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A Survey on Applications of Distributed Ledger Technology in Healthcare †

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Abstract: Blockchain technology is a distributed, accessible, open, and decentralized digital ledger used in healthcare to record transactions between devices. It addresses issues like data integrity, privacy, and confidentiality. The COVID-19 pandemic has accelerated the deployment of digital technologies, such as Distributed Ledger Technology, which enables a decentralized consensus between operational data states. This technology can enhance data access, integrity, and patients' control over their credentials. A survey was conducted with the help of the World Health Organization, Kaggle, and the Ministry of Health Government of India and Kerala with the aim to identify potential uses for blockchain technology in immunization and the collection of patient data.

Keywords: blockchain technology; COVID-19; distributed ledger technology; World Health Organization

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1. Introduction

The healthcare sector, encompassing clinics, hospitals, and community health organizations, differs significantly from other workplaces due to the intricacies of medical systems. Professionals in this field need broad knowledge across areas including insurance, patient care, healthcare providers, and legal considerations. A health service involves organizing, financing, and delivering medical care to a community, addressing issues like access, staffing, and facility maintenance. The overarching goal of healthcare systems is to enhance population well-being efficiently, considering collective resources and conflicting requirements. Many nations and the UN recognize healthcare as a fundamental human right or legal requirement. When evaluating healthcare systems, it is essential to consider their alignment with widely accepted norms [1,2].

A state's healthcare system is influenced by various factors, including the unique heritage and traditions of a community or country. Notions of healthcare can differ based on cultural development, values, and priorities, with some territories emphasizing disease prevention over treatment. Cultural variations extend to how health and sickness are perceived, as well as to the definition of appropriate healthcare providers. Another significant factor is the need for an overarching system of ideals to discern disparities in quality, cost, and accessibility. Key concepts include promoting sufficient service, respecting the independence of providers and patients, and ensuring fairness and justice through equity and freedom [3,4].

The design of a healthcare system is influenced by the accessibility of economic means, with a strong correlation between medical costs and a nation's GDP allocation. While healthcare is crucial, some nations prioritize other needs like food, housing, or military expenditure. Financial support significantly influences healthcare spending, with diverse types of systems even in financially underdeveloped nations. The World Health Organization defines a healthcare system as encompassing organizations, individuals, and

actions aimed at promoting health. Collaboration involves understanding medical practices, therapy modalities, and staff duties. Interactions require knowledge of insurance plans, aiding the uninsured, upholding patient rights, and an awareness of local services [5,6].

The contributions of this survey are below.

- To investigate the applications of blockchain technology in the healthcare industry.
- To concentrate on patients' COVID-19 symptoms, deaths, recovery, and vaccination administered globally, which was carried out with the assistance of the WHO, Kaggle, and the Ministry of Health Government of India and Kerala.
- To identify potential uses for blockchain technology in the fields of immunization and patient data.
- To offer topic specialists a clear and organized classification of and perspectives on the available literature.

The survey is organized as follows: Section 1 is an introduction to the healthcare system, blockchain, and DLT. Section 2 is background and related works. Section 3 is research problems. Section 4 is conclusions and future scope.

2. Background and Related Works

2.1. Background

The term "pandemic" ranked as the seventh most searched in 2020, defining an epidemic that spreads across an entire nation or the globe. Since 2002, there have been five significant pandemics, with the possibility of regional impacts, illustrated by the 2014 Ebola epidemic in Africa. While the exact number of historical pandemics is uncertain, records from the Common Era provide insights into 20 communicable diseases which meet the epidemic criteria. Notably, older pandemic data may be less reliable due to challenges in diagnosis and population census accuracy in the past.

Use Cases from the COVID-19 Situation

In December 2019, a new coronavirus, named COVID-19, emerged in Wuhan, China. As it was a novel virus, no one on Earth had immunity to it, leading to rapid human infections globally. Despite initial perceptions of a localized outbreak, the virus quickly spread worldwide. By March, the World Health Organization (WHO) declared COVID-19 a pandemic, with over 500,000 people infected and 30,000 deaths reported by the end of that month. Infections were on the rise in the US and neighboring countries. Figure 1 illustrates various use cases related to the COVID-19 situation globally.

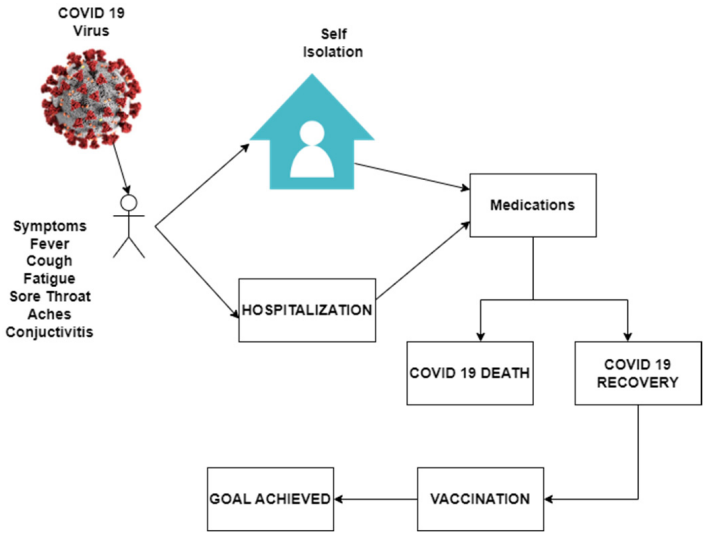

Figure 1. Use cases from a COVID-19 scenario in the universe.

