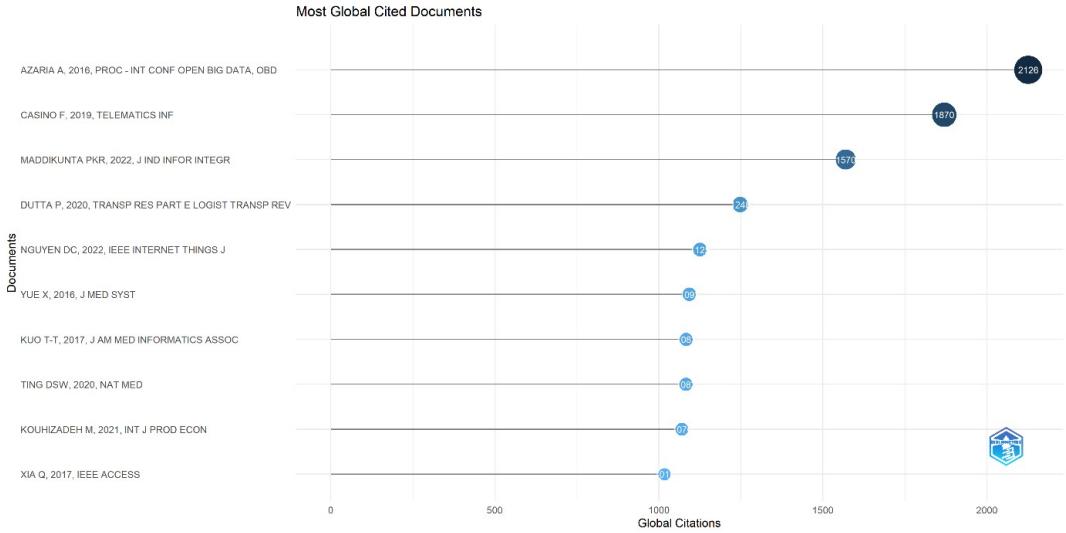

Figure 7: Most relevant Papers

5.6. Most Cited Articles in the Field

Table 1 presents the most cited articles in the field of blockchain applied to healthcare, serving as essential references for understanding the evolution of research in this sector. These works, whose major contributions focus on the security of medical data, the interoperability of information systems, and decentralized governance, provide a solid foundation for guiding future studies. Analyzing them helps identify the most promising technological approaches and pinpoint avenues suitable for developing innovative solutions for healthcare systems, particularly in African contexts where the need for transparency and efficiency is particularly required.

Table 1 : Most cited papers

PAPER	TOTAL CITATIONS	OBJECTIVES	COUNTRY / CONTEXT	METHODOLOGY	RESULTS	LIMITATIONS
STOYANOVA ET AL. (2020)	1110	Identify the major challenges in IoT forensics, analyze existing models, and propose a comprehensive overview of trends and emerging issues.	Germany & Greece	A systematic review of frameworks, legal standards, data collection techniques, and Forensics-as-a-Service strategies.	-Highlighting the lack of standardization. -The importance of blockchain technologies in maintaining integrity. -Identifying challenges related to device diversity and the volatility of evidence.	-Lack of hands-on experience. -A highly conceptual approach.
DWIVEDI ET AL. (2019)	1161	Propose a secure blockchain architecture for sharing medical data via the IoT while ensuring confidentiality and anonymity.	Poland, Canada, India	Design of a modified blockchain model and advanced cryptography (ring signatures, key management).	-Enhanced privacy and resistance to attacks. -Decentralized management of health data. -Optimized for resource-constrained IoT devices.	Theoretical implementation; not intended for large-scale real-world deployment.
MONRAT ET AL. (2019)	1459	Provide a comprehensive analysis of blockchain applications, technical challenges, and future prospects.	Sweden	A descriptive review and comparative analysis of consensus mechanisms, architectures, and application areas.	-Clear classification of use cases (finance, healthcare, industry). -Identification of challenges and future trends: scalability, energy, privacy.	-Does not provide an in-depth discussion of IoT implementations. -Does not propose a concrete experimental model.

