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A FRAMEWORK FOR THE ADOPTION OF BLOCKCHAIN TECHNOLOGY IN MEDICAL RECORDS MANAGEMENT SYSTEM: A CASE STUDY OF PAKISTAN

Master's thesis

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RAAMISTIK BLOCKCHAIN TEHNOLOOGIA VASTUVÕTMISEKS TERVISEANDMETE HALDUSSÜSTEEMIS: PAKISTANI JUHTUMIUURING

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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 are essential for the proper provision of health services to the patient. Record-keeping helps healthcare providers to retrieve the patient's medical history and take appropriate actions. Although different healthcare providers use various forms of record-keeping, one of the main issues is that there is no proper method for information sharing between healthcare providers.

The majority of healthcare providers in Pakistan still uses the paper-form of record keeping. Although some hospitals are using the electronic health records system, yet the majority of healthcare providers use the paper-based record-keeping system. This master thesis aims to analyze the current record-keeping system and find out the issues faced by the healthcare provider due to the current system. Furthermore, the focus of the research is to find out blockchain can resolve the current challenges faced by healthcare providers in Pakistan. The methodology used to find out the answers is the case study methodology. The results indicated that healthcare providers are not satisfied with the current paper-based medical record system. The results revealed several problems related to the existing system, such as missing or incomplete records, lack of privacy, and no information sharing between healthcare providers.

This thesis is written in English and is 72 pages long, including 5 chapters, 6 figures and 4 tables.

Keywords: Blockchain technology**,** Electronic health records, Framework, Paper-Based record keeping, information sharing, Pakistan.

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List of abbreviations and terms

EHRs	Electronic health records system
LRH	Lady Reading Hospital
BHUs	Basic health Unit
RHCs	Rural Health Centres
MS	Medical Superintendent
THQs	Tehsil Head Quarters
DHQs	District Head Quarters
NFC	National Finance Commission

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1 Introduction

While the world is moving toward a digital age and more and more processes are getting automated. In Pakistan, the traditional paper-based record keeping in still used in the health sector. The paper-based record-keeping is widely used in the health sector in many countries around the world. Health information is one of the critical factors that contribute to the strengthening of health care (Acquah-Swanzy, 2015). To ensure quality healthcare, it is essential to have an efficient record-keeping or information management system (Pirkle, Dumont, & Zunzunegui, 2012).

According to (Donaldson, Corrigan, Kohn, 2000), between 44000 and 98000 deaths occur annually only in the United States because of medical errors. The main obstacle in improving healthcare provision is the sharing of patient's data collected by the different hospitals or medical institutions. Today, the doctor needs to record more and more information about their patients, and the paper-based record keeping cannot cope up with this rapidly changing information. The other problem with paper-based record-keeping is searching for information in these records. It is tough to search for specific information in the paper-based health records.

The paper-based medical record-keeping originated in the 19th century and cannot accommodate and meet the new challenges and requirements of health care today. The paper-based medical record is woefully inadequate for meeting the needs of modern healthcare facilities (Shortliffe, 1999). Pakistan, a country whose population is proliferating, needs to move to digital record keeping to improve the health care services in the country. In Pakistan, most of the government hospitals in the rural areas of the country are still using the paper-based record system. That is why it is challenging to know the overall health statistics of the rural areas because there is no proper health record system. Proper management of the health record is essential because it not only helping the patients but also to know the overall health status of a region. Unfortunately, in Pakistan, there is no concept of health record management in government hospitals and also in many private hospitals throughout the country.

On the other hand, the developing countries are improving their health sector by using Electronic Health Records Systems (EHRs). Many developing countries are investing

huge money to improve the health record system of the country and improve the healthcare facilities (Yusif & Soar, 2012).

Section 1.1 sheds light on the problem statement in detail. Section 1.2, highlights the research objectives, and then the context of the thesis, is explained in section 1.3.

1.1 Problem Statement

In Pakistan, the paper-based form of record-keeping is mainly in the healthcare sector. By using the paper-based record-keeping system, it is challenging for the health care providers in Pakistan to provide adequate health services to the citizens. The retrieval of records in case of a paper-based system is not efficient and is time-consuming as all these records are stored in a central location in the hospital.

Based on preliminary interviews it is much clearer now how the medical records are retrieved in Pakistan. For retrieval of patient medical history files, a physical visit to the record room is needed. In critical situations, it could lead to the loss of lives. In emergency cases, the doctors need a quick and efficient way to see the patient medical history. It helps the doctor in many ways, such as knowing about the patient's allergies, medication, or blood group, and the doctors will be in a better position to treat the patient. In emergency cases, the doctors are dependent on the information provided by the attendants of the patient (friends/relatives). There is no other way for the doctors to know about the patient medical history. The doctors either ask the patient or the attendants of the patient about the medical history. Moreover, if the patient wants to get their medical records from the hospital, the approval of the hospital MS is needed. The minimum this process takes is one day while normally it takes four to six working days.

