# The Utilization of Blockchain Technology in Healthcare Management

**Andrzej Chluski**
Czestochowa University of Technology, Poland

andrzej.chluski@pcz.pl

**Abstract:** This paper explores the potential of blockchain technology in healthcare management. It discusses the key features and characteristics of blockchain technology that can enhance management in the healthcare sector, particularly in knowledge management and improving information processing. The paper underlines the potential of blockchain technology to revolutionise healthcare service delivery, presenting new forms of healthcare delivery that are only possible with the cost-effective and efficient use of blockchain technology. The research methods used in the paper include an analysis of selected theoretical studies on blockchain technology and the fundamentals of providing healthcare services, along with the presentation of several case studies. The paper also highlights the practical use of blockchain technology in both large organisations and small niche players serving the global market. The benefits and risks of using blockchain technology in healthcare are also identified.

**Keywords:** Healthcare Management, Blockchain Technology, Information Processes And Knowledge Management In Healthcare.

## 1. Introduction

The business activities in the medical sector are based on providing interrelated services to meet human health needs. Medical services include all necessary activities related to prevention, diagnosis of health status, and treatment of specific diseases (Medical service, 2011).

Every human activity requires access to a certain amount of data and its appropriate use. The sources of these data, the methods of processing and using them, and the information processes form what is known as an information system. The information system in the medical industry is very diverse. It is created and used by various stakeholders to meet the needs of a wide range of clients, such as patients (consumers of services), intermediaries in the provision of medical services, and providers of these services, i.e. doctors and other individuals from medical staff working in the respective centres, while also those who finance the provision of medical services (Rainer, Prince, 2021). Patients' needs include a wide range of information, such as information about specific health conditions, methods of diagnosis, treatment, places of services, and opinions about doctors and medical facilities. This information is partly in the form of other patients' views. Healthcare providers need information about different providers and competitors, as well as information about industry trends, the development of medical science, opportunities for further staff training, and planning while also developing the entity (Winter et al., 2023). Blockchain technology is an essential part of modern information technologies. It enables the distributed storage of data and its direct transfer between users, resulting in increased transparency and more secure transactions. Blockchain technologies, when applied to social media to verify the authenticity of patients' opinions and experiences, can significantly aid in their decision-making process related to choosing the right doctor and medical facility. Implementing Blockchain in healthcare can lead to tangible improvements in the management of diagnostic and treatment processes and the financing and administration of medical entities (Upadhyay et al., 2021). Blockchain technology, including the medical industry, can play a significant role in the economy and contribute to its development (Zhang, 2018).

The article aims to explore how blockchain technology can improve healthcare management by enhancing knowledge management and information processing. It examines theoretical and practical case studies highlighting Blockchain's benefits, risks, and practical applications in healthcare services.

The article presents three practical examples of blockchain use in healthcare to supplement the theoretical considerations. Use cases were selected considering the utility of applying Blockchain technology in healthcare for various stakeholders, including patients, medical staff, and service providers, as well as other stakeholders such as insurance companies, public funding bodies, governments, policymakers, and the public. The author intended to present the broadest possible benefits and risks of using Blockchain in healthcare.

Similar studies were conducted by Kurtz et al. (2018), focusing on business models in healthcare utilizing Blockchain technology. Mikula & Jacobsen (2018) analyzed the use of Blockchain technology in managing access to patient medical data. Reda et al. (2020) examined the impact of Blockchain on health supply chain

management. The system of patient appointment booking in healthcare services using Blockchain technology was described by Sumati et al. (2023). A systematic review of the use of Blockchain in healthcare was also conducted by Zang et al. (2018).

## 2. Blockchain: Distributed Ledger Technology

A blockchain is a chain of blocks (Crosby et al., 2016). Technically, it is a database that functions as a distributed ledger and is accessible to all authorised network users (Chien et al., 2020).

