Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 24s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Unlocking Healthcare Potential: A Survey Of Blockchain Applications And Challenges

Vikranth Kattiri[1], Dr. Md Shamsul Haque Ansari[2]

[1,2]KL UNIVERSITY**,** Computer Science and Engineering, Vijayawada,522502.
Email ID: vikranthkattiri007@gmail.com, Email ID: shamsshamsul@gamil.com

Cite this paper as: Vikranth Kattiri, Dr. Md Shamsul Haque Ansari, (2025) Unlocking Healthcare Potential: A Survey Of Blockchain Applications And Challenges. *Journal of Neonatal Surgery*, 14 (24s), 450-460.

ABSTRACT

Blockchain technology, a transformative force, has become a critical instrument in the contemporary professional landscape. Its capability to cultivate consider, protect data, and propel innovation has resulted in a proliferation of applications throughout various industries.

Blockchain possesses widespread promise within the healthcare enterprise. By setting up obvious, secure, and efficient systems, it could transform operations including supply chain management, medical records, and medical trials. This survey examines cutting-edge breakthroughs in blockchain-based healthcare technologies, emphasizing the opportunities and difficulties that await.

Keywords: *blockchain technology; healthcare; data management; supply chain management; internet of medical things".*

1. INTRODUCTION

Introduction to blockchain technology:

Blockchain technology is a decentralized, disbursed ledger system that securely records transactions across multiple computers, ensuring transparency and resistance to tampering. Initially developed as a foundational technology for Bitcoin, the inaugural cryptocurrency, it has developed to encompass applications past digital currencies. Each transaction in a blockchain network consists of information regarding the transaction, the timestamp of its creation, and a connection with a previous block. As soon as a block is integrated into the chain, modifying it becomes challenging without impacting all following blocks; consequently, the blockchain is impervious to tampering and resilient to fraud. Consequently, this could include sophisticated cryptographic methods; for example, a blockchain may want to hire hashing and numerous consensus protocols. The integrity of data is assured by the network of participants in the blockchain, disposing of the need for any trusted middleman. Several industries now implement technology for their operational needs such as supply chain management, healthcare and real estate and voting systems [23-26]. The receiving node within a blockchain distributed peer-to-peer network checks the message for correctness before adding it to a block. The block accepts stored information after the receiving node confirms its accuracy. A consensus mechanism operates for block data agreement which becomes known as proof-of-work (PoW). The consensus method enables the block to get added to the chain and each network node validates the new block entry. The system will stop and freeze the ongoing sequence. [11,12]. Distributed ledger technology proves to be one of the most substantial implementation fields in health-care technology. The healthcare sector requires this system to manage its data security and privacy-sharing and storage issues [13,14]. Interoperability stands as a basic requirement which healthcare needs to fulfill. Interoperability represents the capability of human or machine entities to accurately exchange information with success in consistent ways [19-22].

This book examined published works on this subject from 2008 to 2019 and offered a systematic literature evaluation. The analysis of the experiments performed in the examined utility domains become insufficiently important. Various significant medical studies evaluated blockchain technology across sectors of health insurance and electronic health records (EHRs) and drug supply chains and biomedical research and procurement systems and scientific education according to Radanović and Likić [29]. The research functioned similarly to precedent research without reviewing extensive blockchain-based healthcare implementations like contracts, data sharing and interoperability with storage in the cloud. Siyal et al. [30] established multiple blockchain-based healthcare solutions for fraud prevention and neurological examination and study management together with electronic health record (EHR) storage. The issue is that the maximum latest published guides had been excluded from the studies conducted through Siyal et al. [30]. McGhin et al. [31] tested the healthcare industry's criteria for safeguarding the privacy of sufferers' clinical statistics through blockchain technology. This survey [31] encompasses many applications in healthcare, including "OmniPHR [32], Medrec [33], Pervasive Social network (PSN) [34], MeDshare [35], and Healthcare data Gateway [36]".

Features of block chain technology in health care:

Securing Data and Privacy [11,26-28]

- Medical records are secured against tampering.
- Enhances the confidentiality of patient information.

Data Interoperability [15-18]

- Facilitates seamless data exchange among diverse healthcare systems.
- Promotes consolidated patient records accessible to all authorized users.

Administrative Simplification [19-22]

- Minimizes documentation through automated validation.
- Enhances efficiency in billing and claims administration.

Supply Chain Management

- Pharmaceuticals are monitored from production to distribution.
- Mitigate counterfeit pharmaceuticals to guarantee genuine.

Clinical Trials and Research

- The integrity and transparency of the study data are upheld.

Advantages and disadvantages of block chain technology

Benefits of utilizing blockchain:

It fosters increased trust among users.

It enhances data security.

Minimize production expenses.

Enhance Velocity Invocation and Tokenization

It offers unalterable records.

Intelligent contracts

Drawbacks of employing blockchain technology:

Data modification is not feasible.

A substantial database necessitates extensive storage capacity.

If the owner forgets or misplaces the private key, access will be permanently lost.

