Blockchain Technology For Electronic Health Records

Ideation Phase

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1. Introduction

Blockchain is a decentralised and public digital ledger that records transactions on many computers so that no record involved can be altered retroactively without altering any blocks afterwards. Blockchain is verified and linked to the preceding 'block,' forming a long chain. After all, Blockchain is the name of the record. As any transaction is registered and checked publicly, Blockchain provides a good deal of accountability. When entered, no one can modify all the information written in the Blockchain. It serves to demonstrate that the data is actual and unchanged. In Blockchain, data are maintained on networks instead of a central database, improving stability and showing its proneness to be hacked. Blockchain offers a fantastic forum to develop and compete with traditional companies for modern and creative business models [1–3].

Blockchain helps marketers to maintain an overview of the products used in medicine. Health and pharmaceuticals will get rid of counterfeit medications using Blockchain technologies, enabling tracing of all these medicines. It helps discover the cause of falsification. Blockchain can guarantee the confidentiality of patient records; when medical history is developed, Blockchain can also store it, and this record cannot be modified. This decentralised network is used with all commodity hardware in the hospital. Researchers allow computing estimates for therapies, medicines, and remedies of diverse illnesses and disorders using the resources saved by these devices [4,5].

Blockchain is a distributed ledger network that adds and never deletes or modifies records without a common consensus. A Blockchain hash's value depends on a cryptographic hash that connects newly added information block records with each data block. The distributed Blockchain ledger architecture ensures that data is not processed in any centralised venue, making it accessible and accountable to all network users. This decentralised system avoids a single attack, strengthening and securing the system. It facilitates better control of health records and patient care by minimising twice the amount of medical practice and monitoring, saving both practitioners and patients time and resources. The patient will watch where their information goes and achieve it by keeping health records on a blockchain [6,7].

Scholars can use this technology to analyse a massive volume of unveiled knowledge about a particular group of individuals. It helps for the advancement of precision medicine to be provided appropriately for longitudinal research. We use Blockchain for healthcare in real-time with the help of the Internet of Things (IoT) and wearable's devices to store and update valuable patient data such as blood pressure and sugar level. It helps doctors track patients who are vulnerable to high risk and, if an emergency occurs, advise and alert their careers and families. Blockchain has a decentralised structure that allows it safely to hack and avoids compromising any single copy of the records [8,9]. This article addresses the following research questions:

RQ1: To study Blockchain technology and its significant needs in healthcare;

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RQ2: to identify capabilities of Blockchain technology to support the healthcare culture globally;

RQ3: to identify and discuss enablers of Blockchain technology for reviving healthcare services;

RQ4: to identify the 'Unified Work-Flow Process' of Blockchain technology realization in providing healthcare amenities; RQ5: to identify and discuss significant applications of Blockchain for healthcare.

1.1. Blockchain

Blockchain is a decentralised node network that stores the data. It is an excellent technology for protecting confidential data within the system. This technology helps to exchange critical data and keeps it secure and confidential. It is a perfect tool to hold all the related documents in one location and securely. Blockchain also speeds up searches for applicants that fulfil specific trial criteria using a single patient database. The Blockchain can be described as a decentralised peer-to-peer (P2P) network of personal computers called nodes, which maintains, stores, and records historical or transaction data [10–12]. It allows a reliable collaboration as the information is stored and exchanged by all network members and keeps a constant track of past and current experiences. This technology can integrate disparate networks to provide insights into the importance of individual treatment. Thus, Blockchain can well be recognised for immutability and safety. Blocks, nodes, and miners are the three main ideas in Blockchain. Blockchain does not save any of its data in a single location. Instead, a network of computers copies and spreads the Blockchain. Every computer on the web updates its Blockchain to reflect a new block to the Blockchain. Fig. 1 shows the basic working steps of Blockchain technology.

A Blockchain system runs on top of the internet, on a P2P network of computers that all run the protocol and have an identical copy of the transaction ledger, allowing for P2P value transactions without using an intermediary by machine consensus. There are various types of Blockchain technologies such as public, private, hybrid, or consortium. Each Blockchain network has different advantages and disadvantages that essentially influence its optimal applications.

A private Blockchain is a Blockchain network that operates in a restricted context, such as a closed network, or is controlled by a single entity. While it functions similarly to a public blockchain network regarding P2P connectivity and decentralisation, it is substantially smaller. In a private Blockchain, the network's inventor knows who the participants are from the start. One cannot develop a permission-based solution on a public web, and users have complete anonymity.