Blockchain technology is a chain of data blocks that store and transmit information about transactions in a network arranged in consecutive data blocks. Each transaction is recorded in this list as a block containing data on its value and time of conclusion. It is an open distributed database with relatively high security ensured using appropriate encryption techniques. Blockchain technology automatically stores data in many different locations. Only a person with private cryptographic keys has the right to edit such records. The keyholder is considered to be the data owner in a blockchain (Odeh et al., 2022).

Blockchain technology is usually associated with virtual currencies, such as Bitcoin. One of the main advantages of these currencies is their independence from state institutions, central banks, etc. The software of the nodes of this network is open and available to any participant. Bitcoin is based on the transfer between accounts using asymmetric cryptography, while all transactions are public and stored in a distributed database. Each transaction in the Bitcoin network is distributed to other nodes and requires confirmation within a time-stamped list of all known transactions, i.e., blockchains. This confirmation is based on mathematical evidence and specific computer operations, otherwise known as *proof of work*.

Another important element of blockchain technology is smart contracts. These are computer programs integrated into network blocks that automatically execute a contract when the specific conditions placed in that contract are met (Crosby et al., 2016). Executing smart contracts using a decentralised cryptographic system enables untrusted parties to conduct transactions securely without using a trusted third party. Smart contracts are most commonly implemented on the Ethereum network. The public Ethereum blockchain was created in 2014 as an open-source project and an alternative to the Bitcoin network. With the introduction of smart contract functionality, applications built on Ethereum can automate selected business transactions without the need for human intervention (from a legal standpoint). The structure of the database, linking all previous to newly added blocks using unique identifiers (hash), makes it impossible to make modifications that are unnoticeable to other users. The result is a database that is considered secure, attack-resilient, and trustworthy.

The most important features of blockchain technology relevant to data management are as follows (Rot, Zygala, 2018):

- security: Blockchain uses cryptography to store data and transactions securely. Each block is protected by mathematical hash functions, making data manipulation and falsification extremely difficult.
- decentralisation: Unlike conventional systems, Blockchain spreads data across multiple nodes, making it more difficult for hackers to attack and alter data.
- transparency: All transactions and operations are visible to network participants, which increases trust in the system and allows processes to be monitored and audited.
- irreversibility: Once the data have been validated and stored on the Blockchain, they cannot be changed or deleted. This guarantees the permanence and immutability of data, which is particularly important for financial transactions and legal documents.
- automation: Smart contracts can automate processes that must be controlled manually. This facilitates management by reducing costs and eliminating intermediaries.

With these features, Blockchain can speed up processes, increase efficiency, reduce costs, and increase trust between business entities.

In the future, more and more blockchain applications can be expected in various sectors of the economy and society, thus allowing further development and innovation in information and communication technology. Gartner (2017) predicts that by 2030, more than 30 per cent of businesses will be using Blockchain as an essential technology for business activity (Antonopoulos, 2017, p. 110).

## 3. Potential Areas of Application for Blockchain Technology in the Healthcare Sector

Every medical activity requires using well-chosen modern information and communication technologies (ICT). This applies to both patients and healthcare providers. Patients can use the technology to optimise their choice of doctor and place of service, while providers use ICT to develop and better promote their services in the medical market. As an essential element of ICT, blockchain technology can be used in several areas of medical activity, as outlined below.

*Improving medical research and knowledge acquisition:* Blockchain technology is increasingly used in biomedical research, knowledge acquisition, and medical education, helping protect privacy and maintaining data integrity while sharing and storing data. It is significant for clinical trials mainly because of its unique properties that ensure the safety and invariability of records. Data stored in the Blockchain are protected from unauthorised access, and cryptographic mechanisms guarantee their integrity. As indicated by Nagasubramanian (2018) and Nugent et al. (2016), this significantly increases data reliability obtained during clinical trials. These authors emphasised that smart contracts used in Blockchain can effectively prevent data falsification and the underestimation of undesirable research results, which is critical to maintaining ethical scientific standards.

