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A FRAMEWORK FOR THE ADOPTION OF BLOCKCHAIN TECHNOLOGY IN HEALTHCARE INFORMATION MANAGEMENT SYSTEM: A CASE STUDY OF NIGERIA

Master's Thesis

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TALLINNA TEHNIKAÜLIKOOL
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SOBIVA SÜSTEEMI LEIDMINE BLOCKCHAIN TEHNOLOOGIA ADAPTEERIMISEKS TERVISHOIU INFORMATSIOONI SÜSTEEMIDESSE NIGEERIA NÄITEL

Magistritöö

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PhD
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Tallinn 2018

Author's declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

Record keeping and information sharing in the health sectors has always been seen as an important aspect of a nation's healthcare delivery system. The reason for this is that such records have to deal with a patient's health history and other information that facilitates health care decisions. Although different forms of record keeping still exists in the health sector, there have been issues on sharing this information with various health care providers and also being able to carefully secure such records as they are known to be sensitive.

The aim of this master thesis is to analyze the role of blockchain technology in addressing these issues with a special focus on Nigeria. The problem statement discusses the present challenges being experienced in the system as a result of the issue earlier pointed out. Furthermore, the various forms of record keeping, its challenges and how blockchain technology can help tackle all these challenges are examined. In order to achieve our goal, the case study research methodology was selected as the appropriate research methodology for carrying out this research while document review and interview were main instruments for data collection. Results indicated that healthcare providers weren't satisfied with the current system as the manual form of record keeping was still the major form of record keeping being practised in the country and as a result, there were several problems like; missing records, incomplete health data, increase in death of patients as a result of incorrect diagnosis and prescribed drugs, and lack of an information sharing system between other healthcare providers. In spite of this, the study revealed some drawbacks in adopting blockchain technology taking cue from some selected countries. In this regard, the study went on to propose a framework for the successful adoption of blockchain technology in Nigeria.

This thesis is written in English and is 57 pages long, including 5 chapters, 3 figures and 3 tables.

Keywords: Blockchain Technology, Electronic Health Records, Information Sharing, Nigeria.

Annotatsioon

Sobiva Süsteemi Leidmine *Blockchain* Tehnoloogia Adapteerimiseks Tervishoiu Informatsiooni Süsteemidesse Nigeeria Näitel

Dokumendihaldus ja info jagamine erinevates tervise valdkondades on oluline riikliku tervishoiusüsteemi toimimiseks; Tervishoiu dokumendid sisaldavad kogu patsiendi terviselugu ning teistest tervishoiu süsteemidest tulenevat relatiivset informatsiooni. Olenemata mitmetest dokumendihalduse formaatidest, on siiski probleeme info turvalisuse ja jagamisega.

Magistritöö eesmärk on analüüsida aktuaalseid tervise valdkonna dokumendihalduse probleeme Nigeerias, kasutades *blockchain* tehnoloogiat.

Töös on läbivalt kasutatud juhtumiuuringu meetodit, mis on parim eelnevalt püstitatud eesmärgi saavutamiseks. Dokumentide analüüs ja intervjuud on põhivahendid. Uuringu tulemusena selgus, et tervishoiu pakkujad polnud rahul praeguse olukorraga, põhjuseks oli: dokumentide võimalik kadumine; ebatäielik tervise andmebaasi ülevaade; kõrge surmade arv, sest patsiendid diagnoositi valesti; välja kirjutati valesid ravimeid ning info puudulik liikumine erinevate tervishoiu süsteemide vahel. Sellest olenemata, uuring tuvastas siiski puudusi seoses *blockchain* tehnoloogia kasutamisega mõnes uuringus osalenud riigis. Viimasest juhinduvalt, uuring jätkus sobiva süsteemi leidmiseks, et *blockchain* tehnoloogia edukalt Nigeerias kasutusele võtta.

Lõputöö on kirjutatud inglise keeles ning sisaldab teksti 57 leheküljel, 5 peatükki, 3 joonist, 3 tabelit.

Märksõnad: *Blockchain* tehnoloogia, elektroonilised tervise dokumendid, informatsiooni jagamine, Nigeeria.

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Firstly, I would like to express my deepest gratitude to God Almighty for seeing me through this study program. My utmost appreciation also goes to my supervisor Alexander Norta for his indispensable assistance and valuable contributions throughout this study.

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List of abbreviations and terms

ANT	Actor Network Theory
API	Application Programming Interface
E-ID	Electronic Identification
EHR	Electronic Health Record
ICT	Information and Communication Technologies
II	Information Infrastructure
IOT	Internet of Things
IT	Information Technology
KPI	Key Performance Indicator
NHIS	National Health Information System
TTU	Tallinn University of Technology
UN	United Nations

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1 Introduction

The health sector of a nation is seen to be one of the most important sectors as it plays a crucial role in the growth of the economy. This is because improving the health of the citizens of the nation can directly result in economic growth since there will be more people to conduct effective activities in the workforce of the nation and the death rate of citizens will reduce. The tremendous growth in this sector overtime has necessitated the need for an efficient information management or record keeping system as this is essential to assuring quality healthcare (Pirkle, Dumont, & Zunzunegui, 2012).

Medical record keeping comprises of recording and archiving medical information of individuals as this is essential to evaluating, ensuring and improving the quality of care they receive from their healthcare provider. In recent times, most developing countries, including Nigeria still store medical records on paper and this document can either be misplaced or not useful when visiting a different healthcare provider which could result in improper health treatment of the patient due to the inaccessibility of the patient's medical history. However, if there is a system in place where individual health records can be archived and accessed by all healthcare providers, there will be an improvement in the quality of healthcare service rendered as the health history of individual patients can be easily accessed and measures to be taken are decided effectively. Therefore, giving credence to the arguments of Williams and Boren (2008) who thought that when record keeping is carried out adequately, it improves the coordination and the continuity of care, reinforces decision-making capacities, augments staff accountability and achieves more accurate and vital statistic (cited in Pirkle et al., 2012).

This chapter introduces the before mentioned problem in more detail in section 1.1. The next section which is 1.2 highlights the research objectives and then the context of the thesis is explained in section 1.3.

1.1 Problem Statement

The use of various forms of technology in providing healthcare services has grown enormously in the last few decades. Paper-based records system are gradually giving way to electronic health records (EHR) system in most developed countries of the world as it is believed that this new system is designed to alleviate the limitations of the paper-based system and improve the quality of care delivered.

On the other hand, governments of developing countries, Nigeria inclusive face many difficulties in carrying out their management duties to deliver proficient healthcare services to their citizens and one of the most important factors contributing to the poor state of the Nigerian health sector as stated by Abimbola and Japheth (2016) is poor record keeping and lack of an effective data exchange system. Consequently, meeting the demands of the citizens have been increasingly difficult due to lack of an effective strategy on how to solve this problem. Oyegoke (2013) throws more light on the Nigerian case by describing the various kinds of diseases in the country and how this increases the death rate in the country because the healthcare providers do not know what kind of medication the patient has been used to or their medical history.

Therefore, it is evident that there is a need for an environment in the healthcare sector where medical records of the citizens can be easily stored and accessed by healthcare practitioners in other to deliver quality healthcare services. Thus, creating an efficient system where technology is used in providing these services will help optimize cost in this sector, increase information sharing and increase citizens trust in the health sector of the country which will result in the sustainable development of the nation overtime.

1.2 Research Objectives

The general focus of this paper is to examine the challenges being faced in the Nigerian health sector in terms of records keeping and information sharing and then propose best ways on how this can be improved with blockchain technology which is a form of the electronic health record system in the health sector today. The objectives of the research are highlighted below: -

- Examine the current challenges being faced by healthcare providers and patients as a result of poor record keeping and an ineffective data exchange system.
- Give insights on how health information management system can be improved using blockchain technology.
- Identify the factors that impede or promote usability of the system to be adopted.
- Examine how the use of blockchain technology in healthcare service delivery process influences stakeholders.
- Propose a framework to guide the implementation planning on how the technology can be adopted.

1.3 Context

Healthcare information management can be defined as the procedures or methods required in enhancing the acquisition, storage, and retrieval of information in delivering healthcare services (Burney, Mahmood, & Abbas, 2010). It can also be seen as the collection and management of health information from various sources and sharing of that information to different audiences in other to deliver higher quality service or make informed decisions (Chetley et al., 2006). According to (WHO, 2008), sound and reliable information is the basis for decision making across all health system building blocks as it is important for providing an efficient service delivery system and also for policy development. Therefore, it is interesting to note that information management is an important aspect of healthcare delivery that ensures its efficiency and effectiveness as it helps in reducing a healthcare provider's uncertainty about relevant situations.

Medical record keeping which consists of both documenting and archiving of health information is undergoing a transition not only in the developed nations of the world but also in the developing ones. The use of paper for record keeping in health service delivery has been the order of the day in most developing countries, Nigeria inclusive. The system has presented itself with numerous challenges and has also not been sufficient for providing the desired medical care and treatment as it has made communicating with care providers extremely difficult. According to (Hinckeldeyn, Johanneshinckeldeynhaw-hamburgde, Dekkers, Robdekkersuwsacuk, & Altfeld, 2010),

the reason for this is that the healthcare industry is mainly data driven and it also depends largely on the accuracy and availability of the data. However, since the records are kept manually, the access to patient's data by healthcare providers is limited, and this acts as a hindrance to healthcare delivery, hence, the need to be replaced by more efficient systems.

Agarwal and Khuntia (2009) described efficient systems to comprise of tools that management of health information should be supported with and they include the following: (1) tools that support health information storage, archival and retrieval, (2) tools that support health monitoring, and (3) tools that support health information seeking and searching. They believed that using such tools would help improve the quality of healthcare service provided as information can be archived and retrieved when needed and this will at the end result in providing a consumer-centric healthcare system. Meanwhile, it is widely believed that the introduction and adoption of information and communication technology (ICT) will help address the issues brought about by the manual system as the role of ICT in improving the management of health information cannot be overlooked.

According to the World Health Organization (2012), Information and communication technology unlike the traditional method of record keeping in the health sector has great potential to improve health service delivery in both the developed and developing nations of the world by enhancing access to information and making health service more efficient, contributing to improving the quality of service provided and reducing cost for the patients. The adoption of ICT for healthcare service delivery, also referred to as e-health has also helped in strengthening healthcare delivery systems by making available innovative programs such as the electronic health records systems (Yusif & Soar, 2014). It has also helped in improving the reliability and effectiveness of health information of individuals.

An electronic health record system can be defined as a systematic collection of electronic health information about individual patients or populations and enables the sharing of this information which is in digital format across different healthcare settings (Dinya, 2013). According to (Ravindra, Chandra, & Dhenesh, n.d.) implementing an electronic health record system in delivering healthcare services have significant

benefits and this includes; reduction of error evident in manual operations, promotes a paperless environment, improves communication amongst medical professionals, allows timely access to patient's medical records for easier decision making in critical situations, creates a data repository for future research and quality improvement and facilitates the continuity of care. Therefore, we can say that if there is a system like this in place, information about a patient's health history can be easily accessed and shared amongst healthcare professionals, treatment of diseases can be quickened, medicine the patient is allergic to can be easily ascertained and so on. In addition, studies conducted in some developing countries have shown that the use of the electronic health record management system in delivering health services leads to improved quality of care which in turn translates into the development of the country as a whole (Cecchini & Scott, 2003; Khan, Shahid, Hedstrom, & Andersson, 2013; Oyeyemi & Wynn, 2015). Likewise, governments of some other developing countries, Nigeria inclusive, have also seen the importance of having such systems in place as this improves the overall well-being of citizens in the country and leads to the achievement of the sustainable development goals. For this reason, the Nigerian government has begun investing hugely in using ICT for service delivery not only in the health sector but in most sectors of the economy.

