E-health System Security Issues and Block chain technology in Kenya

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Abstract:

The adoption of e-health is, amongst other things, seen as potential leverage in responding to problems concerning the healthcare sector globally. Technological advancements have accelerated the deployment of ehealth systems with the potential to enhance productivity, lower costs, reduce medication errors, and ease the manpower strain on the healthcare industry. Faced by a confluence of onerous challenges including escalating healthcare costs, ageing populations and the advance of technology as well as the need to provide effective and efficient healthcare services, developing countries today are turning to ehealth as the silver bullet or panacea. However, despite the significant investments made, to date, many of these e-health solutions have yet to prove their success. Interoperability and security of ehealth systems are cited as some of the challenges in regard to the usage of the systems. By analyzing existing literature using scoping review research approach this paper explored the potential use of blockchain technology in improving the security and interoperability of ehealth systems for the benefit of different stakeholders in the healthcare sector in developing countries such as Kenya. To achieve our main objective, five databases were searched and 184 papers screened for inclusion. As a result of the search and screen process, we identified 23 relevant articles.

Keywords: *Blockchain, ehealth, Interoperability, Security*

1. Introduction

In recent years, the proliferation of mobile computing devices has driven a revolutionary change in the computing world, where ICTs have been adopted for purposes of sharing healthcare expertise across the world. In the healthcare sector the implementation of ICT is perceived as the main driving force in the unfolding healthcare reforms in many developed and developing countries [10]. It is perhaps not an overstatement to state that among the most pressing problems confronting nations today such as poverty and climate change, the health and well-being of populations is of central importance and consumes significant national resources [2]. Developing countries including Kenya bear the brunt of the non communicable diseases. These countries are under pressure to offer quality healthcare services in the midst of shortage of skilled healthcare professionals. E-health systems a key component of medical informatics symbolizes potential solutions for enhanced healthcare. E-health is referred to as the cost-effective and secure use of ICT in support of health and health-related fields, including health care services, health surveillance, health literature, and health education, knowledge and research [20]. It consists of ICT applications that boost disease prevention, timely patient diagnosis, and enhanced patient management [2], [10]. Primarily these applications include electronic Medical Records (EMRs), Telemedicine, Health Knowledge Management, Consumer Health Informatics (CHI), M-Health

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and Healthcare Information Systems (HIS). It is observed that the utilization of ICT applications in healthcare is merely not just about innovation, but rather a means to attain a progression of better outcomes, for instance, health workers settling on better treatment choices and doctor's facilitated to give higher quality and more secure care[2], [20], [22].

Effective ehealth systems should allow healthcare providers to better engage with patients, make more efficient and accurate decisions about care, and streamline provider workflow in real-time [10]. Using ehealth systems, providers should be able to longitudinally and accurately store data through a shared network of information exchange. Further, ehealth systems should help to improve reliability in patient records by ensuring integrity and security of patient data through authentication and various level of access authority [2], [10], [4]. Similarly, evidence in the literature also indicates the system's capability to improve safety in the healthcare by supporting better decision-making in patient treatments. However, in the healthcare sector, the biggest impediment to effective ehealth systems usage in provision of seamless continuum of healthcare is lack of interoperability of ehealth systems used by patients, payers, health service providers and security of patient's clinical data. The lack of integration of clinical data makes it difficult for the providers to access timely information to promote enhanced patient care [2]. Furthermore, in the healthcare context, ehealth systems require to work jointly within and across organizational boundaries in order to advance the effective delivery of health care for individuals and societies as well as enable cost savings, and efficiencies [5]. Additionally lack of integration makes it challenging to maintain the privacy and security of patient's confidential information.

