IJBPAS, October, Special Issue, 2023, 12(10): 162-179
ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)
'A Bridge Between Laboratory and Reader'

www.ijbpas.com

BLOCKCHAIN IN THE HEALTHCARE SECTOR: A BRIEF REVIEW ON THE TYPES, APPLICATIONS, AND CHALLENGES FACED BY BLOCKCHAIN TECHNOLOGY

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Received 10th May 2023; Revised 6th July 2023; Accepted 6th Sept. 2023; Available online 15th Oct. 2023

https://doi.org/10.31032/IJBPAS/2023/12.10.1019

ABSTRACT

Blockchain is one type of shared digital ledger type of technology enabling improved data management, and privacy, and can potentially transform healthcare. It enables a secure sharing of data and data management. The various versions of blockchain such as Blockchain Versions 1-5 are discussed in this article. It also highlights the types of blockchain technologies that are being used currently. An analysis of the key features such as decentralization, transparency, immutability, data provenance, consent, and anonymity is performed. Blockchain's utilization in a number of applications such as in medical records, drug tracking, supply chains, clinical trial process, the detection of medical fraud, health insurance, the food industry, agriculture, mobile health, and also in neuroscientific purposes have been briefly discussed about. The driving forces behind this are also covered by the key traits of blockchain. This article also demonstrates the challenges faced by this technology.

Keywords: Blockchain; healthcare; Blockchain versions; blockchain challenges; applications

INTRODUCTION

A growing list of records called blocks makes up the sophisticated data structure known as blockchain. A block in the network of blockchain consists of four components which are information, the current block's hash (identifying number), the previous block's hash, and the timestamp, which links each new block to its predecessor. The technology of blockchain can be designed in a variety of ways, including public or permissionless, private which is a permissioned variant, and the hybrid blockchains. Healthcare is a clinical field that generates, utilizes, and communicates enormous amounts of data on an ongoing basis. When it comes to managing patient data, the current healthcare systems falls short on security, consistency, dependable verification, accountability and transparency. Blockchain technology seems to be able to solve these problems within the medical systems of today **[1]**.