While the adoption of EHR systems promises some substantial benefits, the Nigerian health sector still delivers its services using the manual or paper-based system and has not fully decided on the exact form of the EHR to implement or adopt. It is in this vein that this research tends to evaluate how blockchain technology instead of looking at the different forms of electronic health record systems can be proffered as a solution and also develop a framework on how this can be adopted. The main reason for this decision is because blockchain is an innovative technology that is believed to have the potential for unleashing countless new applications and capabilities that could transform our everyday lives.

Blockchain technology can be defined as an incorruptible global database that provides a digital ledger programmed to record not just financial activities or transaction but every other activity of value in our lives (Tapscott, Tapscott, & Tapscott, 2017). It can also be seen as a digital registry which cannot be tampered with. This relatively new technology which is more than just ICT innovation has been used in solving different

problems in the private sector and has also been used as a solution by governments in some countries. For instance, Sweden, Georgia and some other countries have provided a solution where the registration of lands owned by citizens are done on the blockchain and as such, it prevents parties involved from making false claims since everyone can see who owns what property (Kempe, 2017). Therefore, this study intends to show how the use of this technology for healthcare information management in the Nigerian health sector will help achieve a better healthcare delivery system in the country.

2 Related Work

The goal of this chapter is to introduce previous works leading to this master thesis and also to review other relevant studies relating specifically to the objectives of this study. The background of this master thesis is divided into two sections. The first section summarizes previous works done relating to the research and it also focuses on defining basic terms such as health information management, record keeping in healthcare delivery and the various types of record keeping in the health sector. The second section which is the theoretical framework explores the various works of authors and their findings in line with the theoretical concepts and practice as it relates to the current research.

Furthermore, the theoretical framework section also sheds more light on the planning and successful implementation of the blockchain technology in some selected countries which include; Estonia, Dubai, and the Netherlands. The aim here is to recommend the best practices that could be adopted not only in Nigeria but also in other developing nations and to provide the necessary framework for the study. Subsequently, the chapter ends with a summary of the entire discussion.

2.1 Earlier Studies

The proper management of information, storage, and retrieval of records are crucial for the growth and success of any organization as they are the basis for which decisions are made and policies developed. In this vein, the system used in keeping records in any healthcare organisation should be interoperable, possess safe storage system for all the data collected by the various healthcare providers, should ensure secure and efficient exchange of health information between the different stakeholders while respecting the privacy of all those whose health information is involved (MedicalChain, 2017). The reason for this is that it is the only sure way the quality of healthcare service provided can be increased. The introduction of blockchain technology for the storage of healthcare information or records in recent times is therefore aimed at achieving the functional aims highlighted above. In spite of these functionalities, the use of blockchain technology in the health sector is also aimed at trouncing the disadvantages

associated with the paper-based record management system that has been used in the healthcare industry for a long time now.

2.1.1 Health Information Management

For the purpose of this study, health information management can be defined as the management of an individual's health information, and this comprises of the accumulation, storage, and accuracy of the patient's records in hospitals or other healthcare organisations that deals with enhancing or improving the delivery of quality healthcare to the public (Kirshner, 2017). According to Jody (2011), countless of lives around the world are lost as a result of inadequate access to quality health information about an individual's health. Therefore, we can infer that a good health information system is like a database that shows the records of the health treatment of a patient and this covers the consistent recording and proper monitoring of the individual's health plan by the doctor, nurses or any other healthcare provider.

In recent times, healthcare system all over the world faces various challenges due to consumer demands for services, innovation in service delivery and access to information (Hajli & Featherman, 2018). Hence, improving service delivery in the health sector is now a major concern of governments around the world and it is also an important factor to the achievement of the "Sustainable Development Goals (SDGs) which includes; building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation" (UNDP, 2016). Therefore, it is interesting to note that an efficient health service delivery is an immediate result to the inputs in the health system of any nation and as such, increased input should lead to improved service delivery. Over the years, the Nigerian health sector has always operated in silos and this has resulted to increased death rate in the country due to lack of access to healthcare information (Nigerian Health Sector report, 2015). As a result of this, a lot of the citizens now travel abroad to get proper treatment. According to the 2016 top markets report on medical devices, about 30,000 Nigerians travel to other parts of the world each year on medical tourism for major treatments (Top Markets Report Medical Devices, 2016). The report also went on to state that an estimated $1 billion is spent on these treatments and this has also taken its toll on the government because it has caused a significant impact on the reduction in the GDP of the nation to 5 percent. Therefore,

one can easily say that keeping records which can be easily accessed in an institution like the health sector is very important and crucial to the development of the sector as well as the patients. Also, Nigeria has some types of diseases that come as a result of the changes in the seasons in the country (dry and raining seasons), and as such, each season has its own illness or predicament (Oyegoke, 2013). Therefore, there is need to ensure that adequate records which can be easily accessed by any healthcare professional are kept in all healthcare organizations worldwide especially in Nigeria which is the focus of this research.

2.1.2 Record Keeping in Healthcare Service Delivery

A health record is a documented account of an individual's medical history which may include; illness, diagnosis, health care plans, treatment, healthcare progress and other outcomes (NSW Health, 2012). Record keeping in the health sector plays a very important role as it facilitates easy access to patient's medical information, saves time by reducing duplication of investigations carried out at different levels, and also helps in managing the patients efficiently (Senanayake, Senanayake, Ranasinghe, & Hewageegana, 2017). Northway, Holland-Hart, and Jenkins, (2017) were also of the opinion that a good record keeping system ensures that the health needs of individuals are adequately met, and this has an impact on both the quality of life and life expectancy. Similarly, Heslop et al., (2014), observed in their study carried out that people who die prematurely are often as a result of delayed diagnosis; hence the need for an efficient and easily accessible record keeping system.

One main importance of keeping records in the health sector according to Amos, Cockrell, Palermo, Rosehill, and Bearman, (2017) is that it helps in ensuring continuity of care, patients' safety and commercial considerations from the government such as insurance and other services. They were of the opinion that poor record keeping could expose patients and medical practitioners to numerous risks which are inappropriate as it could result in the death of a patient. They thus concluded that record keeping plays a vital role in circumstances such as; making a complaint against the medical practitioner, compliance auditing, and forensic applications.

There are two main types of record keeping in the health sector; these are paper-based record keeping systems and the electronic health record-keeping systems. Both record

keeping systems are designed to accomplish two major functions in the health sector (NSW Health, 2012). The first is to help in the accumulation of data of an individual's medical history for future uses (Acquah-swanzy, 2015; Senanayake et al., 2017) while the second is to help in coordinating activities of all stakeholders involved in health care delivery (Acquah-swanzy, 2015; NSW Health, 2012). The following sub-sections throw more light on these categorizations.

2.1.2.1 Paper Based Record Keeping System in Healthcare Delivery

The health sector has since its inception widely used the paper-based record keeping system as a form of keeping a record of its patient's illness, development, and overall general health conditions for over two hundred decades (Scott, 2006 cited in Acquah-Swanzy, 2015). Fitzpatrick (2000) argues that although paper-based records enhances decision making and medication management in health service delivery, it fails to meet its purpose by providing adequate information to healthcare providers in a proper form and at a proper time. In addition, this form of record keeping system has made communication between various healthcare providers extremely difficult especially in developing countries, hence there is a need for more innovative systems (Kalogriopoulos, Baran, Nimunkar, & Webster, 2009). Some other authors also tend to disagree with the use of the manual system for record keeping in the health sector based on reasonable arguments; some of which centre on issues pertaining to inefficient service delivery, privacy, inability to access health records faster, and increase in staff work burden (Hinckeldeyn, Johanneshinckeldeynhaw-hamburgde, Dekkers, Robdekkersuwsacuk, & Altfeld, 2010; Howard et al., 2013; Rodriguez, Murillo, Borges, Ortiz, & Sands, 2002). Thus, according to many scholars, using the paper-based record keeping system in healthcare service delivery is not good enough to be used alone and they justify this by explaining some of its challenges which includes;

- **No Assurance for Information Backup**

The paper-based record has no guarantee for information backups and can be destroyed at any point in time. They could be destroyed by fire, flood or other natural disasters such as a hurricane or even stolen completely. One living example of this was demonstrated by Hurricane Katerina which destroyed the health records of an undisclosed number of people (Bilal Ali Yaseen AL-Nassar, 2011). These kinds of

occurrence could expose patients to a considerable amount of medical risks which could eventually lead to loss of lives.

- **Breach of Privacy**

The use of the paper-based system for keeping health records does not encourage privacy. The reason for this is that there is little or no room to keep track of who might have accessed your data without your knowledge or completely prevent unauthorized access to one's health record. In this form of record keeping system, medical records can be accessed without traces of who might have accessed them or copied them, and this could eventually lead to patients losing their jobs, embarrassments at home, work or school due to the nature of their illness (ISMP, 2000 cited in Acquah-Swanzy, 2015).

- **Lack of Access to the Medical history of Patients and Information Sharing**

This form of record keeping makes it difficult for healthcare providers to have access to the patient's health history in order to carry out proper diagnosis or treatment. Countless of lives have been lost as a result of this and access to records and information sharing is most relevant to quality healthcare and the health system in general (Jody Ranck, Ramesh Krishnamurthy, & Dykki Settle, 2011).

- **Improper Organization of Records**

In the manual system of record keeping, there could be a high risk of assigning codes or symbols to the wrong file and this could make it difficult to locate that exact file for future use. Also, retrieval of files could be time-consuming, and this could impede access to data and information sharing for proper healthcare delivery as well (Howard et al., 2013; Jody Ranck, Ramesh Krishnamurthy, & Dykki Settle, 2011).

From the challenges listed above, it is clearly seen that the traditional form of medical record keeping has restrictions in allowing a global vision of the patient's health condition (Mathai N, Shiratudin MF & Sohel F, 2017).

2.1.2.2 Electronic Health Record Keeping System in Healthcare Delivery

The use of the electronic health records keeping system is seen widely as a means to improve the quality of service delivery in the health sector. This form of record keeping can be simply defined as the repository of information concerning the health status of individual patient or population which is created from each interaction with a health care provider (Acharya, Coats, Saluja, & Fuller, 2013; Mathai N, Shiratudin MF and Sohel F, 2017). Also, according to HIPAA (2009), Electronic health record, is the health record of an individual that is created, gathered, managed, and can be consulted by any authorized healthcare provider. Hence, we can say it helps to facilitate the communication between the patients and their healthcare provider and only authorized persons have access to such record. The Electronic health record (EHR) is usually in digital format which allows information to be shared between different healthcare providers across different healthcare settings. Furthermore, the EHR of a patient contains their medical history and this includes; operations, medications, hospitalizations, laboratory reports, diagnostic follow-ups, allergies, and other health information (Mathai N, Shiratudin MF and Sohel F, 2017; WHO, 2007). Meanwhile, according to Adane, Muluye, and Abebe (2013), this form of record keeping holds great promise in reducing memory strains of healthcare providers, improving efficiency and effectiveness in healthcare quality and increasing accountability in the health sector. Some of the other benefits of the system according to various authors include; complete documentation of health records, fewer medical errors, decrease in redundant services, improved clinical decisions and improved coordination (Acquah-swanzy, 2015; Bilal Ali Yaseen AL-Nassar, 2011; Howard et al., 2013; WHO, 2007).