CHAMOLA ET AL. (2020)	1386	Examine how emerging technologies can mitigate the impact of the COVID-19 pandemic.	India & Qatar	A multidisciplinary journal and analysis of technological applications in monitoring, diagnosis, and crisis management.	-The IoT's significant potential for real-time monitoring; Blockchain for traceability and combating misinformation; Effective AI for rapid diagnosis and modeling.	Lack of experimental validation.
XIA ET AL. (2017)	1453	Develop a blockchain system to share medical data between cloud providers without prior trust	China & USA	Design of a system based on smart contracts, access control, traceability, and immutable logging.	-Reduced risk of data misuse. -Improved auditability and governance. -Ability to automatically revoke access for malicious actors.	-Tests were conducted in a controlled environment, not on actual medical systems. -Scalability has not been evaluated.
TING ET AL. (2020)	1203	Examine how digital technologies (AI, IoT, big data, blockchain) can support the fight against COVID-19.	Singapore & USA	A critical qualitative analysis based on international observations and existing technological implementations.	-The importance of integrated digital ecostems; Use cases for telemedicine, digital tracking, and big data analysis; Blockchain identified as a guarantor of transparency and traceability	No detailed technical models.

KUO ET AL. (2017)	1763	Introduce blockchain concepts and assess their applicability in the biomedical field	USA	Comparative Analysis of Existing Blockchains and Review of Healthcare Use Cases	-Potential for interoperability, data security, and consent management; Identification of benefits compared to centralized databases.	The proposed solutions are still conceptual.
DUTTA ET AL. (2020)	1942	Assessing the applications, challenges, and opportunities of blockchain technology in supply chains.	India & Hong Kong	Review of 178 articles, taxonomy, and sectoral analysis (health, energy, agriculture, transportation).	-Significant potential to improve transparency and traceability; Identification of the sectors most affected; Proposal for a research agenda.	-No united model
CASINO ET AL. (2019)	3516	Classify and analyze all current blockchain applications and their limitations.	Greece	Systematic review and thematic classification (health, supply chain, IoT, business).	Development of a comprehensive taxonomy; Highlighting technical limitations: scalability, confidentiality, energy costs; Future trends identification	-Few empirical evaluations. -Data that is sometimes inconsistent.

The results show that blockchain research is shifting from conceptual frameworks toward practical implementations. Despite challenges related to scalability, regulatory compliance, and integration, a growing momentum is driving real-world adoption, supported by interdisciplinary collaborations.

6. Limits of the bibliometric study

This review covered blockchain applications in the health emphasizing benefits and drawbacks of the most interest articles. It provides a roadmap that might guide in the relevant areas to be explored. However, though it brings a glow in the sector, it still shows some shortcomings. First, only a single database is explored Scopus. This might limit the coverage important literature from others database. Since only scientific papers are explored, information from agencies or government, thesis and technical reports are not considered which can provide valuable information. Second, as the results of this study is obtained from string research followed by the use of different approaches in analyzing data, we might experience a publication bias as data enforcing the need to considers results with care and caution. Thrid, though it is not necessarily demanded in a bibliometric study, It would be more interesting to propose an architecture of a healthcare systems from the drawbacks of the best papers so as to improve the existing literature.

7. Conclusion and perspectives

This bibliometric analysis provides a structured understanding of blockchain research in healthcare. The results highlight a growing body of scientific output, influential contributors, and coherent thematic clusters. Asia, American and European countries are leading the sector while Africa still lagging behind though some efforts are being noticed on the continent. This study also emphasized the need for integrated approaches combining blockchain with other emerging technologies to meet the growing demands of modern healthcare systems. Thus, the effective adoption of blockchain will depend heavily on stakeholders' ability to overcome the technical, organizational, and institutional constraints identified in the literature.

For future perspectives, studies should be conducted regarding real-world deployments and develop governance frameworks that support secure, patient-centered digital health ecosystems. Furthermore, in developing countries as these challenges are exacerbated by infrastructural and regulatory limitations, work should be conducted in designing innovative solutions tailored to local contexts. Challenges remain regarding scalability, interoperability, and regulatory compliances but advances in cryptography, smart contracts, and artificial intelligent inclusion open up promising prospects which should also be explored.

Declaration on Generative AI

During the preparation of this work, the authors used chatGPT-5 mini for the following activities: language refinement, grammar corrections, and occasional structural suggestions. After using this 12tool, the authors reviewed and edited all generated content as needed and take full responsibility for the publication's scientific integrity and content.

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