In the rural areas of Pakistan, most of the primary healthcare hospitals do not keep a proper record of the patient medical history, and citizens are responsible for keeping all their health records themselves. Most of the time, these heath records are lost because it is tough to keep all the records for a long time. All the records are handed over to the patients, and they are responsible for their records. So, the next time if the patient is visiting even the same hospital, the patient must bring all their health records. It is challenging for the patients to keep all their medical records for an extended period.

Most of the time, these records are lost, and the patients have to go through all the medical tests once again.

According to Thurston (1997) record management is not only the process of managing the creation of records but also the use, maintenance, and disposal of the records. Some private hospitals in Pakistan are keeping patients records electronically. However, these hospitals are using their own individual's software system, and the data is not shared with any other hospital. Some government hospitals have also introduced the electronic health record system but there is no concept of sharing data between hospitals. However, most of the government hospitals are using the paper-based system which needs to be changed. But recently some government hospitals have also introduced the electronic health records system (EHR), especially in the Khyber Pakhtunkhwa. One of the leading hospitals in Peshawar, The Lady Reading Hospital (LRH), has recently started using EHR for patient's records management. Even though most of the private hospitals and some government hospitals are using EHR, but still there is no exchange of data between hospitals. Most of the hospitals are not keeping the health care data of the patients for a very long time, and this data is deleted after a specific time. The other problem is that some hospitals are not keeping full health records of the patients.

Even though Pakistan has recently digitalized many services and more and more services are getting online, the country has done very little in the healthcare sector. For the proper treatment of patients, it is essential to know their medical history. Especially in emergency cases or other critical situations, the doctors must know the medical history of the patients or what kind of medication the patient is using. It will help in saving many lives because the doctor will be able to know the patient medical history on time and will be in a better position to treat the patient.

It is evident that in Pakistan, there is a need for a system in the healthcare sector where healthcare providers can easily access health records. Such a system will help healthcare practitioners to treat the patients efficiently. It will also bring ease for the patient as many patients do not have to carry their medical records while visiting any hospital.

1.2 Research Objectives

Currently, blockchain technology is used for many different purposes. Nowadays, blockchain technology is widely used in healthcare services. The main reason is that blockchain increases transparency by time stamping each transaction. With blockchain technology, it can always be traced who viewed that patient's data. Blockchain also helps in anonymizing the patient's records for secondary uses, and it provides a secure mechanism for data exchange.

One to the primary purpose of evaluation research is to evaluate the effectiveness of something; it can be some policy, innovation, or service (Atkinson, 2005). The main objective of this research is to identify and examine all the shortcomings of the current health record-keeping system in Pakistan and how blockchain can meet the current challenges faced by the health sector in record keeping. The research will also focus on finding the obstacles in data sharing among hospitals and other medical institutions. As the implementation of EHR would result in much better health facilities, and it will be beneficial both for the healthcare providers, government, and citizens.

The objectives of this research are:

- Examine the current health record-keeping system in Pakistan
- Identify the shortcoming of the existing health records keeping system.
- Identify the challenges faced by healthcare providers due to the current record-keeping system
- How medical records keeping can be improved
- Propose a framework for the successful adoption of Blockchain technology in Pakistan

1.3 Context

The primary and essential purpose of Health information management systems is to provide the right information to all the stakeholders by providing feedback and data sharing, and they are designed for facilitating data-driven decisions, policy-making, and health planning (Ndabarora, Chipps, Uys, 2014). Medical records keeping not only consists of documenting the patients' health records but also sharing it with other

medical institutes and storing it, to improve the quality of health care. The electronic medical records (EMRs) have the ability to increase the efficiency as well as the quality of the healthcare services (Ellingsen, Monteiro, 2003).

The paper-based health record-keeping is still in practice in many developing countries, including Pakistan. The paper-based record keeping of patient's medical history is facing many challenges, and it is challenging for doctors to provide quality healthcare services without knowing the medical history of the patients. Reliable information and effective communication are crucial elements in public health practices (Chetley et al., 2006). Good medical care depends on high-quality equipment and facilities and highly-trained doctor and nurses, and it also depends on good record-keeping (Ayesha, Abdul, Muhammad, 2014). If the patient's medical history is not well documented, then doctors may not offer the best medical care to the patient.

Medical record-keeping means proper documenting as well as archiving of the health records of the patients. Currently, it is undergoing many changes, and new and new mechanisms are introduced for proper management of the health records in the developed countries. Still, most of the developing countries like Pakistan are using paper-based record keeping, which is facing many challenges and is not meeting the needs of today. In today's world, fast and reliable access to patient's health records is needed in order to say more and more lives. However, when the paper-based mechanism is used for medical record-keeping, then access to these records for patients and health care providers is limited. It is one of the reasons that healthcare providers cannot provide proper treatment to patients.