On the one hand, studies have shown that the Electronic health record keeping system has improved the productivity of healthcare providers by improving the record keeping system, enhancing the documentation of medical examination, availability of records, improving clinical decision, to mention but a few. However, on the other hand, some other authors are of the opinion that the system still needs improvement and they justify this by citing various challenges which include;

- **Privacy**

Security and privacy issues are an important aspect of the health sector because the sector deals with sensitive data of individuals. These kinds of issues have legal and ethical consequences. Xanthidis and Aleisa, (2012) observe that although the system has increased convenience in the health sector, individual patients are still in constant fear about the privacy and integrity of their health information. This makes us understand that the privacy breaches in the health sector have resulted in a decrease in an individual patient's trust that their health record is properly protected and kept confidential, and this further leads to a decrease in the public trust for healthcare delivery system (Hillier, McMullen, Chumney, & Baumer, 2011; Kök, Başoğlu, & Daim, 2012).

- **Data Breaches**

Most healthcare providers do not follow due process when giving employees authorization on who has access to the system and as a result, the system can be hacked, and the unauthorized employees have access to protected health records of individual patients (Rezaeibagha, 2013). Also, studies carried out show that healthcare providers use their smartphones that have individual health patients record on it to send and receive personal emails, browse, and view other social media websites (Darer, Dhanireddy, Elmore, Ross, & Delbanco, 2013). Thus, the environment becomes insecure because several unintentional and malicious threats could co-exist which could at the end result in hacking into the system and stealing health records of individuals (Markle Foundation, 2011). Consequently, we can infer that incidents of data breaches in healthcare service delivery reduce the trust of individuals in the EHR systems.

- **Medical Identity Theft**

Due to the fact that sensitive data of individuals are not protected properly, it exposes those individuals to identity theft. Medical identity theft is when an individual's medical information is used to gain access to medical services, other types of services or even sold to criminals in exchange for money (Portela et al., 2010). Once health record of a patient has been tampered with, it could be harmful to that individual if he or she receives improper treatment as a result of the corrupt information now present in their record. Therefore, there is a great need to ensure that sensitive information about

individual patients are protected (Mathai N*, Shiratudin MF and Sohel F, 2017).

The challenges listed above covers the most important areas in healthcare service delivery and they can only be addressed by adopting an encrypted data storage platform and an efficient data exchange system. It is in this vein that the blockchain technology which has the capacity to enhance information management in the health sector will be discussed.

2.1.3 Blockchain Technology

The term blockchain technology was originally introduced by an individual or a group of individuals named Satoshi Nakamoto in 2008 (Nakamoto, 2008). What Satoshi noticed and articulated was the issue associated with double spending in the case of digital currency. They found out that digital currencies could be duplicated when trying to make an online transaction and this is why a third party (often a financial institution) is always needed to verify these transactions (Mclain, 2017). They then proposed a solution associated to the issue of double spending using a peer-to-peer network which would allow digital currencies to be sent from one party to another without the help of a third party (Nakamoto, 2008). Since its invention, blockchain technology has been a hot topic for research and application in so many different areas. Therefore, there is need to define this technology so as to know its features and overall importance.

Blockchain technology can be defined as a distributed database of records comprising of all events that have been performed and shared by parties involved (Crosby, Nachiappan, Pattanayak, & Verma, 2015). Trautman (2016) throws more light on this by explaining that the technology comprises of a shared and encrypted database that serves as a permanent and incorruptible public repository of information. The technology keeps a record of all transactions that are confirmed by the parties participating in it. The data and information gathered is recorded in a public ledger and can only be accessed by authorized parties and as a result, does not need the help of a third party.

Thus, we can infer that this attribute makes the system more transparent since there is no need for a third party and the parties involved are aware of what is going on around them. In this vein, Yli-Huumo, Ko, Choi, Park, and Smolander, (2016) are of the opinion that the major reason for the sudden uptake of the technology is its major

attribute in providing security, ensuring anonymity and enhancing data integrity of transactions without any third party involved. In addition, the information stored on the public ledger cannot be altered or deleted once the information has been approved or verified by the parties involved. Furthermore, each data or information is time-stamped and stored in a block and linked to the preceding block in order to be valid and thereby creates a chain of blocks (Tapscott & Tapscott, 2017). Therefore, we can say that the blockchain technology offers a unique opportunity to design a secure and trustable system where transactions or activities can be easily accessed by participating parties.

2.1.3.1 Key Components of Blockchain Technology

This section explains how blockchain technology works and the figure (1) below also illustrates the basic components of the blockchain technology that are generated and hosted by software.

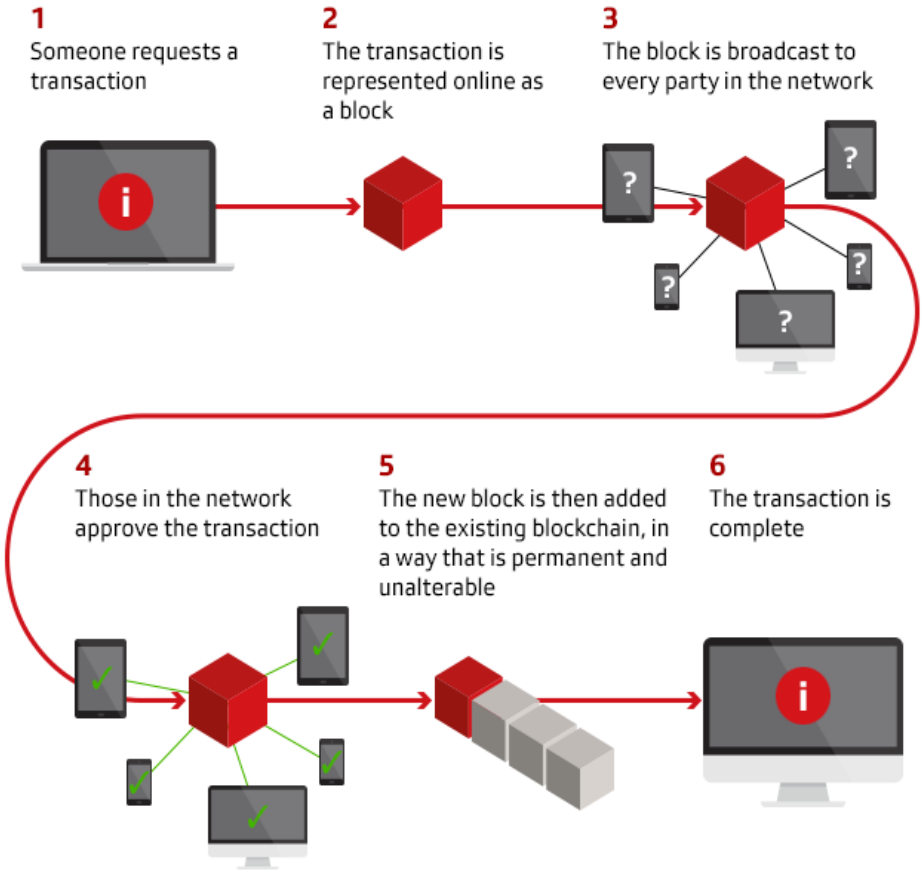

Figure 1. How the Blockchain Technology Works. Source: Hasse et al., 2016.

The figure 1 above shows that the transaction carried out on the blockchain comprises of the sender, the message or transaction information, and the receiver. Furthermore, the blockchain network is made up of several blocks and each block contains several transactions and is securely encrypted. This means that anyone that isn't part of the network would not be able to see the content of the message without a cryptographic key. The following points listed below are the key components of the blockchain technology and they have also been illustrated in Figure 1 above.

- **Message**

The message being passed across on the blockchain which is also seen as a transaction is the submission of data or information for processing by nodes (also known as the computers of participants in the network) with the aim of having the message authenticated and verified and consensus also reached on it so that at the end, it becomes a transaction record (Fullbright, 2016). According to Morabito (2017), this implies that the sender initiates a message which has to be passed across to those participating in the network and the message being transmitted has to include information about the receiver's public address, the value of the transaction and a cryptographic key for proving authenticity of the transaction and also verifying its validity.

- **Transaction Authentication**

This is arrived at once the nodes (computers or users) in the network receive the message that was sent passed across, then they try to validate it by decrypting the digital signature and then placing the authenticated transaction in a pool of pending transactions (Froystad & Holm, 2015).

- **Block Creation**

Here, the pending transactions are bundled together by one of the nodes in the network in other to update the ledger, which is also called a block. Subsequently, at a specific time, the updated block is broadcasted to other nodes waiting for validation. It is also important to note here that blocks can be entirely public (their contents can be visible to all participants) or merely semi-public (other participants can see its container and its label but wouldn't be able to see its content without a cryptographic key to decrypt the

message) (Fullbright, 2016).

- **Block Validation**

This phase has to deal with the validation and authentication of the blocks in the network. This occurs when the nodes in charge of the validation process in the network receives a request to validate a proposed or updated block, they go through an iterative process which requires consensus or agreement from a majority of the nodes participating in the network so as to authenticate the block (Morabito, 2017). Froystad and Holm (2015) throw more light on this in their work by explaining that the various types of blockchain networks available use different forms of validation techniques. They further state that the Bitcoin's blockchain uses the "proof of work technique", Ripple uses a technique called "distributed consensus", while Ethereum uses an entirely different technique called "proof of stake'. They then conclude by saying that these techniques are used in order to ensure that every transaction is authenticated and valid and to also make sure that there are no fraudulent transactions in the network.

- **Block Chaining**

Once all transactions on a block have been approved or validated, the new block is then attached or chained into the blockchain and when this has been completed, the current state of the ledger is broadcasted to the participants in the network (Fullbright, 2016). This whole process takes about 3-10 seconds, thus making the blockchain a very fast technology for carrying out various activities in different industries (Morabito, 2017). In addition, it is good to know that in other to alter a block in the chain, it would be compulsory to alter all the blocks that came after it. Hence, once any data or information in the blockchain network have been changed or is altered, it automatically becomes visible to all the other parties participating in the network. Also, subsequent blocks will no longer correspond to the succeeding block record.

2.1.3.2 Key Attributes of the Blockchain Technology

The points listed and explained below are generally seen as the most important features of the blockchain technology and are also related to the proposed use of the technology.

- **Decentralized and Distributed Architecture**

The use of the blockchain technology ensures that participants in a system are connected to each other. Thus, making the transactions conducted between them transparent without the need for an external party. The information stored in the blockchain is not controlled by anyone and can be reviewed by parties who have access to the system thus ensuring appropriate redundancy (Atzori, 2017).

- **Trust**

Blockchain technology ensures a trustworthy environment without requiring the presence of any third party, unlike the traditional system where participants who do not trust each other have to bring in a third party. According to Pernici and Weske, (2016), blockchain technology should be used in cases of coopetition where multiple businesses come together to accomplish a joint business goal. Here, the technology is used to enable trustless collaboration without the need for control from a single entity or any external party. The use of the technology provides a mechanism to ensure that a transaction has taken place because each block contains information about the block preceding it. Thus, the information in each block is automatically authenticated and can be easily verified.

- **Irreversibility**

Once the transactions that take place on the blockchain have been recorded and verified, it becomes impossible for those records to be altered or corrupted easily because each party has a copy of the information available to them. The technology also provides an immutable audit trail where you can see who performed an action, thus ensuring data integrity, increasing transparency and decreasing the risk associated with the third-party system (Pernici & Weske, 2016).

- **Transparency**

In a blockchain network that is entirely permissionless, once all the messages or transactions have been authenticated and validated they become visible to all other participants in the network. This ensures that there is transparency as all records can be traced back to its sender or issuer. However, in a permissioned blockchain, the content of the message is encrypted and is visible only to authorised parties participating in the network. Therefore, it is good to note that the level of transparency on the blockchain depends on the exact use that particular blockchain is made for (Fullbright, 2016).

