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Research Article

BLOCKCHAIN REVOLUTIONIZING HEALTHCARE INDUSTRY: A SYSTEMATIC REVIEW OF BLOCKCHAIN TECHNOLOGY BENEFITS AND THREATS

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Abstract

Blockchain technology has been gaining significant traction in the healthcare industry in the past few years. The value proposition of using blockchain technology is to augment interoperability among healthcare organizations. However, the disruptive technology comes with costly drawbacks. With this paper, I aim to explore the benefits and threats of blockchain technology as a disruptive innovation in the healthcare sector. I review current applications through studies conducted to identify uses and potential challenges of blockchain technology based on its current implementations. My review highlights the gaps in research and the need for further blockchain studies particularly in the healthcare domain.

Keywords: Blockchain Technology, Disruptive Innovation, Healthcare Industry, Electronic Health Records (EHRs), Applications, Benefits, Threats.

INTRODUCTION

One of the challenges encountered by the healthcare industry is the inability to safely manage and retrieve Personal Health Information (PHI) in a timely manner. Effective management and retrieval of patient data would enable healthcare providers to capture a holistic picture of a patient's health, improve patient-physician interaction, and achieve better use of healthcare-related data (Mettler, 2016). Interoperability has enormous potential to transform the health sector through the development of affordable cures and cutting-edge treatments for numerous diseases but depends upon smooth, effective data exchange and distribution across all the well-known network participants and health professionals (Attaran, 2022). Another challenge faced by healthcare industry is data privacy and security, the rise in cyber security attacks and security breaches of healthcare records has stimulated the pressing need of healthcare organizations to invest in advanced security technologies (Haleem *et al.,* 2021) As a disruptive innovation, blockchain technology is paving the way for new potentials of solving serious data privacy, security, and integrity issues in healthcare and facilitating the paradigm shift of patient-centric interoperability, while enabling decentralization and transparency of stored information (Khezr *et al.,* 2019).The global pandemic has revealed a lack of Interoperability in the current healthcare system and the need foraccurate clinical data that can be widely distributed to healthcare providers in an efficient and secure manner (Abdel-Basset *et al.,* 2021). Blockchain is seen as a key breakthrough that will likely have a big influence on a myriad of different industries such as healthcare, supply chain management, and business. A peer-to-peer network called blockchain was initially proposed by Satoshi in 2008 and then commercialized in 2009 when Bitcoin emerged as its first use case (Ismail *et al.,* 2019). Kassab *et al.,* Reported that in 2016, "healthcoin", was developed by Diego Espinosa and Nick Gogerty as the first platform based on blockchain to manage and reward Type-2 diabetes prevention.

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Users submit their biomarkers into the blockchain. If the biomarker is an improvement, the system rewards the patient with digital tokens: "healthcoin" that can be applied towards government tax breaks and/or discounts on multiple fitness brands (Warkentin and Orgeron, 2020). Future technology may open the door to significant opportunities, ranging from research and economics to interactions between patients and physicians (Dimitrov, 2019). Blockchain technology conflates complexity, novelty, and diversity which has posed challenges in gauging the value proposition of incorporating the technology (Zutshi *et al.,* 2021). Due to its complexity, blockchain may be used for managing business processes or as a workflow system (Yaqoob *et al.,* 2021). Several research studies have been conducted on the benefits and challenges of blockchain technology in the healthcare industry. However, some of the potential applications have not yet deployed (Vazirani, *et al.,* 2019). The objective of this literature review is to explore the research studies that have been conducted on applications of blockchain technology as a disruptive innovation in healthcare industry (Frizzo-Barker *et al.,* 2020), addressing current and potential uses, benefits, and threats of the technology based on the historical research studies. Several researchers suggested studying the outcomes of leveraging blockchain technology in the context of improving security of health records, meeting social determinant of health needs, and improving health outcomes (Prokofieva& Miah, 2019;Lu, 2019;Khezr *et al.,* 2019; Haleem *et al.,* 2021). Based on this context, I analyze the previously available scholarship on blockchain through a systematic review as an assessment tool. The findings convey key insights on the current state of research investigation on blockchain, including benefits and implications as a disruptive innovation in healthcare industry (Bhuvanaet al. 2020). The study also highlights the gaps in research and the need for further blockchain research in healthcare domain. This paper was framed to guide future researchers and decision makers on the current knowledge of benefits, drawbacks, and gaps in blockchain research landscape. I convey the findings to proactively identify key challenges pertaining to blockchain adoption and application in the healthcare domain to support improvement opportunities and tackle challenges at their early stages. I have also framed

this paper exploring the theoretical lens of disruptive innovation theory and innovation diffusion theory. The study was organized to begin with a background of blockchain technology, then explore its key uses and potential benefits within a healthcare context based on the research studies, and addressing possible threats discussed by literature from an organizational, social, and technological level.Finally, my review provides recommendations to guide future research bridge the gaps identified in literature and further examine the prototypes implemented in the healthcare sector.

Theory

The theory of disruptive innovation has been to analyze growth driven by innovation (Christensen & Raynor, 2015), which was originally by Clayton Christensen et al in 1995, has particularly pervaded in clinical healthcare dialect over the past years. The increased adoption of blockchain technology in the healthcare domain will lead to a disruptive shift in the foundation of the healthcare system (Bhuvana *et al.*, 2020). Despite the growing use of the concept in literature, there are gaps in comprehending disruptive innovations in a healthcare context as there is no objective definition in healthcare literature (Sounderajah *et al.*, 2021). In addition, there is no published literature that compares perceived healthcare disruptive innovations. Therefore, key innovations in the sector remain in silos which limits our ability to identify disruption. Innovation diffusion theory states that characteristics of innovation affect how organizations gather knowledge which consequently affect the decision to adopt or reject the innovation (Rogers, 2003).These characteristics are (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability and (5) observability (Hartley *et al.,* 2022). Haleem *et al.,* 2021 andHartley *et al.,* 2022 have noted that lack of blockchain understanding is a barrier to technology diffusion. Given the relatively early stage of blockchain development, most healthcare organizations often rely upon consultants when adopting new technology (Attran, 2022).Additional barriers to the diffusion success are switching costs and the network effect (Frizzo-Baker *et al.,* 2020).

