BLOCKCHAIN TECHNOLOGY AND RECORD-KEEPING IN THE NIGERIAN HEALTHCARE SYSTEM: A SYSTEMATIC REVIEW

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Abstract: *Healthcare is just one of the many industries that blockchain technology has the ability to completely transform. This paper explores using blockchain technology to maintain track of records in the Nigerian healthcare system. With challenges such as inefficient data management, a lack of interoperability and compromised patient privacy plaguing the current healthcare record-keeping practices, blockchain presents a promising solution by offering transparency, security, and decentralization. The study delves into the fundamental concepts of blockchain technology, emphasizing its decentralized and immutable nature, which ensures data integrity and trust. It investigates the unique attributes of blockchain that align with the needs of the Nigerian healthcare system, such as data provenance, interoperability, and access control. Furthermore, the paper examines existing blockchain-based healthcare systems in other regions, drawing insights and lessons that can be applied to the Nigerian context. However, the implementation of blockchain technology in healthcare is not without challenges.*

I. INTRODUCTION

Blockchain technology has become more prevalent recently as a transformative force with the potential to reshape industries and sectors worldwide. Unprecedented opportunities exist thanks to its decentralized and immutable nature to improve data management, security, and transparency. One area where blockchain holds particular promise is the healthcare sector, where efficient and secure record-keeping is crucial for ensuring quality patient care, data integrity, and regulatory compliance. The use of blockchain technology to improve the Nigerian healthcare system's record-keeping procedures is explored in this paper, shedding light on its potential benefits and challenges within this unique context.

The Nigerian healthcare system, like many others globally, faces persistent challenges in managing patient records. Traditional record-keeping methods often involve fragmented and siloed data systems, resulting in inefficiencies, data inaccuracies, and compromised patient privacy. These challenges hinder seamless data exchange among healthcare stakeholders, leading to suboptimal patient care and missed opportunities for medical advancements. In Nigeria, these issues are exacerbated by a diverse healthcare landscape, encompassing government institutions, private providers, insurers, and regulatory bodies, each with distinct data management practices and requirements.

Blockchain technology, characterized by its decentralized and tamper-resistant ledger, has the potential to address these challenges by creating a unified and secure system for recording and sharing healthcare data. By enabling trust among multiple parties, blockchain can facilitate interoperability, data provenance, and secure access control, thereby streamlining healthcare operations and improving patient outcomes.

In order to understand how blockchain technology and record-keeping relate to the Nigerian healthcare system, this essay draws on a variety of scientific studies and real-world examples. It examines the foundational principles of blockchain technology and its potential to revolutionize data management practices in healthcare. Moreover, this study considers existing implementations of blockchain in healthcare systems globally, assessing their applicability and relevance to the Nigerian context.

Key references for this exploration include seminal works on blockchain technology, healthcare record-keeping, and the specific challenges faced by the Nigerian healthcare system. Noteworthy among these references are articles [1,2], which provide comprehensive insights into the fundamentals of blockchain technology and its application in various industries. Additionally, research by [3] offers valuable perspectives on healthcare data management challenges in Nigeria, setting the stage for the integration of blockchain solutions.

As blockchain technology continues to evolve and find novel applications, it is imperative to examine its potential impact on the complex and dynamic landscape of the Nigerian healthcare system. By doing so, we can gain a deeper understanding of the opportunities and challenges associated with implementing blockchain-based record-keeping solutions, ultimately paving the way for a more efficient, secure, and patient-centric healthcare ecosystem in Nigeria.

1.1 Overview of blockchain

Blockchain is a decentralized node networks that securely stores and records data, ensuring system-wide privacy and confidentiality. It is ideal for securely storing relevant documents and expediting the search for candidates meeting trial requirements. Blockchain is based on three fundamental concepts: blocks, nodes, and miners. It operates on top of the internet on a P2P network of computers, with each machine updating its blockchain to reflect the addition of a new block. Blockchains can be public, private, hybrid, or consortium-based, each with unique benefits and drawbacks. Public blockchains eliminate centralization disadvantages, such as security and transparency, and disseminate data around a P2P network. Private Blockchains allow for permission-based solutions and user anonymity, while hybrid blockchains combine features from both private and public blockchains, allowing businesses to control access to data and access to public information. Figure 1 shows the working steps of blockchain technology [13,14,15].