Blockchain DLT technology may be used to swiftly analyze the massive volumes of health data that are generated every day and retrieve insightful data for usage in a range of scenarios. Highly contagious mutations could be anticipated for sickness prognosis before different strains arise. These methods also increase the accessibility of architectural data and allow for the creation of new architectural theories. Mining already-existing databases may increase the effectiveness of therapeutic applications. The pharmacological lifespan, from the preclinical stages through to innovative drug discovery studies, might well be redesigned, as shown in Figure 2.

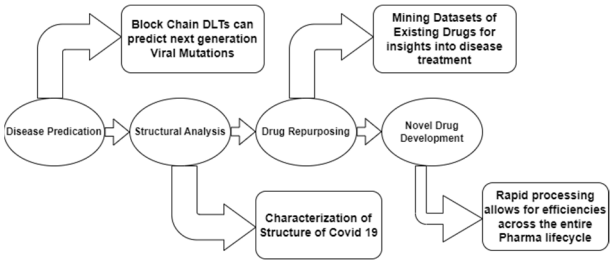

Figure 2. Blockchain DLT applications for an emerging disease.

As a consequence of the corona virus outbreak, millions around the world are now more conscious of the suggested precautions that should be taken throughout a virus outbreak, from careful hand washing to social isolation. Nations all across the globe enacted laws which required citizens to remain at home, shutting areas including universities and shops. The development of diagnoses, treatments, and vaccinations sparked the efforts of hundreds of small firms and lone scientists. The quest to rescue humankind from the epidemic became the main focus of the whole planet. A variable which has several control parameter and coefficients is likelihood. The fundamental premise behind Figure 3 is that COVID-19 survivors will not contract the illness again. The model for a specific person is ended with the death phase, which is denoted by a red hue, and the person is eliminated from the community for further time steps. The outcome of the COVID-19 outbreak is now hard to forecast.

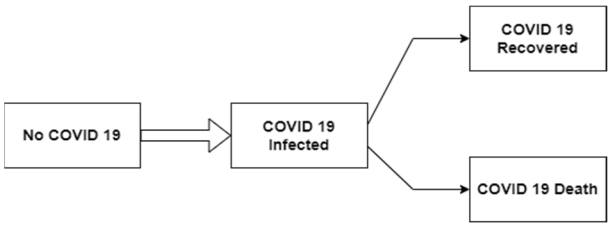

Figure 3. Reference model for an initial use case of COVID-19.

2.2. Related Work

In 2022, Zaman et al. [6] developed a holochain-oriented security and privacy-preserving architecture for IoT healthcare systems, which was found to be more efficient than blockchain-oriented solutions in terms of resource needs. Pedrosa et al. [7,8] proposed an implicit and explicit consent-compliant pseudonymization strategy, which was shown to be extensible and safe assuming acceptable cryptographic constraints. They also proposed a distributed database consensus strategy to enhance EHR insertion procedures, which is a key problem in medical scanning scenarios due to the amount of information involved.

Bigini and Lattanzi [9] imagined the use of the Inter Planetary Health Layer and accompanying IoMT applications in the real world, aiming to manage sensitive information while safeguarding confidentiality and accessibility. Cerchione et al. [10] built a distributed EHR environment by integrating electronic medical records in a secure, permissioned blockchain, improving the preservation of medical records, boosting data flow between healthcare professionals, and lowering information asymmetry.

Bonnot and Teuteberg [11] investigated how Distributed Ledger Technology (DLT) and blockchains could address intellectual property issues in the current age of digitalization. They examined 120 use cases across various categories of intellectual property, including trademarks, copyrights, trade secrets, patents, industrial designs, and geographical characteristics.

Brogan et al. [12] discussed how DLT can advance electronic health by guaranteeing the security and validity of data produced by wearable and embedded devices. Scheibner et al. [8] conducted qualitative data with Swiss medical centers and academic researchers to understand the ethical and legal criteria of these systems.

Erokhin et al. [13] examined DLT as a cutting-edge method of preventing subpar drugs from reaching the market and its sneaky identification. Zuenkova and Khavtorin [14] assessed the potential for DLT to enhance the digital measurement of client experience, analyzing research on independent evaluation of the quality of services offered by medical organizations and contemporary techniques to evaluate patients' satisfaction with healthcare professionals. The various features of the literature works analyzed are summarized in Tables 1 and 2 below.

Table 1. Features of the literature.