METHODOLOGY

Systematic reviews are an effective way of evaluating and interpreting research relevant to a particular research question or topic area or phenomenon of interest based on previous research outcomes (Turner *et al.,* 2010). Systematic reviews are common in the medical field and healthcare domain. Nonetheless, there are many research studies addressing blockchain technology applications in healthcare (Bhuvana *et al.,* 2020; Agbo *et al.,* 2019; Chen et al.2019; Khezr *et al.,* 2019). For example, Kuo, Zavaleta, and Ohno-Machado (2019), conducted a systematic review of the adoption of blockchain platforms in healthcare and how they improved the industry outcomes. To compile data and insights on blockchain in healthcare research, I conducted meta-analysis and identified studies to include in my review using a list of relevant terms through the search of several electronic databases including PubMed, MEDLINE, Scopus, EBSCO, and IEEE Xplore, and other databases for research including ScienceDirect, and Google Scholar. By choosing the mentioned databases, my intention was to focus on peer-reviewed articles that have been published in healthcare journals. The database was searched to determine whether a publication contained at least one of the keywords or search terms in the title, abstract, or keywords. In total, 1830 articles were identified. I have utilized the Boolean operators "AND/OR" combination of search terms and I have used the following search string: blockchain AND (healthcare OR medical) AND (challenge OR threat OR benefit OR uses OR application). Following this process, 37 articles were determined to be relevant to my study. Subsequently, a backward reference-list checking was conducted to identify other relevant literature (Abu-elezz *et al.,* (2020). As a result, 10 more articles were identified. In total, 47 articles were identified to be relevant to this literature review. To narrow down my selection process to the relevant articles, I included all publications that are fully available in English language and published between 2016 and 2022. I excluded duplicate articles, book chapters, and papers that discussed blockchain from a technical and engineering perspective. Based on *figure 1*, 33articles were identified in my final population for analysis as the relevant literature. EndNote software was utilized for duplicate removal and final screening. To ensure reliability, my search process was comprehensively documented to identify studies, assess relevance, and synthesize the structure of the paper. My goal was to find research articles that are focused on Blockchain applications, benefits, and threats in healthcare domain. This literature will answer the following research questions: RQ1: How has blockchain been defined in literature? RQ2: What are the potential blockchain applications in healthcare domain? RQ3: What are the blockchain benefits in healthcare literature? RQ4: What are the possible threats of blockchain technology in the healthcare industry? For the purposes of the review, I categorized my blockchain research into three categories: 1) Applications in healthcare industry 2) Benefits of blockchain 3) Threats of the technology.

Background

Most of the scholars describe blockchain using their properties (Bhuvana et al.2020). Swan, 2015, defined blockchain as a decentralized transparent ledger with transaction recordsBlock chain technology is characterized as "an open, distributed network that may record transactions between two individuals rapidly and in a verified and conspicuous way". Blockchain is described by several authors as a digitized decentralized ledger to allow record keeping of all peer-to-peer transactions without the need for a centralized authority (Sounderajah *et al.,* 2021) Blockchain was also described as "a distributed ledger system which maintains all transactions synced across users" by Zhuang *et al.* (2018). Researchers highlighted that information that has already been used in a transaction cannot be altered or deleted and userscan openly and transparently audit any transactions. The technology protects data from manipulation and alteration. The studies addressed that blockchain offers tremendous efficiency and affordable solutions in healthcare industry. The essential traits include public blockchain, untraceable, safety and integrity, automated, and distributed and public agreement (Siyal *et al.*, 2019). Since 2016, the demand for blockchain technology has increased globally and several large technology firms, such as IBM, Intel, and Microsoft, are heavily invested in blockchain technology development. The World Economic Forum estimates that, by 2025, 10% of the global gross domestic product will be stored on blockchain technology (Mackey *et al.,* 2019). The marketplace for blockchain technology was estimated to be worth around $339.5 million globally in 2017 and it is expected to increase to $2.3 billion by 2021.