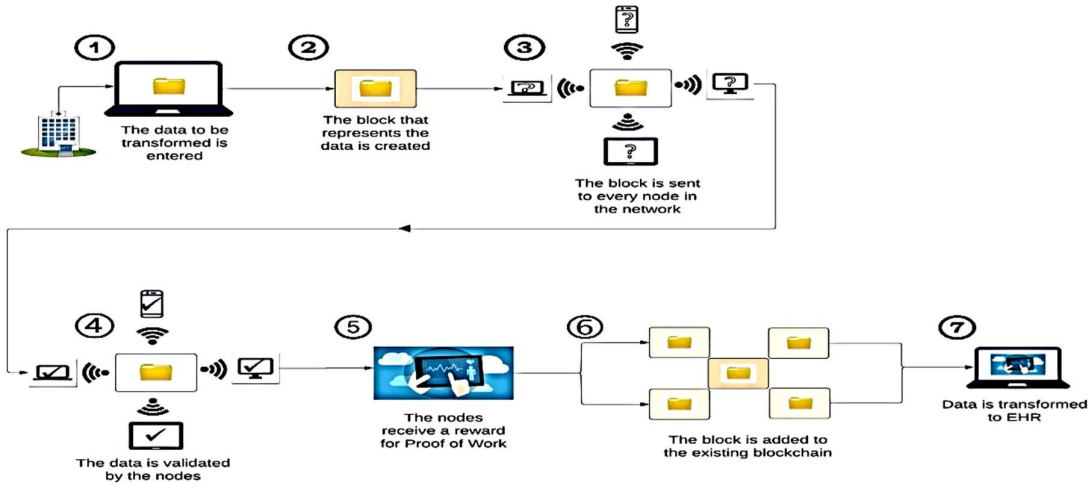

Figure 1: Working of Blockchain in an Electronic Health Record

Since its origin, blockchain technology has been applied to a wide range of industries, that lie between the first crypto to the present applications based on blockchain for pharma for industries. It now forms a very crucial part of a number of organizations whose needs are lucidity, probity, and reliability **[2]**. However, due to the widespread use as well as the continuous rise of newer technologies, the technology of blockchain faces more serious difficulties and threats. Blockchain implementation in the health sector might cover all ailment systems, including controls, stats, economy, audits, and storage of past materials. It may also offer helpful technical support for reorganizing hospital information systems and workflow. Blockchain's technological advancements from version 1.0 to version 5.0 increase its suitability and stability for

industrial, healthcare applications, and business needs **[3]**.

Blockchain 1: The new digital payment system was driven by bitcoin, a programmable currency. It is the forerunner of blockchain technology because to its decentralised, key-based digital money transaction approach.

Blockchain 2: Built on the society based on software, applications that are being based on blockchain are utilized extensively throughout social provinces like banking, peer-to-peer dealings, registration-based information, and copyrights and trademark assistance, and management of intelligence.

Blockchain 3: It expands the use of blockchain for decentralized apps (DApps), and through decentralisation, non-tampering, and reliable sharing, it enhances societal trust and operational efficacy.

Blockchain 4: Industrial Revolution (IR) 4.0 real-life company scenarios are more realistic with the help of Blockchain 4.0, an advancement of the previous generation that through the consensus protocols manages the networks.

Blockchain 5: This generation of blockchain is seen as an emerging one since it eliminates some of the restrictions of existing blockchains and uses virtual connections in order to improve processing speed and security **[4]**.

BLOCKCHAIN IN HEALTHCARE

In the sector of healthcare, blockchain has numerous uses and functions. One advantage blockchain can offer to healthcare and the IoT which means the Internet of Things is privacy or security. Basically, the protection of data, systems, and networks is one of the many areas this benefit addresses. Data management isn't complete without data securityIn the medication supply chain and smart cities, blockchain has recently also been employed alone or in conjunction with other solutions to address some of the latest problems.

The types of blockchains used in the healthcare sector are discussed as:

1**. Unpermissioned/Public blockchains**: When the nodes that connect to the network are accessible to everyone through the Internet, the network's named a public type of blockchain, which includes uncommissioned ledgers like Bitcoin or Ethereum.Anyone may view, read, participate or write on in the consensus mechanism on the ledger. Every node in the network can communicate and synchronize with the blockchain transaction ledger **[5]**. However, this type of blockchain transaction validation process has proved cumbersome and unproductive.

2. **Permissioned or private blockchains**: A single business controls the network in a private blockchain system. This denotes that participation by the general public is not permitted. It doesn't allow access to other

service providers, and only the people participating in a particular type of transaction will be aware of it.The lack of ability to create a decentralized type of system made possible by public blockchains for secured databases, is a significant loophole in the private type of blockchains **[6]**.

3**. Federated or Consortium blockchain**: This combines the use of public and also private blockchains and can be represented as a kind of partial decentralization. Private blockchains and consortiums are distinct from one another. In general, consortium blockchains are a cross between highly trustworthy private blockchains and public blockchains with unreliable entities **[6]**.

KEY FEATURES OF BLOCKCHAIN TECHNOLOGY: The are six blockchain elements that have the potential to significantly improve current healthcare systems. The following part provides more information **[7-12, 14]**.

