

Exploring the Landscape of Blockchain in Healthcare: Addressing Challenges and Seizing Opportunities

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ABSTRACT

Patients and healthcare professionals in the present healthcare scenario face major challenges when it comes to the processes of obtaining, keeping records, integration practices, and securely sharing health records. There is an increasing need for people to have the right to control their medical records, have a complete record of their health issues, have the ability to securely collect data, and provide key information to doctors, which calls for a strong data exchange relationship. In addition, the availability of complete records of patient health data and the establishment of a stronger data-sharing system are vital in enhancing healthcare systems in dealing with emergencies like the COVID-19 pandemic. Such aspirations are often unfulfilled by today's healthcare technologies because of the fundamental inability of privacy, security, and interoperability issues of the ecosystem. Increasingly, blockchain technology has emerged as an innovative solution by offering a secure, distributed, and transparent mechanism for efficient data management. This research explores the role of blockchain technology towards the achievement of three critical goals: data quality, data sharing, and data sovereignty. This report shows that it's essential to adopt a joint approach in which the states enact the necessary legal regulations, healthcare institutions implement blockchain technology, and regulatory agencies establish requirements for compliance and scalability. Therefore, this way of working allows blockchain to be used for the digitalization of healthcare, improving a patient's situation, and equipping the sector to respond to a public health crisis more effectively.

Keywords: Blockchain, EHR, Supply Chain for Pharmaceuticals, Drug Traceability

1 Introduction

Healthcare data management and sharing are the key difficulties in today's healthcare issue. Traditionally, healthcare systems have faced many challenges for example limited interoperability between systems, fragmented data, data security and privacy concerns and more challenges in getting in sharing patient information among health care providers. All these obstacles restrict not only the provision of timely and high-quality care but also medical research, public health surveillance, and healthcare policymaking. However, blockchain technology has emerged as a disruptive breakthrough with a capacity to transform the range of many industries, including healthcare. Fundamentally, blockchain is a distributed, decentralized ledger technology that facilitates safe, open transactions without the need of an arbitrator. Blockchain in healthcare offers different useful advantages such as immutability, cryptographic security, transparency, and decentralization, which could address many of the current issues in healthcare data management and exchange. By introducing blockchain technology into healthcare systems, stakeholders can foresee a future



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in which patient data is securely store and shared amongst healthcare practitioners, researchers, insurers and patients. Blockchain technology enables the construction of a single, comprehensive source of truth for patient health records, ensuring data integrity, privacy, and interoperability. Furthermore, blockchain-based solutions can improve administrative processes, save healthcare costs, prevent fraud and abuse, and give patients more control over their health information. In the introduction, we hope to provide an overview of the issues which come with managing and sharing healthcare data, as well as showcase the potential of blockchain technology to address these challenges. [1].

2 Challenges in Healthcare Data Management

Due to fragmented systems, numerous formats, and poor interoperability of providers, patients often experience problems viewing their own health records. Healthcare practitioners face difficulty in acquiring complete and up-to-date patient information, resulting in missed opportunities in processes such as diagnosis, treatment, and coordination of care. These risks pose obstacles to the safe exchange of health records between patients and providers, including data privacy concerns, unintentional data leaks, loss of data, or inadvertent violations due to unauthorized access to or alteration of records. Limitations of existing healthcare technologies for addressing data privacy, security, and interoperability are Traditional healthcare IT systems frequently rely on centralized databases that are subject to security flaws, hacking, and data leaks. Current solutions in the field of health technology offer minimal protection against encroachments on the privacy of individual patients and their information. Interoperability inadequacies are attributed to the underlying issue of the adoption of proprietary standards and proprietary formats, thereby limiting the free movement of health data across systems and stakeholders. Legacy systems do not allow the use of new methods like the introduction of new information technologies such as AI, data analysis, and cloud storage, which would enhance the management and decision-making process of health information [2].

3 Opportunities for Blockchain in Healthcare

The incorporation of blockchain technology allows for the application of sophisticated encryption techniques on the health data that is stored in the system, rendering the health information secure and confidential in nature. Once the data is entered into the block, it becomes almost impossible to effect or change such a block, for every single entry is cryptographic, followed by linking it to previous blocks of information. Health care organizations are able to achieve better data security and integrity in health institutions through the use of the cryptographic characteristics of the blockchain technology, hence minimizing chances of information leakages, fraudulent activities, and sabotage of patient details [2]. In terms of data and information exchange, blockchain enhances interoperability by providing one integrated health data storage system for different users and other related units [3]. Healthcare companies can deploy smart contracts and protocols based on the blockchain to design fair and automatic systems for the exchange of data without relying on third parties and wasting time on data integration schemes. Trusting and safe sharing of data amongst health service providers, research scientists, insurers, and patients is possible with the use of the blockchain, hence supporting better decision-making, better and more targeted delivery of treatments, and improved recovery of patients [4].