Organisations who desire the best of both worlds will sometimes employ hybrid Blockchain, a type of Blockchain that includes private and public Blockchain characteristics. It allows businesses to create a private, permission-based system alongside a public, permissionless system, letting them regulate who has access to specific data stored on the Blockchain and what data is made public.

1.2. Need of blockchain in healthcare

As far as healthcare is concerned, the urgency of development increases to more incredible speeds. Today the need is for quality health facilities supported by advanced and newer technologies. Here, Blockchain would play a critical role in transforming the healthcare sector. In addition, the landscape of the health system is moving towards a patientcentred approach focusing on two main aspects: accessible services and appropriate healthcare resources at all times. The Blockchain enhances healthcare organisations to provide adequate patient care and highquality health facilities. Health Information Exchange is another timeconsuming and repetitive process that leads to high health industry costs, quickly sorted out using this technology. Using Blockchain technology, citizens may take part in health study programs. In addition, better research and shared data on public wellbeing will enhance treatment for different communities. A centralised database is used to manage the entire healthcare system and organisations [13¯15].

Until now, the most significant problems faced are data protection, sharing, and interoperability in population health management. This particular problem is reliable by using Blockchain. This technology enhances security, data exchange, interoperability, integrity, and real-time updating and access when correctly implemented. There are also significant concerns about data protection, especially in the fields of personalised medicine and wearables. Patients and medical personnel require safe and straightforward means of recording, sending, and consulting data over networks without safety concerns; thus, Blockchain technology is implemented to resolve these issues [16,17].

2. Various Capabilities of Blockchain Technology to support the healthcare culture globally

In healthcare, Blockchain has a wide range of applications and functions. The ledger technology helps healthcare researchers uncover genetic code by facilitating the secure transfer of patient medical records, managing the drug supply chain, and facilitating the safe transfer of patient medical records. Fig. 2 reflects the variety of features and critical enablers of Blockchain philosophy in umpteen healthcare spheres and its allied domains. Protection of healthcare data, various genomics management, electronic data management, medical records, interoperability, digitalised tracking and issues outbreak, etc., are some of the technically derived and impressive features employed to develop and practice Blockchain technology. The complete digitalised aspects of Blockchain technology and its use in healthcare-related applications are the significant reasons for its adoption [18,19].

The Blockchain makes the entire prescription process transparent, from manufacturing to pharmacy shelves. Congestion, freight direction, and speed may all be tracked using IoT and Blockchain. It offers the chance to schedule acquisitions efficiently to prevent disruptions and shortages in clinics, pharmacies, and other medical facilities with a given medication. The deployment of digital frameworks built on Blockchain would help ensure that the logistics data avoid uncontrolled adjustments. It increases trust and prevents the illicit handling of records, payments, and medication themselves by various people interested in purchasing drugs. The technology can effectively improve the condition of patients while at a competitive cost retaining the funds. It eliminates all obstacles and barriers in multi-

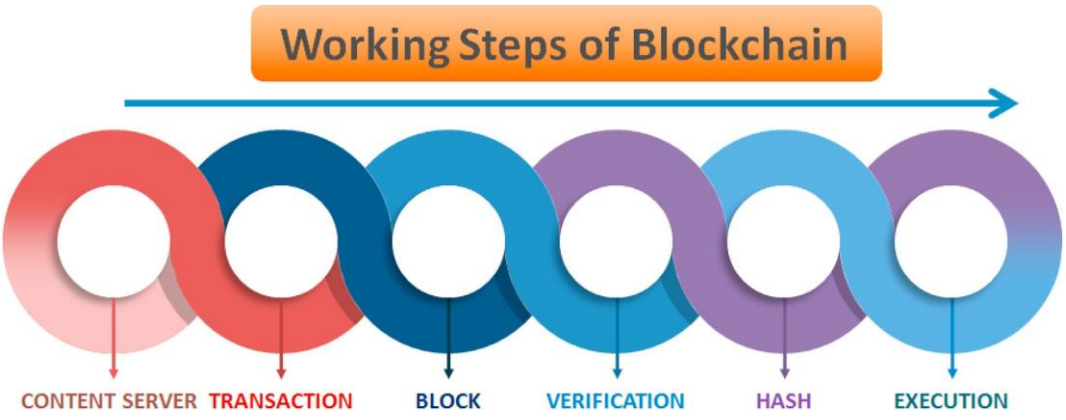

Fig. 1. Working steps of Blockchain Technology.

level authentication [20¯22]. Because Blockchain can preserve an incorruptible, decentralised, and transparent log of all patient data, it is ripe for security applications. Furthermore, while Blockchain is visible, it is also private, hiding any individual's identity behind complicated and secure algorithms that can preserve the sensitivity of medical data. Thanks to the technology's decentralised structure, patients, doctors, and healthcare providers can all share the same information swiftly and safely.