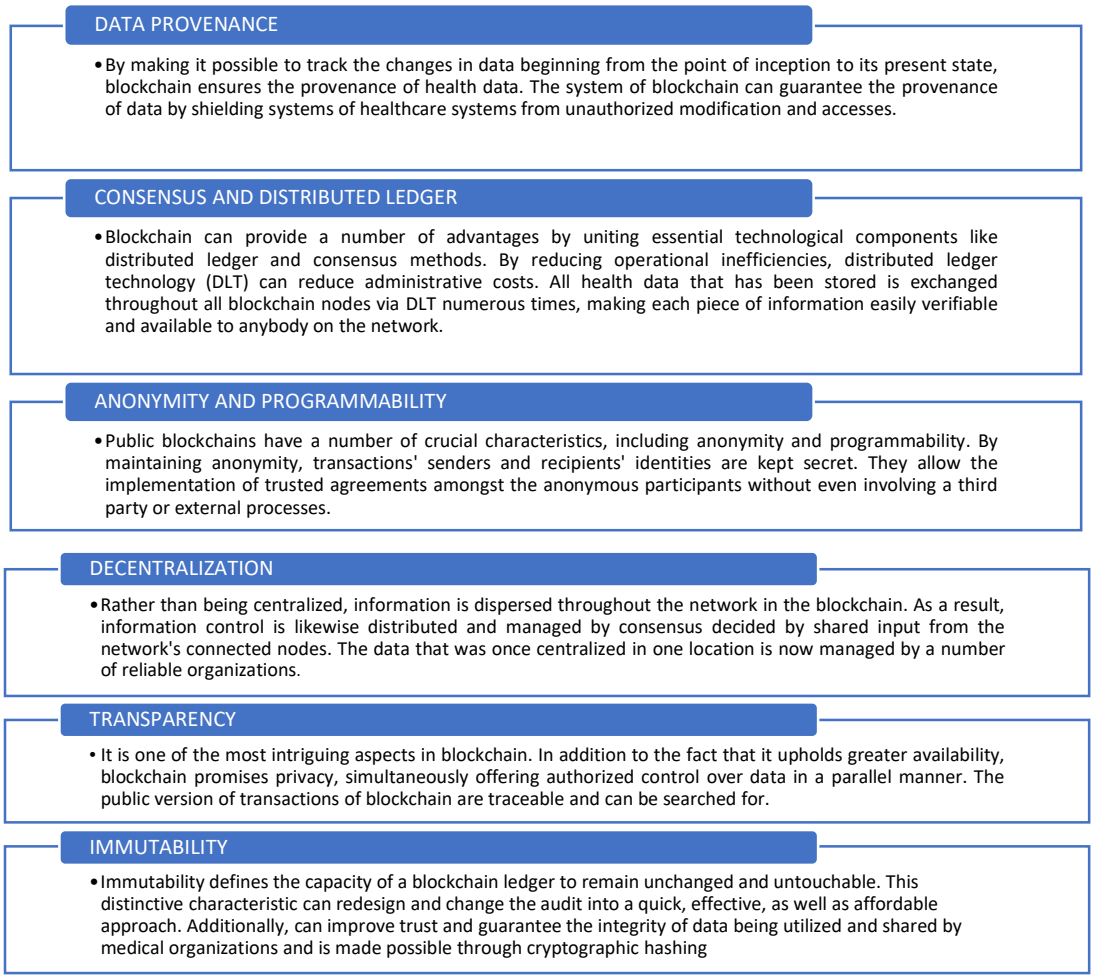

Figure 2: Key features of Blockchain technology

CHALLENGES FACED BY BLOCKCHAIN IN HEALTHCARE:

1. Clinical data transaction volume: Focus data interchange on condensed clinical data, such as a radiology report rather than whole DICOM images. Local blockchains with permissions are designed to manage high transaction volumes quickly and with extensive validation. Blockchain also scales techniques of research and new technologies **[15]**.

2. Privacy and Security of Data: On numerous blockchain cryptocurrency networks, there have been many examples of attacks similar to that and attacks of that strength **[16]**. The data is susceptible to potential security and privacy issues given that the blockchain process enables everyone in the network, as opposed to a single reliable third party, to confirm the information stored in a blockchain structure. However, even the best-designed blockchain's security can be compromised in certain circumstances (such as the so-called 51% attacks), necessitating the implementation of suitable preventative measures to reduce or stop blockchain security breaches. The promise of transparency made by blockchain must be balanced with the General Data Protection Regulation (GDPR), from the European Union, considerably tighter law of privacy which calls to the erasure of personal data upon request **[17]**.

