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SYSTEMATIC REVIEW

Blockchain in the health sector: a systematic literature review of success cases

Blockchain en el sector de la salud: una revisión sistemática de literatura sobre casos de éxito

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ABSTRACT

In the context of digital transformation, Blockchain technology offers a potential solution to the problems of interoperability, data privacy, and resource optimization. This innovative technology has the ability to address these challenges and radically revolutionize health systems. This document will examine the potential of blockchain technology in the healthcare sector and how it can be the key to overcoming current obstacles. The study follows the PRISMA methodology. The review included 10 studies that were selected based on their relevance to the application of Blockchain in healthcare. The studies were primarily focused on the development and implementation of Blockchain solutions in the health sector, with a particular emphasis on areas such as data security, supply chain management, and data sharing. A comprehensive overview of the current state of Blockchain applications in the health sector is provided, including the benefits and challenges associated with its implementation.

Keywords: Application of Blockchain; Blockchain Technology; Health.

RESUMEN

En el contexto de la transformación digital, la tecnología Blockchain ofrece una solución potencial a los problemas de interoperabilidad, privacidad de datos y optimización de los recursos. Esta tecnología innovadora tiene la capacidad de abordar estos desafíos y revolucionar los sistemas de salud de manera radical. Este documento examinará el potencial de la tecnología blockchain en el sector sanitario y cómo puede ser la clave para superar los obstáculos actuales. El estudio sigue la metodología PRISMA para revisiones sistemáticas. La revisión incluyó 10 estudios que fueron seleccionados en base a su relevancia para la aplicación de Blockchain en la atención médica. Los estudios se centraron principalmente en el desarrollo e implementación de soluciones de Blockchain en el sector de la salud, con un énfasis particular en áreas como la seguridad de los datos, la gestión de la cadena de suministro y el intercambio de datos. Se proporciona una visión general completa del estado actual de las aplicaciones de Blockchain en el sector de la salud, incluyendo los beneficios y desafíos asociados con su implementación.

Palabras clave: Aplicación del Blockchain; Tecnología Blockchain; Salud.

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INTRODUCTION

Digital transformation in healthcare is the process of integrating technology in all areas of the healthcare sector in order to improve the quality, efficiency, and equity of care. Digital transformation involves using tools such as telemedicine, artificial intelligence, the Internet of Things (IoT), Big Data, and Blockchain.[1,2,3,4]

Blockchain can contribute to digital transformation in healthcare and even revolutionize systems. It is a technology that enables the creation of immutable and decentralized digital records, facilitating healthcare information's interoperability, security, and transparency.[1,2,5,6,7]

Blockchain technology, based on decentralized and secure data management using encrypted blockchains, offers numerous advantages and applications in various sectors, including healthcare.[8,9] The healthcare sector is characterized as a dynamic and complex field, which requires efficient and reliable solutions to handle large volumes of sensitive information, ensure the quality and security of services, and improve the accessibility and transparency of processes.[10,11,12]

Some challenges facing the healthcare sector are the interoperability of information systems, protection of patient privacy, traceability of products and services, and optimization of resources and costs.[13,14] In this context, the Blockchain emerges as an innovative and disruptive technology that can bring significant benefits to the healthcare sector.[15]

These benefits include improving digital identity management, facilitating access to and sharing clinical data, automating smart contracts, preventing fraud and counterfeiting, and incentivizing stakeholder participation and collaboration.[16] However, the Blockchain presents challenges and limitations like scalability, compatibility, regulation, governance, and social acceptance.[17,18,19,20] The present study aims to describe the results of success stories of Blockchain applications in the healthcare sector. For this purpose, a systematic review was conducted, and a rigorous and transparent methodology was followed based on eligibility criteria, search, selection, evaluation, and analysis of relevant scientific publications on the subject.