Blockchain technology makes the transition to interoperability led by patients easier as it allows patients to make their medical data accessible and access laws. This gives a patient greater power over personal information and improves confidentiality and privacy. The measurement and implementation of quality management and enforcement are difficult.

Any of these technical issues could be solved by Blockchain applications throughout the industry. Blockchain headlines will assist regulatory authorities in tracing legal drugs against falsified ones. This ensures that all approved parties exchange digital transactions containing the patient's details. Patients who move medical practitioners may merely update a single consent to exchange their complete records [23,24].

Blockchain has reached the healthcare industry with a rising acceptance rate. Also, in the early stages, people in the health ecosystem accept the technologies favourably. In the coming years, the holistic vision of Blockchain to transform the healthcare market will be to address problems affecting the present structure. It allows physicians, patients, and pharmacists to conveniently access all the available information at a given moment. Medical firms are exploring, experimenting,

discovering day and night for Blockchain technologies, in the medical field for health records. It has confirmed itself as an irreplaceable instrument in healthcare by following pharmaceuticals, improving payment options, and decentralising patient health history records. In addition to robust technology such as machine learning & artificial intelligence, the medical sector is highly dependent on Blockchain. There are some genuine uses of how Blockchain changes the healthcare industry. The program is built on Blockchain monitoring technology to fine-tune the medical supply chain

[25–27].

Blockchain's ability makes for a sophisticated data storage framework that records a person's whole health history of diagnosis, test reports, prior regimes, and even measurements by intelligent sensors. A doctor can conveniently obtain all the details available to make correct diagnoses and recommendations using this method. Because all the data in a single Blockchain system is stored, it is safe from loss and shift. To avoid an organisation's internal networks, it can use Blockchain. A significant organisation of many separate players, with various control levels on an encrypted Blockchain database, can save organisations from external risks and assaults. If a healthcare organisation correctly implements a Blockchain network, this will eliminate such rescue attacks and other problems, such as computer corruption or hardware failure [28,29].

3. Enablers of Blockchain Technology for reviving healthcare services

Fig. 3 illustrates the several on-ground industrial representatives of Blockchain capabilities to successfully implement healthcare culture perspectives and overall development. There have been various associated industrial/medical-care supporters or providers, which helps carry out the research and investigations for realising the Blockchain practices in healthcare and its core domains, too [30,31]. These observed providers BurstIQ, Guardtime, Robomed, Simply vital, Encrypgen, Chronicled, Tieion, etc., are the few agencies supplying and favouring the practising of Blockchain technology at ground levels.

Fig. 2. Capacities of blockchain technology for healthcare domain.