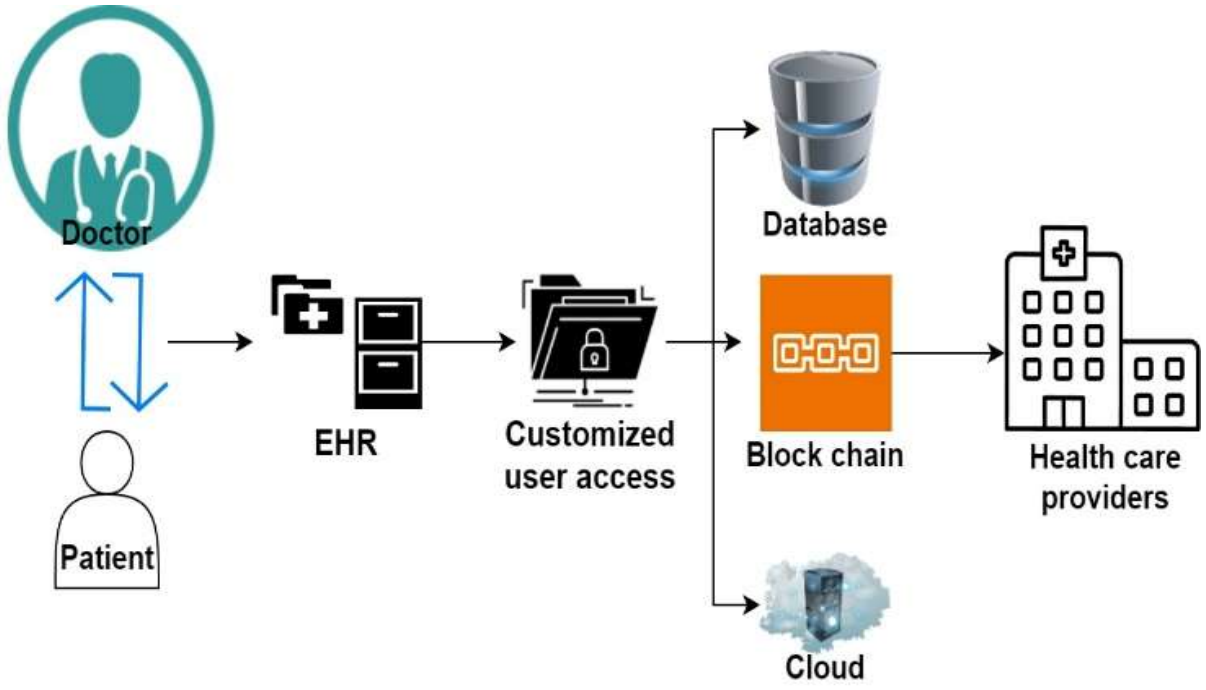
A thorough review of research documents demonstrates that previous works have not performed an extensive classification of their kind. The article establishes technological foundations which explain blockchain applications in healthcare while focusing on recent developments throughout its framework. This paper performs a detailed technical assessment of healthcare blockchain technology implementation while evaluating the pros and cons of the discovered solutions. The examination of existing research problems and unresolved matters and forthcoming research directions takes place within each healthcare application segment. The article delivers a detailed account of all its main findings.

1. Examination of the various applications of blockchain technology in healthcare.
2. Understand what major challenges emerge when healthcare applications use blockchain technology.
3. The article presents descriptions and essential future research standards alongside unresoved questions regarding blockchain healthcare implementation.
4. It presents both advantages and drawbacks of present-day blockchain applications in healthcare.

Blockchain in health applications

Medical data modeling as well as governance follows a new path because of blockchain technology that enables distinctive and efficient mechanisms for medical data segmentation and protection alongside service exchanges. Various healthcare developments in present times rely fundamentally on blockchain technology. Healthcare technology based on blockchain divides into four identifiable layers which include data sources and blockchain technology and healthcare applications and stakeholders. The blockchain-based system for healthcare applications appears as shown in Figure 1. Raw data consolidation must first begin from multiple data sources including medical devices, laboratories, social media as well as other systems

which generate primary information. The raw data eventually evolved into big data after its initial development period. Data stands at the peak of the hierarchy structure as the key resource within blockchain-based healthcare systems.



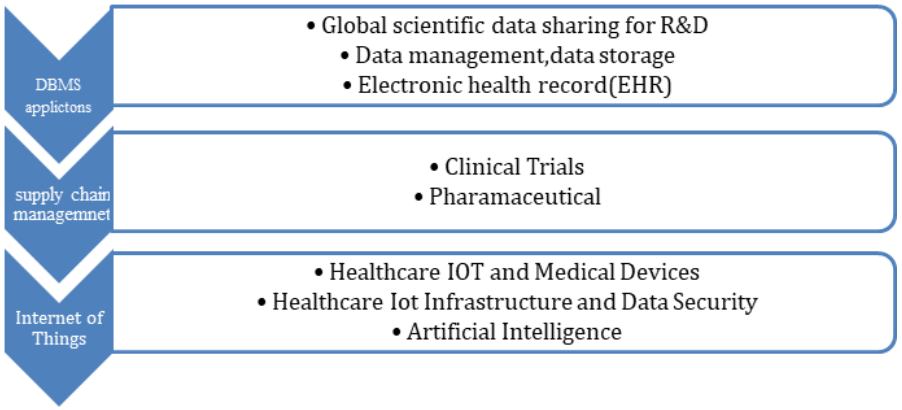
"Figure 1. Healthcare data management in blockchain"

A raw data layer serves as the base of blockchain technology to build four-layered healthcare security architecture with raw data layer and consensus layer and platform layer and application layer. Blocks chains have distinctive traits that encompass methods and protocols of consensus. User transactions are enabled by blockchain structures because various current operational blockchain platforms include Ethereum [38], Ripple [39], and Hyperledger fabric [40].