Blockchain enables data to be securely transferred and shared between various entities without the risk of modification or corruption (Mytis-Gkometh et al., 2017). This is particularly important in large research projects, where collaboration requires a reliable information exchange mechanism. With data transparency and immutability, Blockchain increases confidence in clinical trials. Participants, sponsors, and regulators can verify all the information collected without worrying about its authenticity. With proper implementation and regulation, Blockchain has the potential to revolutionise the medical research sector, leading to significant advances in diagnostics, therapeutics and overall medical knowledge management.

Using blockchain technology helps improve the quality of *monitoring of treatment progress and the overall health status of patients* in the hospital environment. These systems enable secure and uninterrupted real-time tracking of medical data (Griggs et al., 2018). An integral part of such solutions is sensors for health parameters that can be controlled remotely, which aligns with the idea of the Internet of Things (IoT). Processes such as reading, transferring, processing and securing access to sensor data are carried out using blockchain technology (Meisami e. al., 2021). Similarly, results obtained from diagnostic devices used in the hospital can be securely processed and transmitted, for example, to the Electronic Patient Record by using cryptographic methods provided by the Blockchain (Chelladurai, Pandian, 2022).

*Identity and privacy*: Blockchain technology can be used in applications to help establish the identity of patients. The correct verification of a patient's identity, with the patient's informed consent, enables immediate and secure access by authorised persons to all their medical data at the place of service (Mikula, Jacobsen, 2018). It is a similar case in terms of *the verification of the identity of a doctor* as an employee authorised to access a patient's distributed medical data (within a blockchain database). The benefit of this solution is that an authorised employee of the medical entity (doctor, physiotherapist, radiologist) has immediate access to all the necessary patient's medical data stored in a distributed blockchain database.

*Inventory management* of medicines and medical supplies: Inventory management in the medical sector is critical due to its large share in the cost of such services. Blockchain technology can improve inventory management and reduce costs by decentralising and reducing the role of intermediaries. Controlling the quality and originality of medicines and other medical supplies is crucial. Medicines, medical supplies, and technical diagnostic equipment must meet stringent requirements for the quality, type, and origin of drugs, diagnostic materials and other auxiliaries. Depending on the procurement procedures and how these funds are distributed, different types of fraud are possible in this area of medical activity. This primarily concerns the purchase of counterfeit medicines and other medical supplies (Reda et al., 2020).

*Registration and booking of healthcare services:* Blockchain-based solutions can improve the booking and scheduling of services. Medical services, in the vast majority of countries, are provided within a regulated market. The restriction of the free market forces the time rationing of some medical services. This leads to queues of patients being formed while waiting for services. Such queues should be subject to control processes and some optimisation. This relates to the appropriate allocation of patients to the relevant medical entities while considering the option of patient transport. It is also essential, for example, to properly manage cases where a patient opts out of service and does not inform the healthcare provider while remaining on the waiting list. A centralised waiting list based on blockchain technology can reduce this problem (Sumathi et al., 2023).

*Medical transport:* Blockchain enables efficient real-time processing of medical transport data. Current weaknesses of transport data systems include the need for more connectivity between many medical transport providers and other barriers to transport. This is particularly true of emergency medical transport (Wu, Ho, 2023). Emergency transport resources should be deployed as efficiently as possible (Odeh et al., 2022). Optimisation should not only concern geographical data (the transport to the patient and the destination hospital) but also access to sensitive patient health data. Blockchain allows data collection at all stages of medical transport services. The benefit for the patient is the faster intervention of a doctor with immediate access to all necessary medical data.

*Payments:* Payments for medical services are made at multiple stages of treatment. The patient's resources finance some medical services. Still, more often than not, a significant part of these services is financed by funds of a public nature (from the state budget or various medical insurance companies). One of the areas for improvement of modern computerised payment systems is multiple data exchanges between different entities and numerous verification steps, which limit the possibility of creating one simple global system. As a decentralised database, blockchain technology can minimise inconveniences by streamlining payment processes while reducing potential errors and fraud.

*Opinion-forming social media:* Blockchain technology can simplify the creation and use of opinion-forming social media. With blockchain technology, it is possible to create universal online platforms to collect real-time feedback on doctors and medical entities. The opinions can be signed with private cryptographic keys, thus making it much more difficult to falsify views posted on social media.

