

BLOCKCHAIN-BASED HEALTHCARE MONITORING SYSTEM USING PATIENT ELECTRONIC HEALTH RECORDS

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ABSTRACT

The majority of hospitals and other healthcare institutions have made the switch from paper-based techniques to something that is known as electronic health records or EHRs. This change was made possible by technological advancements. Various parties need to exchange the data records they keep on one another, and users need to be allowed to exercise control over who has access to the information they have on file. The Electronic Health Record (EHR) system is beset by issues relating to managing problems, challenges with trust, and data protection. Data stored on blockchains are immutable, private, and accessible only by their intended users. Blockchain technology's use has also led to managing a system with the potential to provide decentralized data storage. In this research, we determine whether it is appropriate to deploy blockchain technology in EHR and explore its potential uses in the efficient leadership of the COVID-19 pandemic.

"This paper was selected from the Global Conference on Emerging Technologies, Business, Sustainable Innovative Business Practices, and Social Well-being on 10th and 11th December 2022 in India organized by Confab 360 Degree."

KEYWORDS

scalability, decentralization, blockchain, electronic health record systems, technology.

INTRODUCTION

A patient's real-time official health record is referred to as an "electronic health record" or EHR for short. This record is kept in a digital format and is able to be transferred quickly, safely, and easily between different institutions and departments. The term "electronic health record" was coined in 2000. It comprises every piece of information essential to gain the patient's particulars, such as the

patient's medical history, radiological photos, diagnoses, prescriptions, immunization dates, treatment plans, allergic reactions, test results, and so on. As a result of the fact that it enables rapid access to patient's medical records, which are used in deciding how to treat the patient, it plays a significant role in the healthcare business. EHR incompatibility is a serious concern that has to be taken into the mind by healthcare practitioners [1]. The process of file

sharing is hindered by a lack of standardization and regulation, which contributes to the problem. A further degree of complication is added to attaining interoperability due to the difficulties associated with determining the level of secrecy and preserving security while transferring information. Electronic Health Records (EHRs) and other health information technology (HIT) organizations need to be more organized due to poor communication standards across systems, high integration costs, insufficient patient engagement in data sharing, and inconsistent patient identification across systems (HIE) [2].

The term "blockchain" is often used to refer to a distributed ledger that keeps a digital record of transactions [3]. This technology is known as "blockchains" because of its distributed ledger structure. It consists of files containing information on the people involved, organized in a linear fashion known as a chain. These components are referred to as "interlinked blocks" in the database. After a decentralized network of validating nodes has verified a transaction, it is only added to the blockchain. To put it simply, blockchain is a kind of Distributed Ledger Technology (DLT). The overall category title for this set of technologies is "DLT." Due to its decentralized nature, this network of computers cannot be hacked and used to add unlawful or invalid blocks to a particular chain. For each new block added to a blockchain, a cryptographic hash is generated and used to link it to the preceding blocks [4]. This hash is computed using the previous block's contents to connect the newly created block to the existing partnerships in the blockchain. Since blockchains are immutable and may employ cryptographic techniques for secure communication, they are well-suited for the reliable exchange of EHR data. Because of this, blockchain technology might be helpful for EHRs (EHR). Contact tracking, data aggregation, data sharing, lab record administration, Covid certificate for infected and recovered patients, and prognosis for continued development of the infection population are just a few of the many possible use cases for blockchain-based EHR in pandemic management. Blockchain technology allows the supply chain for vaccinations and other necessities to be controlled efficiently and reliably [5]. The research aimed to fulfill the objectives like studying electronic health record (EHR), the importance of blockchain technology in EHR, challenges presented by blockchain technology and its future, and the application of blockchain technology.

