Mesopotamian journal of Cybersecurity
Vol.5,No.1, **pp**. 78–89
DOI: https://doi.org/10.58496/MJCS/2025/006; ISSN: 2958-6542
https://mesopotamian.press/journals/index.php/cybersecurity

Research Article

Exploring the Impact of Blockchain Revolution on the Healthcare Ecosystem: A Critical Review

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ARTICLE INFO

Article history
Received 17 Oct 2024
Accepted 10 Jan 2025
Published 04 Feb 2025

Keywords
Blockchain
Healthcare
Digitization
Medical records
Bigdata

ABSTRACT

Blockchain technology is a type of distributed ledger that provides secure and efficient storage, management, and transmission of data over a decentralized network. With its ability to ensure transparency and immutability, blockchain is increasingly adopted across various sectors ranging from finance, healthcare, and logistics to education. In healthcare, blockchain technology is attracting attention because of its potential to fundamentally transform health ecosystems. The healthcare sector has significantly benefited from blockchain technology by enhancing data security and interoperability and reducing medical errors. In this context, a set of studies highlighted the importance of blockchain in the field of healthcare, enhancing trust and security in the exchange of data and preventing unauthorized access. The article also studies the meaning, structure, function, types, and areas of use of blockchain technology and discusses the distribution of medical products in supply chain management. This article concludes that blockchain technology is highly important for storing health records, enhancing patient privacy, protecting patient data, and allowing the secure sharing of these data with physicians and healthcare workers.

1. INTRODUCTION

Increasing digitization has changed various aspects of modern life and the business world, as CEOs constantly strive to simplify their jobs and enhance efficiency [1][2]. Nearly 61% of business leaders now rely on digital tools to carry out their missions, access their strategic priorities, and benefit from their services [3][4]. This trend reflects the growing recognition of the advantages of digital transformation, as it will increase productivity, reduce costs, and increase flexibility in response to market changes [5-7]. As such, organizations must stay abreast of the latest digital trends and tools to remain competitive in today's fast-paced business environment. The COVID-19 pandemic forced the world into digital transformation, and these operations became critical as businesses and others were carried out digitally. The COVID-19 pandemic has emphasized the importance of using digital transformation processes in many areas, and companies and organizations must adapt to digital strategies and online communication [8-12]. This has led to a significant acceleration of digitization in many areas where companies and institutions rely on digital technologies to maintain and complete their operations with ease and safety [14][15]. As a result, this pandemic has strengthened the need for organizations to invest in digital infrastructure and capabilities to ensure their resilience and agility in the face of future troubles [16][18]. Figure 1 shows an overview of how

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the blockchain works [19][13]. Blockchain technology enables easy health data sharing between patients and physicians by incentivizing patients to share their data, simplifying healthcare services, and reducing their time and effort. It provides reliable platforms that help patients receive instructions from their doctors. This technology requires investments, providing compliance rules and updating local regulations in patient data management[17]. To implement these strategies, healthcare institutions must train their medical staff to use modern technologies and artificial intelligence. This technology provides an important strategy to reduce the spread of counterfeit drugs, improve data exchange, and prevent tampering and hacking. The most important challenges associated with this technology are cost, data volume, and scalability [20-26].

Blockchain technology is utilized in healthcare services by placing the patient at the center of the healthcare ecosystem; ensuring the security, transparency, and interoperability of healthcare data; and supplying healthcare workers with patient details via the internet[29][32]. Blockchain technology contributes to the development of the traditional healthcare approach by providing health organizations with strategies for big data analysis, the internet of Medical Things (IoMT) and 5G technology. Blockchain technology has a practical effect on the growth of the healthcare domain because it significantly improves clinical research management, regulatory compliance, and the sharing of electronic health records in a decentralized framework. Moreover, this technology has practices in transforming the healthcare industry by improving data security, ensuring the integrity of health data and information to healthcare workers, preventing unauthorized access, and addressing cyberattacks by preventing tampering with patient records. This technology can also improve data interoperability by enabling seamless data exchange between different healthcare providers and systems[36][40]. This can help improve care coordination, reduce errors, and facilitate more efficient and accurate billing and reimbursement processes. This technology is expected to revolutionize the healthcare industry by improving data management, privacy, and security. This is accomplished by sharing private medical data securely, storing clinical trial data, monitoring the movement of medicines and medical supplies, managing medical records, and allowing patients to control and see their data. Moreover, this technology assists healthcare providers in accessing accurate and up-to-date patient information and monitoring their health status through the internet[44][48]. The use of this technology in the healthcare domain has the potential to enhance patient outcomes, increase efficiency, and reduce costs in the pharmaceutical and medical supplies industry. However, some challenges, such as regulatory and legal issues, interoperability with existing systems, and stakeholder adoption, need to be addressed.