An electronic health record system is a digital collection of the medical records of individual patients or populations. It enables the sharing of this information, which is in digital format across different healthcare settings (Dinya, 2013). In most developed countries ICT is widely used for record-keeping in healthcare services. The use of ICT in health care can ensure the proper recording of the patients' medical history and reduce patient's waiting time at the hospital and ensures continuity of care. The patients' medical records must be kept safe; it is both beneficial for the patients as well as the doctor. The role of ICT in health information management cannot be ignored. It is due to the ability of ICTs to capture, store, retrieve, analyze, and transmit large volumes of health information from multiple locations (Norman, Aikens & Binka, 2011).

Governments in developing countries have realized the importance of the use of ICTs in healthcare, and many developing countries are investing heavily to improve the health sector.

There are multiple international standards used for electronic health records. One of the most famous is the HL7 (Health Level 7), which is a set of standards used internationally for transferring administrative and clinical data between the software and different healthcare providers. DICOM (Digital Imaging and Communications in Medicine) is another standard that is used for communication and storage of medical imaging information. xDT is another standard that is widely used in Germany by various healthcare providers; it is a family of data exchange formats.

2 Related Work

To have exhaustive research, it is imperative to understand the problem and all the related work related to the problem. This chapter aims to introduce the previous work that has been done by other researchers prior to the current master paper regarding the study object.

The first section of this chapter sheds on the earlier studies, while section 2.1.1 provides information about paper-based record keeping in the health sector and the shortcomings of using paper-based record keeping. The next section provides information related to the electronic health record system and the problems that arise by using EHRs. Section 2.1.3 explains blockchain technology, its types, attributes, and applications. The last section of this chapter summarizes the theoretical framework.

2.1 Earlier Studies

Record keeping is crucial because it provides a complete track of something's history. That is why it is necessary to use the best method for record-keeping, so these records last longer and are trustworthy. Many computer science experts believe that blockchain will revolutionize every industry; it will change the way we work and the way we live. Interoperability is one of the main issues in record-keeping, as there is no exchange of information between hospitals, so each hospital has a separate record of the same patient. It means that one patient might have multiple records because each hospital is creating a record of the patient locally. Blockchain would improve interoperability between multiple systems as well as enhance the interoperability between organizations (Randall, Goel & Abujamra, 2017). Blockchain will not only solve the interoperability issue, but it will also add transparency to the health record-keeping as all the transactions in blockchain are timestamped. Transparency is essential because it will help in increasing the patients' trust in the system.

In Pakistan, there are mainly two types of health record-keeping system, the paper-based record keeping, and the electronic health record-keeping system. Both of them will be discussed in this chapter in detail.

2.1.1 Paper Based Health Record Keeping

A health record is a documented account of the patient's medical history, such as illness, treatment, diagnosis, medication, and other outcomes (NSW Health, 2012). It is either received by a healthcare provider or they are the ones to create it and exchange it with other healthcare providers. In the past, paper-based record-keeping was the most common way of storing health records. Even today its vastly used as a method of record-keeping in many developing countries around the world. Health records are used to provide better health care facilities to the patients and save their lives. However, if these records are not appropriately managed, then they can become a liability, and valuable lives can be lost. Dr. Zulfikar Ramzan, the CTO of RSA Security, explains it by saying that even if there are minimal errors in the patient file, then it can have a terrible impact, and it will cause the ripple effect. Because if the doctor takes a decision based on this of data that is corrupted, then it will be disastrous, data which is usually considered an asset will turn into a liability in this case for the healthcare providers (Healthcare IT News, 2019). John S. Luo (2006) argues that paper-based record keeping has certain limitations, just like the paper-based records might be stored in one room in the hospital, and other departments might not have access to it, especially in the case of large hospitals. It might have other problems like the space needed for storing these records and making sure that they are not damaged or destroyed by any artificial or natural disasters like fire or water. Furthermore, it is difficult to track who has access to these records, which is a huge security risk.

- **Error Prone and Time Consuming**

Paper-based records are manually written, so there are high chances of writing errors or other kinds of human errors. Sometimes the paper-based records are tough to read because of the legibility. The study conducted in Spanish hospitals indicated that about 15 % of the records were unclear (Rodríguez, Marin, Sanchez, Borrachero, & Pujol, 2002). Paper-based records are time-consuming because the retrieval of the patient file is not easy as all the files are stored in a central location, and someone needs to go there and take the patient file. It is tough to search for a specific record of a specific patient in a large hospital. These records need to be managed and stored in an organized manner for easy access (John, 2006).

Retrieving information in a paper-based system is very hard and time consuming for both the doctor and the patient as well as the stockholders. It is also hard for the government to have statistical data about the healthcare of a city because everything is paper-based. The only way is to collect data manually form all the hospitals in the city and combine all the data and then analyze it. It is not only challenging but very time and resource consuming. It is also very hard for the doctor to go through all the records of the patient in case of paper-based records. In case of emergency, there is no way for the doctor to know the medical history of the patient.