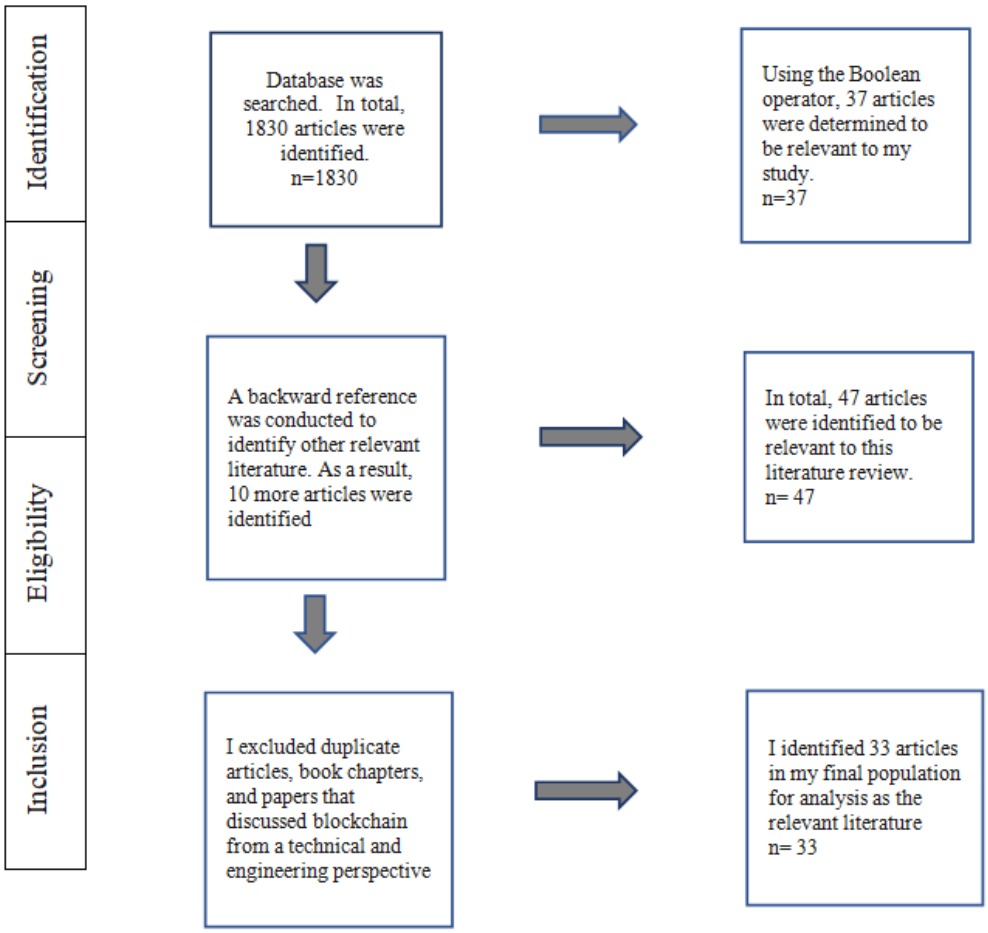

Fig.1. PRISMA for Identification and Inclusion Process of Systematic Review

By 2030, blockchain is anticipated to provide $3.1 trillion in economic value. According to "International Data Corporation (IDC)", worldwide spending on blockchain will increase from about $1.5-$2.9 billion in 2018- 2019 and a sudden rise in $11.7 billion in 2022 (Frizzo-Barker *et al.,* 2020) For the anticipated period of 2017–2022, the anticipated annual compounded growth rate is 73.2% (Aguiar *et al.,* 2020). The U.S. healthcare industry is the world's largest and absorbs more than $1.7 trillion per year (Hillestad *et al.,* 2019). Today, the average annual cost of healthcare per person in America is $10,739, which is more than residents of any other country (Hillestad *et al.,* 2019). Abdel-Basset *et al.,* 2021, noted that the blockchain technology can be used to manage the pandemics by making consideration of different data sources which can be statistically analyzed to extract essential features and patterns for the healthcare professionals and government.

Although understanding blockchain technology might be challenging, the fundamental ideas behind it are rather straightforward. Blockchain is a database of a group of data that is electronically stored on a computer network (Tanwar *et al.,* 2019). In an examination of academic literature where blockchain applications have been applied to diverse topics,it can transform the traditional industry with its features, which include decentralization, anonymity, persistency, and auditability (Fatoum *et al.,* 2021). The studies reviewed have covered several instances of blockchain technology being used in healthcare, as well as the issues and potential fixes. The design decisions and compromises made by the researchers were addressed in the many situations where this innovation technology was used (Prokofieva and Miah, 2019). The Office

it could take some time for this technology to build an anticipated and expected stages of transformational change in business, mostly due to implementation obstacles in the manner of organization, societal, and social issues such security concerns or governance (Yaqoob *et al.,* 2021; Sounderajah *et al.,* 2021; KUO *et al.,* 2019). This may also be made worse by widespread misunderstandings about how blockchain technology is used in government policies and regulations. By removing these obstacles, recent research aims to assist blockchain clear changes and expedite its spread (Yaeger *et al.,* 2019). The papers reviewed described many blockchain uses and potential issues often at the conceptual level. However, empirical studies are very limited as blockchain research remains early-stage and immature, particularly in healthcare (Mackey *et al.,* 2019; Abu-elezz *et al.,* 2020; Prokofieva and Miah 2019). Blockchain technology is a prominent example of disruptive innovation. However, poor identification can lead to poor understanding of the technical features and potential of an innovation and the possible barriers to adoption and ways to overcome them (Yli-Huumo *et al.,* 2016).

Healthcare Industry Challenges

Some of the numerous concerns hospitals and other healthcare organizations deal with daily include patient data access, medication storage logs, and medical records. Patient care, information security, and privacy must all be balanced in the healthcare sector. Major challenges the healthcare sector faces include putting the patient first, privacy and access, accuracy of medical data, pricing, management of supply chains and prescription records. Even if the conventional technique of

storing data through a centralized database can be damaging as indicated in research, it can also be susceptible to hacking or even a single failure point (Bhuvana *et al.*, 2020). The fact that all the servers temporarily go offline while the changes are being made to the databases used to store medical data is another problem with a traditional data base. Given that healthcare is a 24/7 industry, this little gap might prove to be quite deadly (Chen *et al.,* 2019) another concern with medical records is the cost associated with transferring records among different entities. The lack of availability of test results can be dangerous in terms of delayed treatment. Also, sending data via email is considered a security risk. A system integrating patient consent and access to authorized individuals would improve efficiency and save on financial costs (Vazirani *et al.*, 2019). Blockchain technology is being promoted as the "solution" to issues in a variety of healthcare issues (Hasselgren *et al.,* 2020). By doing a thorough literature review and responding to the research questions posed in my research, I attempt to discover blockchain technology capabilities in the healthcare sector in this study. The potential of blockchain extended to the healthcare sector, enabling a change in the way the present system and its utilization of technology currently operate.

My study seeks to emphasize the potential paths for blockchain research in healthcare, as well as to emphasize the possible uses of the platform. According to literature, blockchain technology is currently being researched in the field of healthcare, where it is mostly employed for network access, data exchange, and record management (Chen *et al.,* 2019). Additionally, it demonstrates that many studies lack implementation or prototype information. The authors of literature reviewed reached the conclusion that blockchain application-based research are expanding and growing at an exponential rate (Abu-elezz *et al.,* (2020). The research has also demonstrated that the exponential growth of blockchain technology initiatives in the healthcare industry are projected to have a significant influence (Shahnaz et al.2019). I conducted a systematic study method, employing a well-planned monitoring strategy to look for pertinent papers. Several studies have put out various scenarios for the application of blockchain in healthcare systems. The assessment also identifies benefits as well as shortcomings and potential future research topics. In order to further comprehend, define, and assess the usefulness of blockchain in healthcare, additional study is still required (Vazirani *et al.,* 2019).