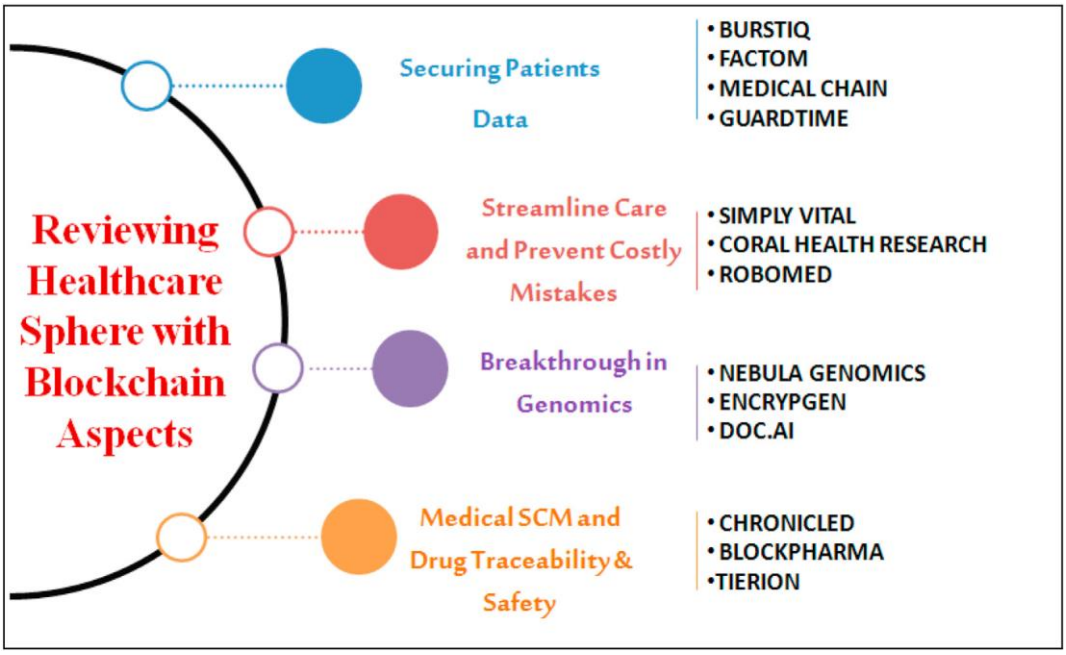

Fig. 3. Enablers of blockchain implementation in healthcare services.

Blockchain involves the development of new patient data cards for medical practitioners in other hospitals. Newly added information is usually repetitive and leads to loss of time, which is a severe health malfunction. Each individual can have different privileges or accessibility choices due to the location on the supply chain. In addition, any block containing the medication information would have a hash connected to it to another block.

Furthermore, the data transparency feature in the Blockchain framework will help find the entire root route and eradicate the distribution of fabricated drugs. A new medical card is established for the patient and deposited in a specific facility when the patient visits a new clinic. These details are ordinarily incomplete to the general public and contain collected records from the caregivers at the facilities concerned. Blockchain can conveniently assemble problems in the data processing. This technology will create open and similar Blockchain medical records around the world [32¯34].

In healthcare, clinical trials are being conducted to assess the effectiveness of such therapies to treat or provide a partial remedy to a particular disease. Scientists can record data on test outcomes, person numbers, patient records, and other variables. Data collected during clinical trials should be authenticated so that scientists, pharmaceutical firms, and policymakers can be confident in the quality of results. In clinical trials, Blockchain technology could provide greater transparency and accountability. The health care Blockchain has enormous recordkeeping leverage, as the blocks are made available to clinicians and patients, while the processing of medical history is done with an awareness of patient issues. Blockchain in the supply chain is very popular, and it also fits well for medicines in the healthcare area [35,36].

Blockchain provides easy forward-thinking on the practices and services of health professionals. In the health care industry, this Blockchain power operates to handle approval efficiently to process and acquire. It is convenient to avoid wastage by standing in a line to improve productivity and spruce up workflow with Blockchain. This technology aims to encourage personalised medicine, clinical advice, and practical research into health. Blockchain has become one of today's most popular technologies. The newest thing about the Blockchain is that the company believes that the platform can turn the healthcare industry more effectively. This will, in many ways, turn the healthcare industry into a reliable and stable digital directory. Blockchain healthcare technologies will strengthen various challenges, such as clinical studies, patient records management, and prescription traceability [37,38].

Blockchains can be used successfully in healthcare to make the right choices in the health ecosystem. The distributed Blockchain platform offers the health sector opportunities to trace fraud, reduce overhead costs, reliably manufacture jobs, eliminate duplication of labour, enforce openness in the health environment. Further, it is used to hold assets, such as immutability and confidence, and decentralisation. The clinical trials and the approval organisations for the subject are the areas where Blockchain has the opportunity to boost medical professionals' and researchers' reliability, auditability, and accountability. The benefit for patients is that their medical histories are protected more confidently and that their diagnostic accuracy improves chances of further care [39,40].

In the processing of their health records, patients will now have a better voice. It will be allowed to exchange data as partners of the Blockchain network, thereby ensuring further privacy and control. Blockchain's pledge has widespread consequences for health care stakeholders. Disparate networks are likely to interact to provide insights and help evaluate treatment's importance based on this technology. An electronic medical records Blockchain network around the country will increase efficiencies and promote improved patient health results in the long run. In particular, Blockchain is a mutual, unchanging record of transactions made from connected transaction blocks and held in a digital booklet [41,42]. Medical details like patient life, medical equipment logs, or medical products' temperatures can be recorded during the shipping, following the medical field.