METHOD

A systematic literature review was conducted by applying the established methodology PRISMA[21,22,23] (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The review aims to synthesize published scientific information on the results of the implementation of Blockchain technology in healthcare systems, from the analysis of the advantages and challenges of adoption and the success stories reported in the literature.

The systematic literature review was conducted by addressing the following research questions (PI):

PI 1: What are the outcomes of the development of Blockchain solutions in the healthcare sector?

This question seeks to understand the impact and outcomes of implementing Blockchain technology in healthcare. It addresses efficiency, data security, and interoperability between different healthcare systems.

PI 2: At what stage is the application of Blockchain technology in the healthcare sector currently: in the modeling phase or implementation?

The purpose of this question is to identify the stage of development of Blockchain technology applied to healthcare.

PI 3: What are the possible areas of healthcare that would benefit from implementing Blockchain technology?

This question aims to identify the prospects for research in this area and the areas of most significant interest for implementation.

Search strategy

An information search was developed in different bibliographic database systems and search engines, such as Scopus, Dialnet, Scielo, Redalyc, LILACS, and Pubmed/Medline. The following search terms were used: "Blockchain," "Blockchain," "Health," and "Health." The results were refined using filters to simplify the number of results to a considerable number for a more detailed review of the retrieved sources.

After refining the search results in the databases above and discarding duplicate articles, 723 studies were considered for the review, which were checked for compliance with the inclusion and exclusion criteria set out below:

Study selection

The study included scientific articles published in academic journals on developing Blockchain solutions in healthcare systems, applications, benefits, experiences, and implementation success stories. Publications in English or Spanish conducted between 2018 and 2023.

Articles with no points of contact with the application of Blockchain to healthcare, articles approached from an overly personal and impractical perspective, and literature review or systematic review research were excluded.

After applying the selection criteria, the sample was adjusted to focus exclusively on those articles that provide information relevant to the proposed objective.

By the established criteria and after review of the titles, 665 articles were eliminated in the screening phase for not being directly related to the objectives of this study, leaving 36 for evaluation. On reading the abstract and full text, 40 were discarded for needing to be within the health context or for not having significant results to mention in the study. As a result, ten studies were selected for review (figure 1).

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Figure 1. Flow chart according to PRISMA methodology

RESULTS AND DISCUSSION

Of the studies included in the review, the most frequent were those developed in the United Arab Emirates (n=3, 30 %), followed by China and India (n=2, 20 % respectively), and to a lesser extent Italy, Vietnam and the United Kingdom, with only one study each. The UK study was conducted in collaboration with the United Arab Emirates.

The methodology applied by the studies focused on applied technology development research. 40 % of these have experimental or simulation phases of Blockchain technology application. One of the studies had a methodology based on modeling.

Table 1. Characteristics of the studies selected for the review

Author	Country	Methodology	Modeling/ Implementation	Results
Wang et al.[24]	China	Applied research for technological development, with experimental phase	Modeling	The study proposes a secure and traceable data-sharing scheme based on Blockchain. The scheme uses attribute encryption to protect data and enable fine-grained shared access. The scheme combines on-chain and off-chain data storage, using the Interplanetary File System (IPFS) to store the encrypted data and the Blockchain to store the hash value of the encrypted data. The scheme employs a clever contract-based record-tracking mechanism, which stores the data-sharing records in the Blockchain and displays them visually. Experimental results show that the scheme can effectively secure data, track the identities of both parties sharing data in real-time, and guarantee high data throughput.
Singh et al.[25]	India	Applied research for technological development, experimental	Implementation	The study uses benchmarking to evaluate the proposed system's performance under different scenarios and control parameters. The results show that the proposed system can effectively secure data, track the identities of both parties sharing data in real-time, and ensure high data throughput. The results also show that the proposed system has lower latency, higher throughput, and lower resource utilization than existing systems.
Majdalawieh et al.[26]	Arab Emirates	Applied research in technological development, experimental	Implementation	The study proposes a Blockchain and IoT-based framework to regulate and monitor the functioning of the poultry processed food supply chain industry and improve the safety and quality of food products delivered to the end consumer. The study uses Ethereum smart contracts to develop a transparent, reliable, and tamper-proof food supply chain framework. It ensures the integrity of supply chain transactions by eliminating a central authority.
Omar et al.[27]	Arab Emirates, United Kingdom	Applied research in technological development	Modeling	This paper presented a Blockchain-based approach using smart contracts to transform personal protective equipment supply chain operations in the context of the COVID-19 pandemic. Adopting a Blockchain-based solution for personal protective equipment supply chains is economically viable and provides a transparent, secure, and reliable mode of communication between the various stakeholders.