Main Features of Blockchain Technology

The four key characteristics of blockchain were identified by research studies and serve as the foundation upon that it has expanded. Technology's four distinguishing characteristics are: Decentralization, Immutability, Transparency, and Provenance (Yaqoob *et al.,* 2018). Healthcare systems have used centralized systems up to the advent of blockchain to fulfill data exchange requirements. A centralized institution is employed to hold all the information in a central network, and only that entity and the user may communicate with each other. Even though centralized systems have indeed been in use for a long time, there are certain restrictions associated with this kind of network. Since the data is kept in a single central place and by a single organization, this turns into a red flag for would-be cybercriminals or hackers and even represents a single source of failure (Ekblaw *et al.,* 2016; El-Gazzar *et al.,* 2020).

Blockchain offers a decentralized network as an alternative option to a centralized one, removing the necessity for a single centralized power to rule over the network. (Agbo *et al.,* 2019). Chen *et al.,* 2019, discussed the idea of immutability which states that once data or information has been generated, it shouldn't be changed. Once a blockchain record has been created, it can't be changed once it has joined the network (Vazirani *et al.,* 2919). This is a crucial aspect of the blockchain that may be used to stop a lot of unethical or questionable behavior in any sector (Holbl *et al.,* 2018). Blockchain transparency is a term that is frequently misunderstood. With the use of sophisticated encryption, a person's identity is concealed and just their upgradable is shown (Yaqoob *et al.,* 2021).The provenance feature of the blockchain implies that any additions to the blockchain are visible to all the patient's network members (Kassab *et al.,* 2021).

Blockchain Applications in Healthcare

Blockchain is a relatively emerging and developing technology that offers creative uses in the healthcare industry. The development of affordable cures and cutting-edge treatments for numerous diseases depends on smooth, effective data exchange and distribution across all the well-known network participants and health professionals. In the upcoming years, this will hasten the expansion of the healthcare sector. The studies reviewed highlighted that Ethereum and Hyperledger fabric seem to be the most used platforms/frameworks in this domain (Lu, Y. (2019). The studies unveiled blockchain technology prospects in the supply chain highlighting the benefits for the healthcare business. This is among the primary areas that the digital revolution enhances and innovates since it immediately affects living quality. Blockchain technology is also growing in popularity in the healthcare industry, it presents a number of significant and spectacular opportunities, ranging from research and economics to interactions between patients and physicians (Dimitrov, 2019). The most significant research explored in this area and are organized according to several use cases, including electronic healthcare records, remote monitoring of patients the pharmaceutical distribution network, and increase healthcare insurance claims (Yaqoob *et al.,* 2021; Frizzo-Barker *et al.,* 2020; Kuo *et al.,* 2019; Bambara & Allen, 2018).

Electronic Medical Records

The administration of health data, which might be enhanced by the capacity to integrate disparate systems and enhance the precision of Electronic Health Records (EHRs), should be given priority in the effort to change healthcare. While the phrases electronic patient Records (EPRs) and electronic health records (EHRs) are sometimes used interchangeably, they have different meanings. EMRs, or electronic medical records, are a more recent name for the paper charts kept by clinicians in their offices. The medical and treatment histories of patients in a single practice are recorded in an EMR. EHRs, on the other hand, put a greater emphasis on a patient's overall health, going beyond the usual clinical data gathered at the doctor's office and taking a more comprehensive approach to a patient's care (Vokerla *et al.,* 2019). According to the studies reviewed, blockchain helps manage EHRs. To handle

authorization, and data exchange across healthcare entities, Ekblaw *et al.,* described MedRec, an EHR-related solution that suggests a decentralized method. MedRec platform provides patients information and understanding about who may access their medical records. FHIR Chain (Fast Health Interoperability Records and Blockchain), is another program that incorporates EHRs (Ekblaw *et al.,* 2016). It is a medical record management-focused blockchain-based platform for exchanging clinical data that is developed using bitcoin and patients can get solutions from FHIR Chain. Similar to this, Xia *et al.,* introduced Medshare, an ethereum program for systems that experience a lack of communication for information sharing among cloud computing owing to the negative risks towards disclosing the content of private data information. When exchanging medical data in cloud archives, Medshare offers data monitoring, and governance amongst large data organizations. MedBlock and BlockHIE are two further EMR apps built on the blockchain. MedBlock offers a method for searching records. The suggested method keeps track of the addresses of health records blocks that are organized by health professionals. Each patient assessment has a link to the relevant blockchain record. Jiang et al proposal for BlockHIE presents a blockchain-based healthcare system (Hasselgrenetal., 2020; Yeasmin& Baig, 2019). BlockHIE blends off-chain retention, in which data is kept in database systems of external institutions, with on-chain validation to continue taking advantage of current databases. Another blockchain-based healthcare platform addressed in the literature called Ancile, which employs smart contracts to ensure data security, confidentiality, access management, and EMR compatibility (Rot & Blaicke, 2019).

Remote Patient Monitoring

Remote patient surveillance refers to the gathering of medical data using smart phones, wireless body sensor sensors devices, and IoT (Internet of Things) devices in order to be able to monitor various patients' conditions (Radanović &Likić (2018). Blockchain technology is crucial for the storage, exchange, and retrieval of remotely gathered health data. It offers a solution in this setting where information is sent from mobile devices to a blockchain-based application on Hyperledger (Attran, 2022; Chen *et al.,* 2019). By providing real-time patient monitoring applications, Ethereum platform contracts may allow automated interventions in a safe setting (Griggs et al; Lu 2019). Other literature suggested ways highlight the enormous potentials of the Internet of Things (IoT) in various fields, particularly how it is being widely utilized in e-health. IoBHealth, a data-flow architecture that integrates the IoT with blockchain and may be used for accessing, storing, and managing e-health data, is a suggestion made in this area. (Ekblaw, A., *et al.,* (2016).