4. Unified Work-Flow Process of Blockchain Technology realization in healthcare amenities

Fig. 4 explores the schematic reflection about the integrated workflow for the overall development of Blockchain technology and its associated benefits/merits from a healthcare services perspective. The master patient indices claim adjustments, devoted medical supply chain management, interoperability, single and longitudinal records capturing, etc., are related benefits associated with the Blockchain practices in healthcare sectors [43,44]. The interactive work-process flow started with the distributed network flow, digitalised transactions, and shared data and ledger, which ultimately enables the Blockchain drivers to work more emphasised to make healthcare services healthier and more innovative than before [43,45].

The principle of Blockchain technology is very straightforward and constantly evolving, increasing the network of blocks that adapt to the industries various needs and specific characteristics. The independent Blockchain framework provides a highly complete monitoring alternative and allows for the immediate

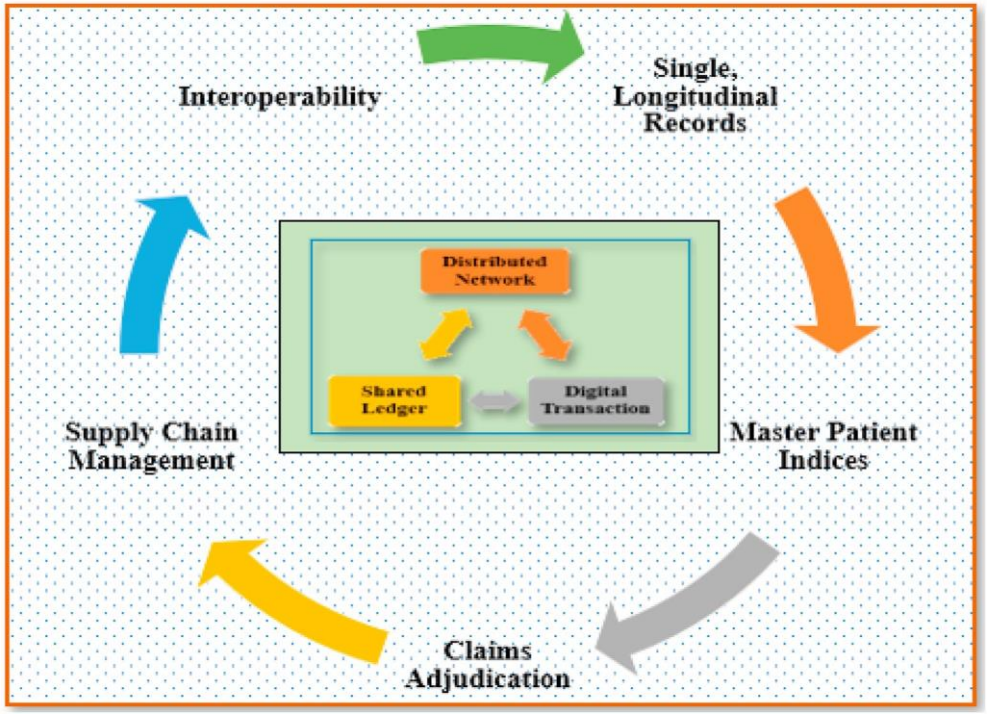

Fig. 4. Integrated work-flow process of blockchain technology for healthcare culture.

refreshment of results. Blockchain will significantly minimise financial failures and also avoid theft and the illicit transferring of records. It can solve problems of changing results and snooping data. It allows the transfer of permanent time-stamped clinical trial reports and results, thus reducing scam and mistake occurrences in clinical trials. The health industry is primarily responsible for adopting Blockchain technologies [46–48].

Blockchain is a technology that in some way affects each industry. Particularly in areas where must create trust between different parties and stakeholders, Blockchain technologies are used. In the present fragmentation that a patient sees signing a new consent on any appointment, clinical operation, or medical test, Blockchain could radically alter the way informed consent has been granted. The exchange of clinical test data and the possibility of discovering benefits for testing subjects are some of Blockchain's commitments for these applications. Blockchain can become a fundamental aspect of the administration of consents to healthcare that facilitates knowledge exchange. Patients can now link to other hospitals and automatically receive their medical information via Blockchain technology [49–51].

An approved Blockchain is a closed network with connections to the networks for all system members. Thus, it is developed and used within organisations and companies to share information and render transfers safely. Once a transaction has been processed by consensus, it is considered a permanent record and added to the current Blockchain as a new block. The internet encourages everyone to build their website. Everyone in the network can communicate with other users in the same network in a Blockchain with no authorisation by generating their network address [52,53].

