A Review of Concepts, Advantages and Pitfalls of Healthcare Applications in Blockchain Technology

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Abstract
Recently, research in blockchain technology has grown in popularity. Most of these researches have pointed out designing and improving conceptual structures to create digital systems that are more secure, accessible, and effective. Although blockchain offers a wide range of advantages, it also has some pitfalls. This research aims to present an understanding of the properties of blockchain, the advantages, pitfalls, and applications based on blockchain technology. To achieve the goal of understanding blockchain technology concepts, a systematic literature review approach was introduced. 93 papers were chosen and reviewed in total. Therefore, this research provides a summary of recent studies that have been published in the field of blockchain. Moreover, we have created concept maps and tables that aid in a deep understanding of blockchain technology concepts and exhibit some of the blockchain applications. In blockchain-based applications, we focused on two areas, namely the Internet of Things (IoT) and healthcare.
Key words: *Blockchain; healthcare; concepts; properties; pitfalls; systematic literature review*

1. Introduction

Blockchain technology is one of the modern techniques that provide a new paradigm to organize business and human activities [1]. It is a mechanism to store information of the transaction in a Peer-to-Peer (P2P) network. It is a distributed and open-source project that was designed to create a digital currency known as Bitcoin [1]. Blockchain concept exceeds using in cryptocurrency. Blockchains have two types which are public or private [2]. A public type does not need prior permission; therefore, anyone can join such as Bitcoin. However, a private type is needed prior permission such as Hyperledger of IBM [2].
A smart contract is a part of code that performs prior actions when the selected conditions are accomplished. Blockchain has platforms such as IBM Hyperledger and Ethereum. These platforms can be able to store different types of data. Also, it supports a smart contract. Therefore, currently, blockchain becomes utilize in various fields to obtain security, efficiency, flexibility, and transparency. The fields involve informatics of health for managing and storing data of patient [3], [4], guaranteed energy trading [5], sector of banking and financial to simplify and facilitate transactions [6],[7],[8], e-governance to develop services of government [9], smart city improvement [10],[11],[12], based-blockchain internet of things (IoT) services [13], [14], validation system of auditable and decentralized software [15]. In other studies [1], [16], [17], there are threats of implementing technology of blockchain, such as wasted resources, lack of usability, scalability, and privacy. Therefore, it is important to understand the blockchain concept and its applications.
This paper aims to present the basics of the blockchain concept, that through displays a set of concept maps [18] to clarify in-depth definitions, features, benefits, and pitfalls of blockchain technology. Moreover, the benefit of this research is enhancing its effective usage in future technological solutions development and to build a perfect concept map or to comprehend it must understanding the main requirements. Furthermore, the concept maps are utilized to simplify and facilitate learning, research, evaluation, procedure, and data analysis [19], [20].

The rest of the paper is organized as follows. Section 2 displays the literature review. Section 3 displays the research method. Section 4 demonstrates the benefits, features, and pitfalls of the blockchain technology. Section 5 describes the blockchain-based applications in healthcare sector. Finally, section 6 displays the conclusions and future research directions.

2. Literature Review

The related work carried out on the working principles, applications, advantages, and disadvantages of the blockchain are briefly discussed in this section. Moreover, we will explore the previous related works in many fields where the blockchain technology is applied, especially at the healthcare sector.

Davidson et al [6] described the blockchain as a catallaxy that means "political economy". The blockchain is a robust and protected as it executes a secured mechanism utilizing cryptography. According to Crosby et al [21], the blockchain is a distributed online database of all digital

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events that have happened between participant nodes in the network. They offered a summary of blockchain technology and highlighted some obstacles that blockchain might solve and some restrictions to be tackled in future work.

Buterin [22] pointed the blockchain as a magic machine that is crypto-economically secured and contains self-executable programs with records of all prior and current states. Carlozo [23] described the blockchain technology as the bedrock of any digital transaction. It might provide businesses with more dynamic approach.