3. Difficulties with latency and throughput limitations: Because the main technologies behind the blockchain demand time to form an agreement to be reached and all the transactions duties to be performed on time, real-time integration of blockchain into health could pose challenges. Blockchain needs time to process transactions when there is transaction latency **[18]**. For instance, it takes 10 minutes for the network to confirm any transaction on the Bitcoin blockchain. The suggested waiting period for each transaction's confirmation is one hour, even if four or five additional blocks should be added to the already present chain before the final confirmation. In contrast, majority of the traditional systems of database just need barely any amount of time to confirm a transaction in activity **[19]**.

4.**Legislative aspects**: Making sure blockchain technology conforms with national privacy laws and regulations is another concern. A further obstacle to the implementation of blockchain is the lack of information on compliance. Blockchain-related regulations are in their preliminary stages yet **[20]**. Since the laws and regulations of the laws are meant to be matured, businesses should keep an eye on how they change. It is important to fully understand data ownership, rights, and the architecture of blockchain. Healthcare organizations should be providing

recommendations for authorities and specify the necessary regulatory requirements **[21]**.

5**. Knowledge gap**: To properly integrate blockchain technology into sector of medical care, it is necessary to have a suitable infrastructure, connection, technicians, and specialists. A problem that has to be acknowledged is that most of individuals do not fully comprehend blockchain technology and this is the most specific, and intricate part that comes to play while using this technology **[6, 22]**.

6. Tokenization: This is regulatory ambiguity with tokenized assets. There is also lack of an internationally recognized, legal digital identity. Establishing tokenization standards and legal frameworks allows for the creation of digital identities that are recognized legally everywhere **[7, 23]**.

7.**Reluctance to Share**: A number of the parties involved in the delivery of healthcare services are reluctant to disclose the data. For instance, hospitals and also some of the insurance companies might not wish to easily share with other institutions. One explanation for this would be that the hospital wants to keep the cost information to themselves and may establish different prices for certain patients **[24]**. It contributes to the economy of the hospital. Therefore, trust between many entities must be built for each entity to agree to share the data to build a better healthcare system **[25]**.

8. Technical challenges: The technology behind blockchains is continually being explored and improved. This technology does not have enough space to store a lot of information yet. A network of connected computers (referred to as nodes) exists to provide the computational power needed to generate blocks. There is also the problem of Informational deterioration potential and constraints on storage space and throughput capacity. When business legacy systems and systems of record are involved, integration issues arise and require choosing a blockchain protocol, which serves as the framework for building the blockchain and developing various applications **[26]**.

9**. Issues with blockchain size** : Through blockchain transactions like RPM and EHRs, a sensor device links to patients, constantly increasing the need for miners. IoMT devices broadcast enormous amounts of data that blockchain cannot handle **[27]**.

10.**Lack of definite standards**: This form of technology is still in its early phases and is continually changing, thus there isn't any defined guidelines and standards. Thus, the implementation of this in the healthcare industry will require additional time and a lot of effort. All of the international organizations have set of standards which have to be implemented while functioning in the health sector. This cannot be overlooked. These standards if established because they could be easily enforced within the

organization making it simple for adapting to this technology **[28]**.