Blockchain systems contain five essential components which include smart contracts, signatures, wallets, events, membership and digital assets. Different protocols are used for program-to-program communications as well as framework communications and network-level communications. Blockchain architecture includes three main operational systems: P2P, centralized, decentralized, and distributed systems. The choice between public and private and federated techniques rests on policymakers according to their required range of services [40]. The platform creation using blockchain technology follows the deployment of applications that must integrate with the complete system. The applications combining blockchain capabilities in healthcare operations fall into three basic groups.

The domain of data management includes several subgroups which encompass global scientific data exchange for research and improvement together with facts management and facts storage through cloud-based platforms and electronic healthcare records. The second category encompasses SCM programs, inclusive of clinical trials and pharmaceuticals. The 0.33 classification examines IoMT this includes healthcare IoT and medical devices integration together with healthcare IoT infrastructure and AI data security applications.

Business users along with researchers and patients occupy the highest position in a blockchain-based healthcare hierarchy because they receive benefits from these programs. At the first level of user concerns the main responsibilities include data sharing and processing and management together with safety and privacy maintenance protocols. The workflow comprises four essential levels that include healthcare raw data and blockchain as well as healthcare applications together with stakeholders. The decentralization of blockchain technology enables numerous healthcare stakeholders to take advantage of its applications.



"Figure 2. Blockchain-based healthcare"

2. LITERATURE SURVEY

Hoai Luan Pham and colleagues, remote healthcare systems, utilizing blockchain technology's smart contracts, recognize the necessity to protect user and device-generated data [1]. A data processing system for medical devices was introduced to enhance efficacy below critical patient conditions.

Tanesh Kumar et al. assert that the usage of data in healthcare systems has created numerous opportunities for stakeholders within the healthcare sector, encompassing secure and effective data interchange, storage, and access. The primary objective of this essay is to employ blockchain technology to establish a secure and efficient way for data accessibility in contemporary healthcare systems. Furthermore, we assessed whether our proposed plan satisfies the requirements for confidentiality, integrity, and authentication.

Daniel Bowden and colleagues, The Blockchain is a capability technical instrument that could enhance security protocols in the healthcare systems of global smart cities [3]. Blockchain obviates the necessity for an intermediary to authenticate transactions in the healthcare sector. Consequently, the removal of intermediaries from financial transactions enhances both data security and patient confidentiality in healthcare institutions. Furthermore, Blockchain technology is probably used to improve protection throughout numerous economic sectors in smart cities, such as potential tourism and energy industries.

Anastasia Theodouli and colleagues, Blockchain technology was first created and utilized in financial and accounting sectors. Nonetheless, it's far currently utilized in numerous additional applications, especially inside the medical industry [4]. Patient health information can be retained and disclosed at any time with the patient's consent, rendering it on hand to those who require it. This study examines the utility of blockchain technology to protect patient privacy and facilitate data sharing while ensuring secure data access.

Thomas k. et al. indicate that blockchain technology is increasingly employed in the healthcare field, with everyday developments evident. The following are the three principal areas of focus: among them are cost-saving measures, patient statistics privacy, patient facts interchange, access control, efficiency, and interoperability.

Nguyen et al. supplied a mobile cloud platform for electronic health record interchange [6]. They have installed a reliable system for control and access for patients, physicians, and healthcare people. A smartphone application utilized the Ethereum blockchain to disseminate real-time data. They safeguarded the patient's confidential data against hostile attacks.

3. THEORETICAL ANALYSIS

Block chain-Based Healthcare Management applications

The combination of electronic health data along with rules for patient privacy protection and cloud-based healthcare storage enables improved health fact sharing and management options for patients. A data-driven business needs the integration of data along with storage and transaction systems combined with smooth management processes especially in healthcare where blockchain technology offers potential solutions to these major challenges. In a robust and reliable manner. The workflow stages for healthcare data management on blockchain are depicted in Figure 3 and include the following summary. The considered field contains four main applications regarding data sharing and management with cloud storage and EHR systems that receive detailed discussion.

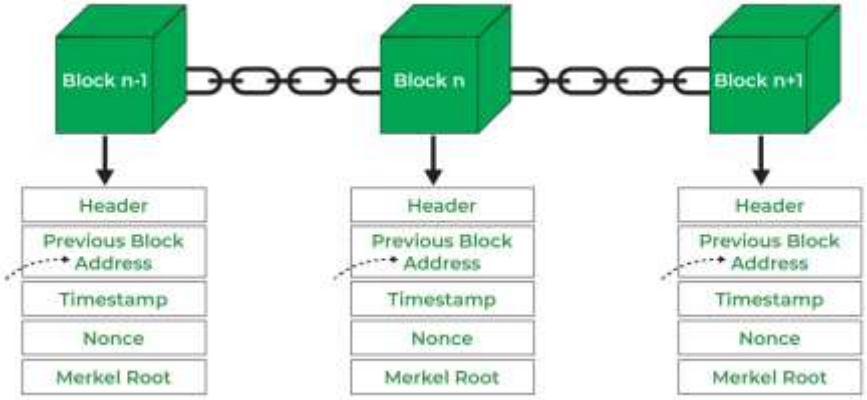
Step 1: The first stage of recording primary information happens during interactions between healthcare providers and their patients. Healthcare records including medical background, active health conditions and supplementary physical information form the composition of this data collection.

