



## The Application of Blockchain Technology in the Health Care Industry

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### Abstract

Many industries, including banking, government, energy, healthcare, etc., have taken an interest in blockchain technology since its inception in the last decade. A comprehensive overview of blockchain's potential uses in the healthcare industry is provided in this article. Research in this field is indeed progressing at a breakneck pace. Thus, we have discovered several cutting-edge applications of blockchain technology, such as medicine supply chain management, electronic medical record sharing, remote patient monitoring, etc. We have also highlighted the shortcomings of the methods that have been examined, and we have wrapped off by delving into some unanswered questions and potential spots for more study. The new Internet of Things applications in Industry 4.0 include blockchain technology, which is immutable, cryptographically secure, distributed ledgers, and a component of decentralized systems. Various entities or parties maintain and distribute exact copies of a succession of transaction lists using this technology. Blockchain technology's capacity to link disparate systems and improve the accuracy of electronic health data, together with a patient-centric approach to healthcare, make it an area with enormous promise.

**Keywords:** Blockchain, Health Care, Data, Ledger, Security

### Introduction

Distributed ledger technology, or blockchain, is publicly and decent rally records transactions on several machines. To create an unbroken chain, a blockchain verifies and connects each "block" to the one before it. Finally, the ledger is called Blockchain. Blockchain ensures a high level of accountability since its records and verifications are publicly available. Once data is put to the Blockchain, it cannot be altered... The data is shown to be authentic and undamaged. Blockchain, which uses distributed ledger technology to store data instead of a central database, improves security while also revealing its vulnerability to hacking. For innovative and forward-thinking business ideas, blockchain provides an excellent platform to compete with more conventional enterprises.

Marketers can keep track of all the medical products via in conjunction with blockchain system. Blockchain technology's use in the healthcare and health industries eliminate counterfeit pills by making it possible to track each one. It is useful for figuring out what makes falsification happen. Because it cannot be altered, blockchain technology is perfect for in healthcare settings,

where patients' records must remain private. The entire All of the hospital's common hardware is linked to this distributed system. With the money and time saved by these gadgets, scientists may look into potential treatments, drugs, and cures for much more. disorders and diseases.

Because it is a distributed ledger network, blockchain makes sure that no one can remove or change records unless everyone agrees to do so. The cryptographic hash that connects each data block to the records of newly added blocks determines the value of a hash on a blockchain. There is no one location where data is processed. Because on a network with a distributed ledger, all users contribute to the total. may see and audit transactions on the blockchain. This decentralized structure makes the system more resilient to attacks by preventing them from happening all at once stronger and more secure overall. It helps improve record-keeping and patient care by cutting down on medical monitoring and practice by half, which is good for everyone involved. Keeping medical records on a blockchain allows patients to track their data's journey.

These days, new methods and therapies for a variety of ailments are being developed as a result of medical data

exchange. One way to accomplish this is by enabling remote access and storing the medical data digitally. Patients are the only owners of the data kept in their electronic records since it is information that they have voluntarily provided after visiting the hospital. Big data, which is comprised of the ever-increasing amounts of data kept in electronic records, has multiple applications within the medical field. Considering how crucial data storage and sharing, numerous companies have emerged to gather, process, analyze, and store data for the purpose of sharing it with other permitted sectors. Businesses are increasingly relying on data availability for operations and survival as a result of this process, which is driving interest in cloud computing, data analytics, and provenance. Several parties have placed money using the internet and cloud storage to keep up with the increasing demand for huge data storage. Many users, including patients, healthcare providers, and researchers, are interested in this storage since it allows for the flexible data dissemination that is regulated across domains to those who benefit from it in cloud repositories. Concerns about data exposure to unauthorized third parties pose the greatest threat to cloud data storage and exchange.