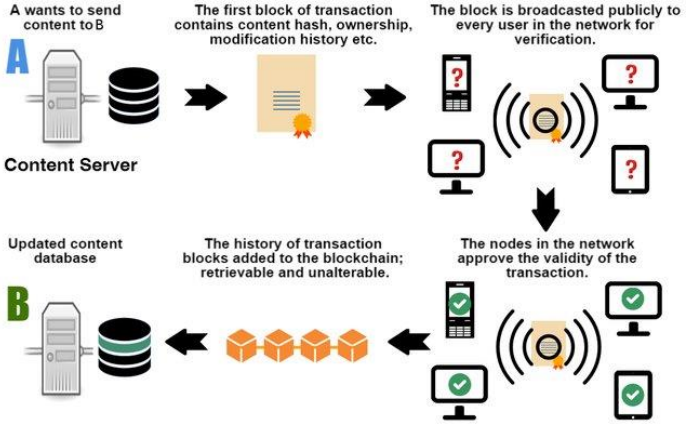

Fig. 1. Overview of the blockchain working principle.

This article presents a literature review on the use of blockchain technology in the healthcare domain, highlighting its potential benefits and key findings from previous studies. By examining a range of relevant literature, this article provides a detailed overview of blockchain technology, including its structure, scale, and types, as well as its growing importance in healthcare services[51][55]. Through this review, the vital role that blockchain technology can play in enhancing healthcare data security, interoperability, and efficiency while enhancing patient autonomy and privacy is outlined. The effects of this study emphasize the need for healthcare providers to design policies to utilize this technology as a transformational tool to strengthen healthcare delivery and outcomes.

2. BLOCKCHAIN TECHNOLOGY

In 2008, Satoshi Nakamoto, the founder of Bitcoin, introduced the term "blockchain" in a white paper [27][28]. Nakamoto's paper defined blockchain as the foundational technology that underlies Bitcoin. Blockchain is a distributed ledger system that records transactions securely and transparently, making it a powerful digital transaction tool. Since its inception,

blockchain has been adopted in various industries for objectives beyond cryptocurrencies, such as supply chain management, healthcare, and voting systems. In its simplest form, a blockchain is a computer file used to store data and information. Like any computer file, it is on a digital storage medium and takes the form of a string of binary "bits", ones and zeros, which computers can process so that humans can read them. This technology is based on a decentralized system where online payments in Bitcoin and other virtual currencies are sent directly from the sender to the recipient, without the middleman of a financial institution. It is a distributed ledger technology that enables secure and transparent peer-to-peer transactions. It works by grouping transactions into interconnected blocks, which are then added to a decentralized digital ledger that is maintained and proved by multiple nodes (peers) in the network. Once added to the blockchain, transactions are immutable, suggesting that they cannot be altered or deleted without consensus from the network. In a decentralized system such as blockchain, data are distributed across a network of nodes, ensuring redundancy and resilience. This means that multiple copies of the same data are stored on various nodes, which helps to prevent data loss or corruption. Additionally, blockchain uses encryption techniques to protect the data from unauthorized access or tampering. Unlike traditional centralized systems where a central authority validates transactions, blockchain uses a consensus mechanism to validate and record transactions. This is typically done by miners, who are incentivized to contribute computing power to the network in exchange for rewards such as cryptocurrency. Instead, miners compete to solve difficult mathematical issues that allow them to add new blocks to the blockchain and validate transactions. This decentralized validation approach assists in preventing fraud and makes a more transparent and trustworthy system.

