A Framework to Integrate Healthcare Records in the South African Public Hospitals Using Blockchain Technology

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Abstract

In the public sector in South Africa, health records are not integrated into a single system and a new file is opened every time a patient consults in a different hospital. This compromises the quality of the medical services as the doctors diagnose a patient without the medical history. At times, healthcare providers find it difficult or impossible to treat the patients without access to the medical history of patients because it involves high risks that include repetition or duplication of treatments and prescriptions. This study conducted literature review to demonstrate a need for a framework which involves the use of blockchain technology for security to integrate healthcare records in the South African public hospitals. It was established that one of the elements that impedes the integration of the health records in South Africa is security of information. A framework that enables public hospitals using blockchain technology for security to integrate health records is suggested. The framework enables public hospitals anywhere in the country to access the complete, accurate and secure health records of a patient, irrespective of where the file was opened. Blockchain can be used to secure such information so that when health records are integrated, a complete, accurate and secure medical history can be generated. In that regard, a health record of a patient can be accessed and added anywhere in the country, leaving a digital trail for a system that can be trusted inherently.

Keywords: Health Records, Medical Records, Healthcare, Patient Records, Blockchain Technology

Introduction

One of the provisions of quality healthcare is a complete set of data that provides a full "picture of the patient's story". This is usually achieved through an Electronic Medical Records System (EMR) (LeSueur, 2017). This is because healthcare institutions like other organisations need a system that can assist them in supporting the implementation of a framework for governance in order to properly run their healthcare service delivery business (Masegare and Ngoepe, 2018). However, lack of integration of healthcare systems, especially in countries such as South Africa, prohibits government from offering quality healthcare to citizens. Many commentators lament of health records that are not integrated into a single system and a new file is opened every time a patient consults in a different hospital. For example, in a study by Marutha (2016) it was established that even within one province in South Africa, health records are not integrated. As such, a new file is opened every time a patient consults in a different hospital within the same province. This is even worse if a patient has to consult in a different province. As a result, this compromises the quality of healthcare as a medical practitioner diagnoses a patient without the full medical history.

Difficulty in accessing health records always affects timely access to healthcare information by healthcare practitioners and results in patients waiting for a long time prolonged unnecessarily. At times, healthcare providers find it difficult or even impossible

to treat the patients without access to the medical history of the patients because it involves high risks that includes repetition or duplication of treatments and prescriptions (Marutha and Ngoepe, 2018). This can be regarded as a burden for patients and their relatives. Eventually, citizens may be judging the quality of healthcare and regarding it as a calamity to the entire community (Brandenburg, Gabow, Steele, Toussaint and Tyson, 2015). Hence, healthcare institutions need integrated health records to achieve improved healthcare outcomes that increase healthcare quality and provide enhanced safety for patients (Alnuem, EL-Masri, Youssef and Emam, 2011).

One technology that is increasingly being discussed as a possible solution to records problems, such as the need for trusted digital records, is identified by Lemieux (2019) as blockchain technology. There are several alternative technologies to blockchain technology such as centralised transaction systems and databases that provide greater scalability, secured cloud storage services and other distributed ledger technologies (Joshi 2018; Wang 2020), but blockchain technology appears to be extraordinary. Blockchain technology does not work like a normal database, since the information shared through it is "encrypted and stored in every node connected to the network and eliminate the possibility of having single point of failure, fraud, and corruption" (Kombe, Manyilizu and Mvuma, 2017). Blockchain technology holds immense promise to revolutionise almost every field, including health, finance, auditing, justice, security and other areas. Srivastava, Parizi and Dehghantanha (2020) underscore that blockchain technology started changing focus from finance to healthcare sector. Wang (2020) alludes that during the corona virus pandemic, healthcare facilities relied much on technologies such as cloud computing as patients were restricted from moving around in between healthcare facilities but this was to be better with the presence of blockchain technology. Blockchain is capable of interconnecting or collaborating with more than one organisation rendering related services together. With regard to healthcare, collaboration in the "hospital electronic health records (EHR) system" may contribute to improved patient waiting times and access to quality healthcare information (Brandenburg, Gabow, Steele, Toussaint and Tyson,

2015). Alnuem, EL-Masri, Youssef and Emam (2011) further state that using electronic health record integration for hospitals also brings about:

> Improving transparency and effectiveness, enhancing accessibility and quality, strengthening quality and satisfaction of patients, reducing medical expenses, management rationalisation of healthcare organisation, and enhancing accountability through public healthcare inspection system.