A comprehensive analysis performed by Yli et al [17] highlighted recent advances in blockchain research and presented potential future research directions, including the introduction of a new cryptocurrency, the use of multi-level authentication methods, and the management of energy-efficient resources for distributed systems. In order to illustrate how blockchain offers advantages such as flexibility, tamper-resistant, and automatic confirmation in a system. Ruoti et al [24] studied the operating principle of blockchain technology in many domains. Beck et al [25] suggested that it is more suitable for blockchain to simplify difficult business transactions and to build new business models.

Some studies have been working to identify the threats of the implementation of blockchain technologies. In terms of throughput, latency, security, and usability, Swan [1] described some technological challenges. Amosova et al [26], from the viewpoint of law enforcement authorities, financial companies, civil society, individuals, and regulators, analyzed the vulnerabilities of unregulated use of blockchain technology in the financial sector. The types, characteristics, and working concepts of blockchain technology were briefly presented in Pilkington [27], [28]. The centralization and decentralization principle of bitcoin, its use, merits, and demerits were defined by Bohme et al [29].

Blockchain has used in both financial and non-financial areas [30]. In the financial domain, blockchain is designed to facilitate online financial services [30] such as digital cryptocurrency named Bitcoin [1]. Furthermore, companies can directly issue the shares through this technology [30]. In the non-financial domain, it uses in healthcare [31], IoT [32], supply chain, and e-voting [31]. IoT is the network of physical objects based on sensing technology for real-time sharing of information with other devices and systems over the Internet [33].

Khurshid et al [34] and Wijaya et al [34] summarized IoT as the integration and the combination of the physical with the technology of communications. Moreover, IoT associates with artificial intelligence such as vision-based systems [35]. Li et al [36] claimed that the IoT devices has increased risen significantly, which leads to an increase in data privacy leaks. Therefore, there is a need to adopt a technology to be able to preserve information security on IoT devices. Blockchain technology improves the security of IoT applications in an effective way.

There are some studies [33], [37] that have adopted apply of blockchain in the field of the IoT as a distributed database. Defeng et al [33] proposed a system for storing location information for IoT devices based on the blockchain. Blockchain helps to effectively solve the security problem in location information of IoT devices due to its distributed architecture and the way it encrypts the data. They used mathematical functions for encryption instead of conventional substitution methods.

Tseng et al [37] described the blockchain as “a distributed replicated database”. Ren et al [38] proposed a scheme that enhances the protection of wireless body area networks (WBAN) in the healthcare field based on blockchain. The proposed sequential aggregate signature scheme allows only authorized people to view information and helps in compress the storage space of blockchain. Some studies have used blockchain as a technology for managing data securely and effectively by issuing certificates for the IoT devices and retrieving these data through these certificates [39].

The supply chain can also benefit from blockchain technology. An example of this is what has been proposed in the field of the supply chain [40] where a food traceability system based on the IoT and blockchain technology to manage perishable foods. The authors in [41] presented an approach that merges blockchain and the IoT in supply chains. The architecture of a system is a distributed network of nodes that provide different types of services. This structure relies on there being no centralized body to supervise the nodes. The system contains several types of nodes where each of them is responsible for providing a specific service. Also, in the field of the supply chain, the authors in [42] presented a framework based on blockchain. The proposed model helps in tracking drugs and monitoring their temperature through sensors. Therefore, there are many applications that can adopt blockchain technology.

There are many areas that have adopted blockchain technology to improve data security, such as the healthcare industry [43]. The authors in [44] proposed a blockchain-based system to allow all healthcare providers access to the blockchain to verify patient records. This system can improve the protection and privacy of patient records and prevent tampering. Gordon et al [43] claimed that the use of blockchain in interoperability makes it easier for health organizations and institutions which do not have a specific relationship with each other to integrate securely and effectively. With the use of blockchain technology, it can enhance interoperability by allowing the patient to control their personal data. However, many barriers and challenges still stand in the way of patient-driven interoperability by blockchain.