APPLICATIONS OF BLOCKCHAIN IN HEALTHCARE

1**.Electronic health records/EHRs**

The Electronic Health Records (EHRs) are often stored by hospital systems and contain vulnerable and private type of patient data. Patients frequently struggle to obtain their own health information because it may be shared with several entities. Toshniwal et al. in 2019 presented PACEX which is a system based on blockchain that gives patients or clients exclusive ownership over their EMR, as a solution to this problem. While minimising on-chain data storage, PACEX keeps track of all exchanges of EMR and stores values of hash of the EMRs inside the blockchain for authenticity **[29]**. Blockchain has the capability of significantly altering the healthcare sector and providing the patients access to their data. One particularly captivating step in this direction is MedRec **[30]** which provides patients and physicians with a transitory log of medical records. PPRs which is an abbreviated form of Patient-Provider Relationships are being mapped using Smart Contracts by MedRec, where the contract usually displays the total list of references outlining all connections between the Blockchain nodes. Additionally, it places PPRs in the patient's control, which allows them to reject or accept, and also helps in the change of partnerships with healthcare providers like insurers, clinics and hospitals **[30, 31]**. With the use of blockchain technology, there is encryption of data and then the hashing of data which makes it difficult for unauthorized users to gain access **[32]**.

2. **Drug tracking**

By exploiting the indestructible nature of the blockchain, drug monitoring offers the opportunity to establish an unbreakable chain of ownership from the manufacturer to the patient. Chronicled, an emerging technology company, is creating its product, Discover32, that generates a chain of control model demonstrating where the drug was manufactured, its location, and when it was delivered to patients **[33]**. Chronicled uses the immutability of the distributed ledger to avoid the theft and fraud of pharmaceuticals. This enables healthcare providers to adhere to the latest healthcare regulations surrounding pharmaceutical supply reliability, with a renewed focus on interoperability across healthcare providers. A new initiative from Hyperledger, the Open-Source Blockchain Working Group, called the Counterfeit Medicines Project34 seeks to solve the problem of phony medications. Blockchain is used to track the source of fraudulent medications and remove them from the regular pharmaceutical supply chain **[30, 34]**. The utilization of blockchain in drug tracking provides integrity, accountability,

authorization, and availability while also preventing attacks of MITM. All the transactions on the blockchain must be endorsed by initiator's secure/private key in order to be validated **[35]**.

3.**Health Supply chain**

Due to cost management Health care organisations now view supply chain management as a critical factor in achieving their objectives. In order to meet consumer needs in the most effective manner, supply chain management (SCM) works with many categories of flows, including flows of items, flows of information, and flows of cash inside and among supply chain participants. Blockchain in healthcare enhances patient security overall, addresses the problems of medicine supply chain traceability and authenticity, and permits secure communication between healthcare organizations **[36]**. The Internet of Things (IoT) is a highly networked platform of goods, such as electronic and engineered technology, with individual IDs. These gadgets are capable of sending and receiving data online. In a word, IoT devices have the ability to sense, collect, and send data via the Internet.Some benefits that has been brought by IoT sector to the logistics and transport sector include online tracking, control of traffic, avoiding traffic jams, conditional monitoring, providing an efficient supply chain, and quick decision taking process **[37]**.

4.**In the Clinical trials**

Medicines should undergo a protracted process for ensuring their safety, efficacy, statistical validity, and patent protection. Clinical trials typically consume a large amount of time during this lengthy process, which usually lasts from discovery to commercialization. Because of lack of security/privacy, a lengthy process like this is prone to drug recalls as well as counterfeiting. Utilizing blockchain technology throughout the entire pharmaceutical industry removes this barrier. Therefore, blockchain technology ensures that events are recorded in the correct chronological order, prohibiting a posteriori reconstruction study with regard to data integrity and historicity. The confidentiality of data is first ensured through each transaction's encryption validation. One of the main features of the system is timestamped transactions, which allow for traceability and historical data. This data is openly accessible, and each user has access to a copy of the documentation for the time-stamped information **[38]**. In clinical work, blockchain can be used to achieve a huge amount of data in an encrypted format. It is done using either the open network or the closed network. Tools for completing these "slicing" and "chaining" operations are provided by blockchain technologies, which are named Smart Contracts. This tool enhances

transparency, controls, and traceability over our clinical trial sequences making the work a lot easier **[39, 40]**.

