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Reviewing the Role of Block Chain in Securing Patient Data for Health Care Applications

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Abstract: Every day, there is an increasing need for healthcare applications. The patient data must still be stored securely. But in order to avoid security breaches, a variety of security measures may be used for the storage of patient data. However, these methods are out of date. Using block chain technology, security concerns should be alleviated. Health care data may be kept secure with the use of block chain, which promotes decentralization.
Keywords: Block chain, Security, Health care Application

[1] Introduction

As a result of its status as a cutting-edge technology, blockchain has been the focus of much academic and industrial study in recent years. Since no third party is required to record transactions in a decentralised, distributed, and immutable ledger, the technology is known as blockchain. Non-financial industries such as government, energy, and health care are at the forefront of Blockchain 3.0, the next generation of the blockchain technology. Healthcare facilities have embraced and exploited these technologies in several ways. Decentralization, privacy, and security are three of blockchain's most essential features in healthcare, since they may be utilised to safeguard patient information from unauthorised access.

1.1 Blockchain

When it comes down to it, a blockchain is a peer-to-peer network that was initially suggested as part of the Bitcoin protocol in 2008. To keep track of all transactions in the network, the blockchain has a public ledger known as a chain of blocks. There are two parts to every block: a header and a body. The previous block's hash may be seen in the header of each new block. ' There are chains or linked lists that connect each block in a chain to the one before it. Merkle trees, timestamps, and nonces in the block headers limit the amount of labour required to analyse transactions in a block. To solve a mathematical issue, miners often change the nonce number, which is an arbitrarily large quantity.

An example of a Blockchain transaction is a tiny unit of work that is kept in public blocks. The majority of the system participants must agree on each transaction before it can be completed. Because the transactions are stored on the Blockchain, they are tamperproof. Because of the immutability of the blockchain, a single copy of the ledger is kept by all users. Business logic is encoded using smart contracts, a self-executing code that runs on the blockchain architecture and allows for straight-through transaction execution on any blockchain. Smart contracts are permanently tamper-proof, since no one can modify what has been written, self-verifying owing to automated capabilities, and self-enforcing when the rules are satisfied at all stages when they are incorporated in the Blockchain. Blockchain has a number of important features, including as decentralization, immutability, availability, and anonymity, which make it almost impossible to tamper with and censorship-resistant.

1.2 Blockchain Use Cases in Healthcare

Health care is one area where blockchain is seen as having enormous promise. In 2016, the Office of the National Coordinator for Health Information Technology (ONC) created an ideation challenge for asking white papers on the possible use of blockchain in healthcare. In response to this problem, a number of blockchain-based healthcare solutions have been developed.

1.3 Electronic Medical Records

With the possibility of connecting heterogeneous systems and increasing the accuracy of Electronic Health Records (EHRs), healthcare should be transformed. The phrases "electronic medical records" (EMRs) and "electronic health records" (EHRs) are sometimes used interchangeably, although they have distinct meanings. An electronic medical record, or EMR, computerised replica of the paper records kept at a doctor's office. A patient's medical and treatment history is stored in an electronic medical record (EMR). Electronic health records (EHRs) emphasise the patient's overall health, going beyond the traditional clinical data obtained in the doctor's office to give a more comprehensive picture of their treatment. According to the mapping research, blockchain technology aids in the administration of electronic medical records. To provide patients control over who has access to their medical records, MedRec leverages the Ethereum platform. FHIRChain (Fast Health Inter-operability Records + Blockchain) is a second application that combines EHRs. Health care record management is the topic of a blockchain-based application created using ethereum. ONC criteria are met by FHIRChain's services for patients. Additionally, research aims to address the problem of systems that are unable to work together to share data across cloud services because of the dangers associated with disclosing private data. In order to exchange medical data in cloud repositories, Medshare offers data provenance, auditing, and governance between huge data organizations.

1.4 Remote Patient Monitoring

Mobile devices, body area sensors, and IoT devices may all be used to monitor a patient's health remotely. Data from distant biological locations may be stored, shared, and retrieved using the power of the blockchain. A Hyper ledger Fabric-based blockchain application transports data via mobile devices. Real-time patient monitoring and automated interventions are now possible thanks to Ethereum smart contracts. Electronic health records are one area where the Internet of Things is now under investigation and being fully used.To access, store and manage electronic health data using data-flow architectures that combine IOT with the blockchain, like IoBHealth, one option.