Pharmaceutical Supply Chain

The pharmaceutical sector is another recognized use case for blockchain as patients may suffer severe effects if they get fake or subpar medicine. According to a study by the World Health Organization (WHO), over 100,000 people die in Africa due to improper dosing from counterfeited drugs obtained from untrusted vendors (Khezr *et al.,* 2019) and research has determined that blockchain technology has the power to solve this issue. Drug counterfeit has also been tackled by the researchers, who suggest a safe, irreversible, and verifiable supply chain for pharmaceuticals built on blockchain - based technology to prevent it (Sounderajah *et al.,* 2020; Hasselgren et al 2020). In relation to drug regulating issues, drug standardization difficulties were addressed. Authors have drawn attention to the challenges in identifying fake medications and suggested a blockchain-based approach to do so. Even though the suggested approach is only implemented in a small number of articles, several intriguing studies have addressed problems with the pharmaceutical supply chain (Khezr et al.2019).

Health Insurance Claims

One area of healthcare that can profit from blockchain's absoluteness, openness, and traceability of stored data on it is healthcare insurance claims. Blockchain technology has promising solutionstohandle health insurance claims. However, there are very few prototypes and applications of these systems (Varzini *et al.*, (2019). I can locate MIStore, a crypto currency health coverage system that offers the medical coverage data that is well-secured and maintained (Shahnaz *et al.*, 2019; Hasselgren *et al.*, 2020).

Benefits of Blockchain in Healthcare Sector

The blockchain technology enables medical professionals to embrace the notion of a public database that can be used to develop shareable, customized healthcare plans for their patients. As a result, this may readily assist in the facilitation and creation of personalized health plans that classify the patients based on their shared genetic data, age, and gender (Swan *et al.,* 2017). Researchers have identified and divided blockchain benefits into: Individual benefits, Organization-related benefits, and Government benefits. Since users may only establish their identities once within the blockchain network, and the recorded identification traits are encrypted and kept in every blockchain server, users won't need to re-register their identities for accessibility in the foreseeable future. Additionally, several researchers have highlighted the benefits of blockchain technology and how they addressed existing challenges in healthcare applications. (Sounderajah *et al.,* 2021; Ben Fekih & Lahami, 2020; Lu, 2019). For example, Cheng *et al.,* (ChengYing *et al.*, 2018) explored the benefits of blockchain as a way to link patients' electronic health records across the different healthcare services.

Patient-level Benefits

The literature on blockchain technology offers proof that the technology can get around some of the problems with the current healthcare system. The advantages of blockchain technology allow for efficient maintenance and interchange of health records. The decentralization of patient information creates a single point of truth for connectivity and efficiency (Attran, 2022). Data reconciliation between all parties engaged in the transaction is made unnecessary by leveraging blockchain, which improves cost effectiveness (Frizzo-Barker *et al.,* 2020). Only authorized people are granted access to sensitive and important patient data and protected health records and a lifelong and continuous health status record may be created using blockchain technology (Olnes *et al.,* 2017). Patient data in the current healthcare information systems is frequently corrupted, prone to data breaches, or at high risk of failing. Data security is hence the main advantage of blockchain technology. According to a survey on the present status of EHRs with a sample size of 8,774, almost 40% of

physicians view connectivity and EHR design as the main causes of their dissatisfaction (Yaeger *et al.,* 2019). It is challenging to transfer, retrieve, and analyze data due to the restricted data exchange and absence of compatibility amongst healthcare storage solutions.Berryhill *et al.,* noted that better compatibility is made possible by blockchain technology.

Organization- level Benefits

In terms of organizational advantages, blockchains have the capacity to offer safe patient data sharing across healthcare organizations. The group of authorized healthcare organizations taking part in the private network would be able share and access the information stored in the blockchain in a safe and trustworthy fashion (Haleem *et al.,* 2021). Other studies emphasized the need of using blockchains to streamline the management of clinical trials because the study involves extremely sensitive patient-related data (Mackey *et al.*, 2019).

Government Benefits

Blockchain technology has enabled the government to offer new public healthcare designs, assist in addressing fraud and waste, reduce the cost and sophistication of different health activities, and identify misuse and fraud activities (Monrat *et al.,* 2019). It is thought that establishing a public blockchain will save costs, speed up learning, reduce risk, boost technology acceptance, and have an impact on regulations (Hillestad *et al.,* 2019). Another advantage of blockchain applications is successful care surveillance, especially for very ill patients since this technology can help physicians perform appropriate medical treatments. To do this, patients' wearable technology, including smart watches, cell phones, and smart glasses, must be linked to the public blockchain of the healthcare provider (Khezr *et al.*, 2019). In this section of the literature, I am highlighting the blockchain benefits that are most explored and addressed by previous studies.

Securing Patient Data

Protecting patient information is the most important aspect of the healthcare industry. Falsifying patient records might contribute to difficulty for hospitals and physicians to diagnose and treat their patient's illness or issue. According to research studies, around 176+ million medical data were compromised between 2009 and 2017. The data was hacked by cybercriminals, who then exploited it unethically (Shahnaz *et al.*, 2019). Health data may be gathered using blockchain without having to move it all to a single place or centralized database. In the current EHR system, healthcare professionals hold the records, while patients have the right to have their own health records. Improved security and data integrity are made possible by the dissemination of health records and the data integrity of the data (Bhuvana *et al.*, 2020). Data integrity is essential to healthcare since the current healthcare system has problems when it comes to providing patients with accurate or sufficient information. Blockchain reduces the likelihood that unauthorized users would be able to extract health information (Fatoum *et al.,* 2021).