Step 2: Following Phase One data collection medical staff use essential information to build one Electronic Health Record (EHR) for each patient. The EHR database receives both nursing care data as well as medical images together with prescription history information.

Step 3: Electronic health records (EHR) ownership belongs to the patient and access permission exists only for the individual record owner. Entity access needs approval requests before following the process to arrive at the EHR owner for access receipt authorization.

Steps 4, 5, and 6: All crucial process elements can be found in this steps because they include the database, blockchain and cloud storage components. Database and cloud storage use distributed storage methods but blockchain supplies improved privacy features that enable specific authentic user permissions.

Step 7: The end users who will seek secure access to healthcare delivery services include healthcare providers at ad hoc clinics and network care centers and hospitals. They receive their authorization from the owner. Your mobile device combined with distributed ledger authentication technology known as blockchain provides access to your health record from anywhere in the world [42].



"Figure 3. Working methodology of block chain storing"

Clinical trails

Barriers in clinical trials within the healthcare quarter privacy of personal data, data dissemination, and patient enrollment [45]. The mentioned challenging circumstances find solutions through blockchain technology implementation. Blockchain technology provides methods for medical trial data sharing which keeps data secure and traceable and repeatable. Smart contracts on a private Ethereum network serve to rebuild trust and improve research transparency. The goal of this work was to enhance the medical validity of medical trial findings, which can be compromised by issues such as data omission and selective reporting. to augment the efficacy of medical trials and precision medicine, this features a blockchain-based disbursed and parallel computing prototype for big data analytics; a data management component for data integration; an identity management component for the privacy protection of IoT devices; and a data sharing management component for a collaborative research ecosystem [46]. Choudhury et al. [46] put forward a progressive data management system which employs permissioned blockchain technology through smart contracts. The authors pursued to reduce management costs in their effort to secure data privacy and integrity for medical trials across multiple locations. Time stamping enables proof-of-idea blockchain operations through the purchase consent system where smart contracts are established for registration. An implementation of temporal traceability can verify sensitive medical documents for full transparency through public storage on websites.

Pharmaceutical

The Pharmaceutical Company works towards enhancing and developing medications which treat a wide range of medical conditions. Drug development spans an extended period because of patent regulations along with safety testing and proof of efficacy performance and regulatory evaluation which mainly extends through medical trials. The pharmaceutical sector can solve its current problem by implementing blockchain technology company-wide. A blockchain distributed ledger together with its tamper-proof blockchain nodes can protect privacy while assuring security by recording trial events. A private blockchain system provides a solution for confirming compliance of drugs with patent protection regulations. The smart contract works as an instrument which enables integrity along with traceability and transparency [45]. Current data demonstrates that pharmaceutical institutions have placed or studied blockchain technology implementation for upcoming industrial incorporation at about sixty-one percent. The worldwide public along with consumers face substantial risks from counterfeited medications in present-day health systems. An experimental pharmacovigilance blockchain system which

Sylim et al. developed through simulations allowed them to assess the practicality of blockchain technology and its design concepts within pharmaceutical surveillance systems. Uncredible medicine prescription chains should become easier to track through the implementation of this system. The system aims to overcome the counterfeit medicine distribution practices that have seriously impacted some Asian nations. The international Governance Coin known as Gcoin plays an active role in multiple operational areas. For example, nodes with connections encompass a coin company, complete node, miners, or a preferred node. Gcoin operates as part of pharmaceutical supply chain control systems. The information travels from producers to wholesalers and then to outlets and subsequently reaches pharmacies as well as hospitals before reaching purchasers. The implemented transaction monitoring system in medicine leads to a drug distribution system transition that shifts auditors' functions to comprehensive event-based oversight. The established drug delivery model will transform its framework from examination-based inspection to become a surveillance community system [48].

4. INVESTIGATION AND RESULTS

Investigation on Blockchain use cases in Supply Chain Management

Claims and Billing Management: The 1 trillion-dollar worth of skilled health services derives its value from healthcare costs which show strong expansion. Medical billing exists as an essential foundation which supports the healthcare industry. Adequate provider delivery becomes impossible when there is no billing system in place. The billing process begins when patients enter the hospital to continue until they leave completely after discharge. The healthcare billing process operates at different stages beginning with check-in followed by financial verification then requires coding and billing regulations and ends with claim submissions and receipt of insurance bills. The billing method demands complex calculation because medical insurance covers some costs in full but other costs become patient financial obligations. Medical billing faces its main problem from overbilling because physicians and patients as well as insurance companies do not share adequate trust or transparency with each other [43,44]. A clear and accessible framework for the entire stakeholder group would help stop ongoing cases of abuse in healthcare billing practices. Blockchain technology establishes a clear system which helps every participant stay involved without loss of confidence.

Claims and Billing Management: A monetary cost exists within healthcare activities because it supports an industry that reaches trillions of dollars and demonstrates fast growth [47]. Medical billing stands as a central healthcare system matter which affects its operations fundamentally. Right service delivery remains unattainable unless billing operations are executed properly. A complete process begins when patients enter the hospital and ends when health facilities release them.

