

**Publisher**<http://jssidoi.org/esc/home>**BLOCKCHAIN TECHNOLOGY FOR HEALTH INFORMATION MANAGEMENT: A CASE OF ZIMBABWE*****Sharon R.T. Chilunjika¹, Dominique E. Uwizeyimana²**^{1,2}*School of Public Management, Governance and Public Policy, University of Johannesburg, South Africa**E-mails: ¹srtchilu@gmail.com; ²dominiqueu@uj.ac.za**Received 29 December 2023; Accepted 14 March 2024; Published 30 March 2024*

Abstract. Porous paper-based systems, manipulation of data, information access constraints, and untimely reporting of information characterize Health Information management in developing countries such as Zimbabwe. This article aims to explore how the adoption and implementation of Blockchain technology can solve health information management challenges in Zimbabwe's public health sector. This article explores the opportunities and challenges of implementing Blockchain technology in Zimbabwe's public health sector through qualitative desk research. The significant findings in this paper reflect that blockchain has the potential to prevent health records from being manipulated, modified or corrupted without a consensus, making the technology secure. It also improves access to health data for all stakeholders in the medical domain. Furthermore, this technology has the potential to improve data management and enforce accountability and transparency in vital clinical functions such as procurement and finance, resulting in the provision of quality health services. However, blockchain has not been given much attention in Zimbabwe's public health sector as its implementation has the potential to be hampered by numerous challenges such as inadequate information communication technology infrastructure and skills, security and privacy concerns, usability, resistance to change and lack of financial resources to procure hardware and software needed for this technology. Thus, this paper recommends that health policymakers engage in more research to understand better and evaluate the value of this technology in Zimbabwe to ensure it can thrive in resource-constrained settings.

Keywords: blockchain; health information system; Zimbabwe; opportunities; challenges

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1. Introduction

There is considerable literature to support that Blockchain technology is part of the 4th industrial revolution (4IR) and offers significant benefits for the health domain (Chukwu and Gary, 2020; Niyitunga, 2022; Ghosh et al., 2023). Blockchain technology is defined by Haleem et al. (2021) as an electronic, distributed ledger which is only editable with consensus. This feature enables this technology to be immutable. The immutability of blockchain is one of the chief reasons behind its wide adoption in the medical field (Kaur et al., 2023). While its adoption and implementation appear to be in its infancy stages in developing countries, and some pilot projects have been unsuccessful, this emergent technology is considered crucial with great potential to revolutionize health information management in developing contexts (Niyitunga, 2022). As such, this

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technology is finding its way into the healthcare industry across the global south to deal with the prevalent challenges in health information systems.

Manual paper-based health information systems, Electronic Health Information Systems and Electronic Health Records (EHRs) currently used in developing countries, Zimbabwe included have several disadvantages. Firstly, the security of health information is a serious matter for the health domain in developing countries (Chilunjika and Chilunjika, 2023). Many healthcare institutions in these countries keep valuable health data in centralized repositories (usually in ageing and outdated Information Technology infrastructure) (Luthuli and Trywell, 2017). In most cases, these data repositories become prime targets for cyber-attacks. These security concerns also raise data validity issues and health information sharing, which has exposed many healthcare consumers to possible societal stigma and financial threats. Another challenge facing health institutions in developing countries is that health data is generally inaccessible and non-standardized across health information systems, making it difficult to retrieve, scrutinize, present and disseminate data in an aggregated manner (Tossy, 2014). Health information is also collected from numerous sources and is kept in centralized repositories, which makes data management and sharing difficult and time-consuming. The COVID-19 pandemic also highlighted the lack of Interoperability among healthcare systems in the global south (Chilunjika and Chilunjika, 2023). A situation which hampers the timely dissemination of health information to support tasks such as diagnosis, health surveillance and health policymaking. Taking these matters into consideration, there is thus a need for an improved, decentralized, interoperable and immutable health information system to supersede the existing system. Blockchain technology is a novel and innovative system that can help solve some of the challenges faced by health systems in developing countries (Matlebjane and Ndayigamiye, 2022).

Nonetheless, research about Blockchain use in the health domain is currently limited, particularly in developing countries such as Zimbabwe. As Blockchain technology is making its way into health systems, it is essential to examine whether it can transform health information management in a developing context using Zimbabwe as the case study. This paper, therefore, seeks to explore the benefits of adopting Blockchain technology in the medical domain, with a particular emphasis on examining and conceptualizing the potential benefits and challenges of this technology for managing health information systems.

This article seeks to answer the following research questions:

1. How can Blockchain technology be used to improve health information management in Zimbabwe's public health sector to improve the delivery of health care?
2. What challenges can hamper the adoption and implementation of Blockchain technology in Zimbabwe's public health domain?

The subsequent section sets out the conceptual framework used for this paper and the methods used to collect and analyze data. Next, the findings are presented and analyzed, followed by conclusions and recommendations.