- **No Backups**

The primary issue with paper-based record-keeping is that there is no backup of the records, and if for some reason the records are lost, then there is no way to these records back. As paper base records have no backup and if a backup is made, then it will be too expensive for the health care institutes. These paper-based records can be destroyed by natural disasters such as flood, fire, or hurricane. Hurricane Katrina and Hurricane Rita destroyed a considerable amount of health information data. The hurricanes almost destroyed all the records in many medical centers, and it took months to recover from that loss (Smith & Macdonald, 2006).

- **Privacy Issues**

It is impossible to ensure privacy in the case of the paper-based record system. It is hard to know who has access to the health records and who has viewed them. Someone can sell the patients' health records to medicine companies, or these records can be misused. Anyone who has access to the records keeping room can view anyone's health records without leaving a trace. Similarly, records may be forged, or false records may be entered into any patient's file. Security of the paper-based health records is limited mainly to locked storage, without the ability to log record access (John, 2006). There is no way of tracking who has access to the health care data of the patients.

- **No information sharing between Hospitals**

The problem with paper-based record-keeping is that information sharing is very difficult, sometimes not possible. Currently, in Pakistan, there is no concept of information sharing between hospitals, and the patients are responsible for sharing their information manually with the hospitals. It is impossible to send this information from

one region to another region unless and until the patients are carrying these records themselves. It is even hard to send information from one department to another department in the same hospital. So, in the case of a paper-based record-keeping system, information sharing amongst hospitals cannot be imagined. Without data sharing between hospitals or without a decentralized system for health care services, it would be tough to improve the overall health status of the country.

- **Information Manipulation**

In the case of the paper-based record keeping, each patient has a file that is kept in a room. Any unauthorized person can access this file, and it is very easy to add some additional documents to this file or remove the existing documents from it or make changes in the existing documents. The problem with paper-based record-keeping is that there is no way of knowing who has accessed the records so if changes are made to a file, it will be impossible to know who made these changes.

2.1.2 Electronic Health Record Keeping

The electronic health record-keeping system is widely used in many developing countries. According to Seymour et al. (2012), "electronic health record is the digital version of the patient's medical records which are created by the healthcare providers and stored in paper form". These records are usually created and managed by the health care providers and can be shared between various healthcare providers. According to Devkota et al. (2013), there are many advantages of using EHRs such as it can help in enhancing patient safety and also help in decreasing the healthcare costs. Devkota et al. (2013) further explain that EHRs can reduce the mortality rate by improving the efficiency and continuity of care.

The electronic health records system solves many problems faced by the paper-based record keeping. In the case of electronic health records, it is not difficult to take a backup of all the records. EHRs make the retrieval of patient's information much faster and only authorize people to have access to it. However, the EHRs are also facing some issues which are discussed below.

- **Interoperability issues**

The term interoperability means the ability of two or more computer systems to exchange data or information (Young, Chaki, Berzins, 2003). The problem with EHRs

is that there are many EHR products available, and different healthcare providers are using different EHR systems. These systems come with different capabilities, clinical terminologies, and different technical specifications, making it very difficult to have an interoperability format for sharing data (Reisman, 2017).

Interoperability does not just mean the sharing of data; it means the systems must be able to share information and then be able to use this information. For two or more systems to understand each other's data, they must have some standard format in which they can share data. With these different kinds of EHR systems available and healthcare providers using different systems, it is tough to achieve interoperability. As different healthcare providers are using different EHRs, so it will be a huge problem to identify patients and match patient records across and within healthcare providers. In order to achieve interoperability, there should be only one EHR system used across the country or the communication between the EHRs should be in a standard format. It is nearly impossible to have one EHRs across the whole country or to have a standard format for sharing information between different EHRs. The best way to solve this problem is by using the Estonian model. The electronic health record system in Estonia, also known as e-health records, is a system used in the whole country which integrates the information from different healthcare providers within Estonia to create a common record for all the patients. This common record can be accessed by any authorized healthcare provider and also by the patients themselves. Estonia is using the X-Road for gathering the data from the healthcare providers in a secure way.

- **Privacy and Confidentiality**

Privacy of the patient's data is the central issue because EHRs are dealing with sensitive data. Privacy is one of the major concerns of the patients regarding the electronic health records keeping system (Zurita and Nøhr, 2004). Many cases in the United States were registered in which unauthorized users accessed patients' medical information. After the 2011 shooting, several employees of a hospital in Arizona United States were fired because they inappropriately accessed the health records of the victims (Menachemi & Collum, 2011). The health information that is shared between healthcare providers is confidential, and it needs to be protected (Harman, 2006).