Patients changing healthcare institutions and healthcare doctors, bring about a problem for informed medical treatment as every doctor and healthcare institution create and use their own health records for the same patients without any possibilities or platform to share the medical background (Allen and Carr, 2009). This eventually compromises the quality of clinical care rendered to the patients. Healthcare institutions and practices need a secured system that can interconnect patients from homes to ambulances, care facilities, diagnostic laboratories and other healthcare facilities, institutions and providers of healthcare services for informed decision-making during healthcare service at all the levels (Allen and Carr, 2009). There are many benefits in the sharing of healthcare information, which provides for quality in caring for patients. Nevertheless, the shared information needs to link to the correct patients and be distinguishable from other healthcare information. The information must also be accessible timeously to appropriate healthcare givers in an appropriately reliable format for easy and timely patient care (American Hospital Association, 2018). Timely and accurate information access will assist in improving healthcare services through a comparative analysis of the background of the medical condition with other practitioners, as well as exchanging of medical information in both public and private practices. This will also enable patients to network with each other on their record about dietary and medical matters (Allen and Carr, 2009). Mathioudakis, Rousalova, Gagnat, Saad and Hardavella (2016) indicate that patients may also need to access their own records where it is deemed necessary to study them and understand the kind of medical care and treatment that were provided to

them. Alnuem et al (2011) list the benefits of sharing electronic healthcare records. These include reduction of time required for movement of physical records between healthcare facilities, availability of more information about patients for accurate services, reduced time and diagnosis costs, reduced medical error for increased quality of care, and finally produce medical information important for planning and strategies for improvement of healthcare services and systems.

Furthermore, it is with the improvement of information technology from time to time that healthcare providers are now able to share healthcare information by storing it and transferring it to each other by means of an electronic system. This may enable them to realise improvement, efficiency and effectiveness in the quality and organisation of healthcare (Mehraeen, Ghazisaeedi, Farzi and Mirshekari, 2017). The introduction of a medical records management system reduces the work of practitioners and allows them to focus on the quality of healthcare. Roland, Guthrie and Thome (2012) underscore that instead of designing computer systems in the clinical services for billing of patients systems also need to be designed in such a way that it is used to render clinical services and measure clinical service quality. They further state that in doing so, records will follow the patients wherever they go when changing from clinical practice or specialist. The reason for this is that medical records "contain a lifelong record of patient's medical care" (Roland, Guthrie and Thome, 2012). Roemer (1970) states that "careful medical record-keeping helps in promoting a better continuity of medical care", to which Mathioudakis, Rousalova and Gagnat (2016) add that "good clinical record keeping should enable continuity of care and should enhance communication between different healthcare professionals". Roemer (1970) further underscores that the achievement of good quality medical care depends on the direction of social action of "establishing proper underlying conditions and influencing system operations", and that quality medical care requires sufficient resources. Technology is necessary in the healthcare services to improve several things, such as handling of health records, safety of patients, quality of healthcare and productivity of providers (Allen and Carr, 2009). Allen and Carr (2009) show that:

One of the most significant obstacles to improved patient care, at a reasonable cost, is the relative lack of real-time access to current, comprehensive patient medical information that is easily retrievable for patients, healthcare providers, and healthcare payers. To impact the quality of US healthcare, patient information must be captured, updated, and shared with all stakeholders in a timely and effective manner to not only ensure universal access to quality data, but also to extend essential information to key clinical decision makers.

In most of the sub-Saharan countries, blockchain technology is being used for many different purposes from country to country rather than for healthcare. For instance, Ghana used it for registration of landowners and land claims, Ethiopia used it for tracking of coffee exportation, Kenya used it for controlling the process of micro-landing affecting farmers, Eastern and Southern African countries used it for buyer and seller connection in trading for common market. Currently blockchain technology is targeted by many countries in the sub-Saharan countries for different purposes including South Africa, Rwanda, Uganda, Mauritius, Tanzania, Sierra Leone, Democratic Republic of Congo, Botswana, Nigeria, and Senegal (Kombe, Sam, Ally and Finne 2019; Barigaba, 2017; Kombe, Manyilizu and Mvuma, 2017; Gebre, 2018). "Despite early adoption of blockchain technology in different domains in sub-Saharan Africa, the healthcare sector lags behind…" (Kombe, Sam, Ally and Finne 2019). For instance, Malawi is still relying and trusting on manual paper-based medical records that are only kept inhouse within different sections of the hospitals such as clinics, dispensaries, etc. which makes it even more difficult to compile district health information statistics. There is no integration of healthcare records (Tough and Lihoma, 2018). This study aims to develop a framework for integrating health records in South African public hospitals to enable countrywide access to complete, accurate and secure health records through blockchain technology.