### Literature Review

Muhammed. *et al.* (2025) <sup>[1]</sup> When used to by resolving long-standing issues with interoperability, transparency, and privacy, Blockchain technology offers a revolutionary approach to data management in healthcare systems. Conventional healthcare data systems are prone to centralized weaknesses, record fragmentation, and a lack of patient autonomy. Providers have instantaneous access to medical record thanks to blockchain's distributed and immutable ledger, which improves privacy and security of data. It is possible that blockchain technology can make data more accessible and integrity, promote openness in data transactions, and preserve sensitive patient information.

Independent. *et al.* (2021) <sup>[5]</sup> Data management solutions that are safe, transparent, and efficient are in high demand owing to the growing digitization of healthcare systems. The potential applications of blockchain technology are the focus of this study. in healthcare data systems include improve interoperability, data consistency, and security. Better control, privacy, and confidence in data transfers among stakeholders may be achieved by healthcare providers by using the decentralized and irreversible features of blockchain.

Shubham *et al.* (2025) <sup>[4]</sup> This research looks at how healthcare systems might use blockchain technology to their advantage by improving control, bolstering data security, and streamlining system-to-system communication. Federated Learning, Zero-Knowledge Proofs, Real-World Byzantine Error Examples of the state-of-the-art are tolerance and proof-of-authority. -the-art approaches employed in the study to tackle major problems with medicine data security. The findings indicated that the blockchain architecture achieved 35% quicker transaction processing and 22% more accurate data retrieval than the conventional approach.

Andrei *et.al* (2024) <sup>[2]</sup> The revolutionary possibilities in order to make healthcare data management more transparent and secure, this study looks at using blockchain technology.

It delves into how Blockchain's auditability, decentralization, and immutability might revolutionize the way medical records are handled. By making it impossible to remove or change information undetected, blockchain improves data integrity and inspires trust among stakeholders.

Lakshmana *et al.* (2024) <sup>[3]</sup> Among hospital administrators, the new Blockchain technology significantly enhances the transparency and safety of data. This focuses on potential blockchain applications in healthcare study., namely how it might improve data security, simplify paperwork, and increase trust via openness. This paper takes a look at the problems with healthcare data management today and shows how blockchain technology may solve them. It backs its claims with examples of blockchain in action and case studies.

### Blockchain

A distributed ledger, the blockchain securely links ever-expanding lists of records (blocks) using cryptographic hashes. Data about transactions (sometimes every block has a timestamp, a cryptographic hash of the block before it, and a representation of the data structure as a Merkle tree, with data nodes acting as leaves. Given that every The data structure resembles a linked list in that each block is linked to the blocks that came before it. Data cannot be removed from a single block once inserted. ledger without simultaneously modifying every block that follow it and getting network consensus to accept these changes, transactions recorded in the blockchain are immutable.

Blockchains are public distributed ledgers that are usually maintained via P2P computer networks. In these networks, nodes follow a procedure using a consensus mechanism that adds and verifies new transaction blocks. Due to the possibility of blockchain splits, blockchain records are not immutable; yet, blockchains exhibit considerable Byzantine fault tolerance as a distributed computing system.

In 2008, building upon prior efforts by Stuart Haber, W. Scott Stornetta, and Dave Bayer, a person or group using the pseudonym Satoshi Nakamoto created a public record to record all Bitcoin cryptocurrency transactions. Having pioneered the use of digital money to use blockchain technology, Bitcoin made it impossible to spend twice. We no longer needed a central server or trusted third party. Many alternative public blockchains and apps have been developed as a result of Bitcoin's concept. One possible use case for the blockchain is as a payment rail.

Some businesses are considering using private blockchains. The promotion of privatized blockchains without an adequate security architecture was nicknamed "snake oil" according to Computerworld. Opponents, however, argue that permissioned blockchains, if meticulously crafted, might really be safer in reality than permissionless ones due to their decentralized nature.

The term "blockchain" describes a distributed database or ledger that may be accessed from any device on a network. Although they are crucial to cryptocurrency systems because they maintain a distributed ledger of transactions safe, their use extends much beyond that. With blockchain technology, data in any sector may be rendered unchangeable, or "immutable."

