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Issues in the Development of Blockchain Technologies in Electronic Health Record Architectures: A Scoping Review

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Abstract. Blockchain technologies (BT) offer transformative potential for healthcare data management, particularly in enhancing electronic health record (EHR) systems by addressing data security and ethical challenges. This study explores the barriers to integrating blockchain within EHRs. Through a review of eight key studies, we identified several critical challenges, categorized into ten primary areas, that hinder the incorporation of BT into EHR architecture. Findings from this scoping review highlight the complexity of embedding BT within EHR frameworks. Addressing these barriers will require coordinated efforts among healthcare professionals and policymakers. Further research is needed to develop practical solutions that maximize the benefits of blockchain while mitigating its limitations within EHR systems.

Keywords. Blockchain, Electronic Health Records, Challenges, Scalability, Privacy, Interoperability, User Experience, Data Integrity, Security

1. Introduction

Blockchain technologies (BT) have emerged as a transformative innovation with the potential to contribute to multiple sectors, including healthcare. The adoption of electronic health records (EHRs) has gained considerable traction, with the goal of enhancing patient care and improving data management. Nevertheless, conventional EHR systems encounter significant challenges, including data security, privacy, and interoperability issues. In this context, BT provide the possibility for a decentralized and secure framework that has the potential to mitigate these challenges [1-3].

This scoping review investigates the difficulties associated with integrating BT into the architecture of EHRs, offering a thorough overview of the existing research landscape.

2. Methods

The methodology selected for this study is a scoping review. Our objective is to examine existing research on BT in EHRs and to outline the associated challenges.

Systematic searches were performed across the three scientific databases (PubMed, IEEE, and Web of Science), using fixed search strings incorporating relevant keywords related to BT, EHRs. The specifics of the search strategies are detailed in Appendix 1. Studies published from 2015 till December 2023 were considered for inclusion. Only articles published in English and available in full text were included in this review. The exclusion criteria eliminated articles that did not specifically focus on BT within the context of EHRs or those that did not provide relevant insights into the associated challenges.

Data extraction and thematic analysis were conducted following a screening process based on established inclusion and exclusion criteria. Two researchers independently evaluated the retrieved articles‘ titles, abstracts, and full texts. A structured template was utilized to extract data from studies that met the inclusion criteria. In the event of any disagreements, a third researcher was consulted to facilitate resolution. The information extracted from each study included various aspects, such as study characteristics (e.g., first author, publication year, country, and study design) and the primary domains of challenges and their components.

3. Results

The search results and procedure for selecting relevant studies are illustrated as a PRISMA flow diagram in figure 1.

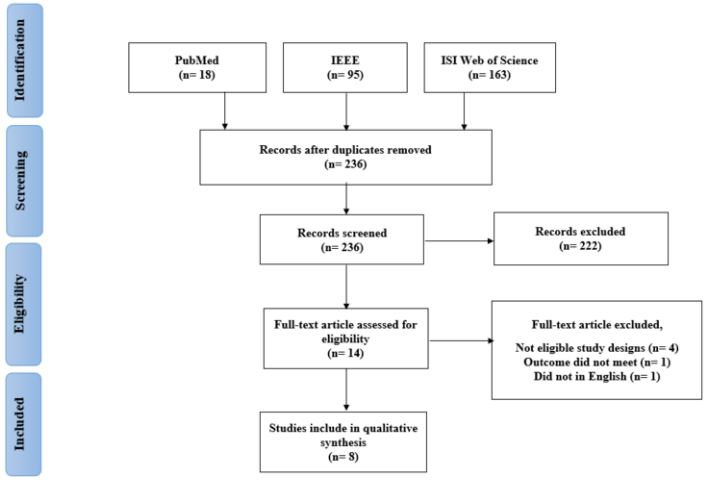

Figure 1. PRISMA Diagram of the Literature Search and Selection.

The results presented in Table 1 summarize the main challenges identified in integrating BT into EHR architectures and their key components. It is noteworthy that the studies placed particular emphasis on the security, interoperability, and scalability aspects of BT implementation. The focus was on ensuring robust privacy and confidentiality measures, as well as addressing the need for efficient handling of large volumes of healthcare data.