Security of the ehealth systems is a matter of concern especially where patient's data is transmitted over a network [4], [22]. Blockchain technology presents a promising solution to solving ehealth systems interoperability and security issues in developing countries. Blockchain is a decentralized, trustless protocol that combines transparency, immutability, and consensus properties to enable secure, pseudo-anonymous transactions stored in a digital ledger [6]. Invented by Satoshi Nakamoto in 2008 for use in the cryptocurrency bitcoin, as its public transaction ledger, the working processes of blockchain entail a sending node recording new data and broadcasting to network [7]. The receiving node checks the message from the data it received and if the message is correct it stored to a block. All the receiving nodes in the network execute proof of work or proof of stake algorithms to the block. The block is stored into the chain after consensus algorithm is executed, every network node admit the block and incessantly extend the chain base on this block [1]. As records are added to the blockchain they are ordered in blocks and each block contains timestamp links to the related blocks [8]. In a blockchain system, there is no central authority; instead, transaction records are stored and distributed across all network participants [9]. The blockchain preserves incessantly distributed and immutable list of records, hence records in a blockchain are easily verifiable and secure. In addition, blockchain relies on established cryptographic techniques to allow each participant in a network to interact without preexisting trust between the parties. Interactions with the blockchain become known to all participants and require verification by the network before information is added, enabling trustless collaboration between network participants while recording an immutable audit trail of all interactions. It is for this reason that many systems built on the blockchain technology achieve secure distribution of entities amongst untrusted nodes. In health care industry, the blockchain technology has the potential to address the interoperability and security challenges currently present in ehealth systems [13], [22]. The technology has the ability to provide technical architecture that enables individuals, health care providers, disparate entities and researchers to securely share electronic patient's data across multiple platforms [7], [3], [9], [22]. This paper

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explores the use of blockchain technology as a solution to solving ehealth systems interoperability and security challenges in developing countries such as Kenya. The following research questions were explored

i.) How is the blockchain used to provide secure interoperable ehealth systems?
ii.) What are the benefits of using blockchain technology in ehealth systems?
iii) How can an ehealth blockchain be used to manage non communicable diseases?

2. Research Approach

This study employed a scoping review in order to determine the current challenges of ehealth systems and potential solutions aim at addressing interoperability and security challenges of different ehealth systems using blockchain technology. A scoping review is defined as a "form of knowledge synthesis that addresses an exploratory research question aimed at mapping key concepts, types of evidence, and gaps in research related to a defined area or field by systematically searching, selecting, and synthesizing existing knowledge"[7]. A scoping review was selected as it allows the researcher explore the nature, extent and range of research activity, determine the value of undertaking a full systems review, identify research gaps in the existing literature and summarize and disseminate research findings [11]. The scoping review was considered appropriate as use of blockchain in the healthcare industry is on it early stage.

2.1 Scoping Process

In conducting the scoping review, the process involved a formal and detailed review protocol to address research questions. As recommended by leading methodologists, the protocol was not rigid tool to be used in a strict manner [7]. In contrast, it served as a guiding framework, which was modified as the researcher saw fit. In line with the scheme of a scoping review, the objective was to conduct comprehensive overview of prior work relevant to the research questions but willingly excluded even high quality papers on blockchain technology if they did not help answer the research questions. The process involved defining sources of research to search, ways of accessing them and the rudimentary criteria for inclusion and exclusion a single paper [7] [14]. As this research focus was on scientific knowledge on the application of blockchain technology on ehealth systems, the research was only interested on scholarly literature and hence excluded ideas, visions and manifold statements of blockchain proponents. To have the best possible scoping review outcome different databases were searched. The databases comprised Emerald, ACM, IEEEXplore, ScienceDirect, MIS quarterly and SpringerLink. For the purpose of quality assurance, all working papers and workshop proceeding to be published were not considered and we retained only published academic work in conference proceedings and scholarly journal articles. The databases were selected to cover the fields of the multidisciplinary research topics. The search was conducted in 2017 and 2020. At first all the health related databases were searched using the term "blockchain" and the technological databases were searched for "blockchain" AND "e-Health". To maximize the breadth of coverage and due to novelty of the concept of blockchain time restriction was excluded on the search. However, only papers written in English were included. All the selected papers were read and those papers that were not targeting the focus area were expunged from the abstract. A set of 22 papers were used to provide contents on the target focus area. Figure 1 gives a picture of the numbers of papers emerged from the selection process. In summary, a wide-range of literature that provided input to content analysis emanated from various disciplines and databases.