Integrating accurate and secure health records through blockchain technology provides a lot of advantages in managing health records

• **A wider access to complete, accurate and secure health records**

Improved quality in health records assists the healthcare institutions to minimise the mortality rate in the healthcare institutions, among others (Dunlay et al, 2008). This is because healthcare services will be rendered free from errors. Privacy of healthcare information, its completeness and access control may be used to balance or satisfy healthcare services to patients (Engelhardt, 2017). The healthcare institutions need to always seem to be striving to improve the quality of patients' healthcare with the assurance of patients' satisfaction, costs saving, keeping confidentiality in privacy of healthcare information and timely access to complete medical history information (Engelhardt, 2017). It is critical for the healthcare providers to have access to the medical history of patients that is complete and free from errors. For instance, the healthcare practitioners need to access reliable information on treatments, diagnosis, prescriptions and laboratory tests to successfully assist patients with required healthcare service (Dubovitskaya, Xu, Ryu, Schumacher and Wang, 2017). Health records must always tell the complete and truthful story about the previous medical transactions on the patients. It is very important that medical practitioners create and provide complete and accurate health records for proper keeping and management of the records to be used for improved patient treatment (Mehraeen et al. 2017). Hartmann and Sooklal (2012) state that:

Dubovitskaya et al. (2017) further elaborates that at times patients happen to consult doctors at many different healthcare institutions and sometimes they happen to be transferred from one institution to another. In the process, institutions need to find a way of sharing their patients' medical background records. "It is vital to have a robust, accurate, reliable, inviolable, and accessible medical record system that is easily shared and understood. Medical records must not degrade or become otherwise inaccurate over time" (Hartmann and Sooklal, 2012). This may assist in resolving concerns about timely information access, and records integrity, quality and legibility in the healthcare institutions (Hartmann and Sooklal, 2012).

Furthermore, sharing of health records in a national platform needs a central database for the central keeping of health records. In this instance, the medical history of patients from different healthcare institutions is stored on and accessed centrally from the national database by all involved healthcare practitioners affiliated to the collaborative system. The benefits are that all information, regardless of who created it or where it was created, will be readily accessible to relevant healthcare givers. The architectural part of this kind of system may not be easy since it needs budget for appropriate resources such as computer hardware, software and information communication technology (ICT) practitioners who will take charge of the creation, administration and maintenance of the system. This is because health records need to be safeguarded against complete loss or theft through unauthorised access, especially in case patients lose their identity cards or documents. Hence, "adequate access control and back-up solutions" are a necessity. Unlike traditional paper-based records sharing, electronic records will be easy to disseminate and share among the collaborating staff in different healthcare institutions geographically located a bit far from each other (Hartmann and Sooklal, 2012).

• **Health records integration in a single system**

The healthcare institutions are currently challenged with healthcare systems that operate in silos even when institutions have a cooperative relationship. These kinds of systems make it difficult for the healthcare practitioner to share or communicate their work which they are providing to the patients on a daily basis, including the medical history contained in the records (Hägglund, Scandurra, Moström and Koch, 2007). It is clear that "electronic medical records (EMRs) are critical and highly sensitive private information for diagnosis and treatment in healthcare" (Dubovitskaya, Xu, Ryu, Schumacher and Wang, 2017). Still, this kind of information "needs to be frequently distributed and shared among peers such as healthcare providers, insurance companies, pharmacies, researchers, patients' families, among others" (Dubovitskaya, Xu, Ryu, Schumacher and Wang, 2017). However, organisations that are not integrated in terms of "structures and systems" risk a long turnaround time in locating misfiled and misplaced patient records in their custody, instead of spending such time treating their patients. Such kinds of healthcare institutions also spend much time opening files from institution to institution, instead of relying on each other to avoid duplication of files

and efforts. Instead such institutions may organise and structure themselves to implement an integrated medical records management system that can be used for collaborative medical information access, communication tools and work coordination (Hägglund, Scandurra, Moström and Koch, 2007). This is because "automatic integration of patient information received from outside sources into a receiving hospital or health system's electronic health record (EHR) enables more timely and effective use for patient care than if the information must be entered manually" (American Hospital Association, 2018). The system can also be used as a tool for documentation (creating and storing healthcare information) (Hägglund, Scandurra, Moström and Koch, 2007). This is simply because "medicine is an increasingly data-intensive and collaborative endeavour" (Mehraeen, Ghazisaeedi, Farzi and Mirshekari, 2017).