- **Time-stamped and Programmable**

All transactions on the blockchain network are time-stamped and this allows all parties know when exactly a transaction occurred. This is very useful in cases where there is a need to prove a particular transaction for compliance or regulatory reasons.

Also, instructions can be embedded in codes written within a block on the blockchain. These instructions are called smart contracts and are used to perform several actions and can only be executed when certain conditions have been met.

From the attributes listed above, it is evident that the blockchain technology creates a tamper-proof environment, thus ensuring safe and secure systems. This is because it automatically checks and updates itself every few minutes, thus providing a self-reviewing and robust system.

2.1.3.3 Types of Blockchain Technology

So far it is somewhat understood that there are two major types of blockchain technology; the permissioned and permissionless blockchain and they are explained below.

- **Permissioned Blockchain**

In the permissioned blockchain which is also known as a private or consortium blockchain, only the people that come from a selected group or organization will be allowed to join the consensus process (Mattila, 2016). Furthermore, it is important to note here that only trusted members are permitted to participate in the network. Here,

the validation process is controlled by a pre-selected set of nodes.

- **Permissionless Blockchain**

In this environment, all records are visible to the public and anyone can take part in the consensus process (Mattila, 2016). Therefore, we can infer that in this kind of blockchain, it is open access to everyone and no permission is required from any central authority to be a participant in the network. Also, according to Dimitri (2017), the consensus in this kind of distributed environment is reached based on some pre-defined rules which are agreed upon by all nodes participating in the network.

Some major comparisons of the different forms of blockchain technology have been illustrated in the table (1) below.

Table 1. Comparisons Between the Different Types of Blockchain Technology. Source: Author.

Attributes	**Permissioned**	**Permissionless**
Fast	Due to the number of nodes participating in the network, propagating transactions is done faster.	Here it takes plenty of time to propagate transactions and this makes the process relatively slow.
Centralized	It is controlled by a single group.	It is decentralized as anyone has access to it.
Consortium process	Only selected nodes can join the network.	Everyone can join the consortium process since the network is public.
Efficient	It is more efficient as only selected nodes are allowed to participate in the network and this makes the validation process easier.	It takes a lot of time to validate transactions as there is a high number of participating nodes.
Who can see?	Records are private and are	All records are visible to

	visible only to the owner group.	the public.

From the illustration above, we can see that the listed attributes are based on the distinct features associated with the different forms of the technology and are unique to each of them in their own way, depending on the area it is applied to.

2.1.3.4 Potential Applications of Blockchain Technology

When looking at the current state of understanding people have about blockchain technology, it is hard to be specific about what or where blockchain technology can be applied to as the technology is currently being applied in diverse areas and more areas are still being researched. Table 2 represents some of the areas it has the potential to be applied to visible in academic literature.

Table 2. Potential Applications of Blockchain Technology. Source: Author.

Authors	**Applications of "Blockchain Technology"**
Zhu and Zhou (2016)	▪ Currency transfers ▪ Remittance ▪ E-payment systems ▪ Smart contracts ▪ Equity Crowdfunding
Swan (2015)	▪ Voting ▪ Notary ▪ Healthcare ▪ Government

Pilkington (2015)	▪ Digital identifications ▪ Financial applications
Deloitte (2016)	▪ Auditing service ▪ Supply chain industry
Trautman (2016)	▪ Digital rights management ▪ Business models for the internet of things (IoT) ▪ Digital content distribution ▪ Personal data protection
Shrier, Wu, and Pentland (2016)	▪ Ownership rights ▪ Transaction monitoring ▪ Data security

Hence, looking through the diagram above, there does seem to be many areas in which the technology may be applied to as it would be an exaggeration to say that no industry would remain unaffected by the advantages of the technology in the nearest future. The reason for this is that governments of various nations are seriously looking for ways to adopt this technology in its dealings with citizens. In addition, private institutions like the banks are also researching on how this can improve their money transfer processes. Other sectors, such as; the education sector, the agricultural sector, supply chain industries and a host of others are currently researching on ways to leverage this technology to increase efficiency in their operations. Nevertheless, for the purpose of this work, our main goal is to see how the technology can be used to improve information sharing and access to the medical history of individuals in the health sector.

2.2 Theoretical Framework

This section gives a review of related literature to the current research. Thematic issues also discussed include the adoption of blockchain technology for healthcare information management systems, lessons from Early Adopters (Dubai, Estonia, and The Netherlands) of blockchain technology and common barriers to its successful implementation in developing countries

2.2.1 Adoption of Blockchain Technology for Healthcare Information Management

Advancement in information technology has brought about much improvement in the way services are being rendered in the health sector. It has helped in the design and production of large databases where patients' health information is stored, it has helped in the provision of tools that can be used to track health data and also engage individuals more in being concerned with their own health (Linn & Koo, 2014). Furthermore, they are also of the opinion that the combination of these advancements and many others with information technology would continually foster transformative changes in the health sector. Although the use of Information technology tools in the healthcare delivery process has enhanced the conduction of activities in the sector, some issues still exist with interoperability of the system.

Blockchain technology has the potential to address the interoperability issues currently existing in the system as it has the ability to store records that can easily be accessed by any authorized healthcare provider. This new technology as explained earlier has now been integrated into so many applications like banking and payments, voting, supply chain management, land registry and other social services. Today, the technology's potential in the health sector is accelerating globally (Michael Crosby et al., 2015) and various governments have started carrying out different forms of research in other to see how the technology can be applied to governance.

Additionally, the use of blockchain technology in healthcare service delivery centers on some theories, one of which is the Diffusion of Innovation Theory. This theory "encourages that innovations should be communicated through different channels or means overtime for the well-being of individuals" (Rogers, 2003 cited in; JW & Dearing, 2009). Similarly, other theories that support the use of technological

innovations are the "Actor-Network Theory (ANT) and the Concept of Information Infrastructure (II)". These theories were developed to determine the relationship between information system and organizational issues (Faure, 1998). According to Acquah-swanzy, (2015), these theories shed more light on how technology influences human behavior when it is being applied to a complex organization (such as the health sector in this case). Hence, there is a need to also study and take note of how technology impacts its stakeholders no matter the area it is being applied to.

Furthermore, the use of blockchain technology in sharing highly sensitive private information in health service delivery ensures an immutable and transparent history of all transactions in other to promote trust, accountability and transparency in the system. Therefore, we can infer that the use of blockchain technology for healthcare service delivery offers many benefits as it is based on open source software, commodity hardware, and open API's (Linn & Koo, 2014). In addition, Linn and Koo (2014) also believe that the components which make up the network facilitate faster and easier interoperability between systems and that they can efficiently scale to handle large data volumes and more blockchain users. Also, one major importance of using blockchain technology in this field is that it would ensure continuous availability and access to real-time data which would result in improved clinical care coordination in emergency medical situations.

2.2.2 Lessons from Early Adopters

Randall, Goel, and Abujamra (2017) made it very clear that one of the major reasons why blockchain technology has great potentials to be applied in the health sector is its underlying IT (information technology) architecture and its unbreakable chain of data entries that ensures that transactions on the network are open and secure. Pilkington (2015) also draws us to the attention that many nations have begun carrying out extensive researches on how the blockchain technology can be applied to the health sector in their various economies.

Table 3 below highlights the various approaches in use by a few selected early adopters of blockchain technology in the health sector. We selected these countries based on the United Nations (UN) Global Innovation Index 2017 which is tagged "Innovation feeding the World". These countries which are Dubai, Estonia, and The Netherlands are

also the only countries that have adopted the use of this technology in its health sector at the moment. In addition, the index also mentions that various countries currently use it as a 'tool for action' for decision makers and also the countries listed in it projects innovative approaches to transforming various sectors in their economy (The Global Innovation Index, 2017).

Table 3. Lessons from Early Adopters. Source: Dussaux, and Rowell, 2017; E-Estonia, 2012; Dutch Ministry, 2017; Smart Dubai, 2017.

Country	**How it is currently being applied**	**Important points to note**
Dubai	This plan falls under the Smart Dubai Project. Here, the UAE Ministry of Health provides a centralized platform to store health data of individuals or patients which enables healthcare providers an easy access to a patient's medical or health history and other sensitive information that has to do with their health. The government also supports this as it aims to have all documents recorded on blockchain by 2020.	Every patient has a unique identifier and can also access the system and connect with their doctor for an online consultation. They have also taken the initiative to create an app called "Tummy Fish" which encourages individuals to drink water and have also developed an app for the healthcare providers which enables easy access to their medical digital library. The government has also established pilot projects to have all government entities using blockchain by 2020. The citizens are also educated and kept up to

		date on the importance of adopting the various technological innovations and they are always willing to do so.
Estonia	Estonia was among the very first countries to start researching about blockchain technology. The tech-savvy country began testing the blockchain technology in 2008 and since 2012, the technology has been used in various sectors. In the health sector, the technology is used to detect who has violated the law, when and how. It helps to detect every change in the sensitive health data of patients. All the patient's needs to do is to log into the health portal using their e-ID and then they can review their medical history. The National health information system integrates data from the various healthcare providers and then creates a common record for each patient. Additionally, the main reason why blockchain technology is used in the Estonian NHIS is to ensure data integrity.	All Estonian citizens possess a unique identifier that links them directly to their health record. The electronic ID card system used in Estonia uses the blockchain technology to guarantee data integrity and to alleviate the internal threat to the data. The country's success story is based on other key factors which also includes; Legal and regulatory support; the presence of regulations guiding the use of this technology and that also allows the technology to be used in the health sector. Public-private partnership; the Estonian government is currently partnering with Guardtime (a private software company located in Estonia) in deploying the

		technology. Adequate Infrastructure; the government has put in place the necessary technological infrastructures needed to ensure the smooth running of the system. The government has also created an environment that supports research and development so as to support the development of a robust health data infrastructure.
The Netherlands	They are currently applying the permissioned-based structure of blockchain technology to their healthcare system. Here, individuals are kept in charge of their health information and they control which information is released to a healthcare provider or an insurance organization.	The Dutch government has now legalized the use of blockchain technology for communication between its health institutions. Enhancing physician and patient engagement by creating several applications that are used to make the patient aware of the need of being in charge of their own health and seeing a doctor regularly. Adequate infrastructure; the health sector is putting the necessary technologies in

		place that allows for the integration of patients' health data from IoT devices so as to improve diagnosis and care outcomes.

After reviewing the various ways, the technology has been applied in the selected countries in the table (3) above, we can acknowledge that there are some key measures that must be put in place before this technology can be adopted. It is important to take note of some valuable lessons from the selected countries listed below.

- The various governments put in place a unique identifier that allows for citizens to have access automatically to the platform and for them to be easily linked to their health record.
- The governments continue to create a suitable environment where the adequate infrastructure needed for all and sundry is available so as to ensure that the citizens and also healthcare providers become more tech savvy.
- Every individual is kept up-to-date about happenings in the society as well as educated and trained on the importance of adopting the technology.
- The need for legislative regulation and support in the society so as to support the adoption of the technology.
- The need for public-private partnership so as to make sure all sectors are actively engaged in the adoption of the technology.
- The need for continuous research and development so as to be well knowledgeable on what the technology entails.

2.3 Summary

This chapter is of two parts, the earlier studies and the theoretical framework. The first section began with the conceptual clarification of basic terms such as health information management, record keeping in the health sector, and blockchain technology in other to help the reader understand the various concepts as it relates to the study. This section further went on to explain the challenges experienced in the current system and how it affects both the patients and the healthcare providers. It also progressed to describing how the blockchain technology works and the different types of the technology with its characteristics.