Miners try to decrypt the encrypted algorithm with their own processing power, ensuring the validity of the transactions. The solutions of these encrypted algorithms are very complex, but they can be easily verified. Thus, a reward is transferred to each miner participating in the solution and verification after the miners verify the transaction. Blockchains have three properties that, when combined, work very differently on other types of computer files. The first property, blockchain, is a distributed system, which means that a specific file is replicated and stored on many computers across a network. This allows many people to access files over the internet and consider them, ensuring that the data are transparent and widely accessible. The second property, blockchain, uses encryption to secure the data that make up the chain. This ensures that only the individual who possesses private keys corresponding to the correct "block" in the chain can modify the data. Encryption is employed to ensure that the data are tamper-proof and secure. The third property, access to the blockchain, is permissionless, meaning that anyone within a specific network can access and monitor the file in its unencrypted form. However, to make changes to the file, the person must prove that they have the right to do so by employing tokens. These tokens act as digital signatures and provide proof of ownership and authenticity.

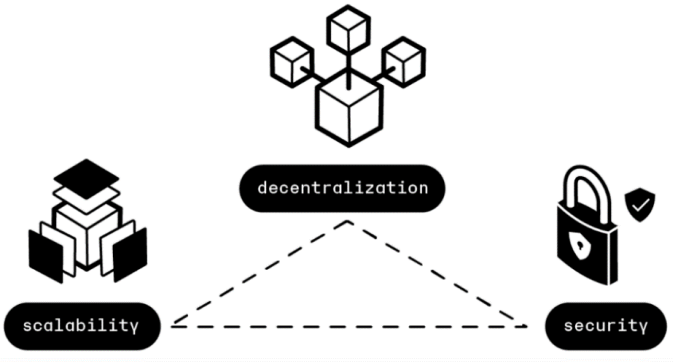

Fig. 2. The three main characteristics of a blockchain [30].

Blockchain sustains decentralization, which is the ability to perform, record, store, and update transactions between any two peers without the need for verification through a centralized organization (for example, a central bank), as is the case in traditional systems. This step reduces the costs allocated to central servers and performance bottlenecks. Thus, blockchain technology is a more efficient and adaptable technology. This technology is characterized by transparency. That is, it increases reliability by confirming that all data in the node are adjustable; for instance, this technology enables healthcare institutions to receive complete knowledge of the essential components of the medical industry and monitor drug distribution among traders. Through decentralization, all transactions are documented in blocks, and each block includes brief information about the previous block and the newly entered information. This information is then transferred to the next block in the chain. In addition, this information is quickly and effectively verified and ascertained, allowing it to be transferred to the required authorities. In short, blockchain has three main characteristics: decentralization, security, and scalability (see Figure 2). Blockchain is divided into three types that have their own characteristics and reflect network behavior: public, private, and consortium blocks. Table 1 shows a brief comparison of the three types.

- Public: All transactions within the blockchain are transparent to all nodes (miners), as any node in the network can participate in the decision mechanisms and verify the validity of the transaction received. Moreover, all nodes in the network are notified of any changes in the blockchain simultaneously. Public blockchains are also utilized as global databases of information that must be referenced as needed but must remain unchanged over time. For illustration, it has been employed as a database for keeping contracts or wills.
- Private: This type of blockchain needs the permission of nodes to join the network whose transactions are controlled by an organization or group of individuals. This organization or individuals can modify the operating rules of the blockchain. The movement of transactions should continue to be monitored, and electronic attacks, especially 51% attacks, should be avoided. This type of attack involves an individual or group gaining control of over 50% of the network's computing power, which can lead to potential breaches. Additionally, this type is characterized by the fact that transactions are less expensive, communication between nodes is better, and access permissions are limited, increasing the security and efficiency of the network.
- Consortium: This includes a partial central structure that determines who has access to the network and what position a user has within the network. Rather than allowing any miner to participate in the control of the transaction process, only a few miners deemed dependable are permitted to do so.

TABLE I. COMPARISONS BETWEEN PRIVATE, PUBLIC AND CONSORTIUM BLOCKCHAINS

Features	Public blockchain	Private blockchain	Consortium blockchain
Access	Anyone	Single organization	Multiple selected organization
Determination of Consensus	All miners	Only one organization	Designated set of nodes
Efficiency	Low	High	High
Immutability	Impossible to tamper	Could be tampered	Could be tampered
Centralized	No	Yes	Partial
Consensus	Permissions, Anonymous	Permissioned, Known identities	Permissioned, Known identities
Transection speed	Slow	Lighter and faster	Lighter and faster

The table above indicates that each type of blockchain has its importance, benefits, and utilization. The private type provides high security, strict control, and processing of many transactions. Therefore, blockchain is considered one of the best types of blockchain for managing medical records in healthcare institutions. The public type allows everyone to view their data and add new transactions. In addition, there is no centralization in managing this type, it is not easy to modify the data, and it is considered a less commonly used type in healthcare institutions. The third type, which is the coalition blockchain, balances transparency and privacy and allows access only to available data while providing high efficiency in performance in handling healthcare data.

