Chapter 4
Securing Healthcare Records Using Blockchain: Applications and Challenges

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4.1 Introduction

Since its inception in 2008, the blockchain has transformed the way we think about problems. Blockchain is a decentralised ledger, a record book which holds the detail of every transaction that takes place on the network, tracking digital assets on network. It has not only changed the financial industry, but it has also shown to be a godsend for secure, efficient, and transparent peer-to-peer (P2P) information transmission. It has solved the key issues like trust in a network which allows any organisation to focus on the issues at hand. With the huge demand of the Internet and related technologies, a variety of Industry 4.0-based applications have been implemented around the world, in which sensors and actuators sense, calculate, and transfer data for industry automation via an open channel named internet. So it is obvious that security and privacy threats have been increased. Due to this, it is essential to consider issues like data integrity, data redundancy, and data heterogeneity [1].

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This technology has come up with better transparency and has enhanced the security system of various sectors.

Today, in the ever-advancing technological era, the healthcare system has progressed significantly. Increased the usage of Electronic Health Records systems has resulted in previously inconceivable levels of healthcare data breaches [2]. Earlier patients were worried about the safety of their medical information. Due to these worries, some people have gone so far as to refuse to share vital personal health data with their healthcare providers [3, 4].

The lack of an efficient, smart, and secure solution to address the problem of securely sharing data among healthcare professionals, patients, and medical researchers is the main roadblock to the widespread adoption of these Electronic Health Records. So, blockchain is a state-of-the-art digital ledger that can be bespoke to record nearly anything of value in addition to financial transactions. The digital data that is stored on a blockchain exists as a shared database that is continually logged.

In late 2019, a coronavirus (COVID-19) outbreak produced a global health emergency [5]. It has a sizable and global impact on healthcare, which makes it easier to embrace digital technologies to meet a variety of needs in the healthcare sector. Despite the fact that the COVID-19 bubonic plague has amply demonstrated the necessity for secure, decentralised, multipurpose platforms for orchestrating the large-scale transfer of sensitive information, such as contact tracking, vaccination status monitoring, and the issuance of COVID-19 health certificates, numerous organisational, technological, and governance obstacles may still prevent ubiquitous implementation of blockchain technology in the healthcare industry. These requirements create a powerful push for a deliberate effort to increase blockchain usage and remove some of the hurdles to widespread deployment [6], Rai et al. [4]. Blockchain in healthcare is all about removing the middleman. It has the potential to improve clinical trial data management by lowering regulatory approval delays and streamlining communication between various supply chain players.

When it came to data breaches, the healthcare industry was the most victimised industry [7]. As reported by several practitioners, between 2005 and 2019, 249.09 million people were impacted by healthcare data breaches. The Health Insurance Portability and Accountability Act (HIPAA) states that at least one data breach of healthcare records occurred every day in 2018. Between 2009 and 2018, data breaches exposed the healthcare records of more than 59 per cent of the US population. In terms of healthcare data breaches, 2015 was the worst year ever with more than 113.27 million records exposed, stolen, or improperly shared [8] (Fig. 4.1).

According to an IBM report titled ‘Healthcare rallies for Blockchain’, 16% of healthcare executives plan to deploy blockchain technology in 2017, with 56% pledging to do so by 2020. The creation of a unified database of healthcare data is on the agenda of world leaders. Doctors and providers can use this information across numerous Electronic Health Records (EHRs), and the data is more secure [9].

Internet of things (IoT) breakthroughs have undoubtedly resulted in continuous advancements in the healthcare business. However the fact that EHR/EMR data is scattered across numerous medical facilities has made it extremely difficult to

