https://doi.org/10.33472/AFJBS.6.Si2.2024.2781-2789

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

BlockChainMed: A Novel Framework for COVID-19 Management and Tracking

[1] Gooda Sai Koushik Sarma, [2]Bhanu Satya Venkatachalam Nimmala, [3]Akula Srikanth, [4] Sheik Ahmed, [5]Jonnalagadda Surya Kiran

[1,2,3,4,5] Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P., India-522502.

[1] koushik9gooda@gmail.com, [2] nimmalabhanusvc@gmail.com, [3]srikanthchowdarys143@gmail.com, [4]ahmedsheik705@gmail.com,[5]kiransurya93@kluniversity.in

Volume 6, Issue Si2, 2024

Received: 09 March 2024

Accepted: 10 April 2024

Published: 20 May 2024

doi:10.33472/AFJBS.6.Si2.2024.2781-2789

Abstract—The COVID-19 pandemic has exposed significant challenges in managing patient and hospital data securely. This study proposes a cutting-edge blockchain-based framework to address these challenges. The framework leverages structured data formats and smart contracts to securely store patient information, test results, and treatment histories. It also implements robust security measures, such as access controls and encryption, to protect sensitive data. A customized consensus mechanism ensures data accuracy and privacy. The framework is adaptable to various healthcare settings and complies with healthcare and data protection regulations. It also provides a detailed guide for practical implementation, covering node setup, data validation, and regular checks. The study also outlines strategies for continuous improvement to maintain system effectiveness and security. By offering a systematic approach to COVID-19 data management, this research contributes to the discourse on leveraging blockchain technology for healthcare. It can improve data security, transparency, and accessibility.

Keywords—Blockchain Technology, Covid-19, Healthcare, Data Sharing, Privacy, Hyperledger, Cryptography, Security

I. INTRODUCTION

Blockchain technology, conceived in 2008 and implemented with the emergence of Bitcoin in 2009, stands as a monumental innovation. Initially designed as a platform for cryptocurrency transactions, it has since burgeoned into a versatile tool with applications spanning across a multitude of industries [1]. At its core, a blockchain is an immutable ledger [5], ensuring that once a transaction is recorded, it becomes an indelible part of the historical record. This tamper-proof [26] characteristic imbues the system with an unparalleled level of security and trust. Moreover, it operates on a decentralized network, devoid of central authority. This absence of intermediaries not only bolsters security but also leads to increased efficiency and cost savings [25]. One of the most captivating aspects of blockchain is its capacity for persistence. Information stored on the blockchain remains accessible and unaltered in perpetuity. This quality proves indispensable for applications necessitating long-term record-keeping and absolute traceability. Privacy-conscious [17] individuals and businesses find solace in the anonymity bestowed by blockchain technology. Transactions [19] can be executed without the need to disclose personal information, thus safeguarding sensitive details from prying eyes. A paramount application of blockchain lies in its potential to revolutionize [25] supply chain management. Through the utilization of blockchain, the entire journey of products across the supply chain can be tracked with transparent precision. This not only improves accountability but also serves as a robust deterrent against fraud and counterfeit [8] products. Furthermore, blockchain empowers the execution and management of self-executing programs [19]. These are self-executing programs entrenched in

blockchain, capable of automating the terms and conditions upon the satisfaction of predefined criteria. This obviates the requirement for intermediaries like lawyers or banks, streamlining processes and driving down costs. In a contemporary landscape where data breaches [2] have become disconcertingly prevalent, blockchain stands as a formidable solution for the management of digital identities and healthcare data. This technology has the potential to shield individuals from the scourge of identity theft and afford them greater dominion over their personal information. In summation, blockchain stands as a potent and emergent technology with the power to reshape industries including finance, healthcare, and supply chain management. Its defining attributes of decentralization, persistency, anonymity, and auditability [6] render it a potent tool for secure and efficient transactions, record-keeping [25], and contract execution. As this technology advances, its transformative impact across various sectors is anticipated to be nothing short of profound.