### Block Chain for the Healthcare Sector

The blockchain was a hot subject in 2016, despite the fact that the technology has been there since 2009 and is a crucial component of the Bitcoin transaction. The National Health Information Technology Manager invests much in the system because of the many basic healthcare problems it might address. With the ever-changing tech scene, it's feasible to manage and move electronic health data while preserving privacy, compatibility, a common framework, and global norms. In the face of healthcare's incessant technological advancements, IT leaders know they must act swiftly to adopt the most appropriate health IT trends and technologies.

Health IT managers should be cautious not to be the first to use innovative technologies that might put patients at risk. In terms of overall economic growth, the pharmaceutical industry is among the world's most dynamic. It has a significant role on patient outcomes and facilitates the commercialization of innovative, potentially beneficial treatments. It maintains the quality and efficacy of prescription pharmaceuticals marketed to the public. It also helps with sterile medicine processing and diagnostics, which speeds up patients' recoveries.

There is a significant risk that counterfeit goods may undermine production or get into the system for counterfeit medications since drug makers sometimes have trouble swiftly monitoring their products. Consequently, it is a major concern for the health of people everywhere, especially in developed countries, due to its production and distribution. For the aim of monitoring, assessing, and assuring the production processes of prospective pharmaceuticals throughout their R&D and manufacturing phases. Here, a DDCS (automated drug management system) would be a good long-term choice for avoiding illegal drugs. The three largest pharmaceutical companies in the world-Sanofi, Pfizer, and Amgen-have joined together to test and assess experimental medications using the blockchain-based distributed ledger technology system (DDCS).

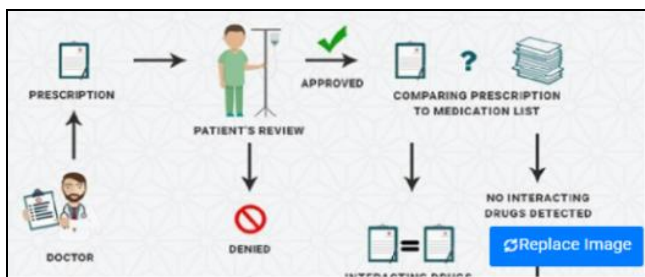


Fig 1: Blockchain solution for interacting with drugs

### Security Concerns When It Comes to Healthcare Blockchain,

**Data Privacy:** Adopting digital ledger Compliance with stringent legal requirements, such as the General Data Protection Regulation (GDPR) in the European Union and the Health Insurance Portability and Accountability Act (HIPAA) in the United States, is a major challenge in the healthcare industry. The right to control one's own data and the paramount significance of patient privacy are both ensured by this legislation. Data saved on blockchain cannot be wiped or modified because of its immutability and

transparency; this can lead to issues with the right to be forgotten as outlined in GDPR.

Applications built on the blockchain in the healthcare industry often use complex methods used in cryptography, including zero-knowledge proofs or limited restrictions regulated access private or consortium blockchains to tackle these privacy problems. Still, a huge obstacle is making sure these solutions are secure and up to code while protecting patients' personal information.

### Security Vulnerabilities

Despite blockchain's stellar reputation for security, it does have several flaws that might compromise sensitive data in healthcare applications. For example, in theory, a public blockchain might have its transactions modified by an attacker who managed to acquire 51% of the network's computer power. Even while these kinds of assaults are easier to pull off on less robust networks, they might have devastating effects on the security of sensitive medical records. An additional point of failure has been introduced by smart contracts and other automated agreements things are executed by blockchain technology. Smart contract outcomes may be manipulated or unauthorized data can be accessed via bugs in the programming. There must be no security flaws in smart contracts for them to be utilized to automate vital healthcare procedures or manage sensitive patient data.