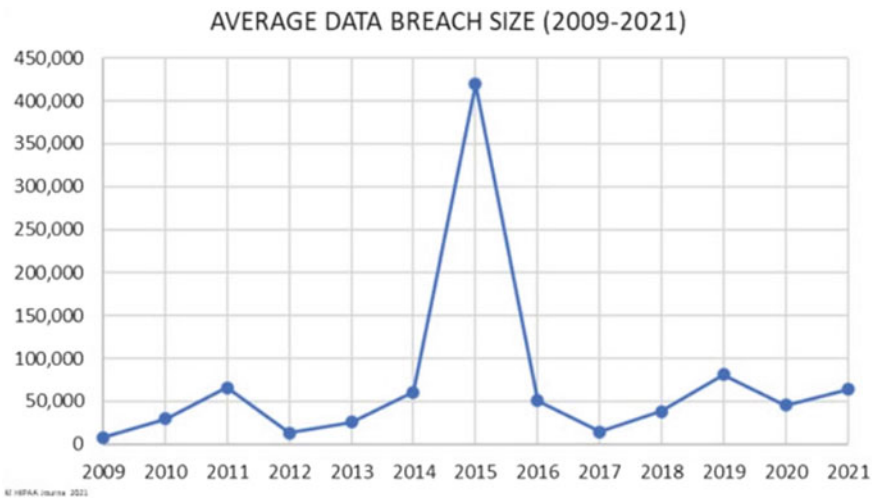

Fig. 4.1 Data showing average data breaches from the year 2009–2021 [9]

process EHR/EMR in a secure manner. In light of these realities, blockchain has gained traction as a viable solution to such problems [10–12].

4.2 Why Blockchain?

Everyone is jumping the hype train. Many IT providers saw the potential lying in Blockchain technology and want their piece of the pie. This is so because of the below-mentioned features [13, 14].

1. Decentralisation

Decentralisation technology allows you to retain your assets in a network without relying on the oversight and control of a single person, organisation, or institution. As the system runs on algorithms, there is no chance for people to scam you out of anything. No one can utilise blockchain for their personal gains. The majority of contemporary healthcare organisations and facilities are largely built on centralised systems, which means that a single body wields far too much power.

2. Transparency

Transparency of data in healthcare industry can assist in the creation of a complete, accurate, and auditable ledger of transactions. The solutions for the management of healthcare data are now unable to simultaneously assure transparency, privacy, and security. Additionally to ensuring greater transparency, blockchain ensures the security of data and enables authorised authority over healthcare data and it can be achieve through encryption and control mechanisms.

3. Immutability

This striking feature of blockchain refers to the potential of a blockchain ledger to remain unaltered and untamperable. It has the power to remodel and alter the auditing process into one that is quick, efficient, and cost-effective. It makes almost impossible for any user on the network to modify, remove, or update the data. This feature can be achieved through cryptographic hashing.

4. Data Provenance

For the healthcare industry, data provenance is crucial to increase public trust in it by providing all pertinent information about how health data is created, accessed, and transferred. It is ensured by the ability to track data changes from its inception to its current state. Blockchain employs a timestamping procedure that entails evaluating the hash values of the provenance record, which is then forwarded to consensus nodes to verify a reliable ledger of all legal transactions is kept.

5. Minting

In essence, there are numerous ways to create a manipulation problem that blockchain can solve. Banks and international tech firms such as Google and Meta create a sense of dependability and accountability to people and corporations in the West. Although mining remains the most prevalent strategy, the prospects for blockchain are now larger in countries that have not yet reached a level.

6. Anonymity and Programmability

Anonymity and programmability are some distinctive attributes of blockchain. Anonymity assures that the individuality of senders and beneficiaries in transactions stay anonymous whereas smart contracts with programmability enable new regulations and transactions being automated. Self-executing programmes known as 'smart contracts' are built on agreements between purchasers and traders.

7. Distributed Ledger and Consensus

Through the integration of fundamental technology components like distributed ledgers and consensus techniques, blockchain can offer a variety of advantages. Consensus is a decision-making procedure for the network's active nodes as when millions of nodes are validating the transactions simultaneously, that time this algorithm helps the system to run smoothly whereas Distributed Ledger System (DLT) makes the process visible and dependable by allowing anyone with the necessary access to observe the ledger (Fig. 4.2).

Blockchain networks have evolved into a formidable combination of security, anonymity, and openness since their inception. The potential for blockchain-based security systems is essentially endless. In a short period of time, technology has irreversibly changed the shape of the global economy, becoming indispensable for many banks, huge enterprises, and even governments.