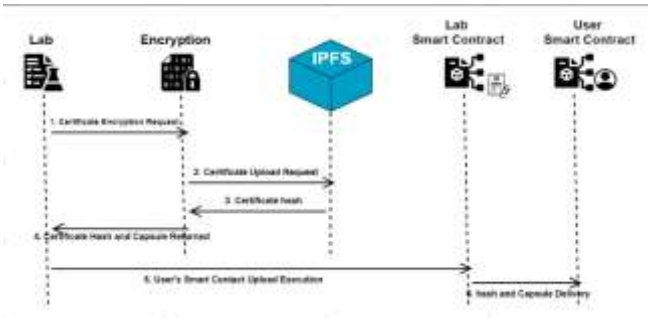

Figure 1 Basic Blockchain Technology Workflow for Encryption

II. LITERATURE SURVEY

A. *Med-Rss: A blockchain-based scheme for secure storage and sharing of medical records*

Authors: Zhijie Sun, Dezhi Han, Dun Li, Tien-Hsiung Weng, Kuan-Ching Li, Xiaojun Mei

The paper aims to create a decentralized healthcare data system, MedRSS, using blockchain technology, specifically Hyperledger Fabric. MedRSS uses Hyperledger Fabric,

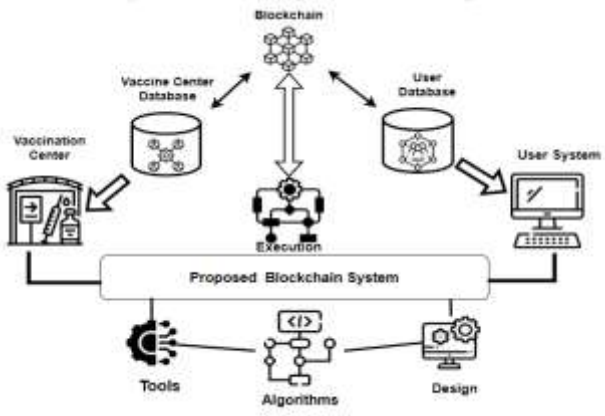

Figure 2. using Blockchain in COVID-19 Vaccination System

ECC, AES, and IPFS for secure patient-centric medical data storage. It tackles centralization issues, ensuring strong security and meeting crucial data [11] integrity and privacy standards. Experiments confirm its effectiveness, showcasing a robust design and improved system performance compared to existing options. To achieve strong anonymity of transactions, uses Kafka Consensus Algorithm and may subject to malicious attacks, Performance in Multi-machine environment [1].

B. *Privacy-Preserving Medical Data-Sharing System with Symmetric Encryption Based on Blockchain*

Authors: Mingqi Hu, Yanli Ren, Cien Chen

The goal is to leverage blockchain technology to tackle the obstacles in medical data storage, sharing, security, and compatibility. The intention is to boost efficiency and security within healthcare institutions by refining how data is handled and circulated. The article emphasizes blockchain's characteristics, such as immutability [6] and robust security, as a remedy for challenges like data breaches. This system employs encryption, patient [11] authorization, power constraints, and chameleon signatures to guarantee both privacy and security. Through security analysis and experiments, the article showcases the system's effectiveness and its superior performance compared to alternative solutions [2].

C. *Sec-Health: A Blockchain-Based Protocol for Securing Health Records*

Authors: Leonardo Da Costa, Billy Pinheiro, Weverton Cordeiro, Roberto Araújo, Antônio Abelém

This study introduces Sec-Health, a protocol prioritizing healthcare record security, particularly confidentiality [13]. Sec-Health improves current solutions by blending decentralization and cryptography. It demonstrates enhanced efficiency in access time and client-side memory usage compared to similar approaches. Plan to enhance Sec-Health with emergency access and anonymity [1] features. Test it in diverse scenarios and optimize performance with various blockchain platforms. [3].

D. *Intelligent data sharing strategy supported by artificial intelligence and blockchain technology: based on medical data*

Authors : *Chengming Li, Yuan Huang, Yiru Wu, Xiaoxing Wang, Yuan Tian, Runqing Wu, Fuyao Qu, Zeyu Wang*

The study puts into practice a secure blockchain-based system for sharing medical data, showcasing impressive results in terms of low latency (340 ms), minimal overhead (less than 600 bytes), and minimal data loss (12.82%). This represents a highly efficient solution for exchanging medical information within smart city networks [17]. This approach facilitates secure, transparent, and traceable transactions, fostering open data sharing both within and between [19]

institutions. The process involves several steps, including initializing the program, deploying smart contracts, employing off-chain and on-chain data storage methods, and generating zero knowledge proofs [4].