2. Literature Review

2.1 Blockchain Defined

To understand how blockchain works, defining it and outlining its key features is essential. While there is no generally accepted definition of blockchain, several scholars have put forward definitions describing what this technology entails. According to Bassam (2021), a Blockchain is a digital, decentralized database containing a continuously growing list of data in chronological order. According to Attaran et al. (2017), a Blockchain is a digital, decentralized architecture containing an incessantly expanding log of transactions called "blocks" connected in a chain through mining. The mining process turns pending records into a mathematical conundrum. Authorized parties (miners) solve the conundrum using computer systems and produce what is called a hash (a sequence of letters and numbers unique to the block) (ibid). Each block contains a timecode, transaction data and a unique cryptographic hash of the previous block. The system contains data from all preceding blocks to create a chain. If information inside any of the blocks is altered, the system sets up a chain reaction that could immediately freeze the whole system. Once the blockchain processes the data, every digital device connected to the network locks in simultaneously, creating a permanent and immutable online record.

de Villiers, Kuruppu & Dissanayake (2021), on the other hand, define Blockchain technology as a subcategory of a digital, distributed ledger, which decentralizes the control of information using an application of cryptography. Consequently, this produces three main outcomes:

1. Transparency- all authorized individuals can see, trace and verify information as a public record
2. Veracity- there is a guarantee that all transactions are accurate and complete.
3. Disintermediation- reduction of central authority in data management (meaning the system is not owned or controlled by anybody but is simultaneously owned and controlled by all parties involved).

Simply put, blockchain technology is a system that exhibits features such as security, transparency, data integrity, decentralization, inalterability, and anonymity with no central authority to control agreement. Due to these features, blockchain is perceived as a technology leading to significant disruptions in all industries, including health.

2.2 Definition of Health Information System

A health information system is vital in medicine, patient treatment, disease prevention and health policymaking. Koumamba et al. (2021) define a health information system as designed to manage all healthcare-related information. This includes applications and platforms that gather, store, manage and disseminate hospitals' administrative data, patients' electronic medical records or a system supporting health policy decisions. The Pan American Health Organisation (2023) also defines a health information system as an electronic system with open information collected from numerous sources and ethically utilized through Information Communication Technologies to produce strategic data for the benefit of public health. According to the World Health Organisation (2019), a health information system generates data that allows decision-makers at all levels to identify needs and challenges, make evidence-based judgments on health policies and distribute limited resources optimally.

Similarly, Koumamba et al. (2021) note that this system can be leveraged to improve patient outcomes, inform medical research and influence health policy outcomes. The quality of health care provision or the effectiveness of health policy making and health planning depends on the availability of reliable, timely and accurate data to support decision-making, which health information systems offer. A health information system is thus an essential component of a viable healthcare system.

Examples of Health Information System platforms include:

Electronic Health Records (EHRs)

These are longitudinal and comprehensive records of patient data in electronic form (Abdulai 2020). EHRs contain key clinical and administrative data, including medical test results, treatments, laboratory data, progress notes and demographics. These records are designed to share information with other digital platforms so that healthcare providers can access a patient's health data.

Practice Management Software

According to Davey and Davey (2015), Practice Management Software is a system designed to help hospitals with administrative and billing tasks. The system can also schedule patients' doctor appointments, process health insurance claims, and track patient records.

Master Patient Index

Prabath-Jayatissa et al. (2018) assert that the Master Patient Index system connects decentralized patient records across repositories. The system contains a record for each patient registered at a specific healthcare centre and indexes all other records for that patient. The Master Patient Index is also used to reduce duplication of patient records and inaccurate patient data that can result in insurance claim denials.

Patient portals

Patient portals give individuals unlimited access to their health information online. This information includes laboratory results, prescriptions, therapy reports, and referral letters. Vyas and Muzumdar (2022) note that some patient portals allow real-time communication between patients and doctors, prescription refill requests and the

ability to schedule appointments. Simply put, patient portals are online gateways for patients, providing quick, 24-hour access to health information from any place with an internet connection.

Clinical Decision Support system

The Clinical Decision Support (CDS) system is used to analyze data from various clinical and administrative systems to help physicians make informed clinical decisions (Sutton et al., 2022). The information generated from this system can help healthcare providers prepare diagnoses or predict medical events such as drug reactions (ibid). This system also filters data to help health practitioners care for individual patients. The benefits of using CDS systems include a reduction in medical errors, increased adherence to clinical guidelines and improved patient safety (Jia et al., 2016).

District Health Information System 2

The District Health Information System 2 (DHIS2) is an open-source health information management software used by governments around the globe. It is a platform used to gather, authenticate, examine and present comprehensive data tailored for various health activities such as early disease detection and notification, service availability mapping, supply chain management and health programme monitoring and evaluation (Dehnavieh et al., 2019). According to Farnham et al. (2023), the system provides accurate, timely, complete health data for health planning, patient monitoring, and disease surveillance. It speeds up health information access for health institutions, governments and other important health organizations.