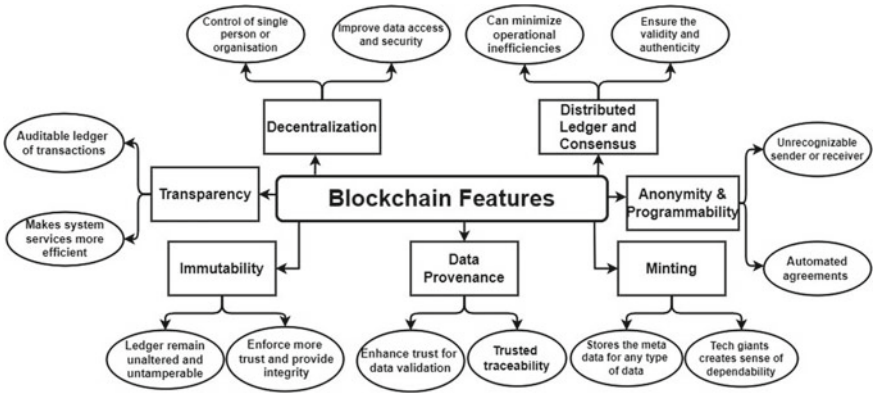

Fig. 4.2 Features of blockchain

4.3 Applications

1. Electronic Health Record

An electronic health record is a computerised representation of a patient's medical file. An individual's health records, prescription details, therapy plans, examination details, laboratory results, test results, and other information are all stored in the Electronic Health Record. Data is dispersed among Electronic Health Record systems, and patients frequently contact with many healthcare providers, making it difficult to access previous records. Furthermore, multiple Electronic Health Record systems are used by different healthcare providers, and some of them are not entirely compatible. These factors make data sharing more challenging [14, 15].

With the use of blockchain technology, patients have full control over how their health records are shared. The blockchain's decentralised, self-trusted, and tamper-resistant structure makes sure that medical data is distributed and stored securely, while also drastically reducing the time it takes to share data and total costs. Patients will also focus more on their own healthcare because they can engage in their own health records.

2. Clinical trial

Recruiting patients for clinical trials is one of the most difficult aspects of any clinical study. There are various challenges that must be addressed from the sponsor's, patient's, and main investigator's viewpoints, resulting in the failure of the most of clinical studies to meet their recruiting targets on time. Conducting clinical trials with insufficient participants reduces the power of definitive conclusions or leads to early trial termination. Blockchain technology can play a crucial role in the future clinical trials as they have a complete set of medical history of the participant, allowing the clinical researcher to make an informed judgement about the trial [14, 15]. From clinical trial analysis results to patients' medical data and genetic information blueprints,

the blockchain provides a safe and secure platform for storing and processing all forms of vital information [15–17].

3. Pharmaceutical supply chain

From acquiring active medicine ingredients to manufacturing the final product that is distributed and delivered to patients, the pharmaceutical supply chain follows a process from beginning to conclusion. The distribution of authentic and high-quality products is the fundamental duty of the members of supply chain as soon as possible because it has a direct impact on patients' health and safety. The pharmaceutical supply chain involves numerous parties and product delivery of goods frequently necessitates a complex process, making it more challenging to trace a medicine.

Blockchain gained enormous acceptance as they enable non-trusting stakeholders to keep a record of transactions in an immutable and transparent manner. The key advantage of blockchain technology is its capacity to monitor asset transactions recorded on a distributed ledger that is decentralised and encrypted with time stamps, enable transaction records to transfer and stored directly and digitally without the help of intermediate service firms [17, 18]. Several drug-tracking activities and processes are made possible by blockchain technology, ensuring accurate provenance, tracing, and tracking.

4. Remote patient monitoring

It is the process of gathering medical information from patients via IoT, body monitors, and mobile devices. Blockchain is useful for storing, distributing, and retrieving biomedical data collected remotely. The COVID-19 pandemic is driving acceptance of telemedicine and telecare technology because it allows for safe connection with doctors and other health professionals across digital channels, reducing infection spread. The data in today's telehealth and telemedicine systems is potentially exposed to several outer and inner data violations, threatening the services' dependability and accessibility [15–17].

Blockchain technology can assist in resolving such critical issues. The new blockchain technology uses a decentralised design to maintain a common database of patient records among multiple participants, with copies of each ledger being validated by and coordinated with each node of blockchain. The following are some of the key challenges that blockchain technology can address: monitoring pharmaceuticals and medical test kits through the supply chain, checking the qualifications of doctors, securing remote patient–doctor consultation records, tracking the locations visited by sick patients, tracking the provenance of defective Kits for medical tests, and more.

The integration of blockchain technology into existing telehealth and telemedicine systems can provide a number of benefits for secure healthcare digitisation, comprising the capability to verify the validity of users requesting patient data, the management of device IDs used for monitoring a patient digitally, the protection of patient confidentiality, and the automated settling of payments.