METHODOLOGY

Blockchain technology may speed up innovation in healthcare models focusing on preventive care and community settings. The advancement of people's health in communities worldwide depends on the capacity to develop healthcare trends to work together. Care delivery and the associated healthcare, financial, and payment systems are complex and might benefit from blockchain technology. A distributed ledger system's ability to ensure data integrity while sharing across parties may make this possible. Cryptography's public and Intelligent contracts and permissioned access to all EHR systems further strengthen the blockchain's robust connectivity. This system's transaction layer allows quick access to many non-patient identifying, standard, and anonymous data. A more open and automated system may lead to greater efficiency and reduced administrative costs. This approach is more suited for the healthcare sector since it does not need a whole overhaul of all systems simultaneously. Patient medical histories are now routinely kept in a digital format known as electronic health records (EHRs). Data processing and security issues have been significantly reduced as a result. This article has covered various EHR requirements, common EHR system issues, and how blockchain technology may be used to solve these issues. We have performed a further study to understand better how blockchain-based EHR may be used in pandemic management. Some examples of these uses include vaccine supply chain management, contact tracking, data aggregation, data sharing, user data privacy, Covid certificates for those infected and treated, forecast of the spread of an illness in a community, and so on. By providing trustworthy, accurate, and secure data storage and exchanges, blockchain has the potential to be used effectively to overcome the shortcomings of typical EHR problems and to aid in the management of the COVID-19 pandemic issue.

RECORD OF ELECTRONIC MEDICAL CARE (EHR)

In the past, all treatment records were documented and recorded on paper, and they were filed away manually. Today, electronic medical records have mostly replaced paper-based methods. These days, computerized versions of treatment records are almost always preferred over their paper predecessors. In addition, these medical records were retrieved and organized with the assistance of shelves built specifically to store the file folders associated with this data. These bookcases were developed especially to serve

in this capacity. Things began going in a more positive direction as people had access to new forms of information technology.

As a consequence of the beginning of the process of transferring records into a digital medium for storage and retrieval, electronic healthcare record systems came into being [2]. Because of this, they were storing records and retrieving them became simpler. The automated administration of the patient records makes the patient records easy to access, and the patient records can be immediately linked to the monitoring devices to record and analyze the data that patients supply in the EHR. This is done to record and analyze patients in the EHR. In a relatively short time, during an era of rapid growth, electronic health records (EHRs) began to be used in production and in vast quantities to retain medical data that was found to help conduct research connected to epidemiology. This data was useful in research because it was found to be useful in conducting research. When carrying out the study, it was discovered that this knowledge was helpful [2].

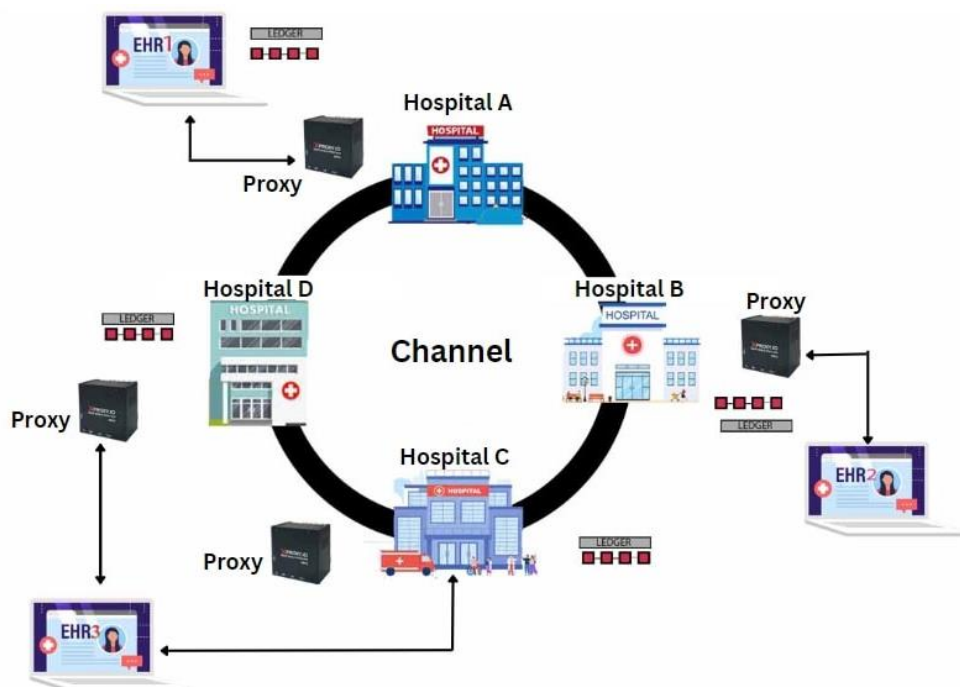
EHR REQUIREMENTS

The following are the prerequisites for EHR:

- Interoperability is the degree to which different devices and systems can exchange and translate data with one another. In the context of electronic health records (EHR), interoperability is defined as the following:

- Privacy and safety: the goal of implementing privacy and safety measures in healthcare settings is to empower patients to take control of their medical records by empowering them with the authorization necessary.
- The confidentiality of the patient's records must be maintained at all times. The term "confidentiality" refers to dependable communication or a contract between healthcare practitioners and patients. It is differentiated from "privacy" by focusing on the distinction between the two.
- Control of access: After that, only authorized medical professionals and patients should be able to view their medical records. Patients need to have access to their data and should have the ability to decide who may see it.
- Data sharing: the exchange of medical information is a necessary prerequisite because several different healthcare providers are providing the patient's treatment; thus, the data is shared with several other medical institutions and the government.
- Data Integrity and Availability: Maintaining the accuracy and reliability of the data is an essential part of maintaining data integrity. In terms of electronic health records, this results in the fact that the data has not been compromised by usage that is not authorized [6].

FIGURE 1. DECENTRALIZING HEALTHCARE: EXPLORING BLOCKCHAIN'S ROLE IN EHR MANAGEMENT [7]



Source: Oodles Blockchain [7]

THE IMPORTANCE OF BLOCKCHAIN TECHNOLOGY IN HER

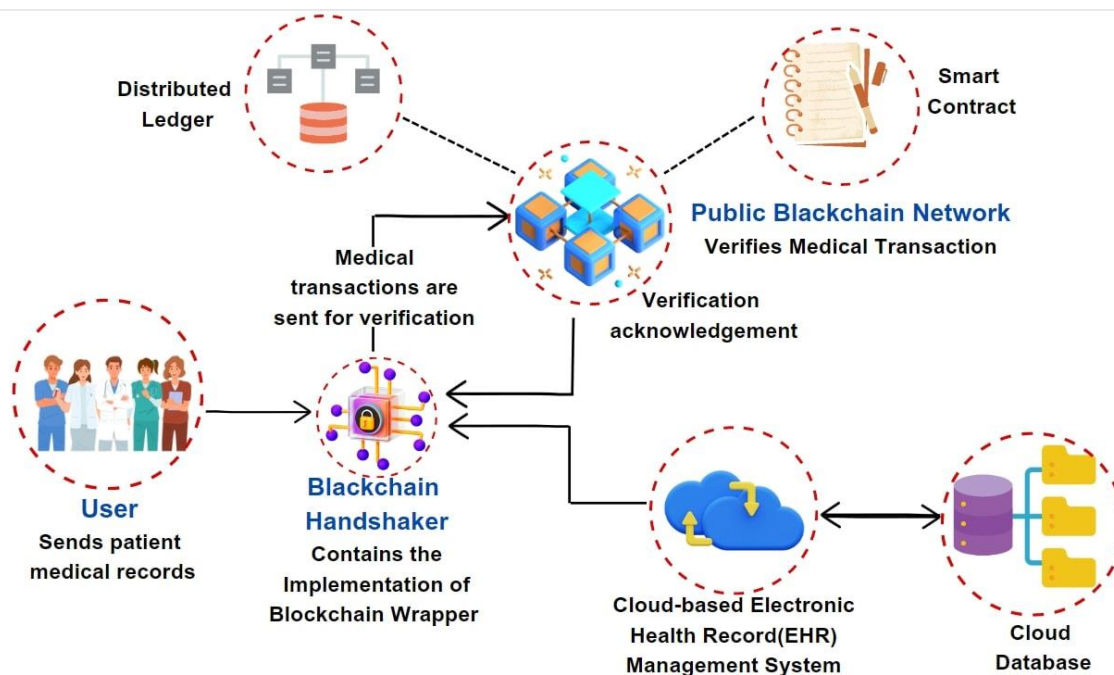
By providing a risk-free channel for the transfer of patient information, blockchain technology has the potential to facilitate a more recent iteration of the electronic health record exchanges now in use in the field of healthcare efficiency [8]. This is accomplished by using a decentralized peer-to-peer connection to guarantee the data's safety while the connection is passed from user to user. The Blockchain methodology is an approach that has been provided as a way of offering support and making the process of comprehending the distributed ledger technology simpler to do. The Blockchain methodology makes this assistance and ease of performance possible. Recent developments in cutting-edge technology known as blockchain have made it possible to optimize a variety of transactional procedures, including, amongst others, those pertaining to insurance billing, medical data, and smart contracts [9]. [10] This has made it feasible to optimize a wide range of transactional procedures. The ability of blockchain technology to include in the blockchain substructure records exchange, enhanced user data accessibility, including continuous surveillance that covers a full device's life cycle is one of the most significant benefits of utilizing blockchain technology in the healthcare industry. This ability is one of the reasons why blockchain technology is becoming increasingly popular in the healthcare industry [11]. The usage of blockchain technology in the healthcare business is already helpful for various reasons, and this is only one of those reasons. The Internet of Things (IoT) and cloud computing are two examples of other developing technologies that might be used in conjunction with blockchain to facilitate the creation of enhanced electronic health record (EHR) systems. A distributed ledger system that utilizes blockchain technology will, as a result, meet the criteria for security,