E. *Block Chain-Based Healthcare Model to Predict Heart Disease Using a Machine Learning Techniques*

Authors: Muhammad Akhter , Hammad Raza, Adnan Ahmad

This paper discusses on how to develop a blockchain-based intelligent healthcare model that use machine learning (ML) and Artificial Neural Networks (ANNs) to accurately [12] predict heart disease while ensuring security of the data and privacy of the patients using Blockchain. ANN is used to analyze the patterns and increase accuracy of [10] predictions. Proposed model has potential to transform healthcare by accurately predicting heart disease, maintaining security for data, and providing patient monitoring in real time which helps Medical [13] Professionals to treat patients better and saves a lot of time for diagnosing other patients. It offers a more reliable and cost-effective healthcare solution [5].

F. *A Blockchain-Based Life-Cycle Environmental Management Framework for Hospitals in the COVID-19 Context*

Authors: Botao Zhong, Han Gao, Lieyun Ding, Yuhang Wang

This study explores usageof blockchain technology to improve management of healthcare in emergencies like COVID-19. It aims to create a system tracking infection control measures, ensuring accountability during rapid construction or renovation. It suggests the practical implementation and validation of the blockchain framework in real hospital projects. It recommends integrating IoT for better data collection, assessing scalability, addressing regulatory compliance, and investigating interoperability with existing systems. This work provides a foundation for enhancing environmental management in healthcare facilities during emergencies, with room for further development.

G. An investigation of the impact of COVID-19 on health-related cryptocurrencies using time-varying parameters and impulse responses

Authors: Theodoros Daglis

This study analyzes the COVID19 impact on the health-related crypto currencies, evaluating price [13] performance and transaction volume causality. It also explores time-varying patterns and potential spillover effects among these cryptocurrencies. COVID-19 had varying effects on health-related cryptocurrencies. In 2021, results were unstable, indicating time-varying patterns. In 2022, the impact was mostly negative, affecting prices negatively and transaction volumes positively in 2020. Spillover effects were observed only in 2022. These findings underline the diverse impact of the pandemic on cryptocurrencies, varying across years [7].

H. *Blockchain-based Supply Chain Traceability for COVID-19 personal protective equipment*

Authors: Ilhaam A. Omar, Mazin Debe, Raja Jayaraman, Khaled Salah, Mohammad Omar, Junaid Arshad

This section lists the specific objectives of the proposed [11] blockchain-based solution. These objectives may include improving transparency, reducing counterfeit products, enhancing traceability, and ensuring compliance with regulatory standards. The paper concludes by summarizing the key findings and the potential impact of adopting this blockchain-based solution on the PPE supply chain during and beyond the COVID19 pandemic. Future improvements could include broadening the solution to various supply chains, integrating new technologies, and adapting to changing healthcare logistics challenges.

I. *A blockchain approach on security of health records for children suffering from dyslexia during pandemic COVID-19*

Authors: Megha Jain, Dhiraj Pandey, Kewal Krishna Sharma

This research automates dyslexia detection in children, designs cognitive assessments, and addresses delayed identification to prevent mental health issues. It also explores dyslexia's impact on mental health, challenges faced by dyslexic students during COVID-19, and employs blockchain for secure healthcare record access, particularly EHRs. The research likely emphasizes early dyslexia [13] detection to prevent mental health issues, especially amid COVID-19. It also suggests blockchain's potential in securing healthcare records. Future work may involve extended monitoring of mental health in individuals with dyslexia and interventions.

J. *Block the Chain: Software Weapons of Fighting Against COVID-19*

Authors: Attila Kertesz

This paper offers a blockchain and fog computing- based remedy for secure COVID-19 vaccination information management. It ensures trust, transparency, privacy, and scalability in data verification and analysis. The study evaluates blockchain systems using [16] real-world data simulations and suggests potential extension for managing other viruses and diseases, aiding in future pandemic responses. The article introduces VACFOB, a system blending fog and cloud tech for secure vaccination verification and tracking. Simulations validate its efficiency with large data volumes. VACFOB builds trust in vaccination data, ensures privacy, and aids in virus spread prediction [10].