[2] Literature Review

There are several researches in area of healthcare and block chain some of the research in relevant field are discussed in this section.

Kristen N. Griggs, et al. (2018) Introduced data transmission and recording security issues are becoming more prevalent as IoT devices and others are gaining popularity for remote patient monitoring. Medical sensors must be analysed and administered in a safe manner, we recommend employing blockchain-based smart contracts (PHI). Our solution uses a private Ethereal-based blockchain to interface with sensors, a smart device; thereafter it calls for and records all blockchain occurrences to be called into action by smart contracts. Using a smart contract system, alerts may be sent to patients and medical providers, and the initiators of these actions could be recorded securely. Many of the security problems associated with remote patient monitoring may be addressed by a HIPAA-compliant notification system, which would also automate the sending of information to all parties involved. [1]

Igor Radanović, et al. (2018) created the history of transactions and assets on a peer-to-peer computer network may be recorded in a decentralized database known as the blockchain, which is made up of cryptographically linked blocks of data. Digital contracts, financial and governmental data, and property ownership all make use of this technology. Medical, educational, intellectual property, and supply chain management are all likely to be future applications. Blockchain technology has several medical uses, including electronic health records, medical

insurance, biomedical research, pharmaceutical supply and procurement systems, and medical education. Even though blockchain technology is still nascent in the eyes of both the public and industry experts, there are still a number of drawbacks that must be considered before using this technology. There are currently concerns with scalability, security, and user acceptance of smart contracts. There is little doubt that blockchain technology can have a transformational effect on healthcare organizations and medical practices because of this, health practitioners and policymakers should be aware of the risks.[2]

Davide Calvaresi, et al. (2018) presented MAS technology was often used to build intelligent distributed systems that manage sensitive information. More and more people are advocating the use of blockchain technology to ensure accountability and build trust in MAS. There is a pressing need to develop a research strategy and identify scientific and technical obstacles in this field, even if most techniques have only just begun to investigate it. This research began with a thorough evaluation of previous studies that used MAS and BCT to find common ground. Examine their application areas' motivations, assumptions and needs to offer a comprehensive analysis of the current state of the art. Discussing current issues and possible solutions to them, they present our vision for MAS and BCT in several application situations.[3]

Aiqing Zhang, et al. (2018) studied the accuracy of diagnosis may be improved via electronic health record exchange, where security and privacy protection are essential considerations. Since its inception in 2009, blockchain has been hailed as a fundamental feature of the technology as a way to protect sensitive health information (PHI). This research proposes a novel BSPP technique for e-Health diagnostic systems, which might help. Private and consortium blockchains are the first to be designed for data architecture and consensus processes. The protected indexes of PHI were stored on the consortium blockchain, while the PHI itself was stored on the private blockchain. All PHI, keywords, and patient IDs are public key encrypted to guarantee data security, access control, and patient privacy. To ensure that the blockchains are constantly accessible, fresh blocks must be added to the blockchains with proof of compliance from the block generators. The suggested protocol's security capabilities have been shown via security analysis. The suggested strategy is also tested on JUICE to see how it performs.[4]

Xueping Liang, et al. (2018) Concerned about their health than ever before because to the rise of wearable technology. Advances in technology help patients and physicians as well as insurance companies. Data generated through wearable devices, which may reflect individuals' health problems and behaviors and increase disclosure risks for healthcare practitioners and application developers, raises serious privacy concerns. Leveraging Intel SGX trusted execution platform, they present a decentralized alternative utilizing blockchain technology to overcome privacy problems in this research paper. Syncing wearable sensor data with an online account and restricting who has access to personal health information (PHI) are both options available to consumers through a web application. An immutable, platform-independent ledger may be used to store protected personal health information, including logs of data access. User privacy and responsibility can be achieved while maintaining acceptable overhead using our method. [5]