dependability, immutability, and interoperability. Accessing the patient's previous medical data to deliver drugs using blockchain technology is vital. Substantial developments in the organizational structure of medical care services will provide no significant problems when it comes to putting them into practice [11].

Blockchain technologies can transform not just one or two sectors but the entire corporate environment. This might be a game-changer for several reasons. 16 percent of the 200 healthcare executives who took part in the survey are optimistic that a commercial blockchain solution would be available at scale at some point during the year 2018. This would completely change the dynamic of the game. The essential actors in deploying blockchain technology will be governmental authorities, trade associations, and market makers. The administration and protection of data in the healthcare sector and the management of supply chains are notable examples of fundamental concepts that stand to be impacted and altered by the potential use of blockchain technology Figure 1. Let's take a minute to go over each one of them one at a time:

When healthcare professionals share data more effectively, patients have a greater chance of receiving accurate diagnoses, more effective treatments, and an overall boost in healthcare organizations' ability to provide cost-effective and efficient care. Because it enables various stakeholders in the healthcare value chain to trace the provenance of data and any modifications made, blockchain technology may make it possible for these stakeholders to share access to their networks without compromising the data's security or integrity. This is because blockchain technology enables stakeholders to trace the provenance of data and any modifications made [12].

FIGURE 2. BLOCKCHAIN-DRIVEN HEALTHCARE: PIONEERING A SECURE AND TRANSPARENT FUTURE [13]



Source: A Novel Architecture for Tamper Proof Electronic Health Record Management System using Blockchain Wrapper [13]

CHALLENGES THAT THE TECHNOLOGY OF BLOCKCHAIN AND THE FUTURE IT PRESENTS.

The storage capacity, in addition to the scalability of the system: The storing of data on the blockchain gives rise to two key concerns, the first of which is privacy and the second of which is scalability. Both of these concerns are discussed more below. The fact that the data on the blockchain is available to everyone on the chain makes the data vulnerable, which is different from the outcome desired for a decentralized platform since it might compromise the platform's purpose. Because all of this enormous data is going to be saved on the blockchain, the storage capacity of the blockchain is going to be severely impacted. The people's clinical background, documents, lab results, X-ray studies, MRI results, and the outcomes of several other studies would all be part of the blockchain information. Lack of social skills: Very few people can fully appreciate how the technology that underpins blockchains operates in its most basic form. This technology's development is ongoing since it is still in the early phases of its life cycle. Because hospitals and other healthcare institutions need to redesign their information systems to employ blockchain technology completely, shifting from dependable EHR systems to blockchain technology would take some time. There are presently no universally approved standards for using this technology since it is still in its early phases and is continually undergoing

development. [14] However, this is expected to change shortly. Because of this, using this technique in the medical field would need far more time and labour than had been first estimated. Mostly as a result of the fact that it would be required to have confirmed standards from international authorities that monitor the process of standardization for every specific technology. These uniform standards would be beneficial in determining the quantity of the data, the structure of the data, and the kind of data that might be kept on the blockchain. They would also help establish the types of data that might be saved on a blockchain, which would be an essential step. Additionally, adopting this technology would be made much easier due to the defined standards, making it much simpler to apply these standards inside organizations. This would allow more people to participate in developing these standards Figure 2.