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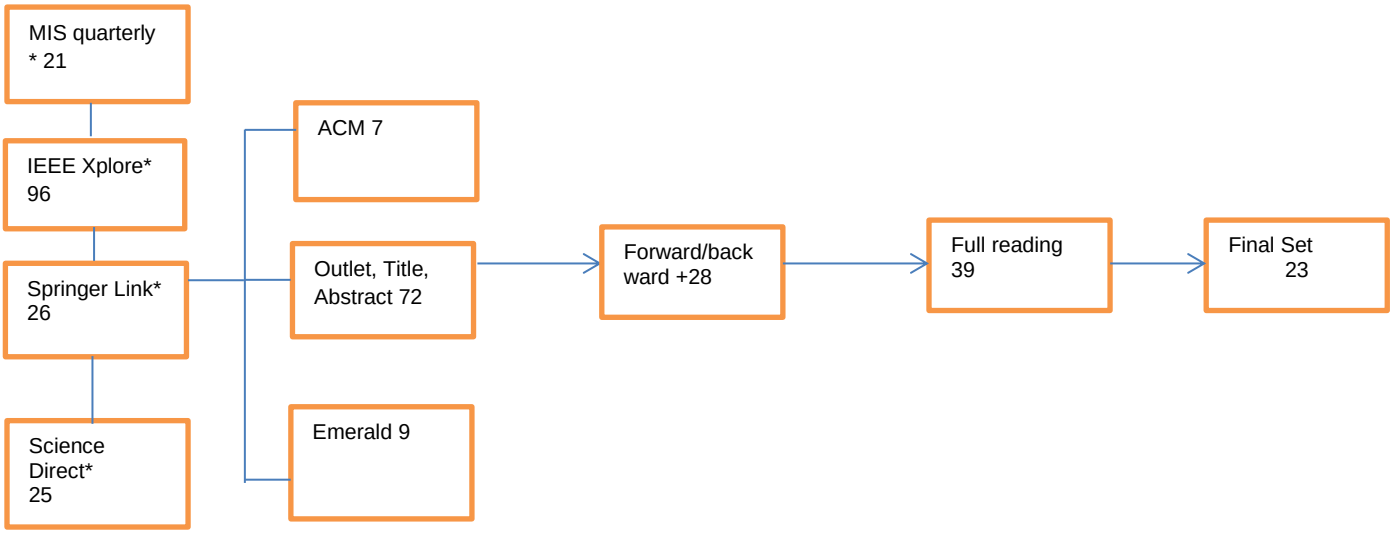

Figure 1. Literature Selection Process

3. The Kenyan Healthcare sector

The healthcare sector encompasses the public and private healthcare system. The private healthcare sector includes private for-profit, NGO, and faith based facilities. Generally the healthcare services are delivered through a network of over 4,700 health facilities countrywide, with the public health sector system accounting for about 51 percent of these facilities. Health is currently a devolved function thus there is need to have the two tiers of governments sharing patient's clinical data to enhance continuity and care. The healthcare sector is acknowledged as having lagged behind other industries, for example the financial sector, in the usage and implementation of new information technologies [2], [10], [22]. Manual processes represent a substantial part of the processes [2].These systems suffer from lack of data ownership, poor data quality, poor data security and backup procedures and consequently rarely used for decision-making. Thus this poses challenges when reporting what is really happening in the health care to support disease surveillance, planning, clinician and strategic decision making [2], [22]. In respect to ehealth systems in Kenya, hospitals have different applications of ehealth systems. Some hospitals have developed their own systems while others purchased ready-to-use applications. The disparate systems are not able to share data and patients get limited benefits from the existing ehealth systems. Lack of data interoperability is detrimental to using new diagnostic technologies. In addition, patients are not confident about the security and privacy of their data. Therefore, in addition to putting up policies and laws needed to support the integration of the ehealth systems various institutions require embracing some of the new emerging technologies to increase the interoperability and security of such systems such as blockchain or distributed ledger technology. Blockchain provides a technical standard that enables individuals, health care providers, health care entities and medical researchers to securely share electronic health data [7], [16], [22]. In essence, blockchain technology is useful in an area such as ehealth systems where: (i) multiple stakeholders are involved. (ii) trust is obligatory between parties than currently exists. (iii) to increase trust or efficiency an intermediary that could be omitted or removed. (iv) there is a need for reliable tracking of activity and (v) there is a need for data to be reliable over time [7], [11], [13].