4 Resilience during Public Health Crises, such as the COVID-19 Pandemic

Blockchain is the answer to ensuring access to critical health information while protecting the integrity of the healthcare system in times of public health emergencies. In times of crisis, such as the COVID 19 pandemic, blockchain-based platforms of health data records can facilitate quick and secure transactions of patients' information, medical histories, test results, and immunization records by medical practitioners and

public health agencies. Initiatives aimed at improving public health during epidemics or any other adverse occurrences to society are made efficient by blockchain because it provides real-time information on how effective the disease is spreading, the people infected, and what medical resources have been utilized [3].

5 Applications of Blockchain in Healthcare

With the assurance of sharing and storing patient records in a manner that is secure and would be unhackable, it is worth noting that the blockchain technology in healthcare has revolutionary use that promotes data sharing and improved data interoperability, as depicted in figure 1.

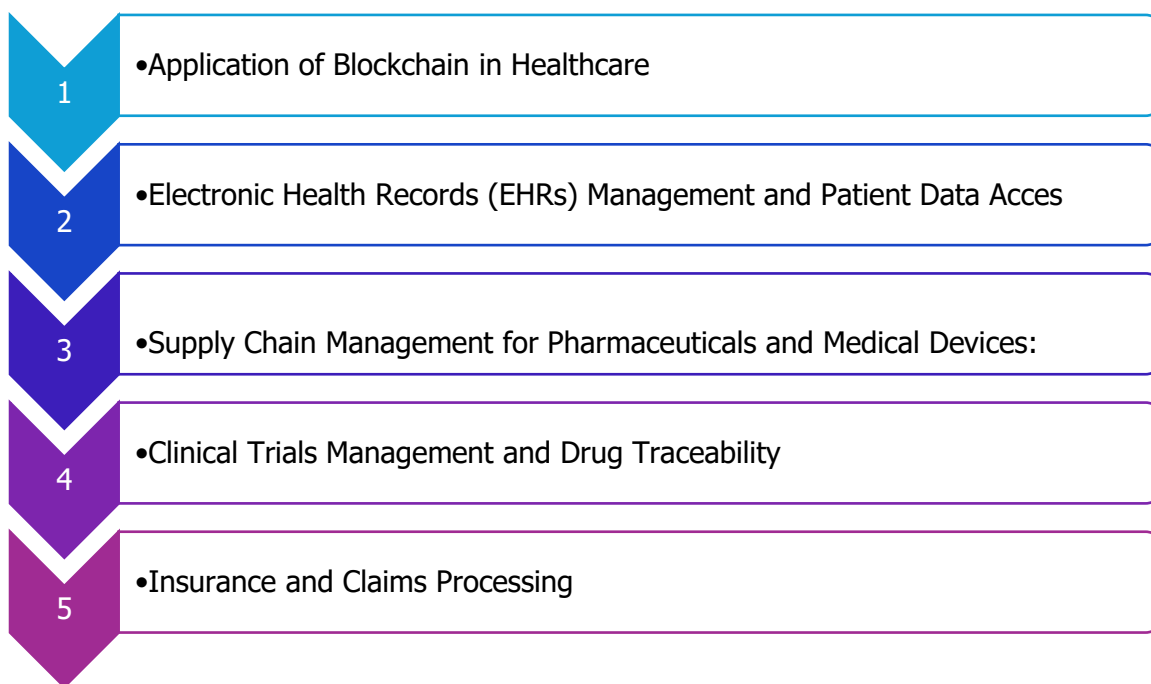


Figure 1: Applications of Blockchain in Healthcare

Blockchain offers the safe and decentralized storage of electronic health records (EHRs), allowing people to access and control their health data across multiple healthcare providers and systems [5]. Patients can offer healthcare professionals access to particular areas of their EHRs, protecting data privacy and confidentiality. Blockchain based EHR solutions improve data accuracy, integrity, and interoperability, resulting in more coordinated and tailored healthcare delivery [4]. Blockchain allows for transparent and verifiable supply chain management of pharmaceuticals and medical devices, starting from production to distribution and delivery. Each transaction or movement of products is tracked on the blockchain, giving stakeholders real-time information and visibility into the provenance, legitimacy, and handling of healthcare products. Blockchain can help prevent counterfeit medications, reduce drug recalls, assure regulatory compliance, and streamline inventory management procedures [6]. Blockchain streamlines clinical trial management by securely storing trial procedures, participant consent forms, and trial data on a tamper-proof ledger. Smart contracts on the blockchain streamline trial agreements, payments, and data exchange between trial sponsors, researchers, participants, and regulatory organizations. Blockchain improves medicine traceability by following the path of pharmaceutical items from production to consumption, assuring product quality, safety, and regulatory compliance. optimizes health insurance and claims processing by increasing administrative efficiency, transparency, and accuracy. Table 1 shows the difference between traditional and blockchain technology in addressing healthcare data management challenges. It Claims adjudication, verification, and payment are automated using blockchain smart contracts, lowering

processing times and minimizing errors and conflicts. Blockchain improves data security and privacy by allowing insurers, healthcare providers, and policyholders to securely share sensitive information [7].

Table 1: Difference between traditional healthcare IT systems and blockchain technology in addressing healthcare data management challenges

Aspect	Traditional Healthcare	IT Systems	Blockchain Technology
Data Storage	Centralized databases prone to security flaws and data breaches.	Decentralized, distributed ledger	ensuring data integrity.
Data Privacy	Limited measures for preserving data privacy.	Cryptographic security	ensuring privacy.
Interoperability	Limited interoperability due to proprietary standards and formats.	Seamless data sharing across systems	through standardized protocols.
Access Control	Centralized control, vulnerability to unauthorized access.	Decentralized control, enhanced security	with cryptographic keys.