Patient's health information should never be released to any other person without the patient's consent (Harman & Bond, 2012). EHRs need to make that the patient's

information is accessible by only authorized individuals. As health information is very sensitive and if any unauthorize person have access to it the consequences can be overwhelming. If the patient feels that their health information is not secure then they might not disclose their health information to the healthcare providers. In October 2017, about 47 GB of patient's healthcare data stored by a medical institution on the Amazon database was accidentally opened to the public, and more than 150,000 patients were affected by this (Chen, Ding, Xu, Zheng, and Yang, S., 2019).

- **Medical data theft**

As patient's information is very critical data, any unauthorized access might have devastating consequences. A hacker may access a patient's information and gain access to sensitive data such as the patient's name, address, prescriptions, and health insurance number and can file claims with the patient's insurance provider or may sell the patient's data in exchange for money.

The sharing of a patient's sensitive information publicly can lead to devastating results, such as a report suggest that many patients have committed suicide because of medical identity theft (Sullivan, 2004). Identity theft is mainly used for financial gains as this data is either sold or used illegally, such as applying for loans. Over nine million cases of identity theft are reported every year (Federal Trade Commission, n.d.).

2.1.3 Blockchain Technology

The year 2008 is considered to be the birth year of the blockchain when Satoshi Nakamoto wrote a paper about Bitcoin. The term "blockchain" was used for the first time in 2008 by Satoshi Nakamoto (Nakamoto, 2008). This peer-to-peer system was initially designed for online payments through which money can be sent from one party to another without involving any financial institution.

Blockchain can be defined as digital information (blocks) stored in public databases (chain). It is a decentralized system where the blockchain network has no central authority. It means that none of the participating parties in the network has full control over the data and the operations, but all the decisions about the data are made collectively through a consensus process. The parties forming the network are called nodes and communicate through message passing (Coulouris, Dollimore, Kindberg, 2005). In simple terms, the blockchain can be defined as a collection of records that are

managed by a cluster of computers, and all the activities are time stamped. A blockchain can also be defined as a distributed database or a public ledger where records are stored and distributed among participating parties. Once the information enters the blockchain, it can never be removed (Crosby, Pattanayak, Verma & Kalyanaraman, 2016).

Yli-Huumo, Ko, Choi, Park, and Smolander (2016) suggested that the main attributes of blockchain are security, anonymity, privacy, and transparency. Blockchain is very secure, and that is why it is very suitable for carrying out various operations such as money transfer, critical information sending from one party to another, medical information exchange amongst healthcare institutes. The primary and essential aspect of blockchain is transparency, as information is only added once the nodes have reached a consensus, and once the information is added, it cannot be altered or removed. All the information in the blockchain is timestamped and stored in a block, and that block is linked to another preceding block in order to be valid and thereby creates a chain of blocks (Tapscott & Tapscott, 2017). Blockchain consists of a distributed ledger where all the transaction information is stored in different nodes. There is no central node, and that is why it is much secure because it reduces the manipulation of information or system failure due to the reason that all the nodes have full information. Blockchain technology can be used for multiple purposes such as land registry, business registration, birth certificates, and educational documents verification (Ølnes, Ubacht & Janssen, 2017).

The above reason suggests that blockchain is more suitable for medical record-keeping as the system is more transparent and secure. Blockchain provides a distributed framework that can be used to support the integration of a patient's health information across various stakeholders. The data stored in the blockchain is available all the time and can be shared with various people and organizations in real-time. Figure 1 has explained the working of blockchain in the health sector in details, all the three scenarios mention by (Dubovitskaya, Xu, Ryu, Schumacher, and Wang, 2017) explains how blockchain can help us in the healthcare sector.
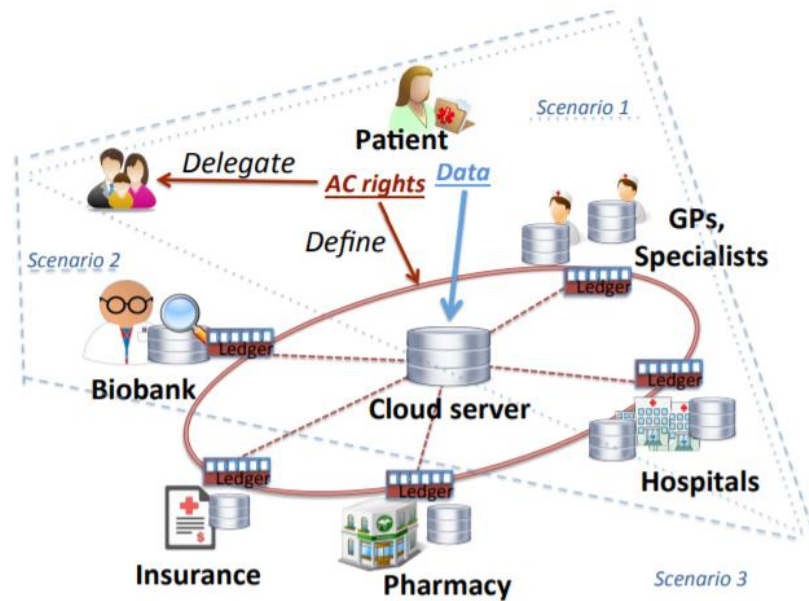
Figure 1: Scenarios of using blockchain in different healthcare settings **Source:** (Dubovitskaya, Xu, Ryu, Schumacher, and Wang, 2017)

Figure one has multiple scenarios for using blockchain in healthcare. Scenario 1: Primary patient care; Scenario 2: Aggregation of the data for the different research purposes; Scenario 3: Connecting all the healthcare providers for better patient care.