5.**In Health Insurance**

Health insurance is now necessary to receive high-quality care in the event of an accident or serious sickness as healthcare costs rise **[41**.] Monitoring and managing data as well as offering customer service are two of the key responsibilities of healthcare insurance companies. Insurance firms are prohibited by law and corporate privacy from sharing patient data, but because the data are not connected and synchronized between insurance providers, there has been a rise in healthcare fraud. The estimates from National Health Care Anti-Fraud Association (NHCAA) conclude that there is an annual financial loss of billions of dollars **[42]**. By doing away with the requirement for a third party, blockchain ensures that every block of data is available to all parties involved in the chain. Policies would be less likely to be manipulated if businesses collaborated to share data on the blockchain **[43]**. Using Blockchain technology, we have combined and linked data about the claimant from different health insurance providers, and this information is used as a guide to identify fraud.

6. **In the Food Industry**

Developments of goods and information across nations have significantly increased as a result of the globalizing supply chains of food and marketplaces. There is a sizable demand for research on blockchain technology's potential for FSCs because it has only recently begun to be included in this field of study **[44]**. The responsibility of Food stakeholders is to respond to newly added safety and health problems posed by FSCs' vast complexity by maintaining sustainable food ecosystems. For instance, Walmart, IBM, and Tsinghua University have investigated blockchain technology’s potential to boost the findability of food throughout the logistical chain of supply in China. Similar to this, the Chinese retailer Jindong has teamed up with the beef producer Kerchin, based in Inner Mongolia, to use blockchain technology to collect digitalized information such as farm information, batch numbering, data of factory and processing, dates of expiry, storing temperature and pressure, and transporting and dispatching information that is connected digitally for the tracing of every step in the processing of the food products. Scanning the QR code on the box, customers can use their system to track down information on frozen meat, like the breed of the animal, the diet of a cow, the farm’s location and also the weight of the cow. The use of blockchain technology can make it easier to facilitate the trading of food, which is a crucial economic activity **[45]**.

7.**Distributed ledger in Agriculture**

The flow of value and information in the agricultural industry may be made more effective, transparent, and traceable thanks to distributed ledger technology (DLTs) and smart contracts. In a wide range of methods, digital records, the use of cryptography and DLTs in order can be used to disintermediate transaction processing, data storage, and supply chains for agricultural products. Firstly, the ability of the technology to monitor a product's historiography involves various product features into each transaction and confirms its legitimacy resulting in notable breakthroughs in traceability, which have a benefecial impact on the safe, efficacy quality and sustainability of food. Second, thanks to smart contracts and the elimination of middlemen in agro-distribution networks, smooth and immediate payments for monetary services are now possible **[46]**. Additionally, real-time issue reporting is being possible with the utilization of Smart contracts. Blockchain technology allows for record keeping of all steps in the value chain, from manufacturing to the disposal of a product **[47]**.

8. In Mobile health

Mobile and wearable technology enabled Personal health information has a tremendous and growing value for healthcare, helping both providers of treatment and patients alike. To promote communication and cooperation within the healthcare sector, personal health information must be shared in a secure and convenient manner **[48]**. Blockchain technology has gained popularity due to its effectiveness in preventing data manipulation. A record's origin and its presence at a certain time are by encryption irrefutable proof in a blockchain's legitimate transactions, which are digitally signed and timestamped by the sender. This is a necessity in mobile health applications. Mobile health(mHealth) can contribute to cost reduction by streamlining care delivery and establishing connections between patients and their medical professionals. Additionally, mHealth data are kept on servers, therefore data management that forbids any kind of modification is essential for both clinical trials and medical practice. An example of a mHealth system using blockchain is mHealth app that enables cognitive behavioral therapy(CBT) for insomnia (CBTi) by the use of a simple smartphone **[49]**. Another example is that of Smart Contract for the detection of blood glucose levels **[50]**.