Data Integrity	Vulnerable to tampering and manipulation.	Immutable records	ensuring data integrity.

6 Challenges and Future Directions

Adoption of blockchain in healthcare confronts regulatory and legal challenges, such as meeting data protection rules (e.g., GDPR, HIPAA) and adhering to healthcare standards and procedures. Clarification of regulatory frameworks and the adoption of industry-wide standards are critical for addressing issues such as data ownership, consent management, liability, and jurisdiction in blockchain based healthcare systems [8]. Public blockchain networks struggle to handle enormous transaction volumes while maintaining good performance. Improvements in blockchain scalability, such as sharding, sidechains, and layer 2 solutions, are critical to meeting the increased need for healthcare applications. Energy consumption linked with blockchain consensus algorithms such as proof-of-work (PoW) creates environmental issues. Transitioning to more energy-efficient consensus methods like proof of stake and optimizing blockchain protocols can help solve these concerns [9, 10]. Develop interoperable blockchain standards and protocols to integrate data across healthcare systems. Investigation into the combination of cutting-edge technologies like artificial intelligence, the Internet of Things (IoT), and decentralized identity management with blockchain can lead to new capabilities and use cases in healthcare. Collaboration among academics, industry, and regulatory agencies is critical for driving innovation, addressing technological obstacles, and developing best practices for the appropriate use of blockchain technology in healthcare [11].

7 Conclusion

This study has emphasized the great power of blockchain technology in tackling the key issues related to handling, sharing, and protecting healthcare data. With its decentralized and secure structure, blockchain can address long-standing problems like data fragmentation, privacy issues, and interoperability between different healthcare systems. The research concludes that blockchain technology can greatly enhance the security and privacy of health records, simplify data management processes, and facilitate seamless information sharing between healthcare providers and patients. A key discovery of this study is the importance of cryptography in blockchain, ensuring the protection of health data from unauthorized access and building trust and transparency in the healthcare industry. Moreover, blockchain brings significant

improvements to how data is shared and operational efficiencies in different healthcare organizations, promoting better collaboration and patient information sharing. This progress could lead to better decision-making, reduced errors in healthcare, and improved results for patients. Additionally, blockchain-based solutions could boost the strength of healthcare systems in times of public health emergencies like the COVID-19 pandemic by enabling safe and fast access to crucial health information. The current research has examined the existing use of blockchain in healthcare and its potential impact on industry transformation. Despite the advantages of blockchain, collaboration among healthcare organizations, government, and regulators will be required for successful implementation. These stakeholders need to work together to address legal and regulatory barriers, verify the scalability and performance of blockchain networks, and encourage continued research and innovation in healthcare solutions based on blockchain technology. Collaboration between these groups is essential for developing and implementing standardized methods for integrating blockchain technology, ensuring its smooth operation across different systems and regions. Ultimately, the adoption of blockchain technology has the potential to revolutionize various sectors.

8 Declarations

8.1 Competing Interests

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

8.2 Publisher's Note

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