•Future

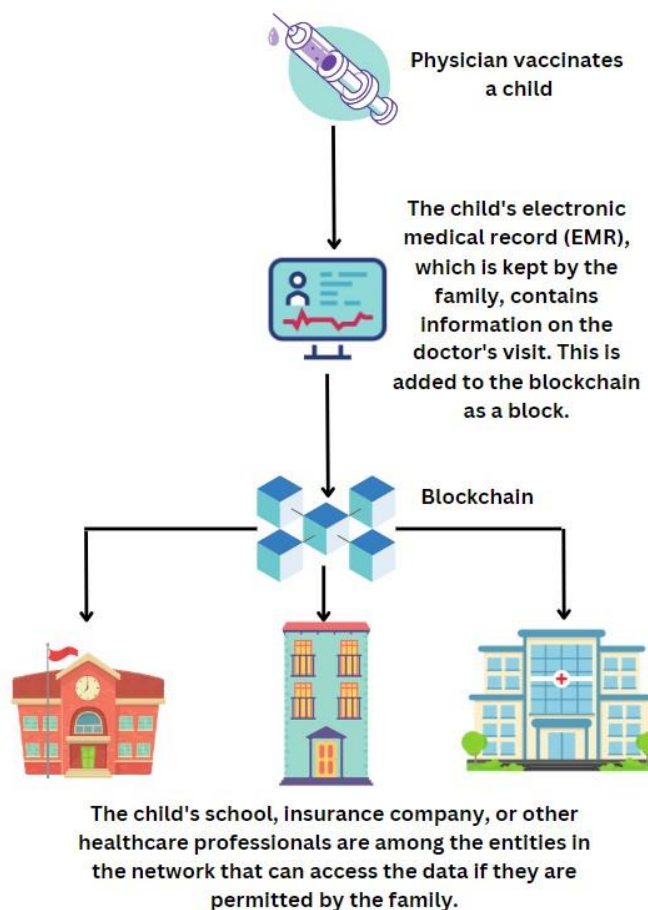
Blockchain technology is advantageous for the healthcare sector and how it may be used to create electronic health records. They continued to need help with several problems, all of which were solved by an innovative technology known as the blockchain. Despite the progress that has been made in the healthcare industry and the technological advancements that have been made in EHR systems, they continue to need help with several problems.

[15] A combination of secure record storage and granular access control for the documents is what we have in mind for the structure that we want to implement. Since of this, the system will be easier to understand for the individuals using it because it will be simpler and less confusing. In addition, the framework proposes processes to guarantee that the system will manage the data storage issue even though it utilizes the off chain storing method of IPFS. This is accomplished by ensuring that the system will address the problem in a manner that ensures it will. The system also benefits from role-based access since it guarantees that medical records are only available to those who can be trusted and related to the patient. This is one of the main advantages of role-based access. As a bonus, the problem of information asymmetries inside the EHR system has been overcome. In the future, one of our goals is to include a payment model in the architecture that is now being used. Because of this, we need to have certain considerations in place, as we need to calculate how much a patient would pay for consultation by a doctor on this decentralized system that runs on the blockchain. Specifically, we need to know how much a patient would pay for the consultation. In addition, we need to sketch down certain laws and regulations that follow the overarching principles governing the healthcare business.

As a result of the many benefits that may be obtained from using electronic health record systems, a wide range of hospitals worldwide have begun to use these systems. These benefits include, most prominently among them, improved safety and decreased expenditures linked with it. Because they offer a significant level of functioning to the healthcare organization, they are primarily considered an indispensable component of the healthcare sector. This is the primary explanation for why the healthcare sector considers them to be an important component. Because of this, they are one of the industry's most important components. Some of the tasks under this category include

the electronic storage of patients' medical information, the management of patients' appointment schedules, invoicing and account management, and laboratory tests. Some of the EHR systems now being used in the medical industry probably include them as part of their offerings. While making medical records accessible across various platforms, the primary goal is to protect their confidentiality, maintain their completeness, and ensure that they cannot be altered in any way. However, these systems ran into several difficulties and could not live up to the expectations placed on them. The introduction of electronic health record (EHR) technologies in hospitals & similar healthcare contexts were based on the belief that accomplishing so will increase healthcare quality. This is notwithstanding the premise that implementing EHR systems in hospitals or other medical facilities was predicated on the premise that accomplishing so will improve the level of professional care given. A study was conducted in Finland to investigate the experiences of nursing staff members using electronic health records (EHR). According to the findings of the research, electronic health record systems (EHR) are plagued by problems stemming from the fact that they are unreliable and provide a poor degree of user-friendliness. The EHR system also suffers from various additional issues, which may be summed up as follows: The process through which different information systems can exchange data is referred to as interoperability. The information has to be able to be utilized for other reasons as well as be able to be traded with other parties. Electronic health record systems need to have the capacity to support data sharing, which is often referred to as health information exchange (HIE). Because there are so many different EHR systems being implemented in many different hospitals, and these systems all have different levels of terminologies, technical capabilities, and functional capabilities, there is currently no universally defined standard for electronic health record systems. This is because many different EHR systems are being implemented in many hospitals [16].