3. BLOCKCHAIN-BASED HEALTHCARE MANAGEMENT APPLICATIONS

With the growth in health-related electronic data, storing healthcare data in the cloud, and protecting the privacy of patient data, this leads to the provision of new opportunities for health data management, easy access to patient data and sharing. Securing data, storing, and transactions and managing their seamless integration is valuable to any data-driven organization, particularly in healthcare. Blockchain technology has the ability to solve these problems efficiently. Figure 3 illustrates the workflow steps for managing healthcare data in a blockchain [31]. Blockchain-based applications in this category include data sharing, data management, and data storage, for instance, cloud-based applications and electronic health records (HERs). Blockchain technology has a variety of applications and utilizes that contribute to the management of healthcare data, including managing personal patient records, securely sharing health records, reproducing clinical research, sharing data without intermediaries for telehealth services, preventing counterfeit drug circulation, monitoring all medical products from the source, and improving operations in companies' health insurance. Furthermore, this technology is vital for improving the medical billing process and facilitating all procedures between patients and health institutions. Unlike standard electronic health records (EHRs), which are provider-centric, personal health records (PHRs) are applications that patients use to record and manage their data.

Personal health records (PHRs) are practical tools for patients aiming to manage their health information. By securely and conveniently collecting, monitoring, and controlling a patient's complete health record, including doctor visit data, vaccination history, prescription records, and physical activity data from smartphones and other devices, PHRs empower patients to take a more active role in their own healthcare. With this information at their fingertips, patients can make informed decisions about their health and collaborate more effectively with their healthcare providers to achieve optimal health outcomes. PHRs help patients operate and share their health information, correct any potential errors in the data, and provide an opportunity for adjustment. Patients who can control their cancer stem cells (CSCs) via blockchain technology

do not need to repeat previously completed diagnostic tests, and the costs of the tests are not increased. In addition, each copy of the patient record is stored on multiple nodes in the blockchain network. This record is shared with physicians and healthcare workers, who are allowed to monitor these records by the health institution.

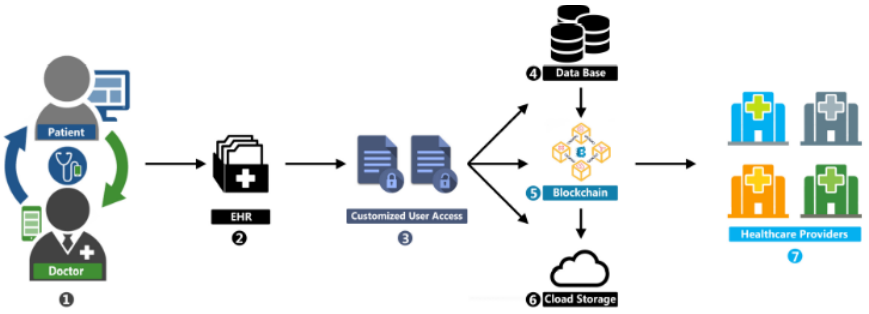

Fig. 3. Mechanism for managing healthcare data in the blockchain.

As healthcare becomes increasingly complex and interconnected, sharing health records among medical professionals has become an essential and valuable tool. With many current medical systems failing to guarantee privacy and security, establishing secure methods for sharing health information is more critical than ever. By allowing medical professionals to access a patient's complete health record, including medical history, allergies, medications, and test results, care coordination can be improved, leading to better health outcomes. However, ensuring that these records are shared securely and only with the patient's consent is crucial to protect their privacy and maintain confidentiality. Blockchain technology permits overcoming these challenges by storing medical data through a decentralized, peer-to-peer network that can be accessed and controlled. As a result, it assists new physicians and healthcare workers in knowing the past history of patients with all the details, which leads them to understand the condition better and treat it appropriately. Healthcare workers and physicians constantly require effortless and straightforward mechanisms to access and view patient data in medical emergencies. Nonpersistent permissions can result in a patient being denied access to data in an emergency situation, which poses an immediate risk to his/her life. Blockchain technology seeks to enable the management of chains and secure permissions, namely, encrypted keys and smart contracts. Encrypted keys allow patients to manage and control their data through master keys; the patient can share their data with physicians, whereas smart contracts enable access to be provided via predefined rules accepted by all individuals in the contracts. Through these methods, patients ensure that they have the ability to control access to their data, have full knowledge of their data sources, and inform them when their data reach physicians. The patients' health dataset is encrypted via blockchain technology, and then, machine learning algorithms are employed to predict the patient's health status and required treatment. Distinguishing smart contracts provides the possibility of verifying personal health records in a transparent and reliable manner.