Medical Drugs Supply Chain Management

Medications or pharmaceuticals are created in laboratories and pharmaceutical firms all over the world. According to each country's needs, these medications are further distributed across the world. What happens if the medications are tampered with while being transported across the nation? As a result, the importers and exporters must have access to a transparent, tamper-proof healthcare supply chain. Blockchain minimizes this issue because of its transparency, decentralization, and tamper-proof properties (Haleem *et al.,* 2021). Each carrying point for the medicine will be added to the blockchain after a distributed ledger has been established, making the whole transportation process visible (El- Gazzar & Stendal, 2020).

Single Longitudinal Patient Records

Every medical chart will be added to the blockchain ledger since it is made up of a chain of blocks called a blockchain. Examining the pre-compiled records would allow healthcare providers to have a broader picture of patients' medical conditions. Additionally, it will assist in mastering patient indices, streamlining data meticulously, and avoiding expensive errors (Fatoum et al.2021).

Supply chain optimization

Authenticating the origin of medical supplies in order to assure the legitimacy of medications is the main difficulty facing the healthcare industry. They may be tracked from manufacture to every step of the supply chain with the use of blockchain technology. This makes it possible to acquire items completely transparently and visibly. This may assist businesses in implementing AI, improving demand forecasting and supply optimization, while also boosting consumer confidence (Engelhardt, 2017).

Drug Traceability

The most trustworthy, dependable, and safe way to trace every medicine back to its source is via blockchain. There will be a hash value associated with every data block including drug-related information. By using this hash code, the data is protected against manipulation. All parties with permission to see the blockchain can see the events. By scanning the QR code and pulling up all the essential details, such as the manufacturer's information, etc., the legitimacy of the acquired drugs will be seamlessly verified (Engelhardt, 2017).

Updated medical supply chain management

Blockchain is ideally suited for organizing and tracking the flow of medicine supply because of its security, dependability, and decentralized storage. Technology improves patient safety through building a reliable supplier network. In a single unchangeable record that's also securely held, blockchain unifies all the operations including manufacturing, packaging, marketing, shipping, and warehousing information. blockchains adopt GS1 (open global standard for tracking healthcare products. (Mackey *et al.*, 2019).

Improved electronic health record systems

Systems for keeping track of patient's health information digitally are known as electronic medical records. By connecting electronic health records and distributing property of the records across all stakeholders, blockchain overcomes issues with availability, compatibility, and verification (Sounderajah *et al.*, 2021).

Table 1: Characteristics and Key Findings of the Included Studies

		Key Findings		
Author and Year	**Puplication Journal**	**Applications in Healthcare**	**Threats of Blockchain**	**Benefits of Blockchain**
Attaran, 2022.	International Journal of Healthcare Management	Sharing of patient medical records, mobile appli cations and remote monitoring, and medical data management system.	"Highly disparate data sources across individual clinics or health care–related institutions"	"Decentralized data storage allows duplicate and immutable health records in the health network"
Prokofieva & Miah., 2019	Australian Journal of Information System	The use of the distribute ledger can improve supervision of drug intake and distribution. A unified decentralised database can store individual patient details, including claims, medical history, transactions, overdue payments, etc.	"Malicious attempts or human processing errors may cause fraud, alterations, or medical disputesAuthorities are required for trust building among stakeholdersMajor issues include drug counterfeiting and provenance"	"Keeping critical items (ie, medical transactions or records) on blocks and permanently recording operations on-chain Mitigating the tampering issue via the verification and consensus architecture."
Chen et al., 2019	Journal of Medical Systems	Secure medical records storage and medical data applications	"Paper-based and manual processing causes difficulties in data aggregation""Siloed data structures hinder interoperations across different databases"	Document type Interoperability. Supporting digitalized health documents deployed on secured shared ledger."Blockchain-based networks enable interactions among health care stakeholders"
Ben Fekih & Lahami, 2020	In International Conference on Smart Homes and Health Telematics	Managing medical insurances	"Inefficiencies that exist in clinical and administrative procedures and frictions among respective health systems have caused poor operations"	"Process automation facilitated by blockchain-based smart contracts enables streamlined claims and transaction procedures"
Haleem et al., 2021	International Journal of Intelligent Networks	Electronic Medical Records, Clinical trials, Store information of an individual patient, and patient monitoring.	"Uncertainties during handovers among participating parties. Poor control in tracking user identities, ownership, and delivery status"	It includes system tracking, healthcare insurance, medicines tracing. and clinical trials. Hospitals can chart their services using a Blockchain framework
Khezr et al., 2019	Applied Science	Blockchain technology in medicine, including health insurance, EHRs, drug supply, biomedical research, procurement processes, and medical education.	Data security, privacy, sharing and storage, personal data privacy, data sharing, and patient enrolment in clinical trials.	Healthcare insurance, medicines tracing, and clinical trials. Hospitals can share health data and securely improve audit logging.
Sounderajah et al., 2021	BMJ Innovations	Mobile health (mHealth) particularly in the context of inpatient care, outpatient self-care, and telemedicine,7 Health informatics, particularly the analysis of clinical big data sets.		The application of omics technologies in the field of personalised medicine is a disruptive innovation, chart their services using a Blockchain framework, applications of AI within academic medical research.
KUO,T. etal., 2019	Journal of the American Medical Informatics Association	Medical record management and insurance claim processes,	There is a wide range of technical features that are critical for its adoption in healthcare projects. There are concerns that adopting blockchain would consume too much energy.	Medical files protection, diverse genomes management, electronic information management, interoperability, digitalized tracking and issue outbreak.

Improved recruitment for clinical trials and Research

A cryptocurrency blockchain that replicates the hiring process has been developed by researchers to safeguard study participants' anonymity while enabling access to study results for all academics (Khezr *et al.,* 2019). Data integrity and provenance are critical characteristics in clinical trials. Blockchain network can transparently show the of the data from the origin to the final clinical report. (Mackey *et al.,* 2019).Technology allows researchers to access vast amounts of unprocessed data that might lead to important medical advancements without jeopardizing patient confidentiality (Olnes *et al.,* 2017).