Having talked about the current system being applied in the healthcare sector, the second part of this chapter centred on talking about the adoption of blockchain technology in healthcare delivery and also finding out things necessary to be put in place from the early adopters. The reason for this is to enable later adopters, such as Nigeria or other developing countries know the various things that should be put in place before adopting the technology. On this note, chapter three would introduce us to our case which is the major focus of this research.

3 Case Study Design

3.1 Introduction

Having understood that the beginning stages of the development of this thesis through a thorough overview of the literature conducted were inconclusive, there was therefore a need to conduct an empirical research. Hence, this chapter focuses on providing a detailed explanation of the chosen design for the study as well as the parameter and conditions under which the research is to be conducted.

This chapter is divided into six sections. The first part starts off by giving an overview of the research questions selected for the study. Furthermore, the section also draws our attention to the central objectives of the study while explaining its rationale for choosing each research question and how it can help achieve the overall research objective. The second section went further by providing a detailed explanation of the case and subject selection. It starts off by explaining what a case study research is, its advantages as it is the chosen research design to be employed in this study. The third part clearly explains the data collection procedures to be used in carrying out the research. This is followed by the next two sections which explain the analysis and validity procedures to be utilized in the research and lastly, the chapter closes with a summary of the whole chapter.

3.2 Research Questions

At the beginning of the development of this thesis, the central objective was to find out as well as recommend means by which the adoption of blockchain technology can improve the information management system in the health sector of developing countries with a central focus on Nigeria. From the literature review, the following became clear: service delivery in the health sector is changing, record management in the health sector is changing, ICTs and innovative technologies are changing the way health services are created/delivered, and blockchain technology has the potential to create major benefits for the society (such as improving the information management system in the health sector). It could also be seen that there is an obvious gap in academic literature exploring how the use of blockchain technology in the health sector

can help improve the health information management system. Hence, the major research question driving the thesis was borne out of the discovered research gap.

RQ. How can blockchain Technology Contribute to the Improvement of the Information Management System in the Health Sector?

For establishing separation of concerns and also to carry out a detailed research, we divided the main research question into three different sub-questions: -

- **SRQ1.** How to study the influence of blockchain technology for record keeping and information sharing in the healthcare service delivery process?
- **SRQ2.** How to find the key criteria that allow for measuring the benefits of adopting blockchain technology for information management in the healthcare service delivery process?
- **SRQ3.** How can the use of blockchain technology for information management influence the key stakeholders in the healthcare service delivery process?

The first sub-research question is discussed in chapter two of this thesis but would also be discussed more in the next chapter and it has the following questions which will eventually be broken down into interview questions under it: -

- What is the initial assessment of the system prior to the adoption of blockchain technology for information management?
- What is perceived an efficient record keeping and information sharing system?
- What are the factors that might impede or promote the usability of the proposed system?

These questions help to understand the current challenges inherent in using the paper system and also how the system ought to be. By identifying the differences, the influence of blockchain technology for information sharing in the health sector can be deduced.

The second sub-research question also has the following questions which will later be divided into interview questions: -

- What are the criteria that determine the extent of the blockchain technology effectiveness in the information management process?
- What are the criteria that determine the extent of the blockchain technology efficiency in the information management process?
- What is perceived a quality improvement in the healthcare service delivery process?

The questions listed above are necessary in order to understand how impactful the use of blockchain technology in the health sector would be.

The third sub-research question also has some questions which will later be divided into survey questions for the purpose of carrying out this research: -

- What are the roles of key stakeholders in healthcare service delivery?
- What are the peculiar characteristics of those respective stakeholder roles?
- What is considered an improvement in the activities of stakeholders in the healthcare service delivery process?

These questions would help us understand if applying blockchain technology in the health sector would benefit the stakeholders.

3.3 Case and Subject Selection

With the appropriate research questions designed for the study in place, it was important that the research methodology selected to guide this research made sense and also had the potential for this research to contribute to the current relevant academic research. Consequently, based on the objective of the study, the research could be seen as being qualitative in nature. Hence, the case study research design was considered the most appropriate research methodology to be employed for the study.

According to Yin (2003), a case study can be defined as an empirical research that deals with investigating a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and the context are not reasonable or

logical. Therefore, we can infer that a case study research not only increases knowledge about a phenomenon but also contributes to the change in the phenomenon being studied. Yin also goes further in his book to explain that the case study research method is the appropriate methodology to be employed where there are; how and why research questions, the researcher does not have control over behavioral events and also when the research has to deal with a contemporary event (Yin, 2003). If the research meets the listed criteria, then the next step would be to decide on how to design the case study and according to Yin, the research design is a logical plan of getting from here (initial research questions) to there (conclusion).

Furthermore, there are different types of case study designs and these include; the single and multiple case studies. A single case study design has to deal with studying phenomena of interest while making use of a single subject, a bounded case or a small group to illustrate the issue under study (Nock, Michel, & Photos, 2007). On the other hand, a multiple case study research design is almost similar to the single case study design, the only difference here is that for the multiple case study design, the researcher employs the use of various subjects or bounded cases to illustrate the phenomenon being studied (Gustafsson, 2017).

Many researchers prefer using the single case study design in carrying out their research as they believe that this method focuses on a single subject of study, which results in a more efficient outcome of the phenomenon being studied (Nock et al., 2007). According to Yin (2003), the single case study focuses more on parameters, establishments and objectives of the research rather than a large sample design. It is in this vein that we have also chosen to focus our study on the single case of adopting blockchain technology for health information management in Nigeria and with the aim of developing a framework to guide the implementation planning on how the technology can be adopted.

Similarly, Yin (2003) is also of the opinion that the case study research design is used in various circumstances in order to contribute to our knowledge of an individual, a group, an organization or any related phenomena. It is also a common research blueprint in psychology, community planning, sociology, social work, economics and even business as it helps in not only increasing our knowledge of a phenomenon but also to bring

about changes (Gilgun, 1994 cited in Yin, 2003). Additionally, it is good to note that case studies do not produce the same results as some other research designs such as experiments, but they help in increasing our knowledge about a contemporary event (Runeson, Host, Rainer, & Regnell, 2012). Also, from the various approaches to the use of case studies which Yin (2003) mentions in his book, we have chosen to adopt the exploratory case study design style for this research. Runeson et al., (2012) are also of the opinion that the case study research is explorative by its very nature as it is designed to investigate the various research questions which are important to the study being carried out.

Additionally, as a result of the research questions and the decision to undertake a case study research, the hospitals selected were from the contact network of the researcher, and at the same time attempts were made in order to make sure that they were selected from different regions in order to achieve as large variation as possible.

3.3.1 Advantages of Using the Case Study Research Design

Some researchers are of the opinion that the case study research design comes with a lot of benefits when used in carrying out a research. According to Zainal (2007), case study research design allows for the exploration and comprehension of complex problems as the research is undertaken in a natural environment where the researcher can go beyond statistical results to understand the behavioral conditions through the actor's perspective. Unlike some other research designs, such as the experimental research design where the event or issue being studied is deliberately isolated from its context or its natural environment with a focus on a limited number of variables.

Additionally, Krusenvik (2015) is of the opinion that the case study research design often involves several sources of data which in turn produces a lot of data for analysis. Some of the sources of data include; interviews, archival records, participant observation, physical artifact, direct observation and documentation. Therefore, we can infer that this research method allows for the use of both qualitative and quantitative data analysis in order to provide a descriptive account of behavior through complete observation, reconstruction and analysis (Zainal, 2007).

One other major advantage of the case study design is that it provides a detailed explanation of real-life situations and views regarding the phenomena being studied as it unfolds in practice (Flyvbjerg 2006 cited in Krusenvik, 2015). Hence, ensuring the understanding of complexities associated with processes in a wider social context and providing a detailed analysis of the individual case which is not captured when some other research designs are employed.

3.4 Data Collection Procedures

Data collection procedure as the name implies can be defined as the procedures or means by which the data to be analyzed for a particular study is collected. According to Runeson et al., (2012) one major technique to improving the validity of the research being conducted is to employ the use of multiple data sources which serves as multiple sources of evidence, in order to limit the interpretation of a single data source. This is known as data triangulation and it helps to provide a broader picture of the phenomenon being studied and also to ensure that the results gotten from the study are trustworthy.

For this study, we have decided to make use of the first-degree data collection procedure. This data collection procedure as stated by Runeson et al., (2012) is a direct method where the investigator is in direct contact with the interviewees and data is collected in real time. Hence, the various sources of evidence that would be used for this research include; document review and semi-structured interviews.

3.4.1 Document Review

Document review simply means the process of collecting information by reviewing existing documents and some examples of this are listed below.

- Administrative documents such as; reports, program logs, proposals, minutes of meetings, newsletters, marketing materials, performance ratings and a host of others;
- Business documents such as; financial and transactional statements, and other business reports;
- Letters, email correspondence, memorandums, and other personal documents.

According to Yin (2003), one major importance of reviewing documents when carrying out a case study research is that they help in gathering background information and collaborating data collected from other sources. In our study, we have made use of various forms of documents ranging from journals, newspapers, academic articles, governmental documents to other forms of research papers particularly in our review of related literature where we had to throw more light on the theoretical concept of the study. The discuss addressed topics such as; the concept of health information management, record keeping in healthcare service delivery, forms of record keeping, blockchain technology, potential applications of blockchain technology, examples of some selected countries who have currently adopted the use of this technology, to mention but a few.

Additionally, document review was also used to give a detailed explanation of the Nigerian case. For instance, the current state of art in the health sector in Nigeria was discussed. Then we progressed to talking about how the health sector ought to be, using a few countries as examples. This was done just to see if the environment in the Nigerian health sector is conducive enough and if it meets up to international standard. Finally, the document review ended on the note that there are barriers in the current system and how it affects the healthcare providers at large. However, unavailability of theoretical evidence hasn't made it easy for us to know the extent of this problem, therefore creating the need to employ the use of the survey method via the conduction of interviews in other to gather empirical data.

3.4.2 Interviews

The interview method of data collection has been seen to be the most frequently and most important in carrying out a case study research (Runeson et al., 2012). According to them, the reason why it is often used is that much knowledge of the phenomenon being studied can be gotten from the minds of people working in the case being researched and cannot be gotten elsewhere. This is done so as to understand the different experiences of the interviewees that the researcher had no idea of. In addition, the investigator uses this method to validate the information gathered from the document review process. For the study, we will be adopting the use of the semi-structured interview process while conducting this research as this is very suitable for an

exploratory research. Here, different questions which consist of a mixture of closed and open-ended will be presented to the interviewee as this will help understand better how they experience the phenomenon. It would also allow for the improvisation and exploration of the various issued raised as a result of the conversation. Also, the proposed interview questions would be used to kick-start the interview process and weren't be limited to these questions alone as it is in the case of the formally structured interviews. Additionally, the selected interview questions were designed to contain questions and categories that are of crucial importance to this research. It is good to note here that the stated interview questions were to ensure that the main research purpose was covered and not selected based on theory. Also, during the process of conducting interviews with each interviewee, the researcher's level of control over the structure of the questions was minimal as already explained by the form of interview being conducted and also to ensure validity. Eighteen (18) unstructured interviews (14 initial and 4 more interviews) were conducted with healthcare providers from the different regions. An appointment was scheduled with the selected interviewees and the interview was carried out at the agreed time. All conducted interviews were done face to face and recorded with a tape recorder at the same time. After the interview, the responses were transcribed, coded and analyzed using RQDA for simplification purposes.