In summary, the previous studies focused on the presentation of blockchain recent innovations, applications, and vulnerabilities in various fields. No research analysis that specifically concentrated on presenting all potential blockchain functionality has been found. Additionally, no research showing a consistent mapping of the benefits, pitfalls, and context of usage defined has been found.

3. Research Method

The authors in [45] performed the procedure for systematic literature review. We adopt it to gain the research purpose. The search strategy specifies the criteria of inclusion and exclusion for the selected articles. Where these articles may be considered and included in the research or ignored. Furthermore, there is a plan for analyzing and data extraction from selected articles. Fig. 1. illustrates the steps of methodology for a systematic literature review.

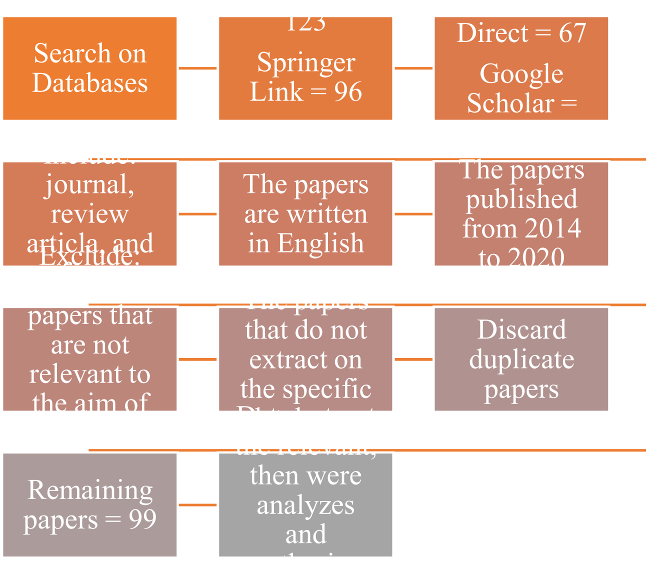

Fig. 1 The systematic literature review methodology steps.

The major scholar databases are used to select relevant significant articles such as IEEE Explorer, Springer Link, Science Direct, ACM digital library, MDPI, Journal of ICT Research and Applications, Google Scholar and Saudi Digital Library (SDL) as shown in Fig. 2. For identifying keywords of search applied for finding articles such as "Blockchain", "Blockchain Technology", "Blockchain Concept", "Blockchain and Concepts", "Blockchain as Database", "Blockchain Data ``Storage", "Blockchain Benefits", "Blockchain and Benefits", "Benefits of Blockchain", "Blockchain Advantages", "Blockchain and Advantages", "Advantages of Blockchain", "Blockchain Properties", "Blockchain and Properties", "Properties of Blockchain", "Blockchain Pitfalls", "Blockchain and Pitfalls", "Pitfalls of Blockchain", "Blockchain Applications", "Blockchain in Healthcare" and "Blockchain in IoT Environment" as shown Fig. 3.

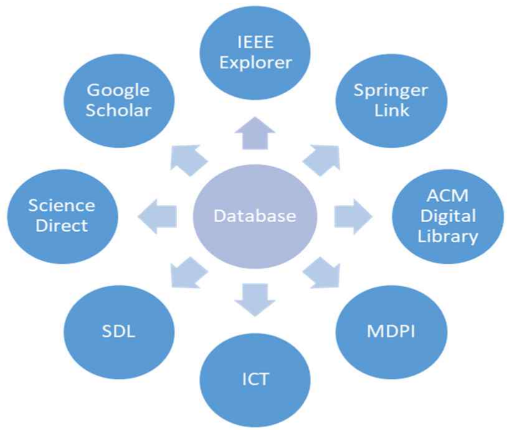

Fig. 2 The research databases.