Threats of Blockchain Technology in Healthcare

Blockchain technology has a myriad of benefits, however, there are also considerable risks associated with the technology. Risks in this research were divided into three categories: organizational, societal, and technological threats. Scaling problems, authorization and security problems, and excessive power and energy usage were all recognized by researchers as the common three technical dangers (Yaeger *et al.*, 2019). The most important technical risk to blockchain advanced technologies is seen as scalability. Since there is no limitation on the number of people who join the network, the

scaling issue has evolved into a major worry for blockchain-based applications. Additionally, issues occur when utilizing wearable technology to track blockchain networks since the amount of data provided by these sensors grows exponentially (McGhin *et al.,* 2019).Researchers have claimed that private permissioned blockchain deployment brings the most benefits for health care applications, however, it is usually combined with security risks (Radanović & Likić 2018). Private permissioned blockchains are most prone to a 51% attack (El-Gazzar & Stendal (2020). Additionally, blockchain is vulnerable to cyber-attacks in which the attackers can seize control of the network. If the attackers disrupt or even reverse transactions that have been validated inside the network, a disaster may result. Additionally, this evaluation identified high energy use as a hazard since it pertains to the usage of public blockchains, which is a mining method that causes a lot of energy consumption. This issue got worse when more people joined the public blockchain and more payments were being processed every second.

The absence of legal authority-issued blockchain technology rules was another major societal danger highlighted. Meanwhile, interoperability problems, shortage of technical expertise for integrating pharmacological suppliers, setup expenses, and transaction costs were the main sources of organizational risks. Interoperability was seen as one of the main obstacles to blockchain technology acceptance in the healthcare industry due to lack of trust between healthcare organizations and a shortage of IT personnel qualified to utilize blockchain technology. Employing blockchain technology without the necessary technical know-how and capacity might have fatal results (Yaqoob *et al.,* 2021). The included research revealed eight challenges to blockchain technology, which were categorized as organizational, societal, or technical/technological concerns. Studies discovered two different forms of social dangers, three different types of organizational threats, and three different types of technological threats. The following section provides more information on the risks explored by researchers (Abu-elezz *et al.,* 2020).

Technical or technological threats

The scalability problem with blockchain technology was due to the network's constrained processing capacity for transactions. Additionally, according to two studies, the exchange between trading volume and the amount of processing power needed to handle those transactions is the major limitation of scalability. Authorization and security were issues and constraints associated with blockchain technology. According to several studies, distributed ledger technology is vulnerable to assaults. Other research studies identified significant issues particularly with blockchain networks, including high consumption of energy and sluggish processing speed brought by a significant increase in network users (Kassab et al 2021; Monart etal., 2019; McGhin *et al.,* 2019).

Social threats

According to research studies, the societal acceptability of blockchain technology was a key obstacle to implementation. Scholars revealed that it is challenging for the legal authorities to grant access due to the decentralization of medical data and the withdrawal of a trusted third-party emphasizing privacy as a valid concern. Literature reviews also emphasized the absence of governance norms and standards as a barrier to blockchain adoption in the healthcare industry (Radanović&Likić (2018).

Organizational threats

According to research studies, compatibility is one of the main problems with blockchain adoption in the healthcare sector from an organizational standpoint. Studies described interoperability issues as lack of confidence among parties and absence of transparent standards, which makes it difficult for healthcare organizations to communicate full patient data. The upkeep of an interconnected supply chain for pharmaceuticals for the networks that lack the necessary technical knowledge to manage the system was another issue noted by research. In addition, the initial cost of installation is rather significant for blockchain, even though it can save costs in the long term (Ismail *et al.,* 2019). Some solutions have been proposed to address the highlighted challenges. For example, as a countermeasure to the challenge of scalability, given the large volume of clinical data involved, the trend is to store the actual healthcare data on the cloud and store only the pointers of the data on blockchain, along with their fingerprints (Agbo *et al.,* 2019). A considerable number of papers on the implementation of blockchain-based EMR applications in which different strategies were considered to tackle these challenges. Yet, some publications propose different workarounds to improve the security and privacy challenges of blockchain(Chen al. 2019; Ben Fekih & Lahami, 2020; Prokofieva & Miah, 2019; Lu, 2019).

Blockchain as an opportunity to approach medicine in a novel way

Blockchain is a potential solution for health data security because of its eternity, autonomy, and total openness (Ekblaw *et al.,* 2016). Patients' identity and medical information will continue to be retained in confidence using blockchain as long as the system is secure. By eliminating inefficient instrumentation, this ground-breaking solution will simplify the challenging billing procedure (McGhin *et al.,* 2019). Blockchain technology may usher in a new framework for the exchange of health data by improving the efficiency, dependability, and security of electronic healthcare records, as a decentralized ledger that stores important transactional data (Prokofieva & Miah, 2019). By allowing the safe transfer of patient medical records, controlling the medication supply chain, and enabling the regular and accurate of patient records, ledger technology assists healthcare scientists in deciphering genetic code. Medical files protection, diverse genomes management, electronic information management, interoperability, digitized tracking, and issue outbreak, etc. are a few of the outstanding and technologically derived aspects used to create and implement blockchain technology (Haleem *et al.,* 2021).