3.5 Analysis Procedures

The importance of this phase in a case study research according to (Runeson et al., 2012) is to understand what has happened in the studied case using the data collected. Therefore, since we are carrying out a case study research, we will employ the use of qualitative data analysis method in order to keep a clear chain of evidence. In addition, for this process, we have decided to make use of RQDA (a software tool used to analyze textual data) as stated earlier. Furthermore, the analysis will be carried out in parallel with the data collection process in order to know if there is a need for collecting additional data. This is usually done in other to find out the new insights that may arise.

Our Interview data were analyzed on the basis of Open Coding. This form of qualitative data analysis has to deal with labelling the ideas or codes generated from the interviews that describes the phenomenon being studied and then going forward to generalize them

into categories based on their characteristics. Our aim here is to develop a descriptive framework for our analysis.

The first step here is for the data to be coded which simply means that various parts of the text are given a code representing a certain construct or a particular theme. One code is assigned to each piece of text and one piece of text can be assigned to one code or more. The coded document will be combined with comments in other to easily identify the hypotheses. Thus, a set of generalizations will be formulated which will, in turn, generate a formalized body of knowledge which is the final result of the research. The codes and categories in our analysis were developed gradually and consistently by reading through the transcripts thoroughly and repeatedly.

Therefore, we can infer just as Runeson et al., (2012) stated that the main steps of the analysis are made up of five steps which are; data collection, coding, hypothesis definition, generalizations/findings and reporting and this is also how we intend to go about in analyzing our result.

3.6 Validity Procedures

As explained by Yin (2003), the validity of a research implies how trustworthy the results gotten are based on the investigator's subjective opinion. Runeson et al., (2012) also state that the validity must be addressed during all stages of the case study research and not just in the analysis stage. For the purpose of our research, we have made sure to employ the use of construct validity and reliability. Construct validity here simply means the extent the operational measures that determine which data is to be gathered and how it is to be collected to represent what the investigator and interviewee have in mind. In addition, it should also be investigated according to the research questions. On the other hand, reliability is used to determine the quality of a study. It shows the extent to which results are consistent over time, even if the research is later conducted by a different researcher. Hence, we can say that conducting our research by employing the use of interview as a survey method, we can achieve construct validity and reliability procedures for our research.

3.7 Summary

This chapter provided a detailed explanation of the case study research design as it was the chosen research methodology adopted for the study. Furthermore, the methods of data collection used in the study were discussed and also, the reliability and validity assessment of the data collection instruments were looked into. Results gotten from this exercise will be used for the analysis which would be the topic of discussion in our next chapter.

4 Results

4.1 Introduction

This chapter of the master thesis provides more explanation of the case and subject selection. It then goes further to present the analysis and interpretation of the interviews conducted. RQDA as explained in the previous chapter, was employed so as to provide a detailed description of the interview outcome and then the chapter concludes with a summary.

4.2 Case and Subject Description

The Nigerian health sector is divided into three different arms; the primary, secondary and tertiary level. On the one hand, the federal government of the nation is saddled with the responsibility of implementing appropriate policies to guide the activities of the health sector as a whole and also providing tertiary healthcare. The state government on the other hand is responsible for providing secondary healthcare, while the local government has to deal with providing a conducive environment for the primary healthcare system. However, since the activities of the local government in the country is not adequately coordinated, it has resulted in creating a poor foundation for the healthcare system in the country. The healthcare facilities that are still operational in the country has been seen as inadequate. While various actions have been taken by the federal government of the federation to better the current system in the health sector, the proper management of a patient's health information has been seen as one area that has not been properly looked into.

In Nigeria, the method of record keeping and information sharing of a patient's health information has been seen to be lacking the use of the present-day information and communication technologies and this has resulted in several problems. For instance, issues such as; missing health records, inadequate treatment and diagnosis of patients, duplication of patients' folders and delayed treatment of patients as a result of healthcare providers searching for the patient's health record to know the previous treatment the patient had received in the past has become very common. Also, it is good to note that with the complexity of modern treatments and also the different kinds of

diseases in the country, it is important that adequate records are kept, and health information is made readily available to any healthcare provider.

As previously explained in the second part of this study, keeping adequate records for health service delivery is very important because of the kind of information and what the information also does. Therefore, we can infer that when adequate records are kept, there will be an increase in the quality of healthcare service rendered.

This research was carried out for the main aim of finding out the importance of adopting blockchain technology to solve the current issues in the system, to find out the impediments to the adoption of the technology for information management in the Nigerian healthcare delivery process and to also understand better the major issues being experienced in the system at present.

As formerly pointed out, the research was conducted with the use of interviews so as to provide an in-depth understanding of the case being studied, to keep adequate evidence on the research being conducted and to also have direct contact with various healthcare providers who could be seen as the direct users of the current system. A total number of 20 healthcare providers from hospitals in different regions of the country were selected for the interview process. We carried out interviews with different healthcare providers, ranging from; radiographers, paediatricians, general practitioners, junior nurses, medical directors and chief nursing officers. This was done in order to get various ideas from healthcare providers with views on what they think is the major challenge in the health sector and what should be done to improve service delivery.

4.3 Presentation of Findings

Having successfully conducted our interviews which was designed to investigate the problem under study, the findings in this section will illustrate the data gotten from the interviews. In addition to this, the data will be presented in different sections in line with the structure of our research questions. While the first section is focused on knowing the general background of the interviewees as a measure of assessing the validity of their responses, the other sections focused on addressing relevant issues that are significant in answering the research questions so that the overall research objective can be achieved. Subsequently, the analysis is followed with an interpretation of the

responses and an explanation for the observation. It is also good to note here that the codes used for the analysis were formulated using the hybrid approach (combination of the inductive and the deductive approach to coding). This simply means that some of the codes used in analyzing our data were predetermined based on the research questions for the study (deductive) while others were emergent (inductive) after reading the interview transcripts thoroughly and consistently. Furthermore, the categories (combination of two or more codes with similar characteristics) were developed gradually.

4.3.1 General Description of the Respondents

This section provides more general information on the respondents selected for this research and it addresses the questions on step two (2) of our interview guide. This was done to ensure validity of the research and to also make certain that the people interviewed had much knowledge about the current problems in the system.

From the interview conducted between various healthcare providers, the majority of our respondents were general practitioners, while the others were chief nursing officers, medical directors, radiographers, paediatricians and junior nurses. Also, most of the respondents had worked for over 10 years while the rest were below 10 years. Therefore, it could be inferred that majority of our respondents have been working as healthcare professionals and have been in the system for quite some time to know the information we seek for this study.

4.3.2 Blockchain Technology and Record-keeping in the Nigerian Healthcare System

One of the central objectives of this research was to ascertain how the emerging use of blockchain technology can influence the Nigerian healthcare delivery system. This section answers the research question “How to study the influence of blockchain technology for record keeping and information sharing in the healthcare service delivery process? To provide a more in-depth explanation, the question was divided into specific sub-questions “what the initial assessment of the system prior to the adoption of blockchain technology for information management is?”, “what is perceived an efficient record keeping and information sharing system?” and “what are the factors that might

impede or promote the usability of the proposed system?" Interviews were carried out to find appropriate answers to the sub-questions and from the results gathered we decided to divide this section into different categories or sub-sections according to the codes used in our analysis and these have been highlighted below:

4.3.2.1 Current Record-Keeping System in Nigeria

As a result of the research question to be answered under this section ("what is the initial assessment of the system prior to the adoption of blockchain technology for information management?"), it was important to find out the current assessment of the system. Therefore, since existing evidence from literature already mentioned the paper-based form of record keeping as the commonly used system in the Nigerian healthcare delivery process, evidence from the interview conducted also supports this fact. It indicated that the manual system is still the major form of record keeping in the Nigerian healthcare system with the electronic form currently emerging. For instance, one of our respondents stated explicitly that; Insta, One medical, MedTech, and Smart doctor are a few of the emerging electronic technologies. Although, he also voiced out his concerns that there were some problems with the design of these technologies as they were not user-friendly for healthcare providers. Majority of our respondents admitted that the paper-based system was the most significant form of record keeping system in many facilities. According to them, it is the traditional form of record keeping and was still being used because they met it in the system even before they joined and that is also what their fore-fathers used during their time.

This section (Current record-keeping system in Nigeria) focuses on the current method of record keeping in the Nigerian health sector and from what was gathered, it was evident that the paper system was still majorly in use by many healthcare facilities. Also, the respondents pointed out that the form of information sharing in the system was to print out health records on paper whenever a patient requested for it in other to take to a different healthcare facility. However, from the review of literature on the subject matter, it depicts that the electronic form of record keeping and not the manual form is what is being practiced. The use of computers for storing and accessing patients' health record is what is prevalent and not the use of papers and folders.

4.3.2.2 Features of an Efficient Record-Keeping and Information Sharing System

This is one of the most important sections in this research as it has to deal with what the interviewees think an efficient system for healthcare service delivery should be. Thus, the section provides an answer to the research question "what is perceived an efficient record keeping and information sharing system?"

A closer look at the results gotten from the interviews conducted indicates what the two most important features a good record-keeping system in the health sector should possess. Majority of our respondents mentioned easy accessibility and retrieval of health records quite often but in different contexts. For instance, one of our respondents was of the opinion that *"A good system ensures speedy health care provision to patients as a result of easy retrieval of patient's health record. In such system lives are saved more often and not always lost because we can save them once we know what treatment they have been used to in the past"* while the other respondent thought that *"A system where records are easily accessible so as to increase quality of care to patients not one where the files of patients are always missing and in some cases stolen" (Respondent).*

The participants also pointed out the advantages of a system where records are easily accessed and retrieved. A large number of the respondents were of the opinion that; continuity of care and timely healthcare provision are some of the benefits in such cases. Other respondents also supported this claim and went further to say that in such a system; there is an increase in the service productivity of healthcare providers, there is also a reduction in the waiting time patients spend in the hospital and overall the process is made less stressful for healthcare providers. In addition, a very few respondents talked about the data confidentiality of patients. They admitted that health data is a very sensitive data and shouldn't be found in the hands of unauthorized individuals, so an efficient system should ensure that patients records are kept secure at all times and only authorized persons are allowed access to viewing such data.

This section was directed towards discovering what healthcare providers understand a well-organized record keeping and information sharing system in the health sector should be. As can be seen from the data gathered, easy accessibility to health records and easy retrieval could be seen as the two major features of an efficient system. Existing literature also confirmed this and went further to provide examples of other

important features such as; interoperability, transparency, accountability, and trust in such system.

4.3.2.3 Factors that Impedes and Promotes the Usability of Blockchain Technology in Nigeria

This sub-section was designed to provide an answer to the research question "what are the factors that might impede or promote the usability of the proposed system?" Our aim here is to investigate the factors that impedes and also factors that promotes the implementation of this technology in Nigeria as it was obvious that there were certain barriers to its implementation taking cue from the key measures that need to be put in place in order for the technology to be adopted as seen in developed countries mentioned in chapter two of this study. Below is a list of the factors capable of limiting the adoption of this technology in Nigeria as indicated by most of our participants: -

- Epileptic power supply
- Funding
- Inadequate infrastructure
- Lack of computer expertise among healthcare providers
- Network issues
- Lack of appropriate rules and regulation.

For instance, in the words of one of our respondents *"we have been running on the hospital's generator for the past two days and fuelling it is very expensive, so most times there is no light in the hospital, the government really needs to deal with this" (Respondent).*

One of our respondent who had spent so many years in practice laid more emphasis on training healthcare providers to know how to use a computer by making it a compulsory course in medical school. According to him, he wasn't taught how to use a computer during his time and doesn't still know how it is used. He went further to advise that once this is done, it will serve as a prerequisite for anyone coming into the field to practice.