Jayaraman et al.[28]	Arab Emirates	Applied research for technological development	Implementation	It explores how Blockchain technology combined with the Internet of Things (IoT) can improve traceability and visibility of products in the healthcare supply chain. The study highlights critical challenges related to healthcare supply chains and how IoT and Blockchain technologies can play a role in overcoming these challenges. The study focuses on the implementation phase and presents favorable results in applying the technology.
Wang et al.[29]	China	Applied research of technological development	Implementation	The study proposes a Blockchain-based medical waste supervision model that connects the participants involved in the process, introduces digital credentials to protect the privacy of operator information, and ensures that the entire data process is authentic and credible. In addition, physical credentials and certificates are digitized using digital credentials to achieve cryptographic security and privacy protection. It can provide authoritative evidence for the supervision and accountability of medical waste disposal and support the construction of a new regulatory information system in China.
Chiacchio et al.[30]	Italia	Applied technology development research	Implementation	The study focuses on the implementation phase and presents the results obtained. The study proposes a decentralized solution based on nonfungible tokens (NFT) that can improve the tracking and tracing capability of the standard serialization process. The nonfungible tokens are minted on the blockchain and inherit all the advantages of this technology. The study presents the concepts and architectural elements needed to support the nonfungible token solution, culminating in presenting a use case with a prototypical application.
Li et al.[31]	China	Modeling study	Modeling	The results obtained include the construction of a Traditional Chinese Medicine (TCM) quality safety traceability system based on Blockchain technology, which can complete the omnidirectional, multi-angle, and comprehensive coverage of data and information in the whole TCM supply chain and realize that the main body of TCM responsibility can be recorded, production records can be queried, product flow can be traced, quality safety can be predicted, primary responsibility can be identified, regulatory information can be shared, and product source can be traced.
Pandey et al.[32]	India	Applied research for technological development, with simulation phase	Modeling	The study proposes a Blockchain-based solution to record the logistical requirements of medicines in the Blockchain network, from manufacturing to the patient. If, at any stage, a counterfeit drug is introduced into the system, it will be immediately detected, and further penetration will be stopped. The system is simulated using a hyperledger fabric platform. The results show that the system formed is computationally intensive but offers a reliable solution to the problem of counterfeit drugs.
Le et al.[33]	Vietnam	Applied research for technological development	Modeling	The study proposes a Blockchain-based system called BloodChain to support blood information management by providing more detailed information about blood, such as blood consumption and disposal. BloodChain exploits private Blockchain techniques with a limited number of relatively fast and reliable participants, making them suitable for B2B (business-to-business) transactions. They also developed a proposed system based on Hyperledger Fabric architecture. The evaluation of BloodChain is performed in several scenarios to demonstrate the effectiveness of their proposed model.

The development of Blockchain-based solutions in the healthcare sector has shown promise and benefits in various ways, according to the studies compiled in table 1. These solutions have addressed various challenges in the healthcare industry, from data management to the medical supply chain.