Mahdi H. Miraz, et al. (2018) presented iot environment, BC, the technology underpinning the bitcoin crypto-currency system, being implemented. Academic and industrial research is now being conducted in this area with a high degree of intensity. BC security is bolstered by the use of a cryptographic problem known as Proof-of-Work (PoW), which keeps a digital log of all transactions incorruptible. Additional privacy is provided by BC, which records user identities via a changing Public Key (PK). Non-monetary uses of the BC have included distributed storage systems, proof-of-location, and health care. All of these have shown success with the BC. As part of a recent review of IoT security challenges and potential solutions, BC for IoT Security was put to the test. [6]

Ahmad Firdaus, et al. (2018) Inspired by the growing popularity of Android mobile devices and blockchain to build mobile malware that can infiltrate the blockchain. In spite of the blockchain's security, malicious actors have managed to get access to it as legitimate users and steal vital information. Root exploits, botnets, and Trojans are all examples of mobile malware, and root exploit is the most hazardous. When the operating system kernel is corrupted, attackers may get root capabilities, circumvent security protections, take control of the operating system, install additional malware on the device, and eventually, steal private keys related to the blockchain. A thorough examination of root exploit malware's innovative qualities and tactics will help ensure the safety of blockchain-based medical data management (BMDM).This project will employ bio-inspired practical swarm optimization (PSO) to find the new Android debug bridge's distinctive characteristics. System command, directory path, and code-based features were all studied in order to improve machine learning predictions for spotting unexpected root vulnerabilities, according to this research. This study found that Logitboost had a 93% accuracy rate in the simulation. All of the root exploit samples were predicted by Logitboost in our own approach for identifying root exploits (RODS).[7]

Hongyu Li, et al. (2018) Created a huge growth in the number of medical data has made medical care a necessity in people's lives (e.g., diagnosis certificates and medical records). Theft, tampering, and even deletion of medical data

are all too commonplace when it comes to electronic records. Medical data cannot be collected or retrieved reliably if the aforementioned happens, which causes a delay in treatment and may possibly put the patient's life in peril. New medical data preservation systems (DPS) based on blockchain technology are presented here. In order to ensure the integrity and verifiability of stored data while also protecting the privacy of the user, their storage solution makes use of blockchain technology.

If tampering is detected, the planned DPS would allow users to save essential data indefinitely and verify the data's legitimacy. They also utilize a range of cryptographic methods and cautious data storage practices to ensure user privacy; for example, even if the data are stolen, an adversary will be unable to read the plain text. The DPS prototype is built on Ethereal, a real-world blockchain network. The suggested system's efficacy and efficiency have been shown by the results of a performance assessment. [8]

Gregory Epiphaniou, et al. (2019) Published a wide range of businesses and sectors are expected to benefit from Distributed Ledger Technologies, including the food supply, pharmaceuticals, real estate and financial services. Companies and individuals alike stand to benefit greatly from the decentralization and decentralization afforded by blockchain technology. In the distributed economy of Industry 4.0, it was able to change and simplify complicated system processes utilizing distributed applications. Blockchain technology has the potential to enhance healthcare and the current security, privacy, and interoperability issues that patients and their personal information face. It's becoming simpler to handle electronic records while also reducing the fictions and expenses associated with present middlemen thanks to new health information exchange economies of scale. To better understand Blockchain's quirks and how it might be used in healthcare, this chapter will focus on its key characteristics and uses. In this article, we'll go through some of the biggest concerns and potential benefits of the Blockchain in healthcare, as well as some recent pilot projects.[9]

Tong Zhou, et al. (2019) there has been a lot of excitement about the potential of electronic medical data being made available to researchers and other healthcare professionals. Because of the fragmentation of medical data and the lack of appropriate sharing methods, it was difficult to exchange medical data under the present medical data management system. Since medical records were kept in a single area, they were more vulnerable to theft and manipulation. A permissionless blockchain (Med-DLattice) and a permissioned blockchain (Med-PPPHIS) are components of our Med-PPPHIS idea, and they work together to provide a chained security mechanism for personal health information and medical data on the blockchain. As a result of Med-DAG DLattice's structure, each account's Account-DAG is updated asynchronously to other accounts that were not linked to the account in question. It is possible that the DPoS-Quorum strategy presented for Med-DLattice nodes would lead to efficient consensus building. This method offers a safe and efficient means of distributing data while protecting data privacy by transforming medical data into on-chain tokens. Using the Med-PPPHIS prototype, they propose for the first time in China a blockchain-based closed-loop solution for managing chronic disease. There were 25 AliCloud ECS virtual machines used to simulate 500 nodes for this test. For example, testing suggests that Med-PPPHIS can block DDoS assaults as well as Sybil attacks with low latency and high throughput.[10]