S. No	Paper Title	Year of Publication	Objective	Technology Used
1	Med-Rss: A blockchain-based scheme for secure storage and sharing of medical records	2023	To create Blockchain-based medical data management system for safe storage and collaborative record sharing.	Hyperledger, IPFS, AES, ECC Encryption Algorithms
2	Privacy-Preserving Medical Data-Sharing System with Symmetric Encryption Based on Blockchain	2023	The goal is to create a solution to tackle issues related to medical data like storage, security, sharing by enhancing the management and flow of medical data.	Blockchain, Chameleon Hash
3	Sec-Health: A Blockchain-Based Protocol for Securing Health Records	2023	This study introduces Sec-Health, a protocol prioritizing healthcare record security, particularly confidentiality.	Blockchain, IPFS, Threshold Cryptosystems, CP-ABE, Public Key Encryption, One-Way Hash Functions
4	Intelligent data sharing strategy supported by artificial intelligence and blockchain technology: based on medical data	2023	Utilizing blockchain to secure, decentralized sharing of medical data, prioritizing privacy, efficiency in smart medical systems.	Blockchain, self-executing programs, and zero knowledge proof.
5	Block chain-Based Healthcare Model to Predict Heart Disease Using a Machine Learning Techniques	2023	The goal is to create an intelligent healthcare model leveraging blockchain technology and integrating Machine Learning (ML) to accurately forecast heart disease.	ANN (Artificial Neural Networks), ML, Blockchain
6	A Blockchain-Based Life-Cycle Environmental Management Framework for Hospitals in the COVID-19 Context	2023	It aims to create a system tracking infection control measures, ensuring accountability during rapid construction or renovation to improve hospital construction in emergencies like COVID-19.	Consortium Blockchain, Smart Contracts

7	An investigation of the impact of COVID-19 on health-related cryptocurrencies using time-varying parameters and impulse responses	2023	This study analyses the COVID19 impact on health- related digital currencies, evaluating price performance and transaction volume causality.	Vector Auto-Regressive (VA-R) Models, Time varying Parameter (TvP) Models, Variable-lag time (VlT) Models
8	Blockchain-based Supply Chain Traceability for COVID-19 personal protective equipment	2022	The objective includes improving transparency, reducing counterfeit products, enhancing traceability, and ensuring compliance with regulatory standards.	Ethereum, Smart Contracts
9	A blockchain approach on security of health records for children suffering from dyslexia during pandemic COVID-19	2022	This research automates dyslexia detection in children, designs cognitive assessments, and addresses delayed identification to prevent mental health issues faced by dyslexic students during COVID-19.	Machine Learning Model for Dyslexia Detection, NLP
10	Block the Chain: Software Weapons of Fighting Against COVID-19	2022	This paper suggests blockchain and fog computing- based remedy for secure COVID-19 vaccination information management.	FobSim, Wonder Network, Ethereum and Bitcoin

Table 1 Literature Survey Table

III. METHODOLOGY

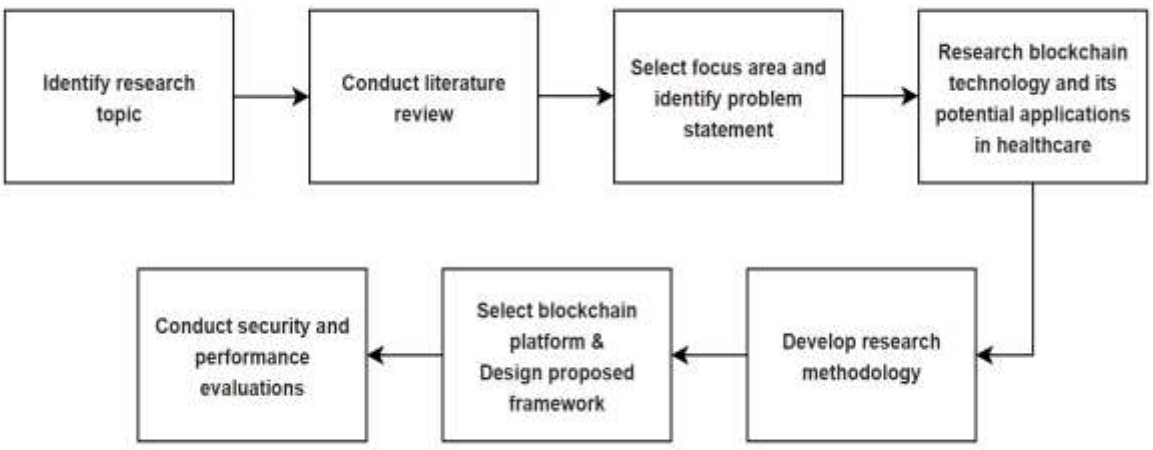

Table 2 Literature Survey Table

IV. WORKFLOW

The research began with the identification of the topic and a comprehensive review of existing literature. This initial step provided a deep understanding of the current advancements in healthcare data security and highlighted the gaps that needed attention. Hospital data management was considered, and the gaps were found. The focus was then narrowed down to a specific area - the development of a framework based on blockchain for managing patient and hospital data securely. The problem aimed to be solved was the absence of a secure and efficient method for storing and sharing patient data. After completing the literature review and discussions, the methodology was defined. This involved detailing the steps and methods that would be employed to develop and evaluate the proposed framework. The next phase is the development of the framework, which includes designing its various components and implementing them using the chosen blockchain platform. Once the framework is ready, security and performance evaluations will be conducted to identify any potential areas of improvement. Simultaneously, the research process and findings will be documented in a research paper. This will not only allow for tracking progress but also for sharing the work with the broader community.