## 4. Selected Examples of Practical use of Blockchain Technology in the Management of Medical Activities

### 4.1 Supporting the Maintenance of the Electronic Patient Record

Any patient-related data entered and processed in the IT system is critical to the patient and the provider. Patient medical data are collected from various healthcare providers. These include the patient's health status, as well as the results of diagnostic tests, methods and course of treatment, outcomes of treatment, etc. They must be accessible and processed independently of their technical implementation and the location where they are created. They should be collected through public resources, such as the Internet, with limited security and access to authorised persons. Essential information about the patient's health and treatment history should be collected to improve the quality and effectiveness of treatment and support lifestyle changes. The most commonly used name is the Electronic Patient Record (EHR).

The International Organisation for Standardisation (ISO) defines an EHR as an electronic repository of patient health data stored and shared securely and made accessible to multiple users with appropriate authorisation levels. It contains historical, current, and predictive information, at least to some extent. The main objective of creating and using EHRs is to improve the quality and efficiency of healthcare delivery by all healthcare providers (ISO/DTR 20514, 2004).

There are several reference models of EHR available in subject-related literature. EHR reference models should be developed so that they ensure the following:

- sharing patient medical data between professionals from different fields of medicine,
- interoperability between healthcare provider organisations, regional and national health system institutions, and, in the future, between supranational organisations,
- interoperability between software developed by different suppliers.

The need to meet the conditions listed above, standardisation, and the object-oriented paradigm approach to programming and data modelling are causing EHR reference models to become increasingly abstract, 'decoupled' from hardware and communication infrastructure, and, therefore, more generic, universal, and flexible. These can be called virtual electronic patient records.

Blockchain technology can significantly facilitate and simplify the practical implementation of EHRs operating according to the proposed reference models.

Computerised systems supporting EHRs have long been developed and implemented in many entities. They use conventional centralised databases maintained in specific computer centres. Administrators also centralise and control access to these data. Blockchain technologies can simplify and automate the allocation of access rights

to these data for medical staff from multiple healthcare providers. The optimal solution would be a distributed blockchain database maintained on a private or public blockchain network (Shahnaz, 2019).

Specialised software companies can provide technological support for the operation of EHRs in medical entities using blockchain technology. Due to the nature of blockchain technology and global access to the Internet, these can be small multi-branch companies. An example of such an entity is Guardtime (Guardtime, 2024).

Guardtime is one of the leaders in implementing blockchain technology in various sectors, including the healthcare sector and healthcare systems. The enterprise uses its proprietary KSI blockchain technology to increase security, transparency, and operational efficiency across multiple applications. Guardtime has been actively researching and developing blockchain protocols and applications for over ten years (Guardtime, 2024) and employs over 120 people (Crunchbase-guardtime, 2024). Outlier Ventures (Outlierventures, 2024) and SCIPA (2024) are the leading investors· Guardtime is working with the Estonian government using blockchain technology to process data in Estonian e-health systems. Their technology allows for the secure management of health records and citizen services that are available online, supporting more than 1,000 different public services (Guardtime-Estonia, 2024).

Furthermore, Guardtime has entered into a contract with a private healthcare provider in the United Arab Emirates. Implementing blockchain technology aims to improve data privacy and security. This project aims to develop a transparent and secure data management system that could serve as a model for other regional medical institutions. Guardtime develops innovative medical data management methods that meet high-security standards and are efficient and compliant with local healthcare data protection regulations.

### 4.2 Automation of Payment Services and Insurance Claims

Health insurance claims are a broad category of problems and challenges that health systems face worldwide. Most problems concern designing organisational structures and procedures to handle health insurance reasonably and efficiently.

Health insurance is often complex and challenging for the average user to understand. The procedures for making a claim, the documentation required by insurers, and the deadlines for dealing with claims are complex. One of the biggest problems is the high rejection rate of claims. The reasons for rejection vary, including errors in the completion of documents, insufficient evidence of the need for a particular medical service, and the pace of the policy being too low. Delays in the processing and payment claims are another critical problem that can significantly affect their patients' lives and health.