Shamaila Iram, et al. (2019) was studied economic stability and environmental sustainability are threatened by an unprecedented rise in energy use. Smart buildings' energy efficiency can only be improved by coming up with new, creative solutions to the problem of rising energy consumption in metropolitan areas. Energy consumption trends in residential buildings may be explored, analyzed, and visualized to assist estimate their energy needs. It may also be possible to predict a sudden rise in energy demand by looking at patterns in the consumption of residential buildings. Charts and graphs like line graphs, bar charts, and scatter plots are outmoded techniques of depicting energy consumption patterns and do not provide a comprehensive and meaningful insight into the daily residential need for energy. Similarly, a great degree of precision in time was necessary. Throughout this project, modern data exploration and data analytics approaches were used to analyze energy time series data. Graphic representations of data exploration findings were shown using heat maps. A heat map is a useful tool for gaining insight into how energy is used throughout the day. Descriptive analysis, diagnostics, and contextual analysis are all methods used to interpret the heat map data.[11]

Geetanjali Rathee, et al. (2020) It was also feasible to store, analyses, and transport patient data provided in many formats, such as photos, text, and audio, via the usage of various smart devices when applying multimedia techniques in healthcare. Various multimedia approaches are being used by healthcare institutions all around the globe to become more efficient, coordinated, and user-centered. However, the administration of a large quantity of data, such as reports and photos of each individual, increases the human effort and security hazards. IoT in healthcare offers a solution to these problems since it improves patient care and reduces costs by allocating medical resources more effectively. IoT devices, on the other hand, are vulnerable to a variety of invaders. Even if the medical store or pathology laboratories aren't well-known, physicians may compel their patients to get lab tests or purchase their drugs from them in order to earn a profit. As a result, while discussing the Internet of Things, it is

imperative that security be a primary focus. Thus, Blockchain technology has been shown to be the most effective way for real-time control system secrecy. Data breach or data modification may be seen by the whole blockchain network, which is why we are using blockchain technology in this book to generate the unique hash for each piece of healthcare multimedia data. Blockchain technology has been shown to be 96% successful in product drop ratios, falsification attacks, wormhole attacks, and probabilistic authentication conditions based on comparisons with more conventional approaches and upgraded simulations.[12]

Table 1 Literature Survey

Sno.	Author/Year	Objective	Methodology	Limitation
[1]	K. N. Griggs/2018	To propose Healthcare Blockchain System that should make use of Smart Contracts. Uses for this technology include remote patient monitoring that is both safe and automated.	Healthcare, Blockchain	Lack of technical work
[2]	I. Radanović/2018	Use Cases for Blockchain Technology in the Healthcare Industry	Blockchain,Health care	There is no implication in future
[3]	D. Calvaresi/2018	Systematic Literature Review on Multi-Agent Systems and Blockchain	Blockchain	There is no security in this system
[4]	A. Zhang/2018	The Consortium Blockchain enables safe and confidential data exchange in e-health systems.	Secure, Privacy,Healthcare ,Blockchain	Scope of this research is very less
[5]	X. Liang/2018	Decentralization of responsibility and self-determination in healthcare systems	Healthcare systems	Performance of this research is very low
[6]	M. H. Miraz/2018	Because of blockchain, IoT ecosystem is now more secure.	Blockchain,IOT,Security	There is no work on healthcare
[7]	A. Firdaus	Management of Medical Data on Mobile Devices: Root Exploit Detection and Functionality Enhancement	Blockchain, Detection	Lack of accuracy
[8]	H. Li/2018	A Blockchain-Based Medical Data Archiving System	Blockchain, Data Preservation System	Lack of security
[9]	G. Epiphaniou/2019	It's time to talk about blockchain in healthcare.	Blockchain,Health care	Lack of accuracy
[10]	T. Zhou/2019	Scientific workout advice and national physique monitoring using a blockchain-based personal healthcare information system	Blockchain, Information System,Healthcare	There is no security in this system
[11]	S. Iram/2019	Connecting to smart cities: Visualizing monthly peak power demand in residential structures using energy time series analysis	Smart Cities,Energy Time	There is no work on healthcare
[12]	G. Rathee/2020	An IoT-based healthcare system that utilises blockchain technology for multimodal data processing	Hybrid framework, Multimedia	Lack of accuracy
[13]	I. Abu-elezz/2020	Scope review: health care applications of blockchain technology and potential drawbacks	Blockchain, Healthcare	Scope of this research is very less
[14]	D. J. Munoz/2020	Healthcare blockchain hyperledger solution Clinicappchain: low-cost	Blockchain, Hyperledger, Healthcare	There is no security in this system
[15]	R. M. Amir Latif/2020	"A Blockchain-based remix IDE: a smart contract-based healthcare framework"	Blockchain, contract-based Framework, Healthcare	Lack of accuracy