2.2.1 The Importance of a Health Information System

Improves health data management

The health domain produces and utilizes volumes of data with the ultimate goal of providing quality services. Health surveys, patient information, research data, health insurance claims and other administrative data all contribute to this data. Even with proper and systematic management, data produced becomes reliable. Evidence suggests that centralized storage and retrieval of this data demonstrate the importance of organizing information into databases to improve secure information access and retrieval (Wagenaar et al., 2015; Amouzou, 2021; Farnham et al., 2023). Farnham et al. (2023) further note that as centralized repositories, health information systems enhance the secondary analysis of health data and provide stakeholders in the medical field with insights useful in identifying challenges and needs and making informed decisions.

Furthermore, the Interoperability of health information systems also enables better health data management. Interoperability of health information systems refers to the seamless exchange and use of health data between different hospitals, systems, stakeholders and applications. According to Wagenaar et al. (2015), the Interoperability of health information systems enables data exchange and optimizes health outcomes. This is because numerous health information systems can access, exchange, integrate and use vital health information in a standardized and meaningful manner.

Leads to informed decision-making

Amouzou et al. (2021) emphasize that health information systems facilitate improved decision-making through various platforms such as practice management software, electronic health records and CDS systems. CDS systems, for instance, utilize Artificial Intelligence (AI), statistical pattern recognition and Machine Learning (ML) to provide evidence-based recommendations to health practitioners to support health decision-making (Sutton et al., 2020). The CDS system encompasses a variety of functions such as disease management, drug-dose calculations, diagnostics and alarm systems that automatically remind healthcare providers of specific actions that need to be done (ibid). According to Lipton et al. (2011) alerts sent by CDS systems are of the main benefits of this technology. Similarly, Calloway et al. (2013) denote that these alerts are among the most commonly used decision-support tools in the medical domain. These alerts can remind clinicians of crucial medical events and guide them in tackling these situations. For instance, a study by Song et al. (2022) concluded that a CDS system can effectively monitor and manage hypertension according to specific protocols based on historical patient trends. The DHIS2 software can also support informed health decision-making by notifying health policymakers of the country's health indicators, which are key when planning and allocating resources (Dehnavieh et al., 2019). DHIS2 software enables policymakers to assess the quality and quantity of health care

services provided, which is important to effective health service delivery. The DHIS2 platform thus helps ensure stakeholders have access to information for forecasting and planning at both institutional and national levels.

Reduces medical errors

Ahmed et al. (2019) argue that medical errors are a major public health problem and a leading cause of death globally. Medical errors endanger patient's health and lead to poor health outcomes. These errors can range from misdiagnosis to administering the wrong drugs. In the United States of America (USA), medical errors are estimated to kill more than seven thousand patients annually. In contrast, the number is estimated to be even higher in developing countries (Wilson Law 2023). Reducing medical errors and improving patient safety are thus important goals in health care. Research evidence shows that implementing health information systems and proper health record management has great potential in reducing medical errors (Niyitunga, 2022; Mutair et al., 2021). EHRs, for instance, contain information that could easily highlight a patient's medical history. Access to these EHRs helps minimize preventable medical errors such as drug allergies. During the COVID-19 pandemic, Chilunjika and Chilunjika (2023) discussed the utility of EHRs and suggested that the Interoperability of these systems helped treat chronically ill patients.

Enhances operational efficiency

As an information-intensive industry, health institutions are constantly seeking ways to improve data management, leading to operational efficiency and quality health services. A major way health institutions seek to improve efficiency is by adopting digital technologies to manage data and automate administrative and clinical processes (Muinga et al., 2020). These technologies include patient portals, practice management software and hospital information management systems. One area where health information technologies can improve efficiency is patient registration and appointment scheduling. When patient data is captured electronically, errors are reduced, and data accuracy is enhanced. The use of patient portals, for instance, simplifies patient registration and facilitates efficient appointment scheduling, reducing patient waiting times. In their study on OnkoNetwork, a cancer patient management network in Hungary, Pitter et al. (2019) noted that using patient portals resulted in a seventy per cent reduction in average patient waiting time. This was achieved by using the platform's capabilities to fast-track appointment scheduling. A study by Reichert and Jacobs (2018) highlighted the adverse effects of long waiting periods in emergency departments on patient outcomes, including higher death rates. Reichert and Jacobs (2018) further note that efficient appointment scheduling facilitated by patient portals can help decrease these adverse effects.

Data accessed through health information systems also allows healthcare managers to allocate scarce resources based on hospital and departmental needs, which leads to operational efficiency (Adeleke et al., 2015). This data includes human resource management information such as the number of staff available, skills inventory, demographics and factors influencing health personnel recruitment and turnover. The availability of such information enables health administrators to utilize human resources efficiently, monitor performance and make strategic decisions on the available staff. Health information systems also support financial data's accountability, security, and integrity. If financial records are not correctly managed, there will be a proliferation of theft, embezzlement, and other related corrupt activities, which, in the long run, affect the delivery of quality health care (Niyitunga. 2023).