The rising cost of health insurance is a global issue, affecting policies' availability and effectiveness. High premiums can exclude people with lower incomes, increasing inequalities in access to healthcare.

Fraud by healthcare providers and patients is another serious problem for health systems. False claims or prescribing unnecessary medical procedures to obtain insurance money entails significant losses. The incompatibility and complexity of health insurance regulations in different countries can also hinder the effective management and enforcement of claims. Differences in legislation make global insurance operations difficult and require detailed knowledge of local conditions by insurers. Differences in standards of medical care between countries can lead to problems with the recognition of claims, particularly for people receiving healthcare abroad. Furthermore, this can complicate the procedures for verifying and assessing medical needs.

All the problems require nationally and internationally coordinated action to make health insurance systems more user-friendly and cost-effective.

Founded in 2018, MediConCen operates in the insurance technology sector. It has quickly gained local and international recognition for its innovative solutions. This company has used blockchain technology and the latest technological advances to automate insurance claims processes, thus revolutionising the handling of these claims. Through its activities, MediConCen streamlines and significantly changes how claims are managed in the insurance sector (Mediconcen, 2024).

MediConCen has developed an advanced computer system based on Hyperledger Fabric technology (Hyperledger, 2024) (Cachin, 2016), automating medical insurance claims and eliminating the need for paper documentation. This is an excellent example of an application that illustrates how blockchain technology can increase the operational efficiency of insurance companies and healthcare providers while eliminating the need for data reconciliation between the parties.

MediConCen has over 600,000 users in 14 insurance companies and over 900 doctors. In 2021, the company was also recognised in the prestigious Forbes Asia 100 to Watch list (Forbes, 2021), which promotes the most promising startups in the Asia-Pacific region.

Implementing digital signatures via QR codes makes the platform scalable. It enables the integration of insurers and healthcare providers globally without compromising data integrity on providers and claims. This innovation significantly reduces the burden on all involved parties, especially the medical staff, who can focus on more urgent tasks.

MediConCen uses blockchain smart contracts that are triggered automatically when certain conditions contained in the policy are met. This process limits human intervention, allowing a neutral and impartial technology to fulfil the contract's provisions once specific criteria have been met. Furthermore, using the company's proprietary API eliminates the need to submit data in paper form, which is a time-consuming conventional process and is often subject to the risk of forgery.

### 4.3 Optimising Pharmaceutical Supply Chain Management

The Drug Supply Chain Security Act (DSCSA) (FDA, 2024) was passed by the US Congress in 2013 as part of a larger legislation framework known as the Drug Quality and Security Act (DQSA). The main objective of DSCSA is to increase security in the pharmaceutical supply chain by introducing stricter rules for identifying and tracking pharmaceutical formulations.

The DSCSA requires operators in the medicines supply chain (such as manufacturers, distributors, and pharmacies) to use systems to accurately track medicines' movement at various distribution stages. This system is designed to protect against counterfeiting, theft, and other forms of fraud. Each pharmaceutical product must be equipped with a unique identifier, which allows it to be identified and authenticated at each stage of the supply chain.

Founded in 2016, LedgerDomain specialises in developing blockchain platforms that enable IT systems to operate efficiently in real time. The company is a member of Hyperledger, the Linux Foundation, and the Clinical Supply Blockchain Working Group. In 2019, LedgerDomain and UCLA Health were selected to participate in the DSCSA Pilot Programme to explore and evaluate methods to improve safety and security in the drug supply chain.

As part of this program, UCLA and its solution partner, LedgerDomain, focused on developing a complete system based on the BRUINchain blockchain that would meet all the key objectives of the DSCSA Act for a distributor operating solely based on commercial technology (Chien et al., 2020).