[3] Problem Statement

An overview of Blockchain in healthcare is provided in this paper. A variety of applications for blockchain in medical ground have already been examined, in part because of the technology's rapid expansion and the promise of more automation. Most blockchain research in healthcare is focused on exchanging Electronic Health Records, according to our findings. Blockchain technology should also be examined by researchers in the biotechnology, pharmaceutical supply chain, and insurance industries. In addition, we found that very few studies focused on how to put the results into practice. Before blockchain technology can be properly understood, developed, and examined, there is still a long way to go in its development. Concerns like scalability, security, and privacy are being addressed, which gives users more confidence in this technology.

[4] Need of Research

When it comes to securing patient data in the healthcare industry, there is a need to concentrate on elements such as performance and security of traditional security systems. It's time for a new strategy to safeguard patient data for health care that doesn't affect the quality of the service. In addition, a comparison of prior research to the proposed study on the basis of accuracy and performance is required.

[5] Conclusion

Smart contracts are being used in a new healthcare blockchain system for remote patient monitoring automation. Researchers looked at the medicinal applications of Blockchain Technology. Blockchain and multi-agent systems have been discussed. A systematic literature review by research was used to express the findings. Research outlined how Consortium Blockchain may be used to securely and privately share data in e-health systems. Proposed work decentralized responsibility and self-sufficiency in healthcare systems. An investigation on blockchain-enabled IoT ecosystem security was conducted. With regards to medical data management using mobile devices and blockchain technology, research reported his findings on root exploit detection and feature optimization. The idea of a medical data preservation system based on blockchain technology has been floated. Currently, blockchain technology in healthcare is being advocated. We tested a medical personal health information system based on blockchain technology for tracking national fitness levels and providing scientific exercise recommendations. “Connecting to smart cities: Using energy time series to depict monthly peak loads in residential structures” was published. Blockchain-based hybrid architecture for IoT-healthcare data processing was presented. Research assessed the pros and risks of blockchain in healthcare. In the healthcare industry, a low-cost blockchain hyper ledger system had been proposed. A smart contract-based architecture based on Blockchain technology was presented for the healthcare sector by researchers. SRHB approach will be researched. Blockchain technology in the cloud was used to secure e-health data. Overview of blockchain in healthcare and health sciences was published. In healthcare facilities, temperature regulation in the recovery unit may be improved by using a cooperative algorithm. The use of blockchain technology in medical imaging was proposed. Clinical trials might benefit from Blockchain Technology. Blockchain-based secure healthcare architecture with the best deep learning model was presented to the audience. It was discussed how blockchain technology may be used to mobile health services and application. Research predicted that blockchain research in healthcare will be a reality.