3 Methodology

This qualitative desktop review study aims to explore the opportunities and challenges of Blockchain technology in Zimbabwe's Public Health Sector. The methodology employed in this paper consists of three main procedures: literature review, search and selection of relevant sources and data presentation and analysis. The first procedure in this methodology involved conducting an unstructured comprehensive literature review to gain an in-depth understanding of the opportunities and challenges of Blockchain technology in the health domain. The review covered relevant scholarly papers, conference papers, books, reports, newspapers and other sources related to the opportunities and challenges of Blockchain technology in the medical field in developing countries, particularly in Zimbabwe. The next step focused on searching and selecting relevant sources that provide insights into the opportunities and challenges of blockchain in the health sector. The authors identified reputable sources such as scholarly articles, conference papers, books, reports, newspapers, and reputable online

literature. Keywords such as Blockchain technology, health domain, opportunities, challenges, developing countries and Zimbabwe were used to search. The selection process included screening the retrieved literature based on its relevance to the topic and research questions. Once relevant literature was identified, a thorough analysis was conducted to extract valuable information about Blockchain technology's opportunities and challenges in Zimbabwe's public health sector. This step also involved synthesizing, organizing and presenting the data obtained from various sources to gain a comprehensive overview of the opportunities and challenges of Blockchain technology in Zimbabwe's public sector.

3. Results

3.2 An overview of Zimbabwe's Public health sector

This section provides an overview of Zimbabwe's public health sector and some of the general challenges that this sector is facing. The Zimbabwean health system is structured based on the Primary Health Care Approach principles. What this means is that health is delivered at four levels, which are clinics, district hospitals, provincial hospitals and lastly, quaternary hospitals, which are meant to function as a referral chain (Muzvidziwa-Chilunjika and Chilunjika, 2020). Zimbabwe's health system is well defined in terms of hierarchy, with the Ministry of Health and Child Care (MoHCC) at the apex. The ministry is responsible for policy formulation and implementation, administration, and overseeing and coordinating all health programs and plans, amongst others (MoHCC, 2023). However, public health sectors in developing countries such as Zimbabwe are considered rigid due to their resistance to change and novel technologies. Over the past four decades, the government of Zimbabwe has implemented policies, reforms, projects and plans to revamp its public health sector and improve health service delivery (Muzvidziwa-Chilunjika and Chilunjika 2020). Despite these attempts, the performance of Zimbabwe's public health sector has continued to deteriorate.

McClure (2020) conducted a review to identify challenges that hamper providing quality healthcare in Zimbabwe's public health sector. They found out corruption, poor health information management systems, manual paper-based procurement and supply chain systems, weak leadership, poor financial management, and lack of ICT infrastructure and skilled personnel hamper the effectiveness of Zimbabwe's public health sector. Similarly, a study by Muzvidziwa-Chilunjika et al. (2020) on health system challenges in Zimbabwe reported that even though there have been attempts to improve the quality of health service delivery in Zimbabwe through different reforms, none of the strategies have resulted in desired goals due to resistance to change, corruption and poor health financing. McClure (2020) believes that the government of Zimbabwe will have to commit itself fully to ensure that implementing health reforms will result in desired health outcomes. Chilunjika et al. (2022) also highlighted a need to allocate adequate resources to improve the performance of public health institutions.

Additionally, there is a need for research to identify flaws within the entire public health system in Zimbabwe and the strategies and reforms that are needed to strengthen and revamp it. These strategies include adopting ICTs to improve the efficiency and effectiveness of the six health system building blocks (health information, health financing, health workforce, leadership and governance, health services and medical products). This is in line with the World Health Organization, which states that innovative strategies such as ICTs are needed to ensure the attainment of Universal Health Coverage in developing countries (Olu et al., 2019).

The next section discusses Zimbabwe's health information management system and its challenges. This is important in identifying the areas in which Blockchain technology has the potential to improve.

4.2 Zimbabwe's Public Health Information System and its shortcomings

The crux of any health information system is to guarantee that accurate data, in the correct format, is provided at the right time and placed to the rightful individual at the lowest cost possible. Given the health information system's outsized role in the medical field, it is imperative to explore the challenges that affect the effectiveness of this system in Zimbabwe's public health sector. Identified challenges include: manual data capturing, lack of Interoperability between health institutions, privacy and security concerns, inaccessible health information, untimely data reporting and poor quality of health information. These challenges are discussed in subsequent sections.

Manual data capturing

This study found out data capturing in Zimbabwe's public health sector is mainly done manually and that most public health institutions rely on the paper-based system. For instance, a study by Khumalo (2018) reported that Zimbabwe's national health information system has been plagued by incomplete data at national, provincial, district and clinic levels due to the paper-based record system. This system utilizes a variety of paper records, which are prepared at all clinics and compiled every month for submission to the district level, then to the provincial and ultimately the national level. However, this presents challenges to the system's efficiency due to persistent shortages of paper registers used for data capturing at the hospital level (Khumalo 2018). These constant shortages mean that data recording at all health system levels needs to be conducted more timely and regularly.