Unrestrictedly, all patient medical data are organized in an electronic health record, which is a large distributed medical repository that is stored on-premises or in the cloud. Cloud storage is fundamentally an electronic storage environment consisting of many storage devices connected to each other to form a large volume of storage to accommodate the most significant amount of data and information. This cloud offers a range of benefits, including fast transfer speeds, easy sharing of files, ample storage capacity, low cost, easy access from anywhere, and dynamic linkages to other applications. These features make it an essential tool for individuals and businesses alike. One instance of a cutting-edge use of information technology infrastructure is a blockchain-based healthcare system. By leveraging the secure, decentralized nature of blockchain technology, this type of system facilitates the transfer of sensitive health data records between patients and healthcare workers while ensuring privacy and security. Additionally, this denotes a significant step forward in the digitization of the healthcare industry, making it more efficient, transparent, and patient-centric. In a study executed by Kaur et al., who introduced the term BlockCloud in the design of a blockchain-based platform, this term is a combination of applications in a cloud environment. The primary objective of this system is to save medical data in a distributed and secure electronic cloud without the involvement of third parties.

4. BLOCKCHAIN-BASED HEALTHCARE APPLICATIONS

Blockchain technology is revolutionizing the healthcare industry and developing the medical e-environment through data modelling and governance. This innovative technology enables healthcare applications and medical services to share patient data efficiently and transparently and not to publish patient privacy in public domains. With blockchain, patient data can be managed, authenticated, and transmitted quickly, accurately, and securely to physicians and healthcare workers. By eliminating the need for intermediaries and reducing the risk of data breaches, blockchain technology helps improve

patient outcomes and increases the efficiency of the healthcare system. Its potential applications range from medical records to clinical trials, and its adoption is expected to continue to rise in the coming years. In addition, all the data received from medical devices, laboratories, social media and many other sources are combined to create raw data, which later developed into the scope of big data. These data constitute the core component of complete blockchain-based healthcare. Through this process, companies or individuals strive to create a secure healthcare structure that is divided into a set of parts. Different platforms are then created to facilitate tasks for users to create and manage their transactions. This section reviews a set of scientific literature that designs applications and mechanisms in healthcare data management in the blockchain. Furthermore, these studies are compared and synthesized in Table 2.

Counterfeit medicines are a global issue in the healthcare industry and pose extraordinary risks to all clients. According to the World Health Organization, an estimated 1 in 10 medicines circulated in low- and middle-income countries are counterfeit (WHO, 2017). The spread of counterfeit medicines, lost product records or packaging errors disrupts entire supply chain management. After the drug production process is finished, it must be transferred from production stock to wholesale distributors and then reach clients through retail companies. Figure 4 illustrates drug supply chain management in hospitals. During this supply chain cycle, there is always the risk of counterfeit medicines entering the chain, which may lead to mistrust of the existing available system. This issue is one of the most significant issues facing the healthcare system. Therefore, it is preferable to use blockchain technology through the use of smart contracts, as the actions of medicines and all medical products can be tracked. Blockchain-based transactions are inflexible and have a timestamp that ensures that information has not been tampered with. Since all transactions are recorded in a ledger and every node in the blockchain maintains a record of the transaction, it becomes easy to instantly verify a drug's source, seller, and distributor. Therefore, blockchain technology, which allows supplier identification information to be checked and verified, provides a vital service for healthcare managers in establishing a reliable and well-performing supplier network. To combat the production and distribution of counterfeit medicines, the Counterfeit Medicine Research Network project, which uses blockchain technology ownership, was established in partnership with Accenture, Cisco, Intel, IBM, Block Stream and Bloomberg and is transparent to all stakeholders. Thus, low-quality and even stolen counterfeit medicines can be tracked and identified, and healthcare officials are notified of the whereabouts of that medicine. In December 2019, Merck, KPMG, Walmart and IBM completed the "Drug Supply Chain Security Act - DSCSA" as part of the U.S. Food and Drug Administration (FDA) pilot project program [53]. This project has confirmed that blockchain technology can be used because it significantly reduces the time required to monitor medicines and medical products with minimal time and prevents the distribution of counterfeit drugs.