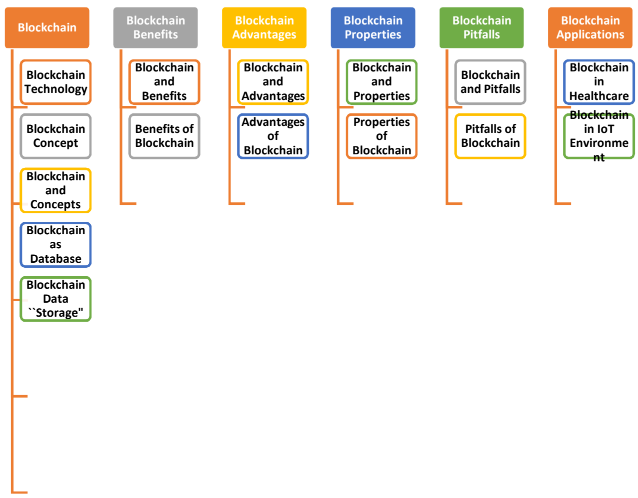

Fig. 3 The research keywords.

After applying these keywords to the above-mentioned databases. A total of 684 papers were found at first. A total of 123 articles from IEEE Explorer, 96 from Springer Link, 67 from Science Direct, 47 from ACM digital library, 35 from MDPI, 8 from ICT, 44 from SDL and 264 from Google Scholar were obtained. After that, we were performed to pick out the best-relevant papers. Based on the research articles were published from the year 2014 to 2020 as well as they are written in English language. Moreover, the papers must be selected from a journal, review article, and conferences. Otherwise, the papers that are not relevant to the aim of this research are excluded as well as the papers that do not extract on the above specific databases. Furthermore, the books sources have been excluded. Fig. 4. illustrates the inclusion and exclusion criteria. 99 papers were selected for review. The extracted relevant data were analyzed and synthesized, in order to offer a set of concept maps about blockchain concepts.

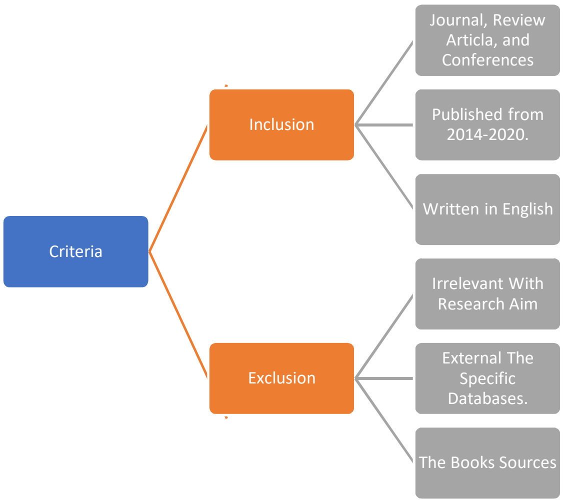

Fig. 4 Inclusion and exclusion criteria.

4. Blockchain Technology

Blockchain technology is a chain of blocks [46] . Each block contains a stored data [47] known as transaction data. Also, the block includes a cryptographic hash for current the block and the hash of the prior block [48], proof-of-work signature [49], and a time-stamp [50]. Moreover, it includes distributed consensus algorithms [51]. When adding a new block into the blockchain, the size of the chain of blocks is an increase [51].

It provides a particular mechanism of data storage, for that reason we can consider it as a database [47]. It is a decentralized database [51]. Blockchain is a technology that relies on the distribution of ledgers in the peer-to-peer network [52].

When adding a new block into the chain, the following procedures will occur. First, a transaction should happen in the network. Second, the specifics of the transactions should be verified and confirmed over the network by the participants. Third, data are stored in the block. Lastly, the new block will link with the previous block through the information of hashed value for it. Consequently, the new block is joined into the blockchain, also becomes public to other participants in the network. Fig. 5. shown how the block is added in blockchain.