A Blockchain-driven supply chain system protects the protection, validity, and timeliness of the supply of medicinal products. It lets the producer maintain the right formulation blend according to medical requirements. Medical devices can charge patient data, verify the treatment with the intended patient, and exchange procedural data anonymously with the patients and the regulators.

Blockchain technologies are fascinating for the healthcare sector. In recent times, medical science with high-quality medical solutions has shown commendable progress. It is a distributed, transparent digital leader, used widely in many computers to monitor transactions. It is recognised for its significant effect on several markets and industries. This technology's existence addresses issues that existing approaches cannot resolve. Excellent healthcare needs confidence, protection, confidentiality, and data interoperability across different systems. Blockchain offers the chance to tackle it in new ways in healthcare [54–56].

Due to its eternal, autonomous, and completely open character, Blockchain shines out as a possible answer to health data protection. Using Blockchain, people's identity and medical records will remain privately held while the system remains stable. This revolutionary technology will facilitate the complex billing process by preventing ineffective and background instruments. In addition, it can help patients upload and enable approving parties to view medical records. By making electronic medical records more productive, reliable, and safe, Blockchain technology could provide a new paradigm of sharing health information. Blockchain is a ledger recording distributed and vital records of transactions [57–59].

5. Blockchain applications for healthcare

Blockchain is a relatively modern and emerging technology that has innovative applications during its successful healthcare implementation. Smooth, efficient data sharing and delivery across all the prominent network members and healthcare providers contribute to developing economical therapies and sophisticated treatments for many diseases. This will accelerate growth in healthcare in the coming years. The opportunities offered by Blockchain technology in the logistics industry have been revealed recently and show the healthcare sector's advantages. As this area directly affects life quality, it is one of the first areas in which digital transformation improves and innovations. At the same time, Blockchain technology is becoming more common, mainly in the financial sphere. It offers several important and impressive chances for the healthcare industry, from science and logistics to relationships among practitioners and patients [60–62]. Table 1 discusses the significant applications of Blockchain for healthcare.

Blockchain's function is to document all sorts of transactions in a decentralised record, aside from other healthcare management structures. It is accurate and straightforward, saving time, effort, and costefficiently and therefore saves on management effort. The biggest problem faced by the healthcare industry is the leaking of essential data and used for malicious devices and other special interests, which the applications of this technology can quickly sort out. Another area of importance is allowing users and parties to the database access to the latest upto-date and authentic patient records and evaluations [124,125]. Blockchain's scope of health care looks super up-and-coming and exciting because it contributes to solving some of the industry's pressing issues. With Blockchain, we can connect therapy associates and other services to the network such that everybody has access to the same data. Many methods will bring positive benefits for businesses as a whole by using Blockchain technologies in health care. It provides patient information, medical science, clinical trials, the medical supply chain, and the integrity of medicinal products [126–128].

6. Discussion

Blockchain technology brings credibility and findings to clinical trials. Those records can be stored in the digital thumbprint as intelligent contracts on the Blockchain. Network infrastructure security at all levels, identity verification and authentication of all participants, and uniform patterns of authorisation to access electronic health information are only a few of the benefits of Blockchain Technologies in Healthcare. A Blockchain is used to maintain the monitoring of the pharmaceutical supply chain and tracking of medication responsibilities. This technology is applicable for storing the information of even an individual patient and, therefore, helps analyse and validate the effects of a particular procedure. Blockchain is used for health record-keeping, clinical trial, patient monitoring, improves safety, display information and transparency. It maintains the financial statements in hospitals and minimises the data transformation time and cost.

In the data-centred environment, it addresses several problems. Blockchain technology will generate a hash for individual blocks of patient health records. Blockchain system would also encourage patients to show their required data to third parties while keeping their identity confidential. A large quantity of data sets is needed to perform a clinical trial. The researchers concentrate on these data sets and perform routine experiments to provide analyses, estimates, and efficiency ratios under various circumstances. The data are analysed, and more decisions are made based on these findings. However, many scientists can manipulate the data and evidence gathered to alter the result.

Further, many drug makers want to record the findings that will provide their businesses with such advantages. Thus, researchers use Blockchain technology to make clinical studies fairer and more straightforward. It will help record clinical trials that are secure, uneven, and straightforward. The gathered knowledge can improve patient treatment and provide post-market analysis to optimise efficiency benefits. These standards are rooted in critical aspects of Blockchain technology

such as open management, transparent auditing tracks, data transparency, robustness, and improved privacy and security. This allows healthcare providers to meet the current healthcare standards, including pharmaceutical supply safety.