FIGURE 3: - UNLEASHING THE POTENTIAL: THE FUTURE OF HEALTHCARE THROUGH BLOCKCHAIN TECHNOLOGY [17]



Source: USF Health, Morsani College of Medicine [17]

APPLICATION OF BLOCKCHAIN TECHNOLOGY

In the following sections, the possible use of the blockchain system to regulate and mitigate the COVID-19 situation is explored and studied in depth. This will be done using the blockchain system Figure 3.

• Clinical Trial Data Management

Data from clinical trials should be stored following applicable legislation, which may include requirements that records be made accessible to relevant stakeholders, that privacy and record protection measures be taken, and that data be immutable. The technology behind blockchain will provide physicians and doctors with the ability to capture real-time information about patients' health and make it accessible. It makes the information more accurate and provides an audit trail, which improves privacy and data security.

• The Supply Chain for Vaccines and Other Necessary Medicines

Blockchain technology may facilitate effective health supply chain management if a pandemic or other emergency requires massive worldwide cross-border

transactions. Up to the time when the approved form of the vaccine is accessible for sales and marketing, there is the possibility of instability in its distribution. The possibility exists that unethical business activities, including issuing fake vaccinations, inflated prices, and stockpiling, will occur. These issues may be effectively addressed using a medical supply chain based on blockchain technology [18].

• Tracking Down a Contact

Although governments and healthcare institutions are involved in patient contact-tracking systems, the gathered data might be misinterpreted and utilized inappropriately. The use of blockchain technology will result in data that is reliable and consistent [19]. The activities of patients may be monitored by blockchain networks, which can also deliver real-time information to the afflicted regions. In addition, a report for the affected and possibly infected population may be generated from the data based on contacts.

• Data Aggregation

To properly react to the pandemic, essential resources include sorting, gathering, and getting the necessary information to monitor the epidemic, interpreting patterns,

and conducting tests. Utilizing a blockchain network offers a monitoring and communications infrastructure, which may assist in collecting, storing, and analyzing data on the containment and spread of viruses. The capability of blockchain to authenticate and store information permanently and in real time provides a guarantee of data integrity.

- **User Data Privacy**

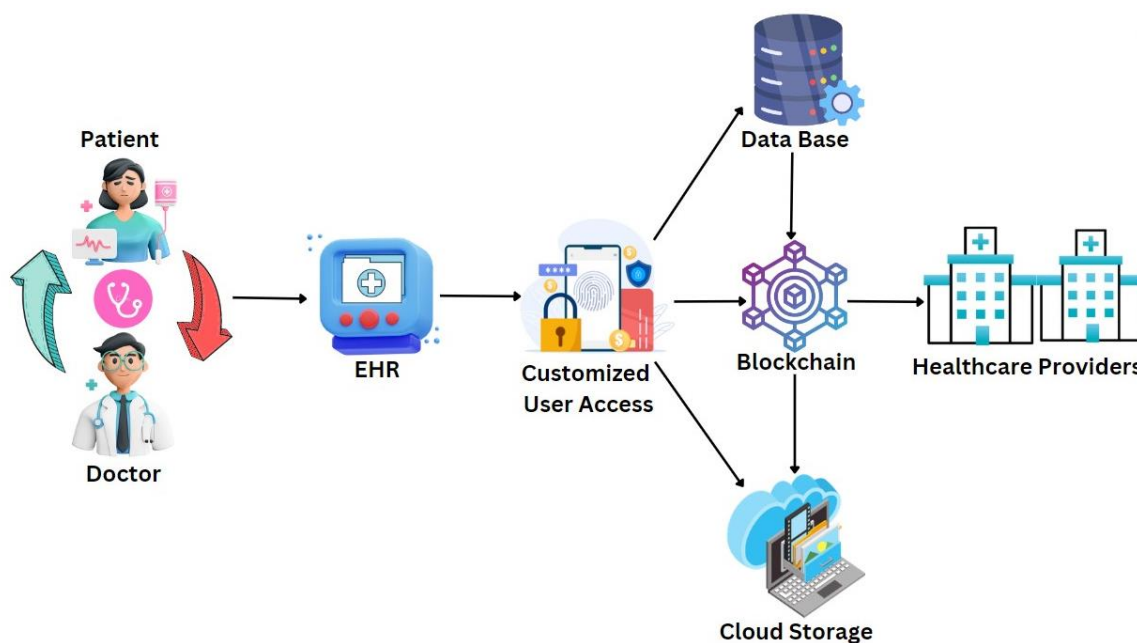
In these troubling times, it is necessary to do a balancing act between the management of records and the management of user privacy to increase Preprints users' confidence in the system. Policymakers & healthcare professionals must acquire client information via patent surveillance and other activities for enhanced decision-making while also discussing client confidentiality and privacy concerns. This is because improved decision-making requires both parties to obtain patient data. While