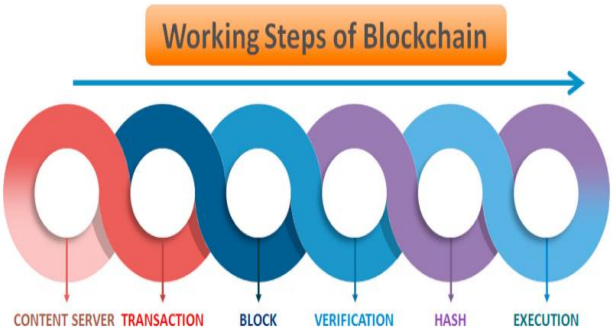

Figure 1: Working steps of Blockchain Technology

II. LITERATURE REVIEW

Blockchain technology is being adopted and explored in healthcare systems worldwide, not limited to Nigeria. Its applications in healthcare go beyond just securing patient data and extend to improving transparency, interoperability, and patient care. Here are examples of how blockchain is used in healthcare in other countries aside Nigeria.

According to the OECD report [16] deployment of blockchain technology in health at a national

scale is rare. However, there are examples from some countries, such as Estonia and Malta, of how blockchain technologies offer useful features such as data security protection and identity verification. Apart from these countries, several other countries are currently evaluating the implementation of blockchain technology in the healthcare sector, including China. This is illustrated in the table below.

Table 1

S/N	countries	implementation	Ref.
1	Estonia	Estonia's e-Residency program and the broader e-Estonia initiative have integrated blockchain technology for secure and interoperable health records.	[17]
2	United States**:**	The U.S. has seen various blockchain initiatives aimed at improving healthcare data management, supply chain, and patient records. Companies like IBM have worked on projects in this domain.	[18]
3	South Korea	South Korea has explored the use of blockchain technology in healthcare to enhance the security and integrity of medical data.	*[19]*
4	China	China has initiated blockchain projects in healthcare, such as managing pharmaceutical supply chains and medical data.	*[20]*
5	Sweden	Sweden has explored the use of blockchain for managing patient records and improving the integrity of healthcare data.	*[21]*
6	India	India has started to experiment with blockchain in healthcare, particularly for managing patient data securely and efficiently.	*[22]*
7	United Arab Emirates	Dubai's "Dubai Blockchain Strategy" aims to make the city a blockchain-powered government. Healthcare is one of the sectors benefiting from blockchain technology.	[23**]**
8	Switzerland	Switzerland is exploring blockchain for clinical trials and medical research. It offers a secure and transparent way to manage research data, ensure data integrity, and track the progress of clinical trials in real-time.	[24]
9	United Kingdom:	The UK is exploring the use of blockchain to improve the efficiency of healthcare supply chains. This technology helps in tracking the authenticity of pharmaceuticals, reducing counterfeit drugs, and ensuring the quality of medical supplies	[25]

III. POTENTIAL GAINS FROM BLOCKCHAIN

Technology for Healthcare System Participants in Nigeria:

The numerous benefits of blockchain technology for various stakeholders within the Nigerian healthcare system, ranging from patients and healthcare providers to regulatory bodies and insurers cannot be overemphasized. These benefits encompass streamlined data sharing, reduced administrative overhead, enhanced fraud detection, and improved patient outcomes, ultimately contributing to a more efficient and patient-centric healthcare ecosystem.