Although blockchain was initially thought to be used only for financial operations and it was designed to support Bitcoin initially. Nowadays, blockchain is used in multiple industries for secure information sharing and transparency. It is mainly used by the private sector, but many government institutes all over the world have shown interest in adopting blockchain technology.

2.1.3.1 How Blockchain works

This section will explain in detail the working of blockchain, the key components of blockchain technology. Figure 5 mentioned below illustrates the working of blockchain in detail.
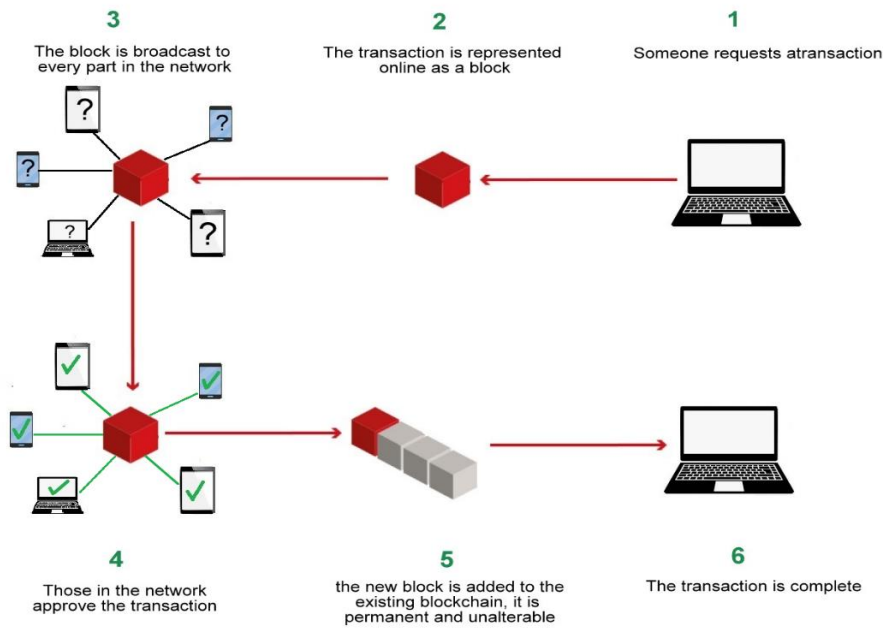
Figure 2: How Blockchain Technology Works, Source: (Crosby et al., 2016)

The figure above shows the process of sending transactions from one point to another using blockchain. The transaction begins with the sender initiating a request, this transaction is represented as a block and is sent to every party in the network, which then validates the transaction. After this, the block is added to the chain in an unalterable way; in this way, the money is sent from point A to point B.

- **Transaction Request**

Transaction is usually the data messages that are inserted in the network by computer programs. These messages are encrypted and processed and authenticated by nodes to become a transaction record (Fullbright, 2016). This message is initiated by a sender and is then sent to the participating nodes in the network. This message includes the receiver's address and a cryptographic hash which proves the validity and authenticity of the transaction.

- **Nodes**

Any computer system that participates in the blockchain network is known as a node. In a public blockchain, a node keeps a record of all the transactions and has access to the complete distributed ledger. The nodes are responsible for sharing information and keeping a copy of all the confirmed transactions.

- **Transaction Authentication**

A transaction is authenticated by the cryptographic hash that is associated with the message. Every transaction has a public and a private key. The private key is used to encrypt the message and the public key is used to authenticate the message. A transaction is authenticated to make sure that the content is not altered (Zheng et al., 2017). Once authenticated the transaction is then added to the pool of pending transactions.

- **Consensus Algorithms**

As any node can participate in the blockchain network so it is very important to ensure the reliability of all the nodes. Through the consensus algorithm, all the peers in the network reach a common decision. The consensus algorithm ensures that the new block added to the blockchain is the only version of the truth on which all the peers agreed (Yang et al., 2018). There are different consensus models amongst which the famous ones are Proof of Work (PoW) and Proof of Stake (PoS).

- **Block**

Data in the blockchain network is recorded into files called blocks. New blocks are created to store the recent data, and once the data is written on the block it can never be removed. This new block is then added to the end of the blockchain. A block consists of the block header and the block body. The header contains important information and consists of the hash of the previous block and the goal of the current difficulty. The block body contains all the confirmed transaction of the block.