5. Cost saving

The cost of interacting with a doctor and the price of medicinal research and development can be used to calculate cost savings. For verification, a medical credentialing application must be sent to numerous organisations. As a result, it can be expensive and time-consuming. By using blockchain technology, hospitals, pharmaceutical businesses, and insurance organisations might save money. One of the key advantages of blockchain systems and electronic medical records is that doctors and patients have better access to medical records, which improves nursing efficiency and quality.

When it comes to patient expenditures and prescription administration, it can be helpful to give ledgers to various organisations, such as the insurance firms and dispensaries. Providing pharmacists with reliable, up-to-date prescription data will enhance logistics, particularly in the context of chronic disease care. Multi-site clinical trials at drug research facilities can save money on trials, and data management solutions based on blockchain intelligent contract technology can reduce the cost of operating multi-site trials in medicine.

6. Health insurance

Between payers, providers, and patients, there is a lack of confidence. Patients usually pay expensive rates while dealing with an absence of transparency and the inability to compare prices, as well as the potential of insurance fraud, which affects all parties involved. Due to its Practical Byzantine Fault Tolerance and multi-node co-maintenance characteristics, the blockchain can guarantee a high level of stability for consumers. The use of blockchain technology in medical insurance can minimise the complexity and expense of medical insurance, protect patients' rights, and reduce hospital uncollected funds and insurance company management costs.

4.4 Limitations

Despite all the advanced features blockchain provides, it still has a variety of limitations and issues that need to be addressed. Lack of standardisation, energy consumption, privacy leakage, scalability, cost, and supporting software vulnerabilities are among the specific issues to be examined in this study [18, 19].

1. Scalability

Communication gaps and information-sharing issues are major roadblocks to healthcare innovation and patient care quality. As users upload data, blockchain expands, recording all of the hashes connected with the newly added data in this scenario. The network may have fewer nodes with enough computer power to analyse and validate blockchain data as a result of the increasing storage and processing requirements. The trade-off between computer capacity and the number of medical transactions may limit the scalability of healthcare systems.

2. Insufficient standardisation

The lack of standards hinders widespread adoption and inhibits progress because this technology is still relatively young and in its infancy. [1]. It is possible to keep patient data, medical histories, and other organised data on the blockchain itself.

Any type of comprehensive medical documentation, including X-ray, scans, and unstructured doctor notes, may be stored outside of the blockchain to address scalability issues. Users may desire some kind of standardisation to manage and access such a wide variety of data dispersed around the firm. There must be a high degree of standardisation among the numerous parties concerned to enable all of these different infrastructures and applications. The issue of standardisation and criteria will become more important as more countries adopt blockchain as a solution.

3. Security and Privacy

Blockchain technology emphasises transparency, which may not be desirable in the health arena in some situations. Blockchains tackle the problem of transactions requiring trusted third parties, which exposes users to security and privacy risks. Although blockchains are being used to create smart contracts between healthcare providers to enable each other access to certain data or patient records, the question of who is accessing the data and whether they are authorised to do so remains.

Another significant issue that could imperil PHI and EMR is the nature of blockchain deployment, which does not guarantee the confidentiality of data stored or transferred off-chain.

4. Cost of operating blockchain

The development and operation of blockchain-based healthcare systems may be costly. For all engaged stakeholders, the government and healthcare industry still need to identify the many types of development, operations, and total deployment costs. As a result, finding the best strategies to lower the overall cost and resources required to develop such systems is critical.

5. Attacks/Vulnerabilities

Additionally, because of how the system is set up and built, blockchain technology has a few unique flaws. 51 per cent attacks, double spending attacks, selfish mining attacks, eclipse attacks, block discarding attacks, difficulty rising assaults, and anonymity issues in blockchain are all examples of blockchain vulnerabilities.

One of the simplest attacks that may be made on the blockchain is a 51% attack since it makes use of the consensus algorithm's legal purpose. An attacker has control of a PoW blockchain if they have 51% of the computational resources. They can launch double-spend attacks once they control the blockchain.

Blockchain is also susceptible to a number of common software flaws that enable for harmful attacks. Theft of data and identity are just two examples of other crimes that can be aided by these destructive acts. When a user's private key is stolen on the blockchain, identity theft happens since the criminal now has access to anything the victim has ever broadcast on the network.

6. Adoption and Incentive for Participation

In order to supply the required processing capacity for both the production of cryptocurrencies and transaction blocks, blockchain technology requires the utilisation of a network of networked computers.

Through incentive systems, participants ought to be compensated for contributing processing power. Additionally, health organisations may require encouragement to use blockchain. According to the quantity of participants, blockchain's influence will increase.

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