Several studies have highlighted the ability of Blockchain-based solutions to improve data security and privacy in the healthcare industry. Wang et al.[24] and Singh et al.[25] have proposed schemes that use advanced encryption methods and attributes to protect medical data, enabling controlled shared access. These approaches effectively secure data and track the parties' identities in real time.[34] This is essential to ensure the confidentiality and authenticity of sensitive medical information.[35,36]

In addition, the medical supply chain has seen significant improvements through Blockchain. Majdalawieh et al.[26] and Omar et al.[27] have presented Blockchain and IoT-based frameworks for regulating and monitoring processed food and personal protective equipment supply chains. These approaches not only improve the transparency and reliability of the supply chain but also eliminate the need for a central authority, reducing the possibility of manipulation and fraud.

In traceability, Jayaraman et al.[28] and Li et al.[31] have explored how the combination of Blockchain and IoT can improve the visibility and traceability of medical products in the supply chain. These studies highlight the ability of these technologies to overcome critical challenges in healthcare supply chains and provide positive outcomes in practical application.

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Medical waste management has also been addressed through Blockchain-based solutions. Wang et al.[29] propose a medical waste monitoring model that connects participants involved in the process, introducing digital credentials to protect the privacy of operator information.[37] This ensures data authenticity and provides authoritative evidence for medical waste disposal monitoring and accountability.

In drug quality and traceability, Pandey et al.[32] propose a Blockchain-based solution for recording drug logistical requirements, ensuring immediate detection of counterfeit drugs in the system. This approach, although computationally intensive, offers a reliable solution to the problem of counterfeit drugs.

In addition, Chiacchio et al.[30] present a decentralized solution based on non-fungible tokens (NFTs) that improves the track-and-trace capability of the standard serialization process in the healthcare sector.

The results of these studies suggest that the development of Blockchain solutions in the healthcare sector has positively impacted data security, supply chain efficiency, medical product traceability, and waste management. These solutions offer an innovative and promising approach to address current challenges in the healthcare industry, improving the quality of care and trust in healthcare-related processes.[38] As technology evolves, advances in the healthcare sector are likely to be evident.

The application of Blockchain technology in the healthcare sector is in phases, both modeling and implementation:

Modeling Phase

Two of the studies focused on this phase of implementation. Wang et al.[16] from China present a technology development and experimental phase study focusing on modeling a Blockchain-based secure data-sharing scheme. Singh et al.[17] from India, focusing on implementation, also use benchmarking to evaluate the proposed system's performance, which involves a modeling phase.

Implementation Phase

In UAE, a Blockchain and IoT-based framework for regulating and monitoring the processed food supply chain is presented, highlighting a practical implementation.[26] Another study proposes an innovative contract-based approach to transform personal protective equipment supply chain operations, clearly indicating an implementation phase.[27,39] Favorable results are also presented in improving product traceability and visibility in the healthcare supply chain.[28,40]

The study by Wang et al.[29] in China proposes a Blockchain-based medical waste monitoring model, also focused on practical implementation. There is also evidence of building a Traditional Chinese Medicine quality assurance traceability system based on Blockchain technology.[31]

Chiacchio et al.[30] from Italy focus on implementation, presenting results obtained using a decentralized solution based on non-fungible tokens (NFT).

Other studies performed the implementation for experimental purposes and with favorable results.[41,42] Pandey et al.[32] propose a Blockchain-based solution for recording drug logistics requirements, indicating a practical implementation in the simulated system. On the other hand, Le et al.[33] from Vietnam propose a system called BloodChain to support blood information management, focusing on the modeling phase but developing a proposed system based on Hyperledger Fabric architecture.

The above shows that the application of Blockchain technology in the healthcare sector is at different stages, with some studies focusing on modeling and others on practical implementation. This indicates a variety of approaches in the development of Blockchain-based solutions to address various problems in the healthcare industry, with evidence of beneficial outcomes for the quality of healthcare systems.

CONCLUSIONS

Exploring the application of Blockchain technology in the healthcare sector reveals a diversity of studies and developments that demonstrate the potential to transform and improve several crucial aspects of the sector. From secure medical data management to improving the supply chain of inputs, Blockchain technology shows promising results in efficiency, security, and transparency.

FINANCING

None.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTION

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