The system developers claim that automated queries to drug manufacturer relational databases implemented using their proprietary BRUINchain technology will reduce the cost of DSCSA compliance to 17 cents per individual drug package. The authors believe that manufacturers adopting an efficient, fully automated computer system based on distributed ledger technology (DLT) can further reduce these costs (Chien et al., 2020).

The interoperability of such a system enables real-time verification without human intervention, which is a critical factor in reducing compliance costs. With 4.2 billion prescriptions dispensed annually in the USA, blockchain technology would reduce the projected cost per unit to 13 cents per unit (saving $183 million per year in labour costs). Still, it would also make incorrect or fraudulent transactions much more difficult. At the same time, it also reduces the need for safety stock and improves the detection and elimination of potentially dangerous drugs from the drug supply chain (Chien et al., 2020).

By working with LedgerDomain, UCLA Health has positively changed its supply chain management for medicines. The appropriate use of blockchain technology can help improve logistics operations in the health sector, which is a significant step forward in combating problems such as drug counterfeiting and other supply issues.

## 5. Conclusion

Blockchain technology is an innovative tool for improving efficiency and reducing costs. It is a revolutionary concept that offers new possibilities for delivering previously unknown or unfeasible services and creating new innovative business models. New approaches to old problems provide excellent application potential, while the technology's flexibility allows it to be freely adapted to different tasks.

Blockchain technology benefits the healthcare sector by improving data and process management. Some main advantages include the following (Shae et al., 2019) (Reda et al., 2020).:

- Data security: Blockchain technology provides exceptional protection for medical information by cryptographically protecting blocks of data, which is crucial for sensitive patient data.
- Transparency and immutability: Blockchain registers are durable and transparent, thus enabling accurate tracking of medical history and preventing data manipulation.
- Operational efficiency: Blockchain automation of administrative and financial processes can significantly reduce costs and management time while improving the efficiency of health services.
- Information sharing: Blockchain technology facilitates the secure and transparent sharing of data between different medical entities, which supports better diagnosis and treatment planning while also improving the accumulation of medical knowledge and its transfer, i.e. the education of medical staff and patients.
- Reducing fraud: The technology can help reduce fraud and abuse in healthcare by accurately tracking medical products and drugs and automating processing insurance policies and other payments.
- Inventory management: Blockchain technology helps manage inventory efficiently to reduce waste and optimise resources.
- Patient rights: Patients can better control access to their health data, strengthening their privacy and security.

These advantages show how blockchain technology can transform healthcare, making it more secure, efficient, and friendly for providers and patients. Blockchain in healthcare is not just the future; it is a technology already transforming healthcare while benefiting all participants in the healthcare system.

Using blockchain technology in healthcare also involves risks (Kuo, Kim, 2019) (Tsung-Ting 2017). These particular concerns are as follows :

- complex implementation that requires integration with existing systems and the need for collaboration between different actors.
- the lack of uniform regulations in different countries, especially about personal data protection and regulations for medical services in other countries, including various ways of financing healthcare.
- cyber-security risks may relate to the theft, leakage, or manipulation of data stored on the blockchain network (particularly applicable in private blockchain networks controlled by individual organisations that are not adequately distributed).
- performance limitations of public blockchains, which are essential in the medical sector and are characterised by the transfer of large amounts of data and the need to perform most data processing quickly.
- the expected broader automation of processes may affect employment in the medical sector, especially in support and administrative staff. This may require appropriate adaptation measures.

Large companies most often implement innovative blockchain technologies. However, the technology's specifics allow relatively small niche enterprises to participate in the global medical market, for example, in areas where services can be provided partly remotely (Kurtz, 2019).

Data transparency, traceability, immutability, flexible access, trust, privacy, and security are the major problems faced by modern healthcare data management systems. Blockchain is a revolutionary and decentralised modern technology that has the potential to significantly change the way data is processed in the healthcare sector and provide a solution to most of these problems (Odeh et al., 2022).