Quality management: A counterfeit medicine consists of incorrect ingredients which the marketer intentionally makes complex for understanding to confirm its authenticity and effectiveness. Supply chain management suffers substantial damage from the counterfeiting activities that target both pharmaceuticals and other items. The pharmaceutical sector operations of these entities creates serious widespread impacts on healthcare product effectiveness and financial profit while weakening industry security. Many consumers are unaware about the origins of their international market purchases and consumption products. Patient health suffers from this type of medicine which poses a life-threatening problem to modern societies [47]. The success of authentic pharmaceutical companies faces a direct threat thus pharmaceutical manufacturers must spend considerably to prevent counterfeits. The analysis established spectroscopic and chromatographic approaches as effective methods to detect counterfeits within their active components and sample image contents. Their dependence on electromechanical devices sets boundaries for their use because it produces increased expenses.

The blockchain resolves this problem by enabling pharmaceutical manufacturers to store their product serial numbers and package numbers within the platform thus providing blockchain access which allows pharmaceutical companies with drug manufacturers and consumers to authenticate data through powerful control and product registration and drug tracking and counterfeit drug identification throughout the supply chain.

Blockchain Use Cases on the Internet of Medical Things Lack Standardization:

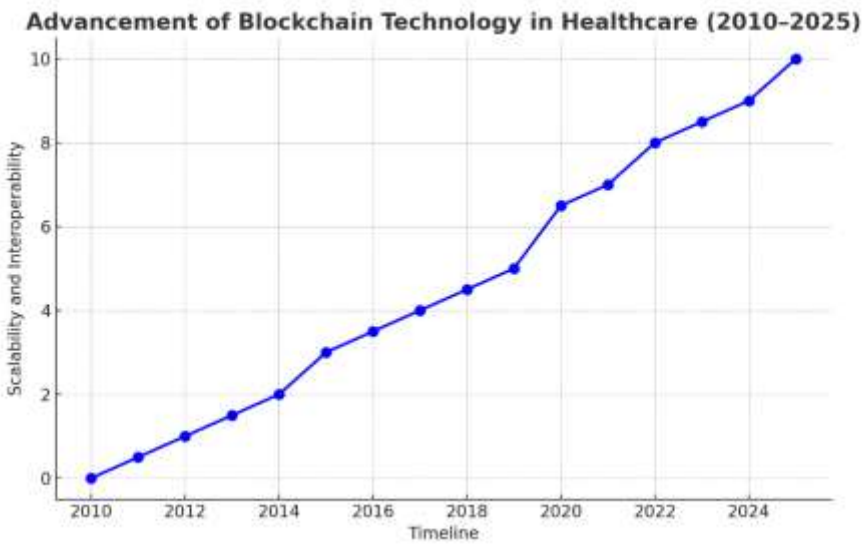
The healthcare industry adopts IoMT technology at a rapid speed [50]. The internet of medical things (IoMT) provides universal medical service reach combined with continuous patient guidance to both medical professionals and patients. The acquisition of bio-signals through wireless devices forms an essential piece of telehealth surveillance applications. The protection of medical data transfer needs to be the number one priority. The technical absence of standards between IoMT carriers emerges from their substantial platform and protocol and device information variation. The modern approach finds it challenging to protect different standard transmission media from threats. Blockchain technology has proven effective for protecting transmitted data against unauthorized access through its decentralized network since the number of communication standards for devices is now irrelevant. Extensive computational power and a 51% consensus among mining nodes have to be gained before modifications to blockchain data can occur and distribution to all network nodes before chain integration.

"Table 1. Comparison table of blockchain technology applications in healthcare"

Criterion	Benefits	Challenges	Examples in Healthcare	Potential Solutions
Data Security	Immutable and encrypted records ensure safety.	Risk of private key loss or breaches.	Securing Electronic Health Records (EHR).	Advanced encryption, multi-signature authentication.
Transparency	Authorized stakeholders can access shared records.	Sensitive data exposure risks with improper access.	Sharing test results between providers and patients.	Access control mechanisms and privacy filters.
Interoperability	Enables seamless data sharing across systems	Lack of global standards for healthcare integration	Consolidating patient records from various institutions	Establishment of universal healthcare blockchain standards
Cost Efficiency	Reduces administrative expenses (e.g., claims)	High initial investment for infrastructure	Automating insurance claim verification processes	Gradual adoption with pilot projects and cost analysis
Data Traceability	Tracks data origin and usage history	Ensuring initial data accuracy remains a challenge	Monitoring the pharmaceutical supply chain to prevent fraud	Implementing robust audit and validation mechanisms
Smart Contracts	Automates processes like insurance claims	Errors in coding may lead to incorrect outcomes	Conditional release of insurance payouts or trial funding	Rigorous testing and validation of contracts pre-launch
Patient Control	Empowers patients to own and manage their data	Resistance from traditional healthcare providers	Allowing patients to share data for research or second opinions	Awareness campaigns and incentives for providers
Regulatory Compliance	Facilitates adherence to data privacy laws	Adapting to varying regional regulations (e.g., GDPR)	Ensuring audit logs for clinical research data compliance	Region-specific blockchain frameworks

Evolution of blockchain technology in healthcare

Healthcare organizations follow several defined procedures that include check-in and financial accountability verification then coding and billing compliance and finally claim submission to insurance vendors who provide payment. Healthcare billing requires complex planning because patients' health plans fully cover certain payments and other payments require out-of-pocket spending. Medical billing contains inflated charges due to weak transparency and confidence levels that exist between physicians and their patients along with insurance providers. The exploitation of healthcare claims and billing occurs despite these problems being reducible when stakeholders have access to transparent systems. Blockchain creates an open system where all stakeholders stay connected and lose their capacity to distrust one another.