TABLE II. A COMPARISON OF DATA MANAGEMENT MECHANISMS FOR HEALTHCARE IN THE BLOCKCHAIN

Articles	Purpose	Type of data	Description
Staffa et al. [33]	Setting the KONFIDO (H2020 project) approach to secure health information exchange between European nations.	EHR	Seeking to improve confidence and security in the sharing and storage of health information through the development of electronic health technologies and the protection and control of personal data securely.
Patel [34]	Develop a framework to share medical images across domains that leverage the blockchain and allow patients to determine access permissions.	Medical image records	Developing a blockchain framework to take advantage of it to prevent third-party access to protected health information by creating mechanisms to meet many interoperable health system standards and facilitate generalization to domains beyond medical imaging. Making this framework suitable for ensuring data privacy in diverse domains.
Castaldo and Cinque [35]	Executing disruptive logging by introducing a new approach to implementing electronic health data interchange through OpenNCP.	EHR	Providing the ability to track and share these data, provide security, enhance efficiency, and get rid of traditional procedures
Hira et al. [37]	An analysis of the factors affecting the application of blockchain technology in Malaysian public hospitals	EHR	Develop a model that combines the Unified Theory of Acceptance and Use of Technology (UTAUT), the Norm Activation Model (NAM), and initial mediator trust. Evaluate this model and verify the validity and knowledge of the suitability of this model through its application in public hospitals; aim to establish a sustainable and safer healthcare system and identify the key factors that influence technology adoption and usage in healthcare settings and to develop the most promising practices for future initiatives.
Azaria et al., [38]	Designing a system (MedRec) employing blockchain technology to manage and deal with medical records.	Electronic medical records	The MedRec system is characterized by the ability to create an electronic environment that gives patients a comprehensive, nonmodifiable record, easy access to all their medical information, and data sharing with confidentiality and authentication. In addition, the