Future research may concern the application of AI and Blockchain in healthcare. Distributed ledger technologies are databases containing static records of specific data. Smart contracts securely execute certain simple algorithms related to this data. The operation of smart contracts is formalised and precisely defined using relatively simple programming languages. The conditions for "triggering" a smart contract are also strictly specified. The general goal of using smart contracts is the automation of selected processes. In this context, an attractive solution might be using artificial intelligence to expand the scope of this automation (Rai et al., 2023). Utilising AI in mathematically formalised and algorithmic areas is relatively safe, as the outcomes of AI algorithm learning must be mathematically proven.

The article's limitations are as follows. This paper is theoretical rather than experimental, focusing on analysing potential applications of blockchain technology in healthcare management. The research sample consists of

deliberately and subjectively chosen examples by the author to illustrate the discussed concepts. Future research should use quantitative methodologies (e.g., Structural Equation Modeling methods). For this purpose, experiences related to the studies regarding information technology adoption models can be utilised (Zolait, 2012).

Blockchain technology can significantly enhance healthcare management by providing a secure and immutable record of patient data, ensuring data integrity and privacy. Additionally, it can streamline administrative processes, reduce fraud, and improve the efficiency of healthcare supply chains through transparent and traceable transactions. Utilising Blockchain in healthcare management can benefit patients, medical staff, administrators of healthcare facilities, and other stakeholders.

## References


Antonopoulos, A., (2017). *Mastering Bitcoin: Unlocking Digital Cryptocurrencies*, 2nd. Ed., New York, O'Reilly.

Cachin, C. (2016). „Architecture of the Hyperledger Blockchain Fabric". *Workshop on Distributed Cryptocurrencies and Consensus Ledgers*, Vol. 310, 4.

Chelladurai, U., Pandian, S., (2022). „A novel blockchain-based electronic health record automation system for healthcare", *J. Ambient Intell. Human. Comput.* Vol. 13 (1). pp. 693–703.

Chien, W., de Jesus, J., Taylor, B., Dods, V., Alekseyev, L., Shoda, D., & Shieh, P. B. (2020). „The Last Mile: DSCSA Solution Through Blockchain Technology". *Blockchain in Healthcare Today*.

Crosby, M. Nachiappan, P., Verma, S., Kalyanaraman, V., (2016). *„*Blockchain technology: Beyond Bitcoin*", Applied Innovation Review*, Vol. 1(2), pp 6–10.

Crunchbase-guardtime, (2024). [online], crunchbase.com/organization/guardtime.

FDA, (2024). fda.gov/drugs/drug-supply-chain-integrity/drug-supply-chain-security-act-dscsa.

Forbes, (2024). [online], forbes.com/sites/forbesasiateam/2021/08/09/forbes-asia-100-to-watch

Gartner, T. Networks. *Blockchain - Leading the Digital Transformation* (2017), [online], gartner.com/ imagesrv/media-products/pdf/Talari-Networks.

Griggs, K.N., Ossipova O., Kohlios, C.P., Baccarini, A.N., Howson, E.A., Hayajneh, T., (2018). „Healthcare blockchain system using smart contracts for secure automated remote patient monitoring", *J. Med. Syst.*, Vol. 42 (7).

Guardtime, 2024, [online], guardtime.com.

Guardtime-Estonia, 2024, [online], guardtime.com/blog/estonian-ehealth.

Hyperlegder, 2024, [online], hyperledger.org

ISO/DTR 20514, Health Informatics – Electronic Health Record – Definition, Scope, and Context, 2004.

Kuo, T., Kim, H. E. (2019). A survey of blockchain security issues and challenges. International Journal of Engineering and Information Systems (IJEAIS), 3, 115-123.

Kurtz, P., Dietzel, C., & Hann, I. (2018). The impact of blockchain technology on business models in healthcare. Springer Online Journal, 1, 157-166.

Medical service. (n.d.) *Segen's Medical Dictionary*. (2011). [online] https://medical-dictionary.thefreedictionary .com/medical+service

MediConCen, 2024, [online], mediconcen.com.hk/about-us/.