V. DISCUSSIONS

A. Disadvantages

Although Blockchain is a good technology for providing better security to data, it still has some disadvantages.

1. Energy Consumption: Dealing with Blockchains like Bitcoin and Ethereum may result in consuming significant amounts of energy when considered from an environmental standpoint.
2. Scalability: Public Blockchain networks like Ethereum can face scalability issues. Storing large amounts of data, especially in real-time scenarios like COVID-19 data can be challenging.
3. Costs: Storing data on blockchain especially public blockchain (Ethereum) with high gas fees can be expensive.
4. Data Deletion and Immutability: In scenarios where data deletion or modification is necessary due to legal or regulatory requirements immutability of blockchain is a hindrance.
5. Latency: Compared to traditional databases, writing data to blockchain can take longer time.
6. Network Consensus: Achieving consensus in a blockchain, especially in large networks, can affect performance as such processes are resource intensive.
7. Storage Limitation: Blockchain's blocks have a size limit. For Ethereum it is 46 KB and for Bitcoin it is 1MB.
8. Synthesis with existing systems: Synthesizing blockchain with extant healthcare system infrastructure can be challenging and requires development effort.
9. User Education and Adoption: Users, including healthcare professionals and patients, may need to adapt to new systems and technologies.

B. Scope of Improvement

1. Scalability
2. Cost Optimization
3. Privacy Techniques
4. Hybrid Solutions
5. Standardization
6. Education and Training
7. Collaboration with Healthcare stakeholders

C. How to Improve

1. Implement Sharding, Layer-2 Solutions, and consensus mechanism improvements.
2. Using cost-effective platforms or alternative consensus mechanisms.
3. Implementing zero-knowledge proofs or Homomorphic encryption.
4. Combining Blockchain with other technologies such as traditional databases or off-chain storage for optimization.
5. Encouraging the development of interoperability protocols to facilitate seamless integration.
6. Training and education programs are provided for healthcare professionals, patients, and administrators to ensure proficiency in using blockchain-based systems.
7. Collaborate with healthcare providers and industry experts to gather insights and co-create solutions that are tailored to healthcare sector.

D. Evaluation Metrics

Evaluation Metrics determine the effectiveness of the given solution. The evaluation metrics considered in Blockchain based systems are,

1. Security: This includes resistance to Unauthorized access to medical data, resistance to tampering of medical data and resistance to other Cyber-attacks and sybil attacks.
2. Privacy: This includes protection of Personally Identifiable Information (PII) like addresses, phone numbers etc., prevention of

unauthorized tracking of users and prevention of data leaks.

3. Efficiency: This is based on some calculations like the throughput (Number of transactions per second), Latency (time the proposed model takes to complete a transaction), its ability to handle many transactions-scalability.
4. Usability: The ease of using the solution/system, the availability of documentation and support for the proposed system, Community engagement.
5. Confidentiality: The protection of information from unauthorized access.
6. Encryption Standards: If the system uses an encryption algorithm, then the security provided by it.

VI. CONCLUSION

This research systematically explored the potential of blockchain and IPFS systems to revolutionize the safe storage of hospital data for COVID-19. It reviewed the literature on blockchain and its applications, surveyed the research papers on blockchain implementation in various fields, and selected a relevant and timely topic like the protection of health and hospital data related to COVID-19. It collected, analyzed, and synthesized the data and provided a comprehensive overview of how blockchain and IPFS systems can enhance the integrity, accessibility, and privacy of this vital data. The insights from this synthesis increased the knowledge base and contributed to the field of health information management. The conclusion reflected on the transformative power of blockchain and IPFS systems in the healthcare industry, as they are set to change the way sensitive health information is secured, shared, and utilized. The importance of this research was emphasized by the ongoing global pandemic, which revealed the need for strong data management practices in the healthcare industry.

The future scope includes scalability, cost optimization, privacy techniques, and hybrid solutions. Hybrid solutions includes integrating the system with other solutions, such as electronic health records, telemedicine, and wearable devices. These aspects are important for enhancing healthcare informatics and delivery.

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