Chen al., 2019 noted that blockchain-based digital structures would ensure that unauthorized changes to the logistical data are avoided. It fosters confidence and inhibits those who are interested in obtaining drugs from handling information, funds, and medicine in an unauthorized manner. The use of technology can significantly enhance patients' conditions while keeping costs low. In multi-level authentication, it removes all hurdles and difficulties. Patients, physicians, and other healthcare professionals may all quickly and securely

exchange the same information because of the technology's decentralized nature. Medical entities are constantly experimenting, researching, and learning about blockchain technology particularly for health records solutions. By adopting medications, enhancing payment alternatives, and decentralizing patient health history information, Technology has established itself as an indispensable innovation in healthcare. The medical industry is heavily dependent on blockchain in addition to advanced technologies like machine learning and artificial intelligence (AI). There are several legitimate ways that blockchains are transforming the healthcare sector. A single blockchain system stores all the data, protecting it from loss and change. Leveraging this approach, physicians may simply get all the information required to make an accurate diagnosis and suggestions. A substantial organization with blockchain database that is encrypted, may get protected from hazards and attacks from the outside world. Such rescue, assaults, and other issues, including computer malfunction or hardware breakdown, will have minimal impact on healthcare organizations appropriately deploying a blockchain network (Frizzo *et al.*, 2020). The research studies highlighted the technology's potential to fundamentally transform the current segmentation in which patients sign fresh consents for every consultation, clinical procedure, and medical test (Chen *et al.,* 2019; Berryhill *et al.,* 2018). It has the potential to become a crucial component of healthcare consent management that promotes information sharing. A blockchain-based supply chain system ensures security, reliability, and promptness of pharmaceuticals delivery. The presence of this technology solves issues that cannot be addressed by current conventional methods (Yaeger et al, 2019). Reliability, protection, and data interchange amongst many systems are necessary for great healthcare (Ben Fekih and Lahami (2020).

DISCUSSION

The research has been describing blockchain technology as a disruptive innovation. However, blockchain research is an emerging field in healthcare which indicates that it is mostly used for data sharing, health records and access control along with other areas such as supply chain management or drug prescription management. Some scholars addressed other applications including the interchange of clinical testing dataset and the potential for uncovering advantages for test subjects. Technology has the potential to become a crucial component of healthcare consent management that promotes information sharing. However, much potential for blockchain is still unexploited. A blockchain-based supply chain system ensures the security, reliability, and promptness of the delivery of pharmaceuticals. It enables the manufacturer to keep the correct formulation mixture in accordance with medical standards. Medical devices have the ability to charge for patient information, confirm that the designated patient is receiving the therapy, and communicate operational data with authorities in an anonymized manner (Abu-elezz *et al.,* 2020). Recent years have seen notable advancements in medical research and enhanced medical treatments. Reliability, protection, and data interchange amongst many systems are necessary for great healthcare system. Research proposed to use blockchain for building a personal health record system to bridge the gap between patient and organization (Hasselgren etal., 2020).Blockchain has the potential to support health records and transfer the ownership of the medical records to the patients. The use of blockchain technology in the healthcare industry is exciting. It is recommended that challenges encountered in implementing blockchain solutions should be explored in these applications. Furthermore, none of the reviewed studies described how the blockchain application was compliant with healthcare regulations which is another era that needs to be more explored on an extended level. Also, blockchain is prone to cyber-attacks along with interoperability issues, and lack of technical skills for integrating systems. In addition, high energy consumption was highlighted in this review as a threat since it relates to the public blockchain use which consumes a great amount of energy.

Limitation and Future Direction

The studies in my review describe many blockchain potential uses, benefits, and issues often at the conceptual level. Despite the growing use of the concept in literature, there are gaps in comprehending it on empirical and theoretical levels due to the limited number of studies. However, the current and proposed studies are growing exponentially. Disruptive innovation is a term that has diffused into the healthcare industry, but there is widespread ambiguity in the use of the term (Sounderajah *et al.,* 2021). Data driven studies on outcomes of specific blockchain solutions in the healthcare industry are highly recommended to pave the way for future applications. Like any emerging technology, it will introduce innovation, benefits, and risks into society. Future research is suggested to include blockchain's instrumental role in population health management and how to mitigate risks associated with utilizing the technology. Expanding healthcare research on the administrative and strategic perspectives of blockchain adoption and its economic impact on healthcare organization will fill some gaps in the research landscape. There is currently very limited research on certain applications and prototypes of blockchain solutions which would open unlimited opportunities for future research to delve into. There is also further research needed to be expanded on the value of blockchain uses in healthcare through developing proof of concepts to deepen researchers understanding of the technology in relation to healthcare system strategic needs**.** Future research is recommended around blockchain scalability and risk of specific blockchain cybersecurity attacks that can halt the entire system and jeopardize users' information. Frizzo-Baker *et al.,* (2020), discussed the argument that only 20 percent of the barriers to blockchain adoption and success are technological, while the other 80 percent are related to organizational practices. I propose to conduct research on organizational strategies and practices in the adoption and implementation of new technologies in healthcare.

Conclusion

The purpose of my systematic review was to examine the current state and research topics of blockchain technology in healthcare, along with the applications and key benefits and challenges associated with this technology. I reviewed studies and my findings show that in the past few years blockchain has gained traction to be implemented in healthcare sector with a potential to improve the authenticity and transparency of healthcare data, while highlighting the major challenges uncovered in this review. Blockchain's decentralization, immutability, and transparency features have enabled better management of patient health records and supply chain management. However, many healthcare organizations remain hesitant to adopt blockchain technology due to threats such as

security, interoperability issues, and lack of technical skills related to blockchain technology. The studies reviewed suggest that we are still at the beginning of the road towards the full utilization of blockchain technology in healthcare sector. I propose that research be conducted on each of digital platforms discussed in the literature to identify use cases of blockchain technology and to assess its feasibility. However, doubts remain regarding the value of blockchain technology in relation to the technical experiences of users. The goal is to empower patients with the ownership of their medical data accessing and sharing. The proper utilization of blockchain can increase interoperability while maintaining privacy and security of data. Increased interoperability would be beneficial for health outcomes. However, more research still needs to be conducted to better understand and evaluate the utility of blockchain technology in healthcare. Furthermore, this paper contributes to the research on blockchain technology by highlighting current studies and thus identifying potential research gaps that could positively impact the industry if properly addressed.

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