Meisami, S., Beheshti-Atashgah, M., Aref, M. R. (2021). „Using blockchain to achieve decentralised privacy in IoT healthcare", *arXiv preprint arXiv:2109.14812*.

Mikula, T., Jacobsen, R.H., (2018). *Identity and access management with Blockchain in electronic healthcare records,* 21st Euromicro Conference on Digital System Design (DSD), 29-31 Aug.

Mytis-Gkometh, P., Drosatos, G., Efraimidis, P.S., Kaldoudi, E. (2017). *Notarisation of Knowledge Retrieval from Biomedical Repositories Using Blockchain Technology*. ICBHI 2017, IFMBE Proceedings, vol 66. Springer, Singapore.

Nagasubramanian, G., Sakthivel, R.K., Patan, R., Gandomi, A.H., Sankayya, M., Balusamy, B., (2018). Securing e-health records using keyless signature infrastructure blockchain technology in the cloud. *Neural Comput Appl*. Vol. 32(3), pp 639–647.

Nugent T, Upton D, Cimpoesu M. (2016). „Improving data transparency in clinical trials using blockchain smart contracts" *F1000Res. Vol 5* p. 2541.

Outlierventures, 2024, outlierventures.io.

Odeh A, Keshta I, Al-Haija QA, (2022). „Analysis of Blockchain in the Healthcare Sector: Application and Issues", *Symmetry,* Vol. 14(9), p. 1760.

Rai, B.K., Kumar, G., Balyan, V., (2023). *AI and Blockchain in Healthcare,* Singapore*,* Springer Nature

Rainer R.K. Prince B. (2021). *Introduction to information systems*, 9th. Ed New Jersey, John Wiley & Sons.

Reda M., Dominique Kanga D.B., Fatima T., Azouazi M., (2020). „Blockchain in health supply chain management: State of the art challenges and opportunities", *Procedia Computer Science*, Vol. 175, pp 706–709,

Rot A., Zygała R. (2018) „Technologia blockchain jako rewolucja w transakcjach cyfrowych", *Informatyka Ekonomiczna, UE Wrocław*, Vol. 4.

SCIPA, 2024, scipa.com

Shahnaz, A., U. Qamar, A. Khalid, (2019). „Using blockchain for electronic health records", *IEEE Access*, Vol. 7, pp. 147782–147795.

Shae Z., Kuo A. M. H., Lee, H. Y. (2019). Challenges, solutions, and future directions in accessing health care: A blockchain-driven solution. Journal of Medical Systems, 43, 328.

Sumathi, M., Dhiraj, I., Mahita, D. S., & Raja, S. P. (2023). „Appointment Booking and Drug Inventory System in Healthcare Services Using Blockchain Technology", *Advances in Distributed Computing and Artificial Intelligence Journal*, Vol. *12*(1), e31607.

Tsung-Ting Kuo, Hyeon-Eui Kim, Lucila Ohno-Machado (2017). Blockchain distributed ledger technologies for biomedical and health care applications, J AM MED INFORM ASSN, Vol. 24, Iss. 6, pp1211–1220

Upadhyay, A., Mukhuty, S., Kumar, V. Kazancoglu, Y., (2021). „Blockchain technology and the circular economy: Implications for sustainability and social responsibility", *Journal of Cleaner Production*, Vol. 293, 126130.

Winter A., Ammenwerth E., Haux R., Marschollek M., (2023) *Health Information Systems: Technological and Management Perspectives*, 3rd ed. Cham, Springer.

Wu T-C, Ho C-TB. (2023). „Blockchain Revolutionizing in Emergency Medicine: A Scoping Review of Patient Journey through the ED". *Healthcare*, Vol. 11(18) p. 2497.

Zdrowie w normie, [online], uhc.com.pl/index.php.

Zhang, P., White, J., Jha, S., Zhao, J., & Benitez, J. (2018). Blockchain technology in healthcare: A systematic review. Healthcare, 6(2), 1–30.

Zolait, A. H. S. (2012*). Knowledge and Technology Adoption, Diffusion, and Transfer: International Perspectives*. IGI Global.