			architecture design includes solutions for data storage, which facilitates the operation of the architecture and makes this system suitable and adjustable.
Sharma et al. [39]	The goal is to organize a secure blockchain-based Proposed Application (PA) that can effectively generate, maintain, and validate healthcare certificates with the most significant privacy and security.	Medical certificates	Internet of Things (IoT) devices are connected to healthcare systems daily, and therefore these systems may be exposed to hacking, phishing, and identity theft. Therefore, a model capable of enhancing the security, privacy and confidentiality of sensitive patient information and creating healthcare certificates is suggested. This model acts as a communication medium between the blockchain network and application entities such as hospitals, physicians, and IoT devices. Moreover, it includes mechanisms to control access to information and enhance the efficiency of healthcare systems.
Hussein et al. [41]	Designing a blockchain-based data sharing system capable of sharing medical records while controlling sensitive patient data private**.**	Medical records	The performance of the proposed system is supported and improved by employing discrete wavelet transform and genetic algorithm techniques. These techniques contribute to the generation of mechanisms to encrypt patient data and control access to the system by identifying and verifying users' identities, which leads to a robust, efficient, and scalable system.
Hajian et al. [42]	The use of confirmatory factor analysis for the validity and reliability tests of a blockchain-based model and how to deal with electronic health record systems.	EHR	Enabling patients to control their health records and share their information with healthcare providers' systems safely and without any loopholes in these systems. This system is characterized by reducing health care costs, improving diagnosis management, protecting patient information, and transferring it to physicians.
Shuaib et al. [43]	Designing a secure and useful system for sharing healthcare data based on the blockchain, which prevents any attacks attempting to manipulate patients' information.	EHR	The suggested system is based mainly on the Istanbul Byzantine Fault Tolerant (IBFT) consensus algorithm and Interplanetary File System (IPFS). The performance of this system is compared by relying on a set of metrics such as based on various undertaking criteria, such as transaction latency, throughput, and failure rate.
Sultana et al., [45]	Appearing a security system by suggesting a decentralized framework for sharing and storing medical images based on the zero trust principles.	Medical image records	The zero trust principles aim to completely distrust all devices, users, and applications, except after complete verification of their source. The presented model ensures the safety of transmitting medical images in an encrypted form and that only authenticated devices and users can view and interact within the network.
Lee et al., [46]	Designing a decentralized system for patient information exchange (PIE) and sharing its records electronically while preserving the privacy of all patients through the exchange of medical information by encrypting data and giving access to authorized individuals only.	Electronic medical records	Data are shared freely, securely, and actually from threats and fraud with users regardless of the size or format of the data through a distributed data-sharing technique using the InterPlanetary File System. The data participant process takes an average of 01014 (SD 0.0028) seconds to download 1 MB of EMR in the suggested PIE system.
Shen et al., [47]	Designing a practical model named MedChain for healthcare data sharing and cloud service reliability. This model combines blockchain, digest chain, and structured P2P network techniques.	Healthcare records	The MedChain model provides for sharing of healthcare records that are gathered from sensors or monitoring devices between all parties in the network via cloud services after confirming them and allowing access to only authorized individuals.
kumar et al., [49]	A secure and efficient model anointed PBDL is developed utilizing blockchain technology, smart contract and deep learning techniques.	Healthcare data	The PBDL model aims to register and validate related entities through the use of a smart contract-based consensus mechanism with the help of zero-knowledge proof. In addition, the data is transcoded or converted to new formats with the detection of any electronic attacks that may occur during the transmission of healthcare data. The IoT-Botnet and ToN-IoT datasets are used to test the strength of the PBDL model.
Jayabalan and Jeyanthi [50]	A blockchain-based model integrated with InterPlanetary File System (IPFS) is developed to protect healthcare records from decentralized tampering.	EHR	The presented model allows patients to act as digital admins of their healthcare data, allowing physicians and healthcare workers to access this data upon recommendation. This model utilizes AES-128 technology to encrypt data before storage into IPFS and uses RSA-4096 to create digital envelopes to pass on the symmetric key to authorized entities. This model is scalable and robust.

Elvas et al. [52]	Designing a lab-based blockchain prototype using design science research methodology (DSRM) to share medical information between health entities in a secure environment and free from unauthorized parties.	Healthcare data	To encourage this model, artificial intelligence techniques are operated to make it work perfectly. This form makes it possible to share data after obtaining patients' consent and allowing hospitals and specialists to access their data.
Notice: The order of articles was based on importance, as 15 studies were selected out of 30 organized articles.			

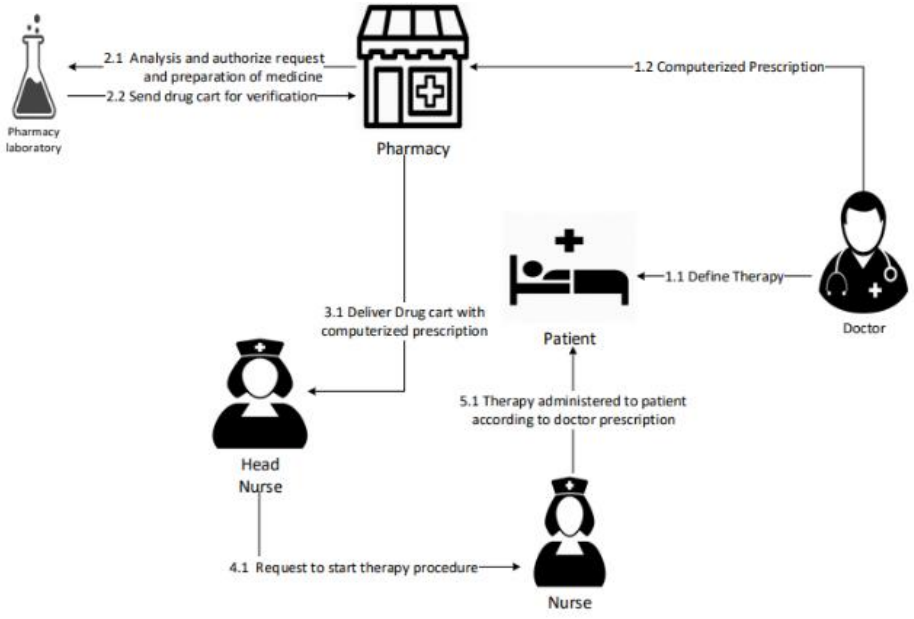

Fig. 4. Drug supply chain management in hospitals [54].