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4. E-health systems interoperability and Blockchain

Healthcare practitioners and researchers today, nevertheless, struggle with fragmented data, delayed communications, and medical workflows caused by vendor specific and incompatible health systems, making it hard to provide personalized care [4]. A fundamental problem is the lack of a trusted link that can connect these independent ehealth systems together to establish an end-to-end reachable network. In an interoperable healthcare environment, ehealth technology platforms, and other software applications should be able exchange data seamlessly, and use the shared data across healthcare stakeholders [8], [19]. Blockchain being a decentralized peer-to peer architecture has emerged as a promising means to provide trusted interoperable health systems. A blockchain has the ability to collect information from web-based and mobile applications, as well as application programming interfaces (API), sensor technologies and integrate through representational state transfer (REST) [7]. Consequently, a ehealth blockchain is likely to promote the development of a new breed of essential applications for healthcare providers that would mine the latest medical research and develop personalized treatment plans [6], [5]. The healthcare provider and patients would have access to the same information and would be able to engage in a collaborative, informed discussion about the best-case treatment options based on research rather than guess work. Combining health data from other applications with data from traditional ehealth systems and genomics can offer medical researchers increased capabilities to classify individuals into clusters that respond well to a specific treatment or who are more susceptible to a particular disease [7], [18]. Daily, personalized health data is likely to engage a patient more in their own health care and improve patient compliance. Moreover, the ability for physicians to obtain more frequent data would improve individualized care with specialized treatment plans based on out comes or treatment efficacy. Furthermore, use of blockchain in ehealth systems ensures continuous availability and access to real-time data. Real-time access to data can improve clinical care coordination and improve care in emergency medical situations [16], [15]. Real-time data can allow researchers and public healthcare resources to rapidly detect, isolate and drive change for environmental conditions that impact public health. For example, epidemics may be detected earlier and contained. The real-time availability of patient's data from the blockchain may facilitate continuous, 24 hour-a-day monitoring of high risk patients and drive the innovation of essential applications that notify care givers and healthcare providers if a patient reached a critical threshold for action. Consequently, healthcare care providers may then reach out to the patient and coordinate treatment options for early intervention [7], [18].

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5. E-health system's Security and Blockchain

Security elements comprise confidentiality, integrity, and availability of information when needed. The decentralized nature of the blockchain combined with digitally signed transactions ensures that an adversary cannot pose as the user or corrupt the network as that would imply the adversary forged a digital signature or gained control over the majority of the network's resources [14], [17]. Similarly, an adversary may not be in a position to learn anything from the shared public ledger as only hashed pointers and encrypted information would be contained within the transactions. Moreover, the blockchain distributed architecture is built-in fault tolerance and disaster recovery. Data is distributed across many servers in many different locations. There is no single point of failure and it is unlikely a disaster can impact all locations at the same time [15].Confidentiality is virtually indisputable in blockchain. Using blockchain, the patient can have full access to the data and control over how the data is shared and maintain patient's privacy and security of data [17], [19]. Further, blockchain relies on established

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cryptographic techniques to allow each participant in a network to interact without preexisting trust between the parties. Due to the encryption of the blockchain information, patient's privacy is preserved when it is passed between stakeholders. Information is accessed by the stakeholders who only posses the correct cryptographic keys. Moreover, each of the stakeholders can trust that the information they have is accurate because each has an unbroken chain that is identical to the other chains and that they can audit to ensure its integrity [1], [7]. For instance, patients who are part of the blockchain would be able to approve or deny any sharing or changes to their data, helping to ensure a higher level of privacy and greater consumer control. Further, identity authentication using blockchain technology follows the best practices established by financial institutions and regulators [5], [19]. Besides, blockchain permits scheming smart contracts: contracts between several parties. These contracts activate defined actions. As a result, a record captures an event becomes part of the blockchain if and only if significant effort is made by players in the network validating its genuineness and authenticity [9].

Further, integrity of data is ensured using blockchain. This is mainly achieved by employing consensus protocol and cryptographic primitives such as hashing and digital signatures [16]. Use of hashing and digital signatures makes patient records or data almost impossible to manipulate, auditable and easily accessible with public and private keys and in essence security is totally guaranteed [7], [12]. Blockchain technology guarantees that the effort needed to change a record for instance for the purpose of committing crime at all times surpasses the gains or benefits that result from efforts to change the record. Consensus of networks is mandatory and alteration of records becomes almost impossible. This lessens motivation of any person or group to alter a blockchain record hence blockchain is accurate and authentic [21], [19], [22]. In essence, blockchain works with standard algorithms and protocols for cryptography and data encryption. These technologies have been heavily analyzed and accepted as secure and are widely used across many industries which can also be applied in health sector.