- **Health records integration using blockchain technology in the public hospitals**

In the healthcare service, it is important to have standardised interoperable IT systems that allow healthcare providers to share healthcare information nationwide. The main intention must be to share healthcare information across multiple healthcare institutions Pauwels and Grevatt, 2017). For instance, study by Wang (2020) recommends integrating what he calls "IoT, Blockchain and Cloud technologies" for healthcare and telemedicine services. The healthcare industry, whether public or private, needs technology that can be used as a means to share patients' medical history and this is because the key goal is to benefit or secure patients' lives. Blockchain technology is one of the technologies required to achieve these goals since it can "guarantee data security, control over sensitive data, and will facilitate healthcare data management for the patient and different actors in medical domain" (Dubovitskaya, Xu, Ryu, Schumacher and Wang, 2017; Wang 2020). Blockchain refers to the ongoing list of transactions arising from the exchange of a cryptocurrency like Bitcoin and it arises from the process of confirming transactions (Pauwels and Grevatt, 2017; Tanwar, Parekh and Evans 2020).

Methodology

This qualitative study relied on the application of literature review to "provide a balanced and objective summary of research evidence" for the topic in this study (Brereton, Kitchenham, Budgen, Turner and Khalil 2007). The study conducted literature review to demonstrate a need for a framework which involves the use of blockchain technology for security to integrate healthcare records in the South African public hospitals. The authors used keywords and phrases in the themes of the literature review to search for appropriate literature on the google scholar and google search which also links to scholarly databases like sage and emerald to access appropriate literature sources for the study. Keywords and phrases used to conduct the literature searches were derived from the title of the study, as well as from the themes in the content of the paper to get relevant sources that addresses the study. These include integrated healthcare records, South African public hospitals, blockchain technology, medical records, patient records and information security. Abstracts were first assessed through annotated bibliography to ascertain relevancy of each source.

Findings, Discussions and Recommendations of the Findings of the Study

The study established that one of the elements that impedes the integration of the health records in South Africa is security of information. A framework that enables public hospitals using blockchain technology for security to integrate health records is suggested. The framework enables public hospitals anywhere in the country to access the complete, accurate and secure health records of a patient, irrespective of where the file was opened. Blockchain can be used to secure such information so that when health records are integrated, a complete, accurate and secure medical history can be generated.

Leaving a digital trail for a system that can be trusted inherently. The need for hospitals as healthcare facilities to interconnect with each other for ease of records sharing is a critical necessity to ensure continuous quality in the healthcare service provided to patients on a daily basis. This interconnection needs the application of safe and secured information technology such as blockchain.

The system needs to ensure all the necessary safety and security measures to the patients'

information shared on the platform against any changes, alterations, concealment, unauthorised additions and removal as well as destruction of such information. This will avoid misleading unauthentic patient medical histories to healthcare providers shared on the block, or healthcare providers rendering their service in the dark without any patients' medical and health histories as held in another hospital. This may be harmful to the health of the patient receiving the service.

Blockchain technology appears to be relevant for this purpose since it has all the safety and security requirements to maintain the characteristics of a record from the moment it was created and added into the system. It is also capable of maintaining patient information confidentiality by ensuring that only credible or eligible individuals and organisation access the patients' information stored in the system. The implementation of such interconnectivity requires

a framework that can guide the process throughout for appropriate implementation.