- **Patients:** Patients may become more empowered by using blockchain to give them more control over their health data. [9]. Patients can securely access and manage their electronic health records (EHRs), granting selective access to healthcare providers. This patient-centric approach enhances transparency and trust, facilitates accurate medical history sharing, and supports personalized care decisions. Patients can experience improved care coordination and seamless transitions between healthcare providers, leading to enhanced overall healthcare experiences.[2]
- **Healthcare Providers:** Blockchain technology can streamline data sharing among healthcare providers, ensuring the availability of accurate and up-to-date patient information [8]. Interoperable EHRs accessible through blockchain enable healthcare professionals to make informed treatment decisions, reduce duplicate tests, and improve care coordination. By eliminating data silos, blockchain enhances collaboration between different providers, leading to more comprehensive patient care and efficient clinical workflows.
- **Regulatory Bodies:** Regulatory bodies can benefit from blockchain's transparent and auditable nature in ensuring compliance with healthcare standards and regulations [12]. Blockchain-based systems can facilitate real-time monitoring of healthcare processes, medication tracking, and adherence to treatment protocols. Regulatory agencies can use blockchain to verify the authenticity of medical records, reducing instances of fraudulent claims and improving overall data accuracy and quality.
- **Insurers:** Insurers can leverage blockchain to enhance fraud detection and claims processing efficiency [10]. The transparent and tamper-resistant nature of blockchain ensures that insurance claims are accurately recorded and verified. Smart contracts can automate claims processing, reducing administrative overhead and minimizing delays in reimbursement. This streamlined process not only improves insurer efficiency but also ensures that legitimate claims are processed promptly.

IV. BLOCKCHAIN TECHNOLOGY IMPLEMENTATION IN THE NIGERIAN HEALTHCARE

Blockchain technology implementation in the Nigerian healthcare sector has a lot of potential benefits but also presents various technical, regulatory, and ethical considerations that must be carefully addressed. This section discusses these aspects

Technical Considerations:

- **Scalability and Performance:** Blockchain networks, especially public ones, may face challenges in handling the scale and performance required by a nationwide healthcare system 15]. Solutions like sharding and off-chain protocols could be explored to mitigate scalability concerns.[4]
- **Data Storage and Access:** Efficient management of large volumes of healthcare data is crucial. Decisions must be taken on the storage of data on-chain vs off-chain and how to guarantee safe access to private health data. [14].
- **Interoperability:** Integrating blockchain with existing health information systems and ensuring data compatibility with diverse stakeholders' systems are technical challenges that need careful consideration [7].

Regulatory Considerations:

- **Data Privacy and Security:** The transparency of blockchain technology may conflict with data protection laws like the General Data Protection Regulation (GDPR). Balancing transparency with patient data privacy rights is crucial [6].
- **Legal Framework:** Establishing a legal framework that recognizes blockchain-based health records, defines ownership, and addresses liability in case of data breaches or errors is necessary [9].
- **Health Data Standards:** Ensuring compliance with standardized health data formats and terminologies is essential for seamless data exchange and interoperability [11].

Ethical Considerations:

- **Informed Consent:** Transparent management of patient consent on blockchain, including granting and revoking access to health data, raises ethical questions about patient autonomy and decision-making [8].
- **Digital Divide:** Ensuring equitable access to blockchain-based healthcare systems, especially in remote or underserved areas, is essential to prevent exacerbating existing healthcare disparities [9].
- **Identity and Ownership:** Defining patients' digital identity on the blockchain and clarifying who owns and controls the data stored on the blockchain are ethical considerations that require careful thought [12].

V. PROPOSED SOLUTION VS TRADITIONAL METHOD OF RECORD KEEPING

1. Traditional Method of Health Record-Keeping (Nigeria):

Security and Data Integrity: Data security in healthcare refers to the protection of patient health information (PHI) against unauthorized access, breaches, or data leaks. In traditional record keeping systems, data security is a significant concern. Common challenges include paper records, which are susceptible to physical theft or loss, and inadequate access controls.

Data Integrity in Traditional Record Keeping: Data integrity involves ensuring the accuracy, consistency, and reliability of healthcare data. Traditional record keeping methods may face data integrity issues due to manual errors, illegible handwriting, or misfiling of paper records.

Poor Infrastructure: Inadequate infrastructure and unreliable power supply can lead to data loss or corruption in paper-based systems.

Limited Access Control: Unauthorized personnel may access patient records due to weak access controls and limited tracking mechanisms. Traditional record-keeping can limit interoperability, requiring manual data transfer and making it challenging to access records from different providers.[5]

Human Error: Manual data entry and record management are prone to errors and inaccuracies. Reducing errors in traditional methods relies heavily on the skills and diligence of healthcare professionals.