Furthermore, some of the respondents proposed the following solutions to tackle the limitations earlier mentioned: -

- Adequate infrastructure
- Constant power supply
- Continuous training of healthcare providers.

An example of the limitation could be seen in the words of a participant who expressed that *"The government needs to provide a complete environment for the provision of healthcare to all and sundry. They should learn to try designing their own things and reduce importing things to the country. There is also need for efficient training of the healthcare providers in the system as there are a lot of doctors who aren't efficient on their job in practice at the moment" (Respondent).*

This part of our research was directed towards discovering the limitations to the successful implementation of the technology in Nigeria. Although, literature did not give us facts hindering the implementation of the technology in developing countries, it indicated that there were barriers prone to the effective implementation of the technology. Therefore, in our bid to find out factors that might impede the successful adoption of blockchain technology, we decided to find out from healthcare providers that had more knowledge on how the health sector operates.

Conclusively, we can see that all sub-sections above provide answers to the main research question. The answers gotten from our interview shows the form of record keeping in use by the Nigerian health sector. However, as seen in existing literature, taking cue from the countries selected as best practice for the purpose of our research shows that this form of record keeping is no longer in use. Therefore, it could be concluded that in order to adopt the use of blockchain technology for record keeping and information sharing, all healthcare facilities in Nigeria have to embrace the use of computers in providing health services. Additionally, we went on to find out if healthcare providers had the idea of how an efficient system should be and from the results gathered it was obvious that healthcare providers already had a notion of what is obtainable in an efficient healthcare delivery system. However, as found out from interviews and existing literature, certain measures must be put in place before the

successful adoption of the blockchain technology. For instance, findings from our literature as shown in the three countries (Dubai. Estonia and The Netherlands) revealed that the following are some of the best practices needed for the successful adoption of blockchain technology in every country: -

- Putting in place a unique identifier for all individual so that owners of health records can be easily identified
- Presence of legislative regulation and support
- Need for public private partnership
- Continuous research on the technology.

4.3.3 KPI's Determining the Efficiency and Effectiveness of Adopting Blockchain Technology for Information Management in Healthcare Service Delivery in Nigeria

Criteria that demonstrates the successful implementation of this technology is another important part of this research as it is important to know if adopting blockchain technology would make a difference to the current happenings in health facilities. This is why the research question "How to find the criteria that allow for measuring the benefits of adopting blockchain technology for information management in the healthcare service delivery process?" was dedicated to evaluating this. For us to provide definite answers, we decided to divide the main research question here into different sub-questions "What are the criteria that determine the extent of blockchain technology effectiveness in the information management process?", "What are the criteria that determine the extent of the blockchain technology efficiency in the information management process?" and "What is perceived a quality improvement in the healthcare service delivery process?". As usual, interviews were conducted to find answers to the already stated questions and results were compiled. From the data gathered, the majority of our respondents were of the opinion that the most important KPI's to be used in measuring the efficiency and effectiveness of blockchain technology in the health sector are: -

- Accessibility to health records
- Affordability of the technology to all hospitals
- Ease of use of the system
- Waiting time
- Efficiency of outcome
- Patients feedback.

To further buttress this, one of our respondents who is a medical practitioner at a hospital in the Northern part of Ogun State, Nigeria stated that *"for blockchain technology to be fully efficient in the Nigerian healthcare system, then it should be very affordable for primary healthcare providers to partake in the system especially in small villages and wards" (Respondent)*.

Based on the answers provided by our respondents, it could be gathered that the outcome of using blockchain technology in the health sector can be measured using significant key performance indicators. According to them, this should be done often so as to know if adopting this system is advantageous and if the activities in the health sector has remained the same even after the adoption of the technology. This is expected as there has to be a way to measure the effectiveness and efficiency of every technology being adopted. Another reason for this is also to ascertain if there is a difference in the system even after the implementation of a new technology.

Participants further went on to highlight proposed benefits for adopting blockchain technology in the healthcare service delivery process to be the following (thus providing an answer to the sub-question "What is perceived a quality improvement in the healthcare service delivery process?"): -

- Increase in the quality of healthcare service provided
- Effective patient management
- Easy detection of medical history

- Continuous healthcare provision.

According to a majority of the participants, they believed that using blockchain technology the information sharing process will provide them easy access to the health records of patients as this is paramount in the healthcare service delivery process and as a result, this will help increase efficiency and productivity on their job.

4.3.4 Influence of Blockchain Technology on the Activities of Stakeholders Involved in Healthcare Service Delivery

This section was designed to provide an answer to the research question "How can the use of blockchain technology for information management influence the key stakeholders in the healthcare service delivery process?". We needed to investigate if the application of blockchain technology in the health sector will benefit stakeholders or healthcare practitioners in the system. For this, we split the main question into different sub-questions; "What are the roles of key stakeholders in healthcare service delivery?", "What are the peculiar characteristics of those respective stakeholder roles?" and "What is considered an improvement in the activities of stakeholders in the healthcare service delivery process?". In other to provide sufficient answers to all three sub-questions, we decided to summarize the answers provided in just one section as the questions were similar to each other and also so that it made sense.

As earlier stated, the majority of our interviewees were general practitioners while the others were radiographers, paediatricians, junior nurses, medical directors and chief nursing officers. In addition, most of the respondents had over ten (10) years working experience in their respective fields while others were below ten (10) years but none was less than two (2) years. Furthermore, it was evident that a larger part of our respondents had similar job characteristics while carrying out their daily routine. They outlined that their main duties were to see patients (both outpatients and inpatients), conduct ward rounds, attending to emergencies and also consulting with patients before referring them to a specialist. The other part of our respondents were medical directors and chief nursing officers and they confirmed that they were in charge of handling the administrative duties in the hospitals such as; supervising junior colleagues, delegating duties, ensuring the smooth running of the wards and the hospital in general and also attending to patients occasionally.

In this vein, we needed to verify what is considered an improvement on the activities of stakeholders in the healthcare service delivery process. From the results gathered participants stated that an improvement in their activity is when they are able to attend to the patients on time and also being able to resolve their complaints efficiently. They also went on to say that providing quality healthcare to patients should be considered as a very important improvement in the health sector and also a reduction in the death rates of patients. Nevertheless, it was obvious that issues such as; delayed treatment of patients, incomplete health records of patients and inadequate diagnosis of patients were experienced more frequently in the system and existing literature also backed up this claim. As a result, they proposed that there was a need for the system to be restructured.

Conclusively, it is evident that healthcare providers support the implementation of blockchain technology in Nigeria as it will help address the issues pertaining to record keeping and information sharing in the current healthcare system of the country.

4.3.5 Summary

This chapter began with a short summary of the case and subject selection for this research. It then went on to provide a detailed analysis of the results gathered from the conducted interviews in other to effectually provide sufficient answers to the research questions selected for the purpose of the study. Furthermore, we could see that categories which generated from the stated research questions were formed and then divided into sub-sections in other to provide well explanatory answers to the questions under study. The reason for this is to ensure that each research question was appropriately covered.

5 Conclusions and Future Work

5.1 Introduction

From the previous chapter of this study, it was evident that healthcare providers supported the use of blockchain technology for record keeping and information sharing purposes in the health sector. However, the results also showed that there are important factors that would hinder the successful adoption of the technology in the Nigerian health sector if not dealt with. Hence, this chapter discusses the main findings and contribution of this research. In this vein, we propose a practical framework for the adoption of blockchain technology in Nigerian health sector. This is explained in the summary of findings section. The following section would deal with relating this work to existing evidence while the subsequent sections will discuss impact/implication, limitations, and possible future work.

5.2 Summary of Findings

After careful review of the results gotten from the interviews conducted, as well as best practices of blockchain adoption amongst early adopters (Dubai, Estonia and The Netherlands) as discussed in the second chapter of this study, the researcher reached a resolution that the federal government of Nigeria needs to establish a system that will help address the issues of record keeping and information sharing in the health sector. Thus, the researcher proposed a framework that would guide this process and also help eliminate the stumbling blocks to its implementation in the country. See figure 2 below;

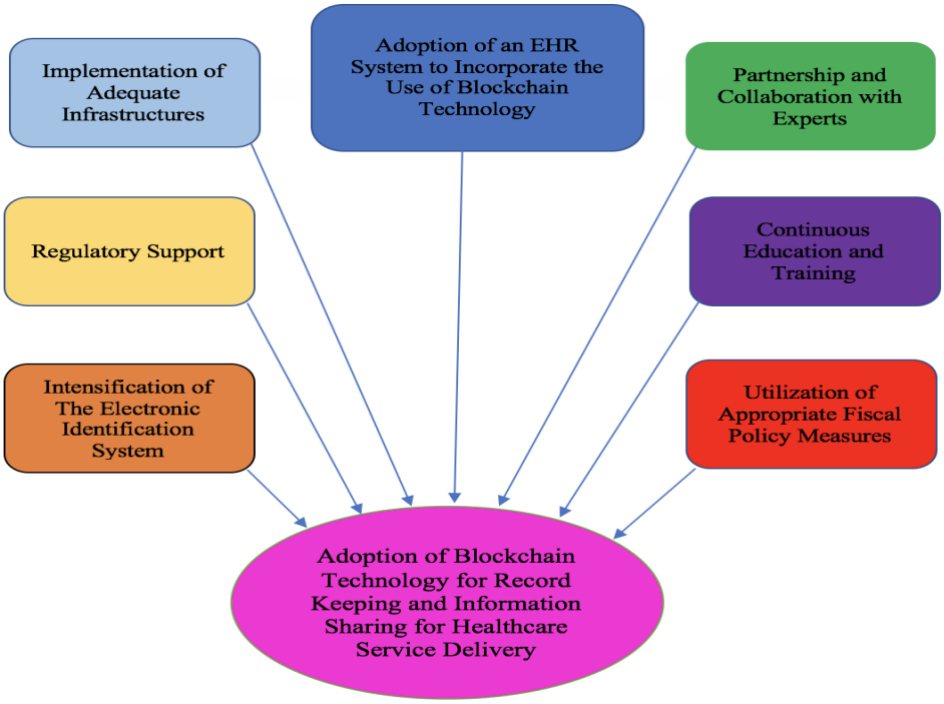

Figure 2. Framework for the Adoption of Blockchain Technology for Healthcare Service Delivery in Nigeria. Source: Author.

5.2.1 Intensification of the Electronic Identification System

Identity management is a very important aspect of governance and this is so because it deals with specifically identifying an individual. Taking cue from the countries used as best practice for this study, we could see that each country had a unique identifier. As a result, the countries were able to link patients to their health record by identifying them through their unique identifier.

In the Nigerian case, the National Identity and Management Commission has been able to provide citizens of the federation with their electronic ID Cards so as to enable them easily access online government services but there is still an issue with accepting this card as a means of identification. Therefore, the government needs to ensure that all entities accept this form of identification as a means of registering and identifying citizens using the unique identifier on their e-ID card. Also, this should be regulated by the law. For example, this is regulated by the Digital Signature's Act and Identity Document Act in Estonia. The card already offers strong authentication and electronic signature but hasn't been regulated yet. It also supports biometric identification through

the use of finger print. Once this is done, the healthcare providers will be able to use the unique identifier on the ID card to link patients directly to their health data just as it is done in the developed world. A sample of the Nigerian E-ID card is shown below.

Figure 3. Sample of the Nigerian E-ID Card. Source: National Identity Management Commission.