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6. Potential Use of an ehealth blockchain in management of Non-Communicable diseases in Kenya

Although the burden of disease in developing countries continues to be dominated by communicable diseases, countries are undergoing a demographic transition leading to increasing prevalence of non-communicable diseases. Non communicable diseases are posing an increasing challenge for healthcare systems, as it requires life-time monitoring of patients. The patients need to maintain their medical history and should also be able to share or access their medical data throughout the treatment and post-treatment monitoring. In practice, these patients may visit multiple medical institutions for treatment. According to the existing data protection act 2019 a patient is given a right over his health information and the subject has rights on who is to access the health information [23]. Therefore, owing to the patient's mobility, data management generated every time a patient visits different hospitals can be cumbersome particularly given the sensitive nature of the clinical data. The challenge is how to ensure that the patient's data is stored securely, complete and can be accessed only according to the patients consent in a fast and convenient manner. Quality healthcare service requires timely access of patient's clinical data by the clinicians. Thus an innovative ehealth system may combine all the clinical history and this can assist clinicians to use the medical data and develop specific care plan for the patients. Different types of data stored in the ehealth systems can be structured depending on the clinician's request and exported in pdf format. The documents that contain the patient's data such as history and physical exams, laboratory results, radiology tests and treatment plans are of high importance for the clinicians and are most commonly used in enhancing decision making on

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the diagnostic and treatment of the patients. However, the current state of affairs in Kenya is that the existing ehealth systems are not interoperable thus sharing of data among healthcare institutions is difficult. There exists no mechanism that enables healthcare institutions to share patient's clinical data. The nature of our patients is that they seek treatments in different healthcare institutions at different times as need arise. This may be either in private or public healthcare institutions. As it is each institution creates and maintains its own medical records each time the patient visits the facility. The lack of integration of ehealth systems among institutions hampers timely sharing of patient's clinical data thus hindering effective management of the subjects. This creates a lack of continuity of treatment incase the patients are treated in different facilities as access to the previous clinical notes is hampered. Moreover, with this approach, it is both costly as the subject as to meet costs of new tests for treatments as well as difficult for the patients to maintain any access control of their data and to have a complete view of the data. From extant literature it is evident that blockchain technology offers a secure sharable platform for patient clinical data from all devices, both at rest and in transit [9].

7. Advantages of Using Blockchain Technology in ehealth Systems

Evidently from the existing literature the challenges of interoperability and security of ehealth systems in developing countries can be surmounted through application of blockchain technology. Consequently, overcoming these challenges provide unique benefits to support healthcare. These benefits includes using shared distributed ledger which provide traceability and guarantee patient's privacy as well as the transparency of the data aggregation process [3], [4], [8].Completeness of information, presently patients clinical data is held by different services providers without full consent of patient. Patients are not also allowed to contribute and correct errors in their own data or share their information with new practitioners. Use of blockchain enables patients to access their information, correct errors and share information with other stakeholders [21]. Sharing the ledger for instance using the permission-based approach among stakeholders such as medical institutions, medical doctors, insurance companies and pharmacies facilitate medications and cost management for a patient [17], [19], [12]. Providing pharmacies with accurately updated data about prescriptions improve the logistics. Access to a common ledger permits the transparency in the whole treatment process, from monitoring if a patient follows correctly the prescribed treatment, to facilitating communication with an insurance company concerning costs of medications and treatment [6], [8].Shared information as evidenced in the literature can enhance safety in the healthcare by supporting better decision-making in patient treatments and also extract medical data and facilitate both personal and population-based research [9], [1], [3]

8. Conclusion and Further Research

The objective of this paper was to offer blockchain technology as a suitable platform to overcome security and interoperability challenges of ehealth systems in Kenya. Blockchain provides an opportunity for implementer of ehealth systems to overcome these challenges. The promise of blockchain is to make it possible for efficient information sharing among stakeholders and protecting patient privacy and ensuring data integrity. Presently implementation, of ehealth systems in many developing nations have been met with significant resistance for many valid concerns such as security and privacy of patient's records. We contend though that these legitimate concerns should not forestall the benefits of ehealth systems and thus a new approach and advanced solutions needs to be developed rather than totally abandoning the idea of ehealth systems as being too complex. In this paper, we argue that blockchain technology has the capability of addressing the current shortcoming of ehealth systems, core being security,

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interoperability and privacy. However, we advocate that, unresolved problems around the use of blockchain technology such as user resistance need to be addressed. Future work related to this research would focus on the adoption of ehealth systems architecture based on blockchain in a developing country.

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