- **Block Validation**

This is the most important phase in which the newly added blocks are validated. Newly blocks are added to the chain by consensus. Different kind of blockchain networks uses a different kind of block validation technique. According to Froystad and Holm (2015), "the proof of work" is used by Bitcoin while the "proof of stake" block validation technique is used by Ethereum. These techniques are used to avoid fraudulent transactions in the network.

- **Block Chaining**

After validation the new block is added to the blockchain, this new block contains the information of preceding blocks. The information of the newly added block and the updated ledger is broadcasted to all the nodes in the network. Adding a new block to the blockchain is very fast and this process usually takes three to ten seconds. (Morabito, 2017). Every new block contains the hash of the previous block and this is how the whole network is interconnected.

2.1.3.2 Types of Blockchains

There are three main types of blockchains:

- **Public Blockchain**

The public blockchains are also known as permission less blockchains with absolutely no access restriction; anyone with an internet connection can join the network. As there is no central authority, and no permission is required so anyone can join the network by downloading the code and running the code on their devices (Nakamoto, 2008). The most famous example of a public blockchain is Bitcoin, Ethereum, and Monero. An example network of the public blockchain is shown in Figure 2.
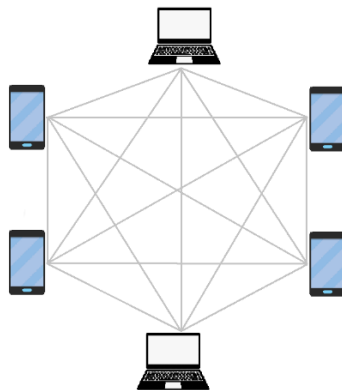
Figure 3: Public Blockchain, **Source:** (www.101blockchains.com)

- **Private Blockchain**

A private blockchain is also known as permission blockchain because permission is required before becoming a part of the network. The main principle of a private blockchain is access control, which restricts people from becoming a part of the network. Each new member in the network is identified and granted permission to join

the network. There are different types of access rights given to the participants. Some participants have full access rights, while others have limited access rights. Usually, one or more entities control the network, and that is why private blockchain is more centralized than public blockchain. As there are limited participants, so the consensus process is much faster in the case of private blockchains (Mattila, 2016). An example network of the public blockchain is shown in Figure 3.
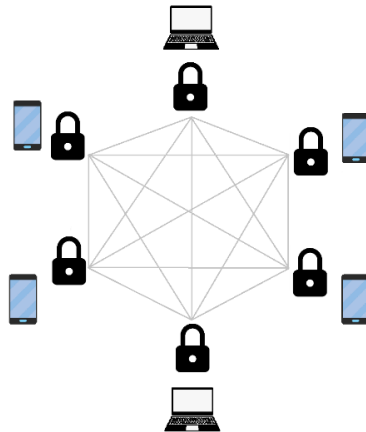
Figure 4: Private Blockchain, **Source: (**www.101blockchains.com)

- **Consortium Blockchain**

The consortium blockchain is much more like a private blockchain where some predefined nodes control the consensus procedures, and this type of blockchain does not allow public access to verify any transaction. It is a semi-private blockchain that is operated by a set of predefined individuals. An example network of the public blockchain is shown in Figure 4.
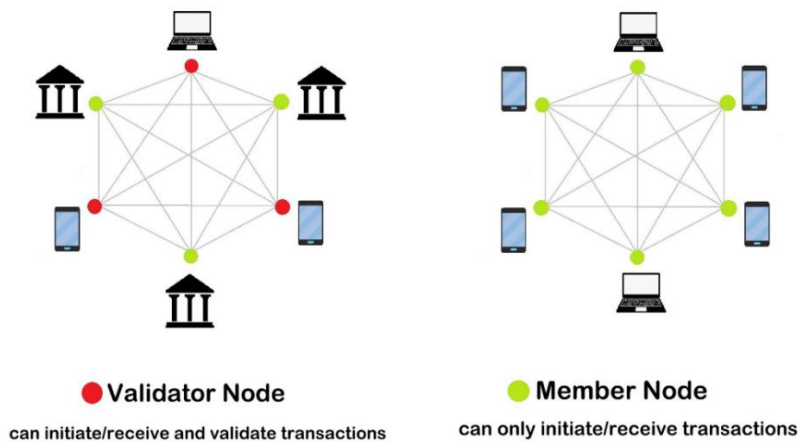
Figure 5: Consortium Blockchain, **Source: (**www. medium.com)

2.1.3.3 Difference between Public, Private and Consortium blockchain

There are many differences between the three types of blockchain. Most of these differences are related to the reading access and consensus process. However, there are many similarities between the consortium and private blockchain. The main difference between the three types of blockchain is illustrated in the table below.