"Figure 4. Advancement of blockchain technology in healthcare (2010-2025)"

5. FUTURE SCOPE

Remote Patient Monitoring

Remote patient monitoring has become essential because the increasing number of chronic diseases in elderly populations presents the main difficulty.

Devices throughout the internet of things network collect authentic health data automatically from individuals through real-time monitoring. The collection process through blockchain offers legal healthcare professionals secure access to these health records. Healthcare interventions get better along with persistent condition treatment because of this system.

Insurance and Claim Settlement

Insurance institutions face three critical problems involving sustained claims procedures and fraudulent actions and opacity within their operations.

Smart contracts operated on the blockchain automate insurance claims processes while providing an efficient claims management system for all stakeholders. Smart contracts using blockchain technology would decrease insurance fraud instances and make both insurance claims processing faster and provide enhanced visibility between insurance companies and their insured clients.

Healthcare IoT and Medical Devices

The internet of things (IoT) comprises technology devices connected through distinct identifiers to share network data automatically over the internet without any human required interaction. Conditional networks have made the healthcare system dependent on IoT technology. The present scope of IoMT encompasses wearable and medical devices. Healthcare facilities derive the main value from WBAN systems which form the core element of IoMT technology. WBAN technology has become a central element for various applications since it enables remote monitoring of physiological data within medical and healthcare scenarios. People can obtain IoT-based assistance regarding their health appointments and blood pressure changes and daily energy consumption among other things. The presentation will review contemporary studies about integrating blockchain technology with internet of medical things (IoMT).

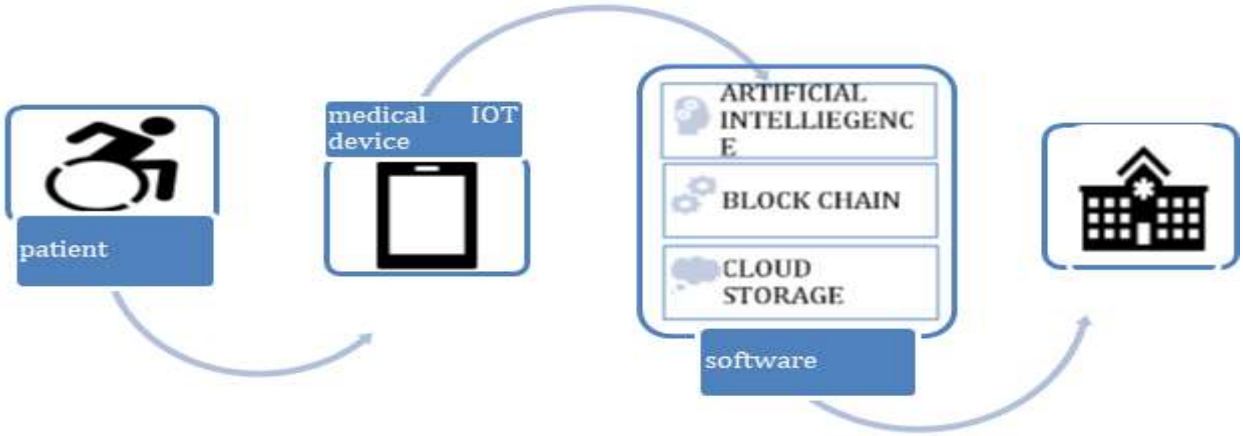


Figure 5. Internet of medical things (IoMT) in blockchain.

6. CONCLUSION

The economy experiences transformation through blockchain technology which affects healthcare sectors alongside other industrial segments. The four key characteristics of blockchain including decentralization and anonymity together with auditability and security will enhance health transparency and secure data management which results in improved healthcare quality while decreasing costs. There is a detailed study of blockchain applications for health data management presented in this research. The program provides patients with tools to manage their health data which results in tamper-proof documents created at scheduled periods. The slower adoption of blockchain depends on three main factors which are the difficulties in data sharing cross-border and differences in privacy standards and laws between regions. The mining process of blocks becomes more difficult because transaction volumes and network scalability problems continue to emerge. The underlying algorithms and methods need to demonstrate new ways of operation. Healthcare supply chain control along with medical trials and drug tracking benefits from Blockchain technology because it strengthens transparency and trust capabilities. RFIDs and barcodes make up tracking systems but face high vulnerability to tampering. New research is needed for implementing tamper-resistant tracking solutions through this blockchain solution.

Medical things using the Internet of Things (IoMT) represent the second domain that protects data from threatening attacks. Advanced communication networks having distinct rules present obstacles that demand well-coordinated synchronization systems with unified access rules. Blockchain technology will be investigated as a solution for future research projects that aim to create unified network and user device infrastructure for IoMT systems.

REFERENCES

[1] Hoai Luan Pham, Thi Hong Tran, Yasuhiko Nakashima, “A Secure Remote Healthcare System for Hospital Using Blockchain Smart Contract”, IEEE Globecom Workshops (GC Wkshps), 9-13 Dec 2018

[2] Vidhya Ramani, Tanesh Kumar, An Braeken, Madhusanka Liyanage, Mika Ylianttila, “Secure and Efficient Data Accessibility in Blockchain Based Healthcare Systems”, IEEE Global Communications Conference (GLOBECOM), Dec 2018.