Recommended Framework to Integrate Health Records

This section presents the framework proposed to integrate healthcare records in the South African public hospitals using blockchain technology. The framework is presented in Figure 1 and it is discussed in four key steps, which are file creation and records capturing, file access and records sharing, file updating and records adding, and file quality assurance. It is proposed that the framework works like a bank account. If a person has an account with a bank, such an individual can access his account in any branch using his identity document or the money in any ATM using his card or even online. A person should be able to access his health records in any healthcare centre irrespective of where such a person first consulted.
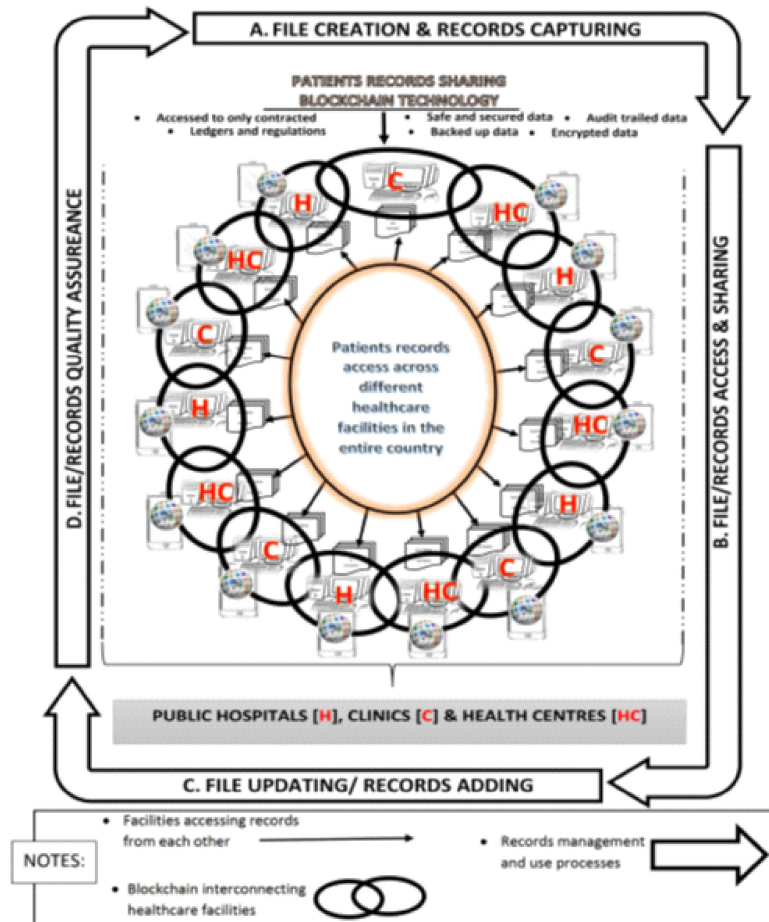

Figure 1: A Framework to Integrate Healthcare Records in the South African Public Hospitals Using Blockchain Technology

The framework to integrate healthcare records in the South African public hospitals using blockchain technology recommended by this study is discussed at the hand of the following four key steps:

A.   File Creation and Records Capturing: This is the first stage when the patient visits the hospital or health care institution. In this case, the healthcare provider will have to open or create a file for the patients online using the system that the health institution implemented. The system will also have a blockchain technology layer to provide security and access to other users inside and outside the health institution creating the file. When the same patient visits another healthcare institution, the healthcare provider in such institution should be able to access all files of the same patient in other institutions. This healthcare provider when creating a file for such a patient, the blockchain technology should add a block which alerts other facilities in the chain about such addition of a block. This means the file can also be accessed by other healthcare institutions that form part of the chain for such a patient. The records created will be encrypted for protection against any tempering such as alteration and deletion. Everywhere where the patient consults, a health practitioner would add a block in the chain of that patient's medical file.

B.   File Access and Records Sharing: Protection of personal information legislation should be observed when providing access and sharing of information. In this step, healthcare providers are able to access encrypted files stored previously by other providers for checking patients' medical and health history during the healthcare service provision. Patients' information can also be accessed by authorised officials or healthcare providers. Patients should also be able to access their health data through a smartphone or other internet applications (apps) using their login credentials such as password and user identity name anywhere and at any time. However, patients should only be granted permission to access data but not to add blocks in the chain. Every time the file is accessed, the blockchain technology layer will capture a digital trail.

C.   File Updating and Records Adding: In this stage, a file may be updated, appended or created by any medical practitioner in any hospital as a block in the chain. Healthcare providers are also able to add new medical information about patients' history in case certain healthcare services or healthcare transactions were conducted for the returning patients needing healthcare service again. Unlike in stage A, here information is just added if the patient is not using the healthcare facility for the first time. The system is also able to keep an audit trail for access and transactions conducted at any given time through any technology, including mobile apps.

D.   File Quality Assurance: The healthcare institution involved must also take responsibility to quality assure their records contained through the blockchain technology because they also depend on it. This implies that every member organisation will regularly assure the quality of the records shared through the system. Again, quality will be strengthened through the legislation and ledgers for use of the system, and records contained in the blockchain which will outline the do's and don'ts of records and system for the permanent authenticity, safety, security and confidentiality of patient information. The centrally established body will play a very important role in the monitoring, evaluation and enforcing of compliance to the hospitals involved. This must comprise a specialised team of different areas, including records management and clinical services.

Conclusion

The study provided a more generic framework to which the healthcare organisation may refocus their own environmental requirements and situation during implementation. It is hoped that this framework will assist in ensuring that through blockchain technology in South Africa, healthcare organisations are able to share responsibilities with the use of shared patient medical and health history in enhancing the quality of care. Quality records will ensure quality healthcare since physicians will always be able to make informed decisions and do problem-solving in treating their patients, regardless of where or which institution created the records. For future focus, the researchers intend to approach hospitals in South Africa for the purpose of testing this framework. Once tested, it will be extended to the private health sector so that the country can provide a comprehensive healthcare with the looming implementation of the national health insurance.

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