	Block chain	**Health care**	**Security**	**Performance**
[1]	Yes	No	Yes	No
[2]	Yes	Yes	No	Yes
[3]	Yes	No	No	No
[4]	No	Yes	Yes	No
[5]	No	Yes	No	Yes
[6]	Yes	No	Yes	No
[7]	Yes	Yes	No	No

[6] Scope of Research

Such studies are expected to have a substantial impact on the healthcare industry as well as commercial applications that need strict data protection. As a matter of fact, many real-time systems are capable of solving real-world issues. Machine learning algorithms may be added to these systems in the future to further improve security.

References

[1]. K. N. Griggs, O. Ossipova, C. P. Kohlios, A. N. Baccarini, E. A. Howson, and T. Hayajneh, "Healthcare Blockchain System Using Smart Contracts for Secure Automated Remote Patient Monitoring," J. Med. Syst., vol. 42, no. 7, pp. 1–7, 2018, doi: 10.1007/s10916-018-0982-x.

[2]. I. Radanović and R. Likić, "Opportunities for Use of Blockchain Technology in Medicine," Appl. Health Econ. Health Policy, vol. 16, no. 5, pp. 583–590, 2018, doi: 10.1007/s40258-018-0412-8.

[3]. D. Calvaresi, A. Dubovitskaya, J. P. Calbimonte, K. Taveter, and M. Schumacher, Multi-agent systems and blockchain: Results from a systematic literature review, vol. 10978 LNAI. Springer International Publishing, 2018.

[4]. A. Zhang and X. Lin, "Towards Secure and Privacy-Preserving Data Sharing in e-Health Systems via Consortium Blockchain," J. Med. Syst., vol. 42, no. 8, 2018, doi: 10.1007/s10916-018-0995-5.

[5]. X. Liang, S. Shetty, J. Zhao, D. Bowden, D. Li, and J. Liu, Towards decentralized accountability and self-sovereignty in healthcare systems, vol. 10631 LNCS. Springer International Publishing, 2018.

[6]. M. H. Miraz and M. Ali, Blockchain enabled enhanced IoT ecosystem security, vol. 200. Springer International Publishing, 2018.

[7]. A. Firdaus, N. B. Anuar, M. F. A. Razak, I. A. T. Hashem, S. Bachok, and A. K. Sangaiah, "Root Exploit Detection and Features Optimization: Mobile Device and Blockchain Based Medical Data Management," J. Med. Syst., vol. 42, no. 6, 2018, doi: 10.1007/s10916-018-0966-x.

[8]. H. Li, L. Zhu, M. Shen, F. Gao, X. Tao, and S. Liu, "Blockchain-Based Data Preservation System for Medical Data," J. Med. Syst., vol. 42, no. 8, pp. 1–13, 2018, doi: 10.1007/s10916-018-0997-3.

[9]. G. Epiphaniou, H. Daly, and H. Al-Khateeb, "Blockchain and healthcare," Adv. Sci. Technol. Secur. Appl., pp. 1–29, 2019, doi: 10.1007/978-3-030-11289-9_1.

[10]. T. Zhou, X. Li, and H. Zhao, "Med-PPPHIS: Blockchain-Based Personal Healthcare Information System for National Physique Monitoring and Scientific Exercise Guiding," J. Med. Syst., vol. 43, no. 9, 2019, doi: 10.1007/s10916-019-1430-2.

[11]. S. Iram, T. Fernando, and R. Hill, Connecting to smart cities: Analyzing energy times series to visualize monthly electricity peak load in residential buildings, vol. 880, no. 3. Springer International Publishing, 2019.

[12]. G. Rathee, A. Sharma, H. Saini, R. Kumar, and R. Iqbal, "A hybrid framework for multimedia data processing in IoT-healthcare using blockchain technology," Multimed. Tools Appl., vol. 79, no. 15–16, pp. 9711–9733, 2020, doi: 10.1007/s11042-019-07835-3.

[13]. I. Abu-elezz, A. Hassan, A. Nazeemudeen, M. Househ, and A. Abd-alrazaq, "The benefits and threats of blockchain technology in healthcare: A scoping review," Int. J. Med. Inform., vol. 142, no. February, p. 104246, 2020, doi: 10.1016/j.ijmedinf.2020.104246.

[14]. D. J. Munoz, D. A. Constantinescu, R. Asenjo, and L. Fuentes, Clinicappchain: A low-cost blockchain hyperledger solution for healthcare, vol. 1010. Springer International Publishing, 2020.