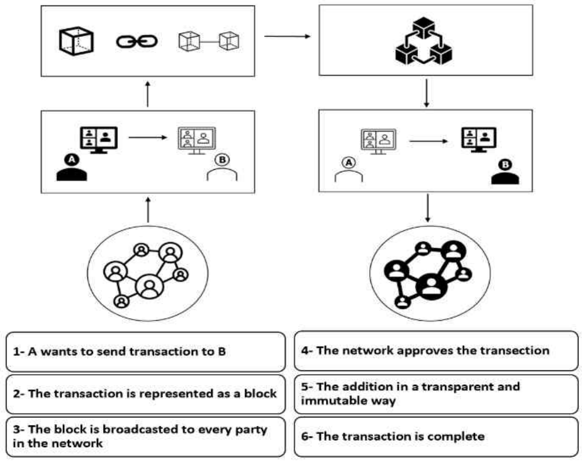

Fig. 5 Shown how does adding block in Blockchain.

4.1 Definition of Blockchain

Literature displayed that blockchain contains a chain of blocks. Each block consists of data, cryptographic hash for current block, hash reference of prior block, and proof of work. When transferring transactions to other participants in the P2P network, the shared distributed databases are tightly secured. Moreover, blockchain keeps the historical record where irreversible, which means that the historical record is immutable transactions data to maintain transparency. It is ensured by utilizing pseudonymous transactions. Fig. 6. shows conceptual map of blockchain definition. According to Islam et al [53] claimed that the formal definition of blockchain is

"*Blockchain consists of blocks containing messages, proof of work and reference of the previous block and stored in a shared database, which is able to perform transactions over P2P network maintaining irreversible historical records and transparency*" [53].

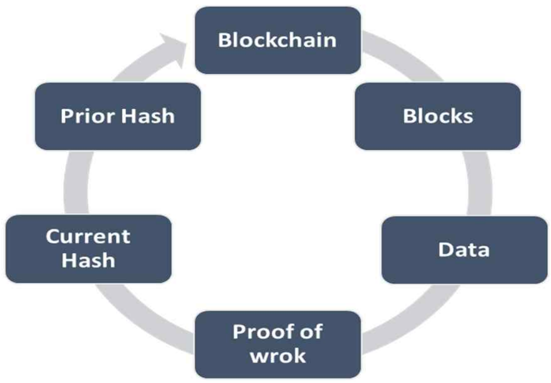

Fig. 6 Conceptual map of blockchain definition.

4.2 Properties of Blockchain

In this section, we will represent the blockchain properties gathered from a literature review. It was mentioned that the blockchain is a distributed database in fifteen articles. Distributed databases are logically connected between distributed networks. The participants cooperate with each other in order to send transactions between them over the distributed network. In distributed networks, there is no central controller. The P2P transmission and time-stamped blocks were reviewed in eight articles. In a distributed network, each of the parties is called a node. Also, the user can transfer or exchange data between nodes known as a duplex mode. Moreover, the blocks are consecutively connected by the time they are created.

There are several related characteristics for preserving the privacy of the data such as immutable record, encryption of data transmission, and disintermediation (autonomic interactions). The immutable block means cannot be modified data after creation as it is linked with the previous block through the hash function. The encryption of data transmission is encrypted data by the public key of the sender and decrypted by the receiver's private key for secure communication. Finally, disintermediation, the blockchain is implemented between two parties only without the need for the third party. Because it uses proof-of-work consensus protocols.

The properties that are considered as services provided by the blockchain are mentioned, such as validation, scalability, interoperability, traceability, and reliability. The validation requires to be verified over the network by other members when any block is produced. This is named as mining in the blockchain context. The scalability means that a blockchain can extend without any limitation. Interoperability is the ability to communicate with and share information between IoT systems and physical systems. Traceability is the ability to trace and validate the spatial and temporal information of a data block stored in the blockchain. Lastly, the reliability is the cryptographic processes namely asymmetric encryption algorithms, hash functions, and digital signatures which are essential in the blockchain. The rest of the properties are computational logic, transaction dependency, transaction rules, distributed trust, and multiple writers. The blockchain computational logic can require the execution of computational logic. Rules and algorithms such as (smart contracts) that can be implemented dynamically during data transfer can be added by the user. The transaction dependency means the transactions rely on pre-specified laws and regulations. The transaction rules are certain transaction rules are stated through smart contracts. In the distributed trust, each user has an address that is uniquely identified. The multiple writers mean multiple enterprises may seek reliable data from blockchain. Different writers in the shared databases have this information. Table 1. demonstrates the sixteen properties of blockchain with its description for each of them.