Attributes	Public	Private	Consortium
Consensus	All the nodes participate in the consensus	Consensus is managed by one node	Consensus is managed by one pre-defined node
Reading access	Records are public so any node can read it	Any node (permission is needed)	Predefined nodes (Permission is needed)
Efficiency	Low	High	High
Centralized	No	Yes	Partial
Transaction validation	As public blockchains are highly decentralized so any node can validate the transactions	Only authorized nodes	Only authorized nodes

Table 1: Difference between public, private and consortium blockchain

2.1.3.4 Important Attributes of the Blockchain Technology

The important attributes of blockchain technology are mentioned below

- **Immutability**

Immutable means something that cannot be altered, removed, or corrupted. Once a record has been added to the blockchain, then it cannot be removed. It is the most important attribute of blockchain because the data in the blockchain will not be corrupted. Every node in the network has a copy of the digital ledger, so the data cannot be removed or altered once it has been added to the block. The main problem with centralized databases is that they can be corrupted and they rely on third parties for data integrity (Altam et al., 2018).

- **Decentralization**

Blockchain has a decentralized network where there is no single authority responsible for the whole network. In case of blockchain there is no single point of failure. The decentralized nature of blockchain ensures scalability and robustness. Decentralization gives any member of the network the ability to send a transaction securely through multiple traceable channels (Linkov et al., 2018). Any member of the network can view any transaction as there is no central authority, which allows the system to be more transparent and immune to failures. The decentralization helps the individual user to have control over their data.

- **Transparency**

In public blockchains, every member of the network has a copy of the whole ledger and is aware of every transaction happening in the network. No transaction can be completed without their authentication because of the consensus algorithm. The consensus is the process of making a decision about validating a transaction, and any node in the network can participate in it. The information is only added to the blockchain ledger once it is validated by the consensus process (Lemieux et al., 2019). Once a transaction is validated, each node keeps a copy of the record, and this information can never be removed. The consensus process makes blockchain more transparent as no single authority is controlling the network, but decisions are taken collectively, and everyone in the network is aware of all the transactions. Blockchain is

an open file where anyone can access the transaction and verify its correctness (Sultan, Ruhi, & Lakhani, 2018).

- **Anonymity**

The term anonymity means that the sender and receiver in the transaction are anonymous or non-identifiable (Xin et al., 2019). Anonymity helps in hiding the identity of the users involved in the transaction. As the transactions are public and anyone can access it, it is imperative to hide the identity of the parties involved in the transaction, so no one can connect the dots and find the users involved in the transaction. The most important thing about blockchain is that it provides privacy, transparency, and anonymity at the same time, which makes blockchains more trustworthy. The healthcare data also used for secondary purposes such as expanding knowledge about diseases, genetics, and medicine; improve patients' healthcare experiences; reduce healthcare costs (Jensen et al., 2012). As the use of patient data for secondary purposes is increasing, there is a growing concern about patient privacy (Garfinkel et al., 2007). It is why anonymity is essential in such cases.

- **Smart Contracts**

According to Szabo (1996), a smart contract is a self-executing contract. It is a set of defined promises which includes the protocols within which all the parties perform on these promises. It is a secure way to allow trusted transactions or agreements to be carried out between two parties without involving any third party or regulatory authority. Blockchains eliminates the need for trusted third parties by allowing the user in the network to interact with each other in a distributed manner.

Smart contracts are the reason that the transaction cost in the blockchain is meager. Smart contracts are a set of computer code that runs on top of the blockchain, and it comprises of some pre-defined rules which are agreed by all parties involved. According to (Voshmgir & Kalinov, 2017) smart contract is a bunch of code which runs on execute on the blockchain network, and this piece of code is controlling the digital asses by implementing arbitrary rules. Kormiltsyn et al. (2019) explained how smart contracts could be used to simplify the doctor's appointment system. The paper focuses on reducing the workload on healthcare providers by reducing the number of patient visits. Kormiltsyn et al. (2019) further explained that the smart contract-based system

would provide treatment information for common health issues, so the patient does not need to visit a doctor.

2.2 Theoretical Framework

This section explains the different theories and different approaches that would impede the adoption of blockchain in the health sector. Lessons learned from this part of the study will help in further analysis carried out during this research.

2.2.1 Adoption of Blockchain Technology

Blockchain is a comparatively a new technology, and its main feature is its decentralized architecture. It is one of the main reasons for its adoption by various private and public sector organizations. Interoperability is one of the main issues with the electronic health record systems, and blockchain is the best solution for that. Blockchain can solve all the interoperability issues that exist in the current record-keeping systems.

Blockchain can change the way patient health records are stored and shared between healthcare providers, as it provides a secure mechanism for the medical data between healthcare providers (Mayer, Costa, & Righi, 2019). However, as blockchain is a new technology, so many companies are hesitating to adopt blockchain. As explained by the Technology Acceptance Model (TAM), the three factors on which the motivation for the adoption of new technology-dependent