Moreover, incomplete health data from these paper forms compromises quality health policy making, planning and equitable distribution of inadequate resources to essential areas such as emergency responses and disease surveillance. A study by Madziwa (2019) also raised concerns over the incompleteness of health information produced from the manual paper-based system used in Zimbabwe's public health sector. This author stipulates that due to this system, there is limited reporting of morbidity and mortality statistics at referral hospitals. Moreover, statistics on postnatal care and sexual reproductive health indicators are not captured in this system (Chilinjika et al., 2022). Subsequently, the MoHCC needs a complete and accurate picture of the country's health status.

In regards to administrative functions such as Human Resource Management (HRM), a study by Gweshe et al. (2022) brought to light that the MoHCC heavily relies on a paper-based HRM system to maintain its employees' records, such as appointment forms, leave records, academic qualifications and other employee-related information. According to the Civil Service Commission, which is the human resource wing of the government of Zimbabwe, all employees' records should be kept at all levels of the ministry's bureaucratic structure, meaning every health worker has at least five paper files with the same human resource information. For example, a primary health care nurse stationed at a rural clinic will have their paper HR records at the parent clinic, district office, provincial office, head office, and Salary Service Bureau. This presents a risk to employee records management since paper files can easily be lost, damaged or not updated promptly. Additionally, Madziwa (2019) found out that financial management at some public health institutions, particularly those in rural areas, could be more efficient as financial records are recorded and stored on paper. Crucial challenges facing these health institutions include embezzlement of funds and manipulating financial records (McClure 2022). These alarming challenges impact the financial stability and operational efficiency of public hospitals in Zimbabwe. Consequently, leading to the provision of poor healthcare to most Zimbabweans who rely on the public health system.

The literature reviewed highlighted that patient information at public hospitals is also captured using the manual paper-based system (Masuku, 2019; Maphosa et al., 2019). For instance, a study by Madziwa (2019) revealed that patient notes in Zimbabwe are currently handwritten and kept in files and storage rooms for retrieval later. This system for capturing and storing patient information makes it difficult for clinicians to access critical information they need to provide necessary treatment to their patients. Moreover, important patient data is usually in different hospitals. Therefore, doctors cannot coordinate care or reduce medical errors. In line with this, Masuku (2019) recommends adopting digital technologies as they can transform data management in Zimbabwe by moving away from manual paper-based recording.

Timeliness of data reporting

The timeliness of health data reporting is also a major challenge in Zimbabwe's public health sector (Madamombe et al., 2022). Since 1992, the country's public health sector has been using the Weekly Disease Surveillance System (WDSS), a surveillance tool to provide early warning of potential public health threats and program monitoring functions that may be disease-specific or multi-disease (Khumalo 2018). This system, however, is characterized by delayed and inadequate reporting from the primary healthcare facilities to district, provincial and national levels due to paper-based recording. Marlowe et al. (2019) underscored that sending paper records from the lowest tier of the healthcare system to the national level can sometimes take up to a

month, thus affecting the timeliness of health data reporting. A study by Madamombe et al. (2022) also provided evidence of the lack of timeliness in the country's paper-based health information system when they noted that in 2020, four out of thirteen health facilities in Makonde District timely submitted forms that had one hundred per cent of the required data filled out. Similarly, Khumalo (2018) highlighted that the timeliness, completeness and accuracy of paper records submitted by health facilities vary significantly by district and province, suggesting that public health institutions in Zimbabwe are only sometimes meticulous when contributing to the national health information system. According to Khumalo (2018), this, in the long run, affects the analysis, interpretation and dissemination of health data needed for policy making, planning and distribution of limited resources.

Capacity

Lack of capacity is also a key challenge facing Zimbabwe's paper-based health information system. According to Khumalo (2018), most public health institutions lack the storage capacity to keep paper registers, files and patient records. Similarly, Niyitunga (2022) notes the poor storage of inactive health records in many African public hospitals. Health records are generally kept in dusty, insect-infested store rooms and outdated formats, meaning they only last briefly because they become fragile and deteriorate quickly. Additionally, Khumalo (2018) notes that Zimbabwe needs more health information officers to capture, analyze, and interpret health data efficiently, as a massive brain drain has rocked the country. Furthermore, the need for more human resource capacity development of the remaining health information officers impedes quality health information management in most public hospitals (Madziwa, 2019). As a result, weak human resources in health information management led to poor capturing and reporting of crucial health statistics, health emergencies and performance indicators at all health system levels.

Lack of Interoperability between health institutions

Efficient data sharing is one of the most important components of any viable health system. It is, however, worth noting that public hospitals in Zimbabwe need more innovative and efficient ways to share health data for better healthcare coordination. Masuku (2019) notes that health information in Zimbabwe's public health institutions is stored in different databases and has various formats and data types. Consequently, this results in an incomplete understanding of individual and population health needs, which leads to poorer health outcomes and higher costs. Moreover, this study established that there currently needs to be healthcare interoperability standards intended for all public hospitals across the country, meaning that each hospital has its standards, which sometimes do not match those used by other public hospitals (Masuku, 2019; Madziwa, 2019). This means that public hospitals in Zimbabwe use a different approach and language for collecting, storing and exchanging data. Lack of Interoperability between public hospitals detracts patients from getting proper treatment and further complicates the possibility of fighting diseases and achieving good health in Zimbabwe.