5.2.2 Regulatory Support

With the recent shift to using blockchain technology in different areas, it is important to note that for the successful adoption of the technology in whatever area it is being applied to, there must be a legal and regulatory support that would enhance its success. Although the federal government has been very supportive of the blockchain industry in Nigeria, it is still of utmost priority that the use of the technology in the country must be legalized. In our case, legalizing the digital solution would allow for the technology to be used as a means communication between the various health facilities in the country. Hence, the researcher has proposed that the government of Nigeria should adopt or amend the following laws: -

- **Electronic Signature: -** Although the Nigerian government has implemented the use of its electronic ID cards and has been able to provide this card to citizens in the country, there has not been any legal provision made for the use of an electronic signature in Nigeria. What can be found in use by the courts in Nigeria is the use of electronic evidence provided by the evidence Act of 2011. Nonetheless, this can be seen as not sufficient enough, so there is the need for an electronic signature law in other to drive the use of digital signatures for accessing online services (in this case the health portal) in the country. Therefore, the government of the federation should reconsider amending the constitution to include a law on e-signatures and also to define what it means, what is acceptable and how it can be easily utilized by the citizens of the

federation. Additionally, policies authorizing entities or agencies to accept digitally signed documents should be constructed.

- **Displacement of Paper Files: -** There is also a need for a law that supports the displacement of paper files in institutions, organizations or entities, agencies, and even the ministries that still use papers and have not fully automated their processes. If this is done, it will hasten the computerization of processes in various offices in all parts of the country. In our case here, it will support the computerization of records in the health sector. It is also good to note here that these laws must be made technology neutral so that it could also be used in the case of a different technology emerging.

5.2.3 Implementation of Adequate Infrastructures

For the successful adoption of this technology, there is a need for the Nigerian government to ensure that all that is needed to sustain the adoption of this technology must be put in place. From the interviews carried out, healthcare providers were seen to refer to issues where they felt the government was lacking in. Therefore, to embrace this technology, the government must make sure that there is constant power supply in the country. Although, the government has been working very hard on this and have now made sure some parts of the country have constant power supply, it is necessary that this spreads to all part of the country, including the rural areas.

Additionally, there is need for computers to be made available to all healthcare facilities in the country. The government could take up doing this or even providing it to facilities at a subsidized rate as this will help hasten the movement to the electronic record keeping system. However, if the government intends to adopt this technology using the public hospitals before bringing in the private hospitals, then they have to provide computers to all public healthcare facilities in the country. Also, there is a need for the government to address the issues on network and server malfunctions because this is a very important part that must be worked on; for instance, there is need for a good and fast network when information needs to be shared between facilities. The government could use other countries like; Estonia, Finland and some other European countries as an example.

5.2.4 Adoption of the Electronic Form of Record Keeping to Incorporate the Use of Blockchain Technology

This is a very important part of this section. As stated earlier, all the countries that had implemented the use of blockchain technology for healthcare delivery were already making use of the electronic record keeping system. Therefore, there is a need for the form of record keeping in the health sector to be digitized. This means that there needs to be a transition to implementing a working electronic record keeping system in healthcare facilities in the country. Once this is done, the working system can now be fully integrated with the blockchain technology.

5.2.5 Partnership and Collaboration with Experts

This is one other important aspect the government has to consider. The government needs to partner with blockchain experts just like it is already doing in Nigeria. They also need to partner with international experts on blockchain; an example is seen in the case of Dubai partnering with Estonia. Estonia's expertise is based on proven practice, so it will be best if the Nigerian government also follows suit.

Also, there is the need for the government to collaborate with IT startups dealing with blockchain technology in the country. They could even go as far as setting up a cyber-security team. This is so that the implementation of the technology in the country's health sector is successful.

5.2.6 Continuous Education and Training

As seen in existing literature, there is a need for continuous training of health workers in the system on the electronic record keeping system and how the blockchain technology works. Also, there is need to carry them along during the design of the system so as to ensure ease of use of the system. Furthermore, the government needs to continuously educate citizens on what the technology entails and also encourage continuous research on the technology. This is necessary so that everyone is carried along in the whole process and also become knowledgeable about it. The government can do this by organizing trainings, workshops and seminars for healthcare providers. On the other hand, educating its citizens on the technology through radio talks, television programs

and even conferences. This is done so that the population can become a tech-savvy one with time.

5.2.7 Utilization of an Appropriate Fiscal Policy Measure

This section has to do with the issue of funding pointed out by the interviewees during the interviews conducted. Although, quite some amount of the Nigerian budget is allocated to the health sector, the country can also raise money from using appropriate fiscal policy measures; for instance, taxation, hence making sure the citizens pay their taxes at the right time. This should be done in order to sustain the transition to the electronic record keeping system as a form of record keeping in the health sector and so that the expected end result of this whole process is achieved.

5.3 Impact/Implication

In this study, we identified the problems with using the paper form of record keeping and also some issues in the electronic record keeping system. We went further to provide details on how blockchain technology could help address these issues and also provide a framework for adopting the technology in Nigeria which is the case of this study. We provided explanations on how an efficient healthcare delivery process should be and how blockchain technology can help achieve this. Our study represents a new measure of achieving a good healthcare delivery system.

The interesting point to note here is that our study also opens up a new perspective of solving the issue of interoperability or information sharing among various healthcare providers.

5.4 Limitations

This section talks about the limitation of our study and it has to do with the conduct and design of our case study. When trying to study the potential limitations of the case study research design, two biggest concerns which have always been pointed out are its limitation in generalizability and lack of rigour (Krusenvik, 2015). As a result, Yin in his book emphasized that when this research design is used, the study is often questioned as to if it can be seen as scientific because of the investigator's close involvement and influence on the study which may result in the study being bias (Yin, 2003). Hence, in

order to address its lack of rigor, the investigator must ensure that multiple sources of evidence are employed, the research is carried out in a way that complies with the case study methodology and that the research design is valid (Krusenvik, 2015). As regards its lack of generalizability, Hyde, Ryan, and Woodside (2012), argue that case study research design is meant to prove a theory and not to generalize findings to a population. They are of the opinion that case studies are generalizable in proving theoretical claims and not to populations or the universe. Hence, we can infer that employing a single case study in research may be used to make a theoretical generalization on the phenomenon being studied and not to make generalizations about the entire universe or population.

Similarly, one other limitation according to some critics is that the case study investigator tends to find the use of a one-shot interview with a respondent from a particular organization acceptable and according to them, this shouldn't be seen as acceptable because they feel that too much is missing and too much reality still remains unknown (Krusenvik, 2015). Hyde et al., (2012) argues that large sample surveys fail to collect the required information for gaining a deep understanding of the situation or the phenomena being examined. Thus, we can infer that the case study research design has both its advantages and limitation just like every other research design, so it is advisable to make use of this research method when it's the most suitable method for addressing the research problem at hand.

5.5 Future Work

Based on the findings of this study and on its limitations, new directions for future studies are proposed below: -

Firstly, the credibility of the methodology used in this research should be tested, it could be reinvestigated by a different researcher and results compared against each other. It is also recommended that further studies could make use of both the qualitative and quantitative research methodology just to ensure diversification of responses from participants.

Furthermore, in this study, we tried to demonstrate an innovative approach to solving the issues associated to record keeping and information sharing in the health sector.

Further studies could design a prototype on how the system should be before adoption. This could include partnering with a few healthcare facilities and simulating different aspects of the system.

Conclusively, future studies could also evaluate the impact of the proposed system from the patient's perspective after implementation. This would help confirm if the intended benefits or the goal of this master thesis was achieved in the first place.

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Appendix 1 – Interview Guide

Step 1. The consent letter is shown and explained to the interviewee.

Certificate 15.03.2018 No. 433

This is to certify that Irene Nonyelum Azogu, born 26.01.1994, is a full-time Master study student of E-Governance Technologies and Services (code 119657) at Tallinn University of Technology since 29.08.2016.
Nominal study period 2.0 years.

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Step 2. Introduction and discussion about the interviewee's work situation.

- What is your role?
- How long have you worked in your current position?
- What are your main working tasks?
- What other person do you need to cooperate most with while carry out your duties?

Step 3. The Investigator presents the goals of the research.

- Can you briefly describe how records about patients are kept in the hospital?
- Can you briefly describe how information about the patient's medical history is accessed or shared with other hospitals?
- What do you know about Electronic health records?
- What do you know about decentralized information systems?
- What is your opinion on moving from the paper-based form of record keeping to the use of a decentralized information system?
- Do you think using a decentralized information system will be beneficial to the current workflow in the facility? YES/NO (If YES, please explain how. If NO, please give reasons).
- How would you rate your computer knowledge? Novice (), Average (), Experienced ()
- How did you acquire the computer knowledge? Self-training, trained by the facility, or trained in the school.
- Do you have prior experience with the use of any ICT program in the performance of your duties? YES/NO (If YES what program (Videoconferencing, electronic health record (EHR), etc)?

- What do you see might be the challenges to having such systems (decentralized information system) in place? Can you perhaps give examples if there are and also what do you think should be done to address these challenges?

Step 4: Questions about the digitalization of workflow in the health sector.

- For which purpose does your department/division use patient health records?
- What information management system do you currently use?
- How significant is the need for the adoption of electronic record management system in the facility?
- We're you involved in the decision to introduce the electronic record management system?
- Did you have any idea on how the system should work before its introduction?

Step 5: Questions on the availability and the accessibility of a patient's health record.

- Do you have need for knowing a patient's medical history before treatment?
- What is your specific need for wanting to know their medical history before treatment?
- At what stage of treatment do you usually need to know the patient's medical history?
- How do you address the need for getting access to health records from other health centres?
- Can you administer treatment to the patient without knowing his medical history or the form of treatment he/she has been used to in the past?

Step 6: General questions on the system as a whole.

- What can be seen as an inadequate information management system in the healthcare service delivery process?
- What features does the current information management system need to have to be seen as a "well fit" for healthcare service delivery?

- What do you think are some challenges currently experienced while using the current system?
- Are the patients' satisfied with the current system in use? YES/NO, (If YES, how satisfied are they? If NO, why are they unsatisfied? Please give reasons)
- What are the steps being taken to address the challenges in the current system?

Step 7: Questions on the measuring criteria for effectiveness and efficiency in the system.

- Do you have metrics for measuring the success in using the current system for the treatment of patients?
- Do you have metrics for measuring the productivity in using the current system for the treatment of patients?
- What do you think are the expected benefits of adopting a decentralized information system which is a form of electronic record management for information management in healthcare service delivery?
- How do you think you can measure the quality of services provided when a decentralized information system is adopted?
- What improvements do you perceive? Give examples?

Step 8: Questions on the roles of stakeholders in the system.

- Do you see yourself as a healthcare service provider?
- Do you deal with patients or come in contact with them in carrying out your duty in the facility? (If YES then the respondent role can be taken from previous (segmentation) question)
- Does the facility understand what characteristics describe your current role?
- If you are aware of your responsibilities, how can you express them in operational terms?

- Do you think using a decentralized information system as a form of electronic record management system will help increase productivity on your job? YES/NO (If YES, in what way? If NO, please give reasons)

- Do you think the decentralized information system which is a form of electronic record management has any benefits over the paper-based record? YES /NO (If YES, please explain how. If NO, please explain why)

- Do you think electronic record management will improve healthcare delivery in the facility? YES/NO (If YES, in what way? IF NO, why?)

Appendix 2 - Link to the interview audio recordings

Click This or the link provided below:

https://drive.google.com/open?id=1gDBYvrBrITd2Dui7fzm4mtJr9dYcVd2S

Appendix 3 – Thematic Map of All Categories and Codes