maintaining patients' right to privacy, recording and presenting medical information, screening patient procedures, and establishing social isolation degrees are all possible applications for blockchain technology.

- **Early Identification of Susceptible Populations**

There are a variety of AI-based triage solutions that have the potential to reduce patient anxiety. The online bot will assist in understanding the early warning symptoms, after which it will lead users toward preventative measures like social distancing, hand cleanliness, and other similar practices. If symptoms worsen, users should be advised to seek medical treatment. Maintaining the privacy and confidentiality of a patient's medical information is of the highest significance for protecting the patient's personal and societal values. The architecture built on blockchain technology can efficiently tackle security and privacy concerns [20].

FIGURE 4: REVOLUTIONIZING HEALTHCARE: EXPLORING THE TRANSFORMATIVE POTENTIAL OF BLOCKCHAIN TECHNOLOGY [21]



Source: Blockchain Technology in Healthcare: A Comprehensive Review and Directions for Future Research [21]

CONCLUSION

Within the context of the existing system, companies' most prevalent concerns about the information carried from one organization to another are maintaining trust and security. There is a significant possibility that a lack of trust will develop because information may be inputted at any point along the chain of communication. This possibility is of utmost significance in medicine because of the sensitive

nature of the information involved [22]. Concerns could be warranted when several providers have different copies of the same health information that has not been verified. This might happen when the information has not been checked for accuracy. As a result, the data could contain a variety of mistakes, in addition to presenting inconsistencies and being incomplete in their representations. Given the ubiquity of dangers such as hacking, data manipulation, and claims of security

breaches, it is no surprising that healthcare industry authorities are worried. When all of these aspects are considered, it is not unexpected that the authorities are concerned about the situation. This technology might be the solution to the bulk of these problems since it is cryptographically secure and because the data that is included inside it can be validated using a digital signature that is unique to each user. Electronic health records, often referred to by their acronym EHRs, are digital records that incorporate the patient's medical history. EHR is a common shortened form of the term. It handled a considerable number of concerns connected to the processing of data and the protection of such data. Those issues included: In this article, we have discussed a wide range of subjects, some of which include the many needs for EHR, the potential difficulties that may develop with EHR systems, and the use of blockchain technology as a solution to these potential concerns. Our group has conducted more research on the wide variety of pandemic management applications that might be suitable for electronic health record (EHR) systems that are powered by blockchain technology Figure 4. Among these applications are the following: contact tracking, information gathering, database exchange, customer information protection, and the Covid certification for sick or recovering people, the forecasting of future infection development in the community, and efficient & reliable supply chain administration for vaccinations as well as other vital goods. Blockchain is an innovation that can effectively overcome the shortcomings of traditional EHR problems and aid in the administration of the COVID-19 outbreak problem by providing trustworthy, precise, & confidential information storing & transfers. Blockchain also has the potential to be successfully implemented to address the deficiencies of standard EHR concerns and to assist in the management of the issue with the COVID-19 pandemic. There is also the possibility that blockchain technology might be utilized to assist in alleviating some of the problems around the pandemic's control.

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