Privacy and Security concerns

The lack of the essential legislative frameworks, political willpower and capacity to deal with ethical concerns such as the security and privacy of medical records and consent to use patient data are recurrent challenges which appear in many health information management studies in Zimbabwe (Furusa and Coleman, 2018; Chilunjika, 2019; van Stam, 2021). Electronic health records, for instance, are susceptible to security and privacy breaches, which negatively impact their use in the health domain. In their study, Furusa and Coleman (2018) found out that patients and health personnel in Zimbabwe want the assurance that using electronic health records will not result in unauthorized disclosure of personal data as this is the backbone of a good relationship between the two parties. Unsecured health records thus pose a hazard to patients and health personnel, as patients may feel unsafe to openly discuss their accurate health conditions, which impedes proper diagnoses and treatment.

4.3 Possible benefits of Blockchain in Zimbabwe's public health sector

As noted in the preceding sections, there are many issues and challenges with the health information system in Zimbabwe, which could be profoundly beneficial if Blockchain technologies were integrated. These benefits include Data security, increased transparency, Interoperability, enhanced data availability and improved management of health records. These potential benefits are discussed below.

Increased transparency

The ability of blockchain to capture transactions on distributed ledgers presents novel opportunities for public health institutions in Zimbabwe to foster transparency, prevent corruption and build confidence in the public health domain. As already discussed, blockchain is a transparent technology with a trust-based framework that makes all health transactions traceable and visible to all participants in the healthcare delivery chain instantly. Any effort to manipulate a record in the blockchain could be easily detected. For instance, the immutable nature of Blockchain technology makes it ideal in health supply chain management systems. Currently, pharmaceutical supply chain management in Zimbabwe is marred by many loopholes where anyone can forge documents or alter or remove evidence of corruption (Chilunjika et al., 2023). Adopting blockchain helps ensure that pharmaceutical supply chain logistics information avoids uncontrolled adjustments. This increases trust and prevents the unlawful handling of records, payments and drugs by various pharmaceutical procurement parties.

Additionally, this technology can help maintain accurate financial records in the financial management process (Alhadhrami et al., 2017). Traditional financial management in Zimbabwe's public health sector involves a lot of manual processing, and accounting information is easy to tamper with, resulting in data distortion, fraud, and theft of funds (Chilunjika, 2012). Unique features of blockchain, such as timestamp mechanisms, provide effective data traceability and auditability, meaning all financial records on the blockchain can be tracked against time stamps and will not be erased. Blockchain also streamlines financial operations by reducing reliance on intermediaries such as third-party providers and vendors, reducing administration costs (Pandey and Litoriya, 2020). Eliminating middlemen also helps to process transactions more transparently and significantly faster than manual methods. A study by Chilunjika et al. (2023) on pharmaceutical procurement in Zimbabwe revealed that using third parties creates widespread corruption, which manifests through bribes and kickbacks. Consequently, this leads to the procurement of sub-standard medicine and vaccines, which are detrimental to the health of Zimbabweans. Blockchain in this critical area in health can help address corruption by providing a transparent track record of pharmaceutical procurement transactions.

Data Security

Data security, privacy, sharing and storage issues are paramount concerns associated with health information management in Zimbabwe (Chidhau et al., 2021). Patient management, particularly, hinges on sharing patient information among various hospitals and physicians, which may result in data loss, data theft and unauthorized access. Adopting a technology (Blockchain) that can reduce these challenges would be an ideal move for public health institutions in Zimbabwe to ensure patient data security. Blockchain platforms work with standard algorithms and protocols for data encryption and cryptography, allowing for secure and controlled data sharing (Matlebjane and Ndayizigamiye, 2022). In the modern world of online health data, there have been tremendous efforts to breach information, including patient data, clinical trials, insurance information and imaging around the globe (Teli and Masoodi, 2021). In their study, Teli and Masoodi (2021) reported numerous health data breaches in which over one hundred and fourteen million people have been affected. Blockchain, with its data encryption characteristic, can make hacking very difficult since no one can access data without the consent of all parties concerned, thus its usefulness in the medical domain. Dubovitskaya (2019) also submits that public health institutions can use the Keyless Signature Infrastructure (KSI), a blockchain-based application that protects online health records from hackers and internal misuse. This application provides data security in the health domain while ensuring the privacy of health information (Dubovitskaya, 2019).