[15]. R. M. Amir Latif, K. Hussain, N. Z. Jhanjhi, A. Nayyar, and O. Rizwan, "A remix IDE: smart contract-based framework for the healthcare sector by using Blockchain technology," Multimed. Tools Appl., 2020, doi: 10.1007/s11042-020-10087-1.

[16]. A. Mubarakali, "Healthcare Services Monitoring in Cloud Using Secure and Robust Healthcare-Based BLOCKCHAIN(SRHB)Approach," Mob. Networks Appl., vol. 25, no. 4, pp. 1330–1337, 2020, doi: 10.1007/s11036-020-01551-1.

[17]. G. Nagasubramanian, R. K. Sakthivel, R. Patan, A. H. Gandomi, M. Sankayya, and B. Balusamy, "Securing e-health records using keyless signature infrastructure blockchain technology in the cloud," Neural Comput. Appl., vol. 32, no. 3, pp. 639–647, 2020, doi: 10.1007/s00521-018-3915-1.

[18]. A. Hasselgren, K. Kralevska, D. Gligoroski, S. A. Pedersen, and A. Faxvaag, "Blockchain in healthcare and health sciences—A scoping review," Int. J. Med. Inform., vol. 134, no. May 2019, p. 104040, 2020, doi: 10.1016/j.ijmedinf.2019.104040.

[19]. R. Casado-Vara, F. De la Prieta, S. Rodriguez, J. Prieto, and J. M. Corchado, Cooperative algorithm to improve temperature control in recovery unit of healthcare facilities, vol. 802. Springer International Publishing, 2020.

[20]. M. P. McBee and C. Wilcox, "Blockchain Technology: Principles and Applications in Medical Imaging," J. Digit. Imaging, vol. 33, no. 3, pp. 726–734, 2020, doi: 10.1007/s10278-019-00310-3.

[21]. I. A. Omar, R. Jayaraman, K. Salah, I. Yaqoob, and S. Ellahham, "Applications of Blockchain Technology in Clinical Trials: Review and Open Challenges," Arab. J. Sci. Eng., vol. 46, no. 4, pp. 3001–3015, 2021, doi: 10.1007/s13369-020-04989-3.

[22]. T. Veeramakali, R. Siva, B. Sivakumar, P. C. Senthil Mahesh, and N. Krishnaraj, "An intelligent internet of things-based secure healthcare framework using blockchain technology with an optimal deep learning model," J. Supercomput., vol. 77, no. 9, pp. 9576–9596, 2021, doi: 10.1007/s11227-021-03637-3.

[23]. J. A. Santos, P. R. M. Inácio, and B. M. C. Silva, "Towards the Use of Blockchain in Mobile Health Services and Applications," J. Med. Syst., vol. 45, no. 2, 2021, doi: 10.1007/s10916-020-01680-w.

[24]. A. Rejeb, H. Treiblmaier, K. Rejeb, and S. Zailani, "Blockchain research in healthcare: a bibliometric review and current research trends," J. Data, Inf. Manag., vol. 3, no. 2, pp. 109–124, 2021, doi: 10.1007/s42488-021-00046-2.

[25]. Sundaram, K.T. (2022) "Digital Transformation with AI/ML & Cybersecurity," *International Journal of Computer Science and Mobile Computing*, 11(11), pp. 1–3. Available at: https://doi.org/10.47760/ijcsmc.2022.v11i11.001.

[26]. Sundaram, K.T. (2022) *Five key steps to realize the digital transformation value and ensuring a successful SAP HANA transformation in Global Organizations*, *Free Press Journal*. Available at: https://www.freepressjournal.in/business/five-key-steps-to-realize-the-digital-transformation-value-and-ensuring-a-successful-sap-hana-transformation-in-global-organizations.

[27]. Sundaram, K.T. (2022) "Five key steps realize the digital transformation value and ensure a successful SAP HANA transformation in Global Organizations," *International Journal of Computer Science and Mobile Computing*, 11(10), pp. 116–118. Available at: https://doi.org/10.47760/ijcsmc.2022.v11i10.009.