[3] Seyednima Khezr, Md Moniruzzaman, Abdulsalam Yassine, Rachid Benlamri “Towards Secure and Smart Healthcare in Smart Cities Using Blockchain”, 1st International Workshop on Blockchain Enabled Sustainable Smart Cities, Aug 2018

[4] Anastasia Theodouli, Stelios Arakliotis, Konstantinos Moschou, Konstantinos Votis, Dimitrios Tzovaras, “On the design of a Blockchain-based system to facilitate Healthcare Data Sharing”, 2018 17th IEEE International Conference on Trust, Security and Privacy in Computing and Communications/ 12th IEEE International Conference on Big Data Science and Engineering, 1-3 Aug. 2018.

[5] Jayneel Vora, Anand Nayyar, Sudeep Tanwar, Sudhanshu Tyagi, Neeraj Kumar, M. S. Obaidat, Joel J P C Rodrigues, " BHEEM: A Blockchain-Based Framework for Securing Electronic Health Records", IEEE Globecom Workshops (GC Wkshps), 9-13 Dec 2018.

[6] D. C. Nguyen, P. N. Pathirana, M. Ding, and A. Seneviratne, "Blockchain for secure ehrs sharing of mobile cloud based ehealth systems," IEEE Access, vol. 7, pp. 66 792– 66 806, 2019.

[7] Michael, J.; Cohn, A.; Butcher, J.R. BlockChain Technology. 2018. Available online: https://www.steptoe.com/images/content/1/7/v3/171269/LIT-FebMar18-Feature-Blockchain.pdf (accessed on 20 March 2019).

[8] Lee, J.H.; Pilkington, M. How the Blockchain Revolution Will Reshape the Consumer Electronics Industry [Future Directions]. IEEE Consum. Electron. Mag. 2017, 6, 19–23. [CrossRef]

[9] Yli-Huumo, J.; Ko, D.; Choi, S.; Park, S.; Smolander, K. Where is current research on blockchain technology?—A systematic review. PLoS ONE 2016, 11, e0163477. [CrossRef] [PubMed]

[10] Yaeger, K.; Martini, M.; Rasouli, J.; Costa, A. Emerging Blockchain Technology Solutions for Modern Healthcare Infrastructure. J. Sci. Innov. Med. 2019, 2. [CrossRef]

[11] Lin, I.C.; Liao, T.C. A Survey of Blockchain Security Issues and Challenges. IJ Netw. Secur. 2017, 19, 653–659.

[12] Nakamoto, S. Bitcoin: A Peer-to-Peer Electronic Cash System; BN Publishing: La Vergne, TN, USA, 2008.

[13] Rawal, V.; Mascarenhas, P.; Shah, M.; Kondaka, S.S. White Paper: Blockchain for Healthcare an Opportunity to Address Many Complex Challenges in Healthcare; CitiusTech: Princeton, NJ, USA, 2017.

[14] Engelhardt, M.A. Hitching healthcare to the chain: An introduction to blockchain technology in the healthcare sector. Technol. Innov. Manag. Rev. 2017, 7, 22–34. [CrossRef]

[15] Mead, C.N. Data interchange standards in healthcare it-computable semantic interoperability: Now possible but still difficult. Do we really need a better mousetrap? J. Healthc. Inf. Manag. 2006, 20, 71.

[16] Iroju, O.; Soriyan, A.; Gambo, I.; Olaleke, J. Interoperability in healthcare: Benefits, challenges and resolutions.Int. J. Innov. Appl. Stud. 2013, 3, 262–270.

[17] Al Ridhawi, I.; Aloqaily, M.; Kotb, Y.; Al Ridhawi, Y.; Jararweh, Y. A collaborative mobile edge computing and user solution for service composition in 5G systems. Trans. Emerg. Telecommun. Technol. 2018, 29, e3446. [CrossRef]

[18] Al Ridhawi, I.; Aloqaily, M.; Kantarci, B.; Jararweh, Y.; Mouftah, H.T. A continuous diversified vehicular cloud service availability framework for smart cities. Comput. Netw. 2018, 145, 207–218. [CrossRef]

[19] Peter, H.; Moser, A. Blockchain-applications in banking & payment transactions: Results of a survey. In Proceedings of the 14th International Scientific Conference Pt, European Financial Systems, Brno, Czech Republic, 26–27 June 2017; Volume 2, pp. 141–149.

[20] Zheng, Z.; Xie, S.; Dai, H.N.; Wang, H. Blockchain Challenges and Opportunities: A Survey; Work Paper; Inderscience Publishers: Geneva, Switzerland, 2016.

[21] Beck, R.; Avital, M.; Rossi, M.; Thatcher, J.B. Blockchain technology in business and information systems research. Bus. Inf. Syst. Eng. 2017, 59, 381–384. [CrossRef]

[22] Cai, C.W. Disruption of financial intermediation by FinTech: A review on crowdfunding and blockchain. Account. Financ. 2018, 58, 965–992. [CrossRef]

[23] Ølnes, S.; Ubacht, J.; Janssen, M. Blockchain in government: Benefits and implications of distributed ledger technology for information sharing. Gov. Inf. Q. 2017, 34, 355–364.

[24] Hou, H. The application of blockchain technology in E-government in China. In Proceedings of the IEEE 2017 26th International Conference on Computer Communication and Networks (ICCCN), Vancouver, BC, Canada, 31 July–3 August 2017; pp. 1–4.