4.3 Advantages of Blockchain

Literature was found that there are ten advantages where "third-party independence" was stated most in the literature survey. Blockchain uses a strong crypto-economy system to verify any transaction. It makes the system untrustworthy. Therefore, no third party is needed. Blockchain provides an improved security advantage, where using cryptography in transactions. Hence, all exchanges of information are secured. Also, it grants easy to change and incorporate it into the new system by the feature of flexibility and effectiveness. The system becomes transparent to all users because it is able to track all transactions, and therefore all records can be audited and verified. The systems based on blockchain technology consider robust where it can recovery of the system from attacks or other system faults. Hence, some of the attacks are impossible such as the man-in-the-middle attack. For this reason, blockchain provides reliability and safety for users, and thus gain the users' trust. Furthermore, blockchain provides low costs as it reduces commission costs. Many users can concurrently access a system and the transactions do not need to be received in the same sequence in which it was created. Lastly, less redundant decreased redundancy because of peer-to-peer association. Table 2. presented the advantages of blockchain.

4.4 Pitfalls of Blockchain

The survey of the studies found that ten pitfalls were summarized in table 3. Blockchain is very complicated to implement the bitcoin API or general blockchain application platform to implement services. A large amount of energy for mining is wasted by Bitcoin, where the power loss is around $15million/day. Bitcoin can allow a multibillion-dollar exchange without any regulatory supervision, which can cause a large dispute. Moreover, there is no name or other user information for the addresses, causing an identity crisis in bitcoin transactions which means the absence of law and legislation. Blockchain guarantees adequate security for each transaction, where the bitcoin blockchain requires a minimum of 10 minutes. Also, it is less throughput where the minimum blockchain transfer rate can be estimated at 1.00-7.00 transactions per second. In addition, the data cannot be erased at block if it has been written considered this feature positive and negative at the same time. In terms of security, blockchain has a high risk of cyber-attacks. The last one of the pitfalls is contractual implementation, this issue occurs where any voluntary contract is approved by the central government and not associated with the shadow of the regulation.

Table 1: Properties of blockchain.

Ser.	Properties	Description	Ref.
1	Distributed database	Using distributed databases, which are logically connected between distributed networks, the blockchain is applied. In order to agree on the true state of the database, users in a distributed network cooperate. At the management level, there is no central controller. Blocks in the blockchain contain a collection of data and transactions.	[33] [36] [60] [38] [7] [13] [22] [28] [61] [37] [62] [63] [64] [65]
2	P2P Transmissions	In a network, each of the parties is called a node. In duplex mode, the user can transfer or exchange data between nodes.	[7] [61] [63] [50] [64] [66] [67] [68]
3	Time stamped Blocks	The blocks are consecutively connected by the time they are created.	[60] [24] [62] [63] [69] [70] [71] [72]
4	Immutable blocks	The block after its creation cannot be modified because it is linked with the previous block through the hash function.	[11] [60] [24] [62] [63] [69] [70] [71] [72]
5	Encrypted data transmission	Data is encrypted by the public key of the sender and decrypted by the receiver's private key for secure communication.	[4] [28] [30]
6	Disintermediation (Autonomic interactions)	In a distributed network, which uses proof-of-work consensus protocols, blockchain is implemented. No third party is needed. Thus, it has excluded the dependence on a third party.	[60] [3] [16] [37] [63] [72] [73] [74]
7	Validation	It requires to be verified over the network by other members when any block is produced. This is named mining in the blockchain context.	[3] [4] /[21] [72]
8	Scalability	Without any limitation, a blockchain can extend.	[11] [61] [37] [62] [63] [75] [76]
9	Interoperability	The ability to communicate with and share information between IoT systems and physical systems.	[72]
10	Traceability	The ability to trace and validate the spatial and temporal information of a data block stored in the blockchain.	[72]
11	Reliability	Cryptographic processes, namely asymmetric encryption algorithms, hash functions, and digital signatures, all of which are essential in blockchain.	[72]
12	Computational Logic	Blockchain Computational Logic can require the execution of computational logic. Rules and algorithms (smart contracts) that can be implemented dynamically during data transfer can be added by the user.	[7] [64] [65] [77]
13	Transaction Dependency	Based on any pre-specified laws and regulations, transactions are completed.	[64] [65] [78] [79]
14	Transaction Rules	Certain transaction rules are stated through smart contracts.	[80] [81] [82]
15	Distributed trust	Each user has an address that is uniquely identified. All transaction information is available over the network to all the participants.	[7] [64] [65] [72]
16	Multiple writers	Multiple enterprises may seek reliable data from Blockchain. Different writers in the shared databases have this information.	[83] [84] [85] [86]