Storage Space: Storing a large volume of paper records can be challenging and may lead to misplacement or loss. [26]

Blockchain Technology in Health Record-Keeping (Nigeria):

Security and Data Integrity: Blockchain offers robust security through encryption and decentralized storage, making it highly resistant to data tampering. Patient data remains secure and immutable. [27]

Interoperability: Blockchain can enhance interoperability by enabling secure and seamless

data sharing among different healthcare providers and systems.

Transparency and Patient Control: Patients have increased transparency and control over their health data, granting access as needed. This aligns with principles of data sovereignty. [28]

Reduced Errors: Smart contracts in blockchain can automate processes, reducing human errors in record-keeping and billing.

2. The Transformative Potential of Blockchain in Addressing Inefficiencies and Vulnerabilities in Traditional Record-Keeping Methods in the Nigerian Healthcare System:

Blockchain technology holds significant transformative potential to address the persistent inefficiencies and vulnerabilities inherent in traditional record-keeping methods within the Nigerian healthcare system. By offering enhanced security, transparency, interoperability, and patient empowerment, blockchain has the capacity to revolutionize healthcare record-keeping, ultimately leading to improved patient outcomes and more efficient healthcare operations.

Enhanced Data Security and Privacy: Traditional record-keeping methods often suffer from data breaches and unauthorized access, compromising patient privacy [6]. Blockchain's cryptographic security ensures that health data remains tamper-resistant and can only be accessed by authorized parties. Patient consent mechanisms are recorded immutably on the blockchain, granting patients greater control over who accesses their sensitive medical information [8].

Transparency and Data Integrity: It is challenging to track the origin and changes to health information in traditional systems because of their lack of openness. Blockchain's distributed ledger technology ensures transparency by recording every transaction in an immutable manner, enabling a trustworthy audit trail of data changes. This transparency enhances accountability among healthcare providers and reduces the likelihood of data manipulation [1].

Interoperability and Data Sharing: Siloed data systems hinder efficient data exchange and coordination among healthcare providers in Nigeria [6]. Blockchain's decentralized architecture and standardized data formats facilitate seamless interoperability, enabling secure sharing of health information among disparate entities. Smart contracts can automate data transactions, reducing administrative burdens and ensuring data accuracy [7].

Reduced Administrative Overhead and Fraud Prevention: Traditional administrative processes in the Nigerian healthcare system are often manual, leading to inefficiencies and opportunities for fraud [10]. Blockchain-based systems can automate and streamline administrative tasks, reducing costs and minimizing the potential for fraudulent activities. Smart contracts can facilitate real-time claims processing, enhancing accuracy and reducing delays.

The transformative potential of blockchain technology lies in its ability to address the inefficiencies and vulnerabilities present in traditional record-keeping methods within the Nigerian healthcare system. By providing heightened security, transparency, interoperability, and efficiency, blockchain can pave the way for a more patient-centered, secure, and streamlined healthcare ecosystem in Nigeria

VI. CONCLUSION AND FUTURE WORK

In conclusion, the exploration of blockchain technology's potential in the Nigerian healthcare system serves as a stepping stone for future research and practical implementation. By addressing technical challenges, regulatory considerations, ethical dilemmas, and capacity-building needs, Nigeria can build a robust foundation for the integration of blockchain technology that enhances patient care, data management, and healthcare outcomes.

Continued collaboration among researchers, policymakers, technologists, and healthcare practitioners is vital to navigate this transformative journey and realize the full potential of blockchain in revolutionizing

healthcare in Nigeria. This foundation paves the way for a more efficient, secure, and patient-centric healthcare ecosystem for years to come.

Exploring the possibilities of blockchain technology in relation to the Nigerian healthcare system offers valuable insights and opportunities for both future research and practical implementation. As this field continues to evolve, it is essential to build upon the knowledge gained and undertake targeted efforts to ensure the successful integration of blockchain into healthcare practices in Nigeria.

Future research should delve deeper into specific aspects of blockchain implementation in the Nigerian healthcare system. This could involve studies on optimal governance models, addressing scalability challenges, refining consent management mechanisms, and developing frameworks for handling legal and ethical implications. In-depth analysis of potential blockchain use cases, such as drug supply chain management, telemedicine, or clinical trials, can guide focused research efforts that cater to Nigeria's unique healthcare landscape.

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