Author Name	Year	Aim	Method
Zaman et al. [6]	2022	Holochain is introduced for security in IoT healthcare.	Blockchain
Pedrosa et al. [7]	2021	Pseudonymisati-on protocol is developed which includes the explicit as well as implicit routes for the health records.	Public key cryptography and threshold secret sharing scheme
Pedrosa et al. [8]	2021	Use of a performance protocol for the purpose of distributed health records databases	Distributed database consensus protocol
Bigini and Lattanzi [9]	2022	Considering the Inter Planetary Health Layer using distributed storages and ledgers	IoMT
Cerchione et al. [10]	2022	Modelling distributed EHR ecosystem using blockchainforthe healthcareservice digitalization	IPT
Bonnet and Teuteberg [11]	2022	Multiple case study analysis for the intellectual property life cycle management utilizing DLT and blockchain	Blockchain
Brogan et al. [12]	2018	DLT is suggested for the health activity data authentication	IOTA protocol
Scheibner et al. [13]	2022	Privacy of health data via distributed ledger computing and homomorphic encryption	Data discovery utilizing homomorphic encryption
Erokhin et al. [15]	2020	Poor quality pharmaceuticals circulation risk minimization using DLT	Supply chain and blockchain
Zuenkova and Khavtorin [14]	2020	Management of patient experience employing DLT	DLT

Table 2. Challenges within the literature.

Ref. No.	Parameters	Advantages	Drawbacks
[6]	High secure database	The space of the and time taken by the holochain framework is minimized.	It cannot detect the smart threats in real time.
[7]	Public database	It can eradicate the offline and statistical attacks.	It does not introduce various optimization techniques for detecting and identifying wrong shares.
[8]	Distributed database	It elaborates the possibility of the developed technique in terms of latency and transaction throughput.	The signature overhead is not considered.
[9]	Decentralized database	It returns better scalability and a modest effect on the effectiveness of the application.	The architecture is not modified to enable the utilization of IoMT data with machine learning applications.
[10]	Distributed database	The potential application includes managerial outcomes, organizational outcomes, and clinical outcomes.	It does not consider the vast extension of organizations and healthcare services.
[11]	Multiple case study	It offers practitioners and scholarly researchers with insights into how enterprises can utilize DLT for improving the management of the intellectual property value chain	The complexity is not reduced to a great extent.
[12]	Distributed database	The authenticity of the encrypted activity data is ensured.	It does not open the door for various on-demand services and remote monitoring for the healthcare transformation into the digital age.
[13]	Interview questionnaire and Vignettes	It helps the social license needed for various initiatives.	It does not address how patients respond to the usage of various technologies for data processing.
[15]	Distributed database	It minimizes the defective product risk that enters the market and also enhances the detection efficiency.	The print quality is below the necessary standards.
[14]	-	It enhances the outcomes and processes of satisfaction assessment utilizing DLT.	It does not provide an independent assessment of the QoS being offered by the medical organizations.

3. Research Problems

This paper explored various blockchain Distributed Ledger Technology (DLT) solutions in healthcare, covering supply chain management, information sharing, privacy assurance, patient monitoring, and drug research. It stands out by offering a comprehensive

and up-to-date analysis of recent blockchain activities in the healthcare sector, presenting a broad overview of potential blockchain applications. The paper discusses techniques used to create blockchain platforms in the healthcare sector, emphasizing the synergy between the IoT and blockchain. Privacy techniques in health, data network access to health files, and blockchain's applications in tracking patients during the COVID-19 epidemic were also covered. The findings suggest the need for further research into innovative approaches that position blockchain as a communication platform across entities. The COVID-19 outbreak is seen as potentially reducing barriers to implementing advanced digital health technologies. The paper serves as a valuable starting point for discussions on the use of DLT in health services among practitioners and researchers, emphasizing the future transformative potential of blockchains in healthcare. Scholars are encouraged to address scientific challenges and explore how specific sectors within healthcare can benefit from blockchain adoption.

4. Conclusions and Future Scope

This article surveys the use of blockchain technology in the healthcare sector during the COVID-19 pandemic, focusing on its applications within recovery, mortality, and vaccination. The survey highlights the need for "BC-oriented EHR" and "PHR" for a distributed autonomous healthcare system. Challenges include security, data integrity, privacy, and administration. The future of blockchain technology in healthcare is uncertain, but there has been a rise in digital medical equipment applications. The survey examines various clustering techniques used in blockchain-oriented healthcare applications and suggests that blockchain technology can be applied in various contexts, providing solutions based on the use case and obstacles.

Future research directions for the use of blockchain technology in healthcare include exploring secure biometric identity technologies, focusing on scalability, and integrating blockchains into digital investigations. The lack of guidelines for creating blockchain-based healthcare applications and scalability challenges are significant challenges. The integration of blockchain and IoT could benefit healthcare monitoring and the medication supply chain. Blockchain technology is being used to enhance health information's gathering, use, and exchange, but it must be private and secure. Further investigation is needed to understand the value of blockchain in healthcare and enhance smart contract skills. Blockchain DLT can help the healthcare industry in various ways, but there is a trade-off between decentralization and privacy. Improving pandemic treatment and future readiness requires the swift alignment of international plans for digital technology's governance, appraisal, and usage.

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