### Interoperability Issues and Scalability

It is quite challenging to achieve interoperability between different blockchain systems and current healthcare IT infrastructures. The data used in healthcare comes in a wide variety of forms and standards, adding to its complexity. Since blockchain interoperability approaches are in their early phases of development., it is challenging to get the level of standardization and compatibility necessary to integrate blockchain solutions with traditional systems. Potential advantages using blockchain technology for medical purposes might be curbed by these obstacles, which make it harder for data to flow freely between various blockchain networks and more conventional healthcare information systems.

Particularly in healthcare applications requiring effective processing of massive volumes of data, scalability is a key concern for blockchain networks. High transaction volumes pose a challenge for most blockchain systems due to performance and security concerns. This limitation could have an impact on healthcare applications like telehealth, RPM, and other forms of remote patient monitoring that rely on constant data availability and processing. Finding blockchain solutions that can scale to handle the ever-increasing data needs of the healthcare sector is a significant technical challenge.

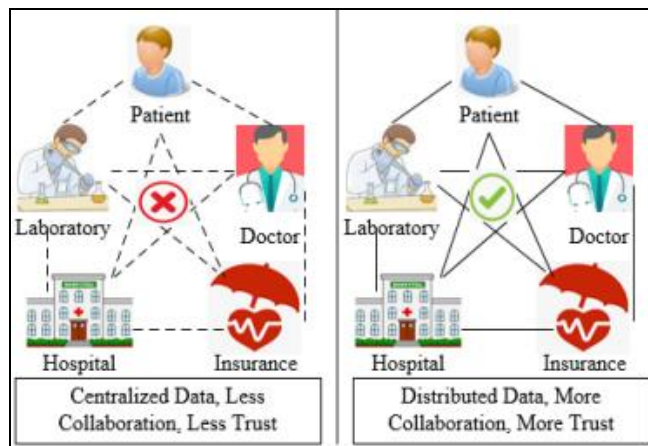
### Regulatory and Legal Challenges

Using There are several healthcare blockchain technology faces regulatory and legal hurdles. Current regulatory frameworks are often tailored to centralized businesses, which is made more difficult by blockchain's decentralized character. Concerns over roles, levels of responsibility, and responsibility for monitoring compliance remain unresolved.

**Technical background of blockchain in healthcare sector**

On a daily basis, people engage with healthcare records. Individual patients' medical records need a safe place to be stored. Private details, such the medical history, diagnosis, and course of therapy plans, may be included in the data. Since cybercriminals may simply breach many documents on purpose, data digitalization has made recovery more difficult. For more recent technological developments, this may represent a knowledge vacuum. Thanks to its decentralization, immutability, and transparency, blockchain technology shows great promise as a tool for the advancement of access-specific EHRs.

Blockchain technology may completely transform the healthcare industry if it were to become widely used making people the center of their own healthcare system. It makes health records more secure, private, and compatible with one another. A wide range of transactions occur frequently inside a typical hosting system. Expenses, health indices, patient identification, invoicing, and account monitoring are all part of the system. These are being closely monitored at all times. Each participant in the program may have their own unique electronic ledger with their own set of identifying characteristics. The EHR connection of a decentralized system compared to a centralized one. Errors, inefficiency, and theft may be tracked by a large number of ledger entries. With blockchain technology, at any one moment, the ledger may be seen by all network nodes. No one else in the class has any trouble verifying or testing the facts. After data has been collected, processed, and validated using smart contracts, it is saved to a specific Blockchain. using the created back-end mechanism. With the help of application programming interfaces (APIs) developed specifically for that network, a number of devices may now access the stored data.



**Fig 2:** EHR Connectivity

**Electronic Healthcare Records (EHRs)**

The One option is to use an EHR, which is a digital medical history that is accessible online information. Details about pharmaceutical control (heart rate, blood pressure, cholesterol level, and imaging studies), clinical data (imaging studies, insurance details, medical recommendations, and lab results), and other medical records are common components throughout the course that is administered to a patient. The term "digital health" the wave of the future in healthcare. records (EHRs), which will enhance the connection between patients and doctors.