Table 1. Long caption. Long caption. Long caption. Long caption. Long caption. Long caption. Long caption. Long caption. Long caption

Main Challenge	Key Components
Scalability and performance issue	- Transaction processing speed [4] - Latency in data processing capabilities [4] - Blockchain type [4] - Latency and throughput restriction [8,2] - Limit on the "block size" and storage capacity [5]
Governance and regulation	- Potential distrust of health providers and patients [7] - Restricting the access to the blockchain [4] - Healthcare policies [4] - Access control Regulatory [2] - Regulatory data security concerns [2]
Energy consumption	- Deployment, infrastructure support of Blockchain, and power consumption (Infrastructure costs)[5] - Injustice and inequity in access and high energy demands [7] - High usage of energy [7] - Data Storage and Storage capacity [1,9] - Computing power and limitation [6] - Huge carbon footprint of computational needs [7] - Implementation, energy and operating costs [4]
Standardization and Interoperability	- Storing unimportant data - Standardization of the size of the data (File Size and File Type Limitations) [4, 2, 5] - Type and format of the data [4]
User Experience	- Adoption and Enticements for Stakeholders [4] - Ease of Use [1,8] - Lack of social skills [9]
Ethical consideration	- Ownership of blocks [4] - Rights on the blockchain network [4] - Records in the ledger and when does this ownership change [4] - Right to be forgotten, and deletion [5]
Privacy	- Patient privacy violations [5] - Privacy concerns of third parties [8]
Security	- Stability [2] - Data Validity [1] - Security concerns of third parties [8] - Confidentiality [1,9] - Robustness [2] - Data integrity [1] - Accessibility [1]
Authentication	- Patient identification [5] - Patient privacy violations and health Record access control (ownership) [2]. - Patient matching [3] - Access control [1]

4. Discussion

Examining the challenges of implementing BT in the architecture of EHRs highlights several critical considerations that must be addressed for successful integration. While blockchain technology presents significant advantages, such as improved data security, and can assist with some ethical concerns, it also faces numerous hurdles that could impede its effectiveness in healthcare settings.

One of the primary challenges is scalability and performance. The ability to efficiently process and manage the vast amounts of healthcare data generated daily is paramount. Without solutions to enhance transaction processing speed and reduce latency, the potential benefits of BT could be undermined [2,4,7-8].

Privacy and confidentiality are also major concerns. Given the sensitive nature of health data, implementing robust security measures is essential to protect patient information from unauthorized access. Techniques must be developed and refined to ensure that data remains private while being accessible to authorized users [5,8].

Interoperability and standardization further complicate the integration process. Achieving consensus on data models and standards is crucial for different systems to communicate effectively. This requires collaboration among stakeholders, including

healthcare providers, technology developers, and regulatory bodies, to establish frameworks that facilitate seamless data exchange.

Moreover, governance and regulatory compliance present additional challenges. As BT evolves, ensuring that it adheres to existing healthcare regulations and governance structures is vital. This includes addressing data ownership, access control, and compliance with privacy laws [2,4,7].

User experience cannot be overlooked. For BT solutions to be adopted effectively, they must be user-friendly and intuitive for healthcare professionals and patients alike. Ensuring that stakeholders are educated about the technology and its benefits will be critical in driving acceptance [1,4,8,9].

Energy consumption is a major concern with BT in general. The environmental impact of BT, particularly in terms of energy usage, must be evaluated. Solutions that minimize energy consumption while maintaining performance will be necessary [1,4-7].

Finally, ethical considerations surrounding BT must be addressed. Issues such as data ownership rights, the right to be forgotten, and equitable access to technology must be carefully considered to ensure that the benefits of blockchain are realized without compromising ethical standards [4,5].

In summary, while BT has the potential to transform EHR architecture by enhancing security, interoperability, and data management, its implementation is fraught with challenges. Addressing scalability, privacy, interoperability, governance, user experience, energy consumption, and ethical issues will be essential to harnessing the full potential of BT in healthcare. Collaborative efforts among stakeholders will be key to overcoming these hurdles and fostering the successful integration of BT into EHRs.

5. Conclusion

In conclusion, the successful integration of BT into EHR architectures hinges on effective collaboration among healthcare professionals, technologists, policymakers, and patients. By addressing the multifaceted challenges of scalability, privacy, interoperability, governance, user experience, energy consumption, and ethical

considerations, stakeholders can work together to unlock the full potential of BT. Continued research and innovation will be essential to overcoming these hurdles, ultimately leading to enhanced healthcare outcomes and improved data management.

Appendix 1.

The search string was constructed using Boolean operators and keywords relevant to the topic. The final search string used was: "Blockchain" AND (("healthcare") OR ("health")) OR (("health record") OR ("EHR") OR ("PHR") OR ("medical record") OR ("EMR")). This search string aimed to retrieve articles that specifically discussed blockchain technology in the context of healthcare, including terms related to electronic health records (EHRs) such as "health record," "PHR," "medical record," and "EMR".

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