Better and Improved management of health records

Porous paper-based health information systems, manipulation of data, untimely reporting, and information access constraints have impacted the quality of health services in Zimbabwe, resulting in high mortality rates (Muzvidziwa-Chilunjika and Chilunjika, 2021). Blockchain technology can improve health records management, providing physicians and patients with centralized and real-time access to their medical history (Capece and Lorenzi, 2020). Because it enables the establishment of easily accessible centralized data, Blockchain technology improves the quality of healthcare services (ibid). Clinicians can use this technology to sync all of their patient's health records in real time; consequently, time is saved, and patients are treated more efficiently. It also improves and promotes health records governance, allowing health information systems to be more interoperable, secure and effective (Chen et al., 2019). For example, in Tanzania, AID: Tech, an

Ireland-based organization, has launched a Blockchain platform designed to provide a secure and transparent system for the management of health records and payments (PharmaAccess, 2018). This system also helps health institutions minimize fraud and improve the accuracy of health financial records. The successful implementation of this technology in a developing country like Tanzania can suggest that if adopted and implemented, Zimbabwe can yield similar benefits.

Improved Interoperability of health information systems

Blockchain-based healthcare systems can address interoperability challenges in Zimbabwe's public health domain. Lack of Interoperability hinders the delivery of timely health services as the right data is not made available at the right time to the right people. According to Mittal and Thakur (2018), restricted data sharing among health institutions results in a loss of 150,000 lives and US\$18.6 billion annually. This statistical evidence warrants the need for health systems to share information seamlessly. Blockchain technology has been proposed to provide secure Interoperability and organize access to health records through patients, third parties and healthcare providers while maintaining the privacy, security and integrity of crucial health data. Kenya is a developing country that has harnessed blockchain technology to improve the Interoperability of its health information systems. Through its Medixus Blockchain-based platform, hospitals and health personnel can communicate and collaborate securely (Omnia Health 2023). The system also provides a transparent and secure platform for sharing patient data such as imaging and prescriptions, enabling more efficient and faster healthcare provision (ibid). Interoperability of health information systems is therefore crucial as it facilitates communication and the sharing of health data in a standardized and meaningful manner.

Sound pharmaceutical supply chain management

One of the main benefits of Blockchain technology in the health domain is its ability to improve the pharmaceutical supply chain. Contemporary pharmaceutical supply chain systems are complex, involving numerous players (manufacturers, suppliers and customers) across the globe (Zakari et al., 2022). The digitalization and online sale of medicines have also opened doors to the production of counterfeit pharmaceuticals, lowered quality and untraced transportation of medicines. Authors such as Bocek et al. (2017) and Zakari et al. (2022) proposed that blockchain would help trace the origins of medical products and track their movement throughout the supply chain process. This safeguards suspicious and counterfeit drugs from entering the distribution chain. Uganda is one African country that has successfully adopted blockchain technology to improve its pharmaceutical supply chain. It uses the Mediconet Blockchain platform to track the distribution of medicines and other pharmaceutical supplies (Omnia Health, 2023). According to Omnia Health (2023), Mediconet allows for the tracking of drugs from manufacturers to the patient, which helps reduce the incidence of counterfeit products and improves the overall efficiency of the health system.

Blockchain technology can also address security concerns through the use of cryptographic technologies which validate blocks of pharmaceutical transactional information (Bocek et al., 2017). It also addresses the falsification of medicines through serialization (Botcha et al., 2019). For instance, when using blockchain, the entire pharmaceutical supply chain has verification checks that authenticate serial numbers. Blockchain also enhances medicine traceability to prevent theft and quality control is achieved through digital signatures. This technology also enables pharmaceutical developers and manufacturers to run clinical trials and share medical samples in a secure environment (Chiacchio et al., 2020). In addition, it improves accountability and transparency in clinical trial reporting as each stage is time-stamped.

4.2 Barriers to Blockchain Adoption in Zimbabwe

To discuss the challenges hampering the adoption of Blockchain in Zimbabwe, this paper adopted the Technology, Organizational and Environmental TOE framework by Tornatzky and Fleisher (1990). Researchers have widely used this theory to study IT adoption. This theory uses three factors to identify IT adoption decisions: technology, organizational, and environmental. As such, this paper categorizes challenges hampering the adoption of Blockchain in Zimbabwe into technological, organizational and environmental themes. These challenges are discussed in subsequent sections.

Technological challenges

Regarding ICTs, the technological context involves technical skills and the complexity and development of technologies for adoption. Numerous scholars have agreed that technological challenges hamper adopting and implementing Blockchain-based applications in the health sector (Capece and Lorenzi, 2020; Chukwu and Garg, 2022; Ghosh et al., 2023). Blockchain is still in its infancy, so it is vulnerable to technical errors and unreliability. Hence, it has yet to be widely adopted in developing countries. Other technological challenges of Blockchain technology include scalability, cost of IT equipment, data integrity and security, time of transaction processing and Interoperability. Consequently, this technology must generally accept technical standards to ensure its Interoperability and the data's consistent formats across different Blockchain platforms (Ndayizigamiye and Dube, 2019).