9.In Neuroscience

Modern technologies of neural science aim to create a new prototype that eliminates connection with the environment and enables the standardization of objects and information through cognitive commands. These types of neurological devices have the ability to interpret the patterns of cerebral

activity and format them into instructions for control of externally present equipment. They may also use brain activity data to infer a person's present mental state **[41]**. The utilization of blockchain can support brain augmentation, brain simulation, and brain thinking. Blockchain enables networking of connected computers for the exchange of hands at regular breaks of a time period to verify the source needed. Real-time communication is made possible via a brain-computer interface (BCI), greatly enhancing the effectiveness of lifecycle, Brain-to-internet connection, and Brain-to-external communication methodologies **[51]**. By advancing information and communication development paradigms, this assistive technology immediately ties the brain and multimedia gadgets onto the internet. Without physical interference, the system transforms brain input into signals that multimedia devices can understand. The Blockchain enables BCI applications' helper cybersecurity in recognizing brain processes on a real-time basis, this is commonly used in health wearables.

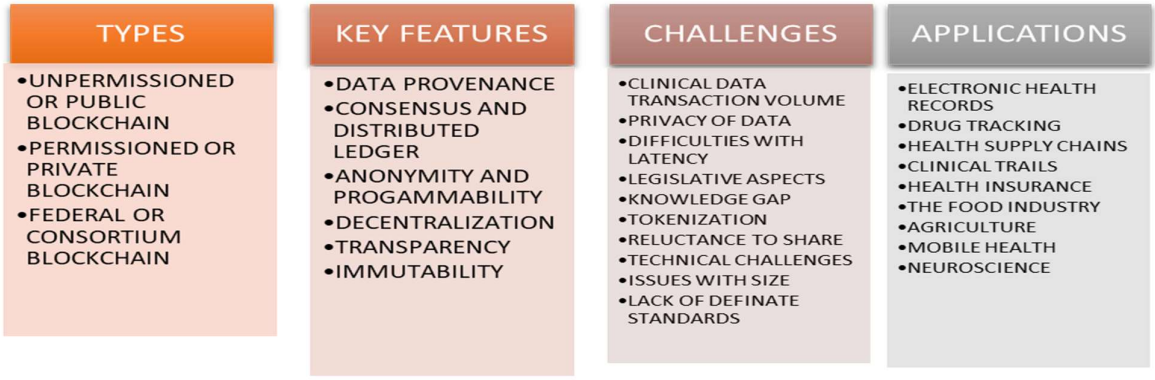

Figure 3: A summary of all the topics discussed in this article

CONCLUSIONS

In conclusion, blockchain technology has the potential to help with some of the issues now affecting the healthcare sector. The healthcare sector has trouble adjusting to the developing infrastructure that's centered on Internet-based, smart, and sensing equipmen **[52]** t. As these innovations enhance the healthcare industry's capacity to provide medical services in a connected world, hackers may also gain access to and modify or delete data by taking advantage of deficiencies in these innovations to make it more challenging for hospitals to share medical records. In this article we learn about the various types of blockchain and their utilization in the healthcare sector. We've also discussed about the various versions of blockchain technology ranging from Blockchain version 1 to version 5.

Blockchain technology can guarantee the privacy, security, accessibility, and control of access to EHR data. An evaluation of the application of blockchain's best conducted within the established framework that is by the Recommendation of the OECD Council on Health Data Governance (OECD, 2019), this is because of its essential role in contributing to health data management **[53]** . The enhancement of health data collection, use, and exchange between patients, researchers, and data subprocessors is the primary objective of other blockchain initiatives. Although the blockchain is being utilized for a vast range of uses in the health sector, it also has certain limitations. Nevertheless, it has emerged as one of the most important and informative technologies that makes our work simpler and eliminate most of the security issues. It is finally concluded that blockchain could make drastic changes in the healthcare sector.

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