**Health Information Exchange (HIE)**

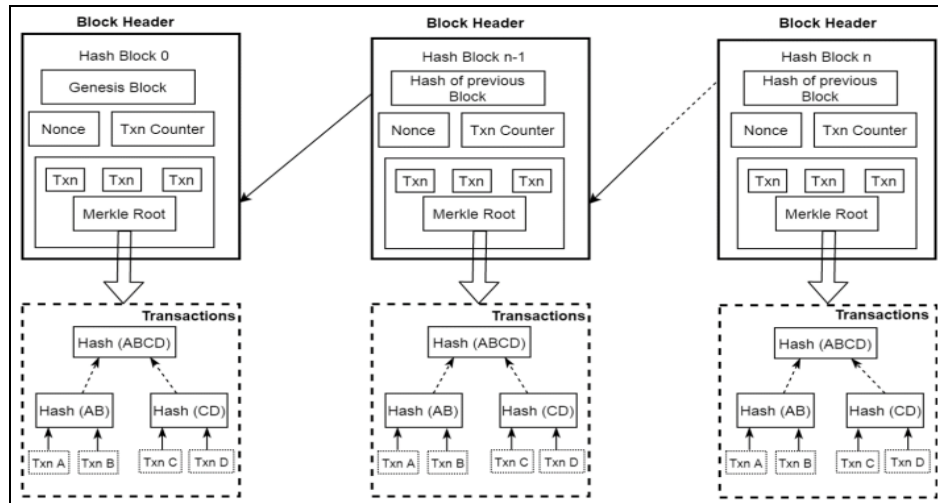
Blockchain is an ideal platform for health information exchanges and clinical trials due to its advantages. It encompasses data management, data provenance and sharing, and decentralized transaction authentication. HIE allows for the exchange of patients' electronic health records.

**Blockchain-Based Radical Changes in Healthcare**

In healthcare, there are a lot of Blockchain variations that provide big alternatives to the old data-related problems. Such implementations allow for the real-time modification of the Blockchain database, which is used for the identification, tracking, and management with respect to health records.

**Secure auto insurance and accident registration built on the blockchain**

New blockchain technology is emerging in computer science and has many possible functions and uses (for instance, two excellent examples of recent evaluations and applications are the works of Charles and colleagues (2023) as well as Emrouznejad and Charles (2022). In a secure, transparent, and generally accepted way, blockchain validates and records user transactions. This is a worldwide public ledger. Connecting and securing the growing database of records that make up blockchain blocks. When building a distributed ledger using building a network that uses blockchain technology is standard procedure. allows users to establish direct connections with one another. According to the research of Nakamoto (2009), each node in the network uses a predetermined protocol for exchanging data with one another and a predetermined procedure for verifying blocks. Any modification to a block needs agreement from most of the network's users and verifies any blocks that follow on the blockchain. As a distributed computer system, blockchain is very error-tolerant and its underlying technology is extremely secure, even if blockchain entries may be updated.



**Fig 3:** A Block Sequence Forms the Backbone of a Blockchain.

A number of implementations are not feasible because people do not fully grasp the situation. Just like any other technical tool, blockchain provides advantages for businesses. Although blockchain technology and its applications have been extensively discussed in theory, very little of it has actually been implemented in reality.

**Conclusion**

The current research provided a synopsis of Blockchain's potential uses in the healthcare industry. The rapid development of blockchain technology has led to its use in several use cases, one of which is to improve the automation of healthcare. The bulk of blockchain-related healthcare research has focused on EHR sharing, according to our analysis. Researchers interested in blockchain technology should think about expanding their studies to include fields like biomedicine, the pharmaceutical supply chain, and insurance. In addition, we found that articles discussing implementation specifics are somewhat infrequent. Blockchain technology has great potential, but more study is required to fully comprehend it, create it in an efficient and secure manner, and assess its efficacy. Continued work is being done to address concerns related to privacy, security, and scalability so that stakeholders have more faith in this technology and it may be used more widely in healthcare.

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