Ndayizigamiye and Dube (2019) also add that inadequate accessibility of IT infrastructure among users impedes stable and effective Blockchain implementation and use. Similarly, Chilunjika and Chilunjika (2023) submit that most developing nations, Zimbabwe included, need better IT infrastructure to support the full and sustainable adoption of advanced technologies such as blockchain. Investment in IT infrastructure is thus an important factor if Blockchain technology is to flourish in developing contexts. The dearth of IT experts due to the massive brain drain witnessed in Zimbabwe is also a significant technological barrier to Blockchain implementation (Furusa and Coleman, 2018). The complexities of this technology, coupled with the need for IT experts, present problems for health institutions in Zimbabwe in adopting and implementing it.

Organizational and Environmental challenges

Dowelani et al. (2022) and Akinradewo et al. (2022) mentioned organizational challenges such as resistance to change, organizational readiness, status quo mindset, inter-organizational connectedness and poor management support as key organizational challenges hampering the adoption of blockchain. Other key organizational challenges highlighted in the literature include a lack of integration with the existing system, uncertain return on investment, lack of funding and inadequate infrastructure (Biswas and Gupta, 2019). Organizational culture in organizations plays a significant role in the adoption of innovations. In their study, Boore et al. (2017) note that corporate culture guides employees through work discipline and expected behaviour towards change. Resistance to change, for instance, acts as a barrier to Blockchain adoption. Organizations and employees usually vacillate to replace or change traditional ways of doing business, creating a major obstacle to Blockchain adoption (Dowelani et al., 2022).

Lack of funding is also a major obstacle to Blockchain adoption in the public health domain (Matlebjane and Ndayizigamiye, 2022). Many ministries of health in developing countries face the need for more monetary resources to furnish public health institutions with advanced technologies such as blockchain due to limited budgetary allocations from the government (Chilunjika and Chilunjika, 2023). In Zimbabwe, the Ministry of Health and Child Care is generally allocated a budget below the Abuja Declaration target of fifteen per cent of the national budget. For example, over the seven years covering from 2015-2021 on average, the country's budget contributed thirty-five per cent of the total actual health spending, while donor partners contributed sixty-five per cent (UNICEF, 2021). This evidence shows that health financing through the government needs to be higher in Zimbabwe, thus hampering the adoption of technologies such as blockchain in the health domain.

Lastly, environmental factors such as lack of political will, poor governance, weak regulations, security and privacy concerns, ecosystem readiness, ecological costs and intellectual property were highlighted by Dowelani et al. (2022) as key environmental obstacles hampering the adoption of blockchain in developing countries. Scholars such as Katuwal et al. (2020) and Matlebjane and Ndayizigamiye (2022), for instance, mention governance issues and lack of clear regulations as substantial challenges for Blockchain technology adoption in developing countries such as Zimbabwe. Since Blockchain technologies represent a significant shift from traditional data management, clear regulations are crucial for successfully implementing these technologies. However, several studies, such as Katuwal et al. (2020) and Matlebjane and Ndayizigamiye (2022), have emphasized that numerous nations still need to be ready to adopt blockchain due to a lack of effective regulation. Matlebjane and Ndayizigamiye (2022) also add that Blockchain-based applications have specific features that should be assessed regarding compliance with data governance frameworks, laws and regulations. The ambiguity about Blockchain regulation issues in most countries creates hesitation among users and stakeholders,

which serves as an obstacle to the widespread adoption of this technology. Effective Blockchain regulations ensure stakeholders can collaboratively participate in decision-making based on their shared trust and established rules, which helps reduce unlawful activities and cybercrimes. In this regard, effective regulations, guidelines, policies, and corresponding enforcement is necessary to ensure proper governance of Blockchain applications in the health domain.

Conclusion and Recommendations

This study explored the opportunities and challenges of implementing Blockchain technology in Zimbabwe's public health sector. The paper began with a conceptual analysis of both health and Blockchain literature, which aided in understanding the role of health information systems and Blockchain technologies and their impact on the provision of health care. The study found that health information systems are vital tools needed to support diagnosis and treatment of patients, health planning, decision making and the allocation of resources. It was also established that poor data management and the use of manual paper-based health information systems continue to impede the provision of health in Zimbabwe, undermining the well-being of Zimbabweans. The paper also found that Blockchain technologies are beginning to lay a path for a new revolution in traditional health information systems in Africa and have the potential to play a more significant role in the future. The underlying characteristics of blockchain can facilitate data management, data security and data integrity. It enables easy access and sharing of health records, allowing timely and better treatment of patients. Blockchain technologies also aid in combating corruption, embezzlement of funds and the proliferation of counterfeit drugs, which plague the Zimbabwean public health sector and hinder the delivery of quality care. Given this, the Ministry of Health and Child Care, together with the government and other relevant stakeholders, should invest in the deployment of this important technology. Effective guidelines, policies, and corresponding enforcement should be implemented to ensure the proper use and governance of blockchain in the health sector. Finally, adequate research should be conducted before the adoption of Blockchain in Zimbabwe to establish their feasibility.

As a new technology, and since there is still a need for more data to assess the impact of Blockchain on HIS in Zimbabwe, this study provides valuable insights that health policymakers can use before its adoption and implementation. This is because the implementation of blockchain in developing countries needs to be prudently planned and managed to realize its full benefits.

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