5. Blockchain-Based Healthcare Application (BCH)

Attention to the health of the members of the community is the most important responsibility for any nation [54]. The data of individuals and hospitals that are being established in healthcare huge increases. This data is most helpful in the industry of medicine for different purposes [55]. The authors in [56] said that medical data could be used to support research and innovation in the healthcare sector.

A research problem related to the privacy and security concerns in the central repository of the health information exchange (HIE) system is solved in [57], [58]. The authors exposed the challenges facing privacy and security for storing patient data in the central repository and they found a solution by blockchain technology to enhance the quality of healthcare [57], [58]. Furthermore, They tried to solve data violation of patient, wrong diagnosis, abuse, and fraud problems [59]. They think that their framework will help providing the optimal solution to secure HIE on electronic health record (EHR) at hospitals in the USA [57]. Moreover, HIE is reducing costs of healthcare, enhancing the quality of healthcare, and oversight of diseases record of the patient [57]. It is a decentralized EHR database, immutable and secure, also easy to exchange EHR via the patient [58].

One of the features of this system is to provide the medical's history of a patient to research organizations for research purposes and development as well as to insurance companies to pay the medical service bills [58]. The authors in [59] presented a blockchain-based telemedicine healthcare framework. The services remotely healthcare help poor communities to treatment without travel long distances, elderly people with remaining in their homes. Also, it provides effective care to the patient at a lower cost. IoT platforms consist of a grid of several devices or components heterogeneous. The authors in [87] proposed the system as a decentralized, interoperable, trustworthy blockchain framework for healthcare ((DIT IoHT). It is reliable cooperative IoT eco-systems and it advantages reliable integration of information between these systems users. One of the features of this system is that connects IoT devices and healthcare framework to provide medical services is more effective and integration. In [59] presented a blockchain-based telemedicine healthcare framework. The services remotely healthcare help poor communities to treatment without travel long distances, elderly people with remaining in their homes. Also, it provides effective care to the patient at a lower cost.

Table 5. provides detailed researches on blockchain-based healthcare. Fig. 7. views the general benefits of utilizing blockchain technology in the healthcare domain.

Table 2: Advantages of blockchain.

Ser.	Advantages	Description	Ref.
1	Third-party independence	Blockchain uses a strong crypto-economy system to verify any transaction. It makes the system untrustworthy. Therefore, no third party is needed.	[3] [6] [11] [12]
2	Improved security	Cryptography is used in transactions. Hence, all exchanges of information are secured.	[7] [11] [15]
3	Flexible & effective	Simple to change and incorporate into the new system.	[6][7] [68]
4	Auditable & verifiable	The system is transparent to all users because it is able to track all transactions, and therefore all records can be audited and verified.	[3] [15] [22]
5	Robust	Recovery of the system from attacks or other faults. Hence, some of the attacks are impossible such as Man-in-the-middle attack	[6] [7] [72]
6	Reduced Cost	Blockchain provides low costs because it reduces commission cost	[3] [7]
7	Auto Synchronized	The transaction does not need to be received in the same sequence in which it was created.	[15] [22]
8	Less Redundant	Decreased redundancy because of peer-to-peer association.	[7]
9	Reliable	Obtaining the users' trust	[4]
10	Multi-accessible	Many users can concurrently access a system.	[7]

Fig.7 General benefits of utilizing blockchain in the healthcare domain.