The healthcare industry relies laboriously on the medical billing process, which includes several critical actions, such as accepting patients, reviewing insurance coverage, and recording prescriptions. Unfortunately, the current systems used for medical billing are prone to careless mistakes, including duplicate transactions and incorrect information entry. These mistakes can lead to a lack of transparency and trust among healthcare workers, patients, and insurance companies. Therefore, it is preferable to use blockchain technology in these systems, automate all medical billing operations, and improve the performance of these systems. This technology reduces billing costs and time in archiving these bills, monitoring the process of performing all procedures by healthcare workers. Moreover, it will lead to nonrepetitional of transactions or errors in data entry, and it will be stored in a correct, secure and transparent manner that cannot be changed and can be returned at any time. In addition, by enhancing the medical billing process, the healthcare industry can increase transparency and trust among all stakeholders and ensure that patients obtain the care they need without facing unnecessary financial burdens.

5. CONCLUSIONS

In this article, the essence of blockchain technology in the domain of healthcare and the benefits offered by this technology are to build secure healthcare systems that are free from defects and ensure the security of transferring medical data between patients and workers in this domain and the absence of a third party to manipulate these data. Blockchain technology has the potential to restructure and grow the healthcare industry by submitting a set of advancements in terms of operational efficiency, data security, healthcare staff management costs (thanks to decentralization), transparency, medical medicines that can be tracked, all medical products validated, and immutability. The most noteworthy advantages of this study are as follows:

- Improving administrative processes in the healthcare system by concentrating on specific operations, enhancing medical billing processes, and enhancing communication between healthcare providers.
- Safe storage of personal health data is one of the most significant features that are executed in the healthcare system to prevent third parties and unauthorized institutions from receiving these data.

- Blockchain technology offers efficient resolution by reducing the demand for additional resources; reducing the time, labor and cost affected; enhancing workflow; and eliminating inefficiencies.
- Safe sharing of data and utilization in clinical research.
- Support proper diagnosis and stop additional treatment costs from sharing personal health records with a physician or healthcare professional upon request from a patient who has been given access to his/her data.
- This technology seeks solutions to the growth of modern medicines and treatments by providing a secure, transparent and effective platform while ensuring the safety and privacy of sensitive information. Owing to its decentralized nature, blockchain can facilitate data sharing across various stakeholders, such as pharmaceutical companies, research institutions, and regulatory agencies, resulting in faster and more trustworthy effects.
- This technology has the ability to trace the product life cycle from raw materials to delivery, prevent counterfeit products and establish reliable supplier networks. In addition, with a blockchain, every transaction can be recorded and traced back to its source, allowing for greater visibility and accountability across the supply chain. This can help reduce fraud and crime risks, increase supply chain efficiency, reduce costs and improve access to medicines and critical medical products.

Blockchain technology provides more trustworthy and transparent data for AI-related machine learning, which helps solve data quality issues, thus enabling AI technologies to increase the accuracy of analytical effects. Moreover, IoT-based healthcare systems contribute a range of services, such as real-time monitoring that can save lives in emergencies, remote medical assistance via smart mobile applications, universal access and monitoring of patient status, and alerting in critical cases. Medical data gathered from IoT devices can be easily managed and shared via blockchain, which is tamper-proof and traceable, ensuring its integrity and privacy. Patients can have more control over their own data, allowing them to share it with healthcare providers. In addition, healthcare organizations can benefit from more accurate and comprehensive data, leading to improved diagnosis, treatment, and outcomes. Moreover, blockchain in healthcare data management can also facilitate research and development, leading to findings and breakthroughs in medical science. In the future, more studies will be conducted on the importance of modern technology based on artificial intelligence in the domain of healthcare.

Funding
The authors had no institutional or sponsor support.

Conflicts of interest
The author's disclosure statement confirms the absence of any conflicts of interest.

Acknowledgement
The authors extend appreciation to the institution for their unwavering support and encouragement during the course of this research.

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