[25] Alketbi, A.; Nasir, Q.; Talib, M.A. Blockchain for government services—Use cases, security benefits and challenges. In Proceedings of the IEEE 2018 15th Learning and Technology Conference (L&T), Jeddah, Saudi Arabia, 25–26 February 2018; pp. 112–119.

[26] Li, X.; Jiang, P.; Chen, T.; Luo, X.; Wen, Q. A survey on the security of blockchain systems. Future Gen. Comput. Syst. 2017, in press. [CrossRef]

[27] Conti, M.; Kumar, E.S.; Lal, C.; Ruj, S. A survey on security and privacy issues of bitcoin. IEEE Commun. Surv. Tutor. 2018, 20, 3416–3452. [CrossRef]

[28] Joshi, A.P.; Han, M.; Wang, Y. A survey on security and privacy issues of blockchain technology. Math. Found. Comput. 2018, 1, 121–147. [CrossRef]

[29] Radanovi´c, I.; Liki´c, R. Opportunities for Use of Blockchain Technology in Medicine. Appl. Health Econ. Health Policy 2018, 16, 583–590. [CrossRef]

[30] Siyal, A.; Junejo, A.; Zawish, M.; Ahmed, K.; Khalil, A.; Soursou, G. Applications of Blockchain Technology in Medicine and Healthcare: Challenges and Future Perspectives. Cryptography 2019, 3, 3. [CrossRef]

[31] McGhin, T.; Choo, K.K.R.; Liu, C.Z.; He, D. Blockchain in healthcare applications: Research challenges and opportunities. J. Netw. Comput. Appl. 2019, 135, 62–75. [CrossRef]

[32] Roehrs, A.; da Costa, C.A.; da Rosa Righi, R. OmniPHR: A distributed architecture model to integrate personal health records. J. Biomed. Inform. 2017, 71, 70–81. [CrossRef]

[33] Azaria, A.; Ekblaw, A.; Vieira, T.; Lippman, A. Medrec: Using blockchain for medical data access and permission management. In Proceedings of the 2016 2nd International Conference on Open and Big Data (OBD), Vienna, Austria, 22–24 August 2016; pp. 25–30.

[34] Zhang, J.; Xue, N.; Huang, X. A secure system for pervasive social network-based healthcare. IEEE Access 2016, 4, 9239–9250. [CrossRef]

[35] Xia, Q.; Sifah, E.B.; Asamoah, K.O.; Gao, J.; Du, X.; Guizani, M. MeDShare: Trust-less medical data sharing among cloud service providers via blockchain. IEEE Access 2017, 5, 14757–14767. [CrossRef]

[36] Yue, X.; Wang, H.; Jin, D.; Li, M.; Jiang, W. Healthcare data gateways: Found healthcare intelligence on blockchain with novel privacy risk control. J. Med. Syst. 2016, 40, 218. [CrossRef] [PubMed]

[37] Saraf, C.; Sabadra, S. Blockchain platforms: A compendium. In Proceedings of the 2018 IEEE International Conference on Innovative Research and Development (ICIRD), Bangkok, Thailand, 11–12 May 2018; pp. 1–6.

[38] Ethereum. Available online: https://www.ethereum.org/ (accessed on 20 March 2019).

[39] Ripple. Available online: https://ripple.com/ (accessed on 20 March 2019).

[40] Hyperledger. Available online: https://www.hyperledger.org/ (accessed on 20 March 2019).

[41] Dimitrov, D.V. Blockchain Applications for Healthcare Data Management. Healthc. Inform. Res. 2019, 25, 51–56. [CrossRef] [PubMed]

[42] Panesar, A. Machine Learning and AI for Healthcare: Big Data for Improved Health Outcomes; Springer: Emeryville,CA, USA, 2019.

[43] Kim, C.; Kim, H.J. A study on healthcare supply chain management efficiency: Using bootstrap data envelopment analysis. Health Care Manag. Sci. 2019, 1–15. [CrossRef]

[44] Clauson, K.A.; Breeden, E.A.; Davidson, C.; Mackey, T.K. Leveraging blockchain technology to enhance supply chain management in healthcare. Blockchain Healthc. Today 2018. [CrossRef]

[45] Shae, Z.; Tsai, J.J. On the design of a blockchain platform for clinical trial and precision medicine. In Proceedings of the 2017 IEEE 37th International Conference on Distributed Computing Systems (ICDCS), Atlanta, GA, USA, 5–8 June 2017; pp. 1972–1980.

[46] Choudhury, O.; Fairoza, N.; Sylla, I.; Das, A. A Blockchain Framework for Managing and Monitoring Data in Multi-Site Clinical Trials. arXiv 2019, arXiv:1902.03975.

[47] Dhillon, V.; Metcalf, D.; Hooper, M. Blockchain Enabled Applications: Understand the Blockchain Ecosystem and How to Make It Work for You; Springer: Emeryville, CA, USA, 2017.

[48] Course 2: The Medical Billing Process. Available online: https://www.medicalbillingandcodingonline.com/

[49] medical-coding-for-billers/ (accessed on 12 March 2019). [49] Counterfeit Medications. Available online: https://en.wikipedia.org/wiki/Counterfeit_medications (accessed on 14 March 2019).

[50] Deisingh, A.K. Pharmaceutical counterfeiting. Analyst 2005, 130, 271–279. [CrossRef].