Table 3: Pitfalls of blockchain.

Ser.	Pitfalls	Description	Ref.
1	Complicated to use	It is very complicated to implement the bitcoin API or general blockchain application platform to implement services.	[1] [13] [17]
2	Legalization	The absence of law and legislation.	[6] [13] [26]
3	Wasted Resources.	A large amount of energy for mining is wasted by Bitcoin. The power loss is around $15million/day	[1] [17] [76]
4	Latency	To guarantee adequate security for each transaction, the Bitcoin blockchain requires a minimum of 10 minutes.	[1] [17] [37]
5	Less Throughput	The minimum blockchain transfer rate can be estimated at 1.00-7.00 transactions per second	[1] [17]
6	Contractual Implementation	This issue occurs where any voluntary contract is approved by the central government and not associated with the shadow of the regulation.	[1] [6]
7	Poor Security	Blockchain has a high risk of cyber attacks	[1] [17]
8	write-once	The data cannot be erased if it has been written	[22]
9	Anonymous Transactions	Bitcoin can allow a multibillion-dollar exchange without any regulatory supervision, which can cause a major dispute.	[22]
10	Identification Crisis	There is no name or other user information for the addresses, causing an identity crisis in bitcoin transactions.	[26]

6. Conclusion

Blockchain technology is availing significant concern from individuals, researchers, as well as various sectors and research organizations. This technology can transform conventional transactions into a more secure and flexible transaction when sharing and exchanging data via the network.

In this paper, a strict literature survey has been conducted to extract features, benefits, and pitfalls for blockchain technology in healthcare sector domains. The fundamental conceptual facilitating future researchers understanding of blockchain technology is provided. We offered existing researches that discussed blockchain technology in the healthcare sector and how sharing of health data for patients at health centers. We found that there is agreement among researchers that using blockchain will be keeping on secret data when exchanged it between healthcare centers. Furthermore, the data of the patient will be truly owned and controlled by himself.

Table 4: State-of-the-art blockchain based healthcare.

Search Objective	Advantages								Publish Year	Ref.
	Architecture	Framework	Data integrity	Access Control	Medical data sharing	Distributed EHRs	Patient encryption key	Algorithm		
The blockchain system for health data exchange.	√	√	√	√	√	√	√	√	2018	[55]
Designed system for sharing of healthcare data smoothly	√	√	√	√	√	√	√	×	2018	[88]
The system provides flexible queries with arrival control of EMRs.	√	√	√	√	√	√	√	√	2018	[89]
System of exploring data protection for medical data	√	√	√	√	√	√	√	√	2018	[90]
Blockchain network-based system to strengthen efficient and secure health data exchange	√	√	√	√	√	√	√	√	2018	[91]
Cloud-based system to secure EHR with attribute-based cryptosystem and blockchain	×	√	√	√	√	√	√	√	2018	[92]
To explore the opportunities for the technology of blockchain in medicine network	×	×	√	√	√	√	√	×	2018	[93]
Blockchain-based system to explore the future heterogeneous information of medicare in the cloud.	√	√	√	√	√	√	√	×	2018	[94]
An automated-based healthcare system with smart contracts for secure to patient monitoring remote.	×	√	√	√	√	√	√	×	2018	[95]
blockchain-based ABE schema with multiple authorities in EHRs.	×	√	√	√	√	√	√	√	2018	[96]
Centric agents-based system to continuous patient monitoring	√	√	√	√	√	√	√	√	2018	[97]
A decentralizing healthcare system to attribute-based signature for blockchain.	×	√	√	√	√	√	√	√	2018	[98]
Scheme of identity-based signature with multiple authorities for blockchain-based EHRs system.	√	√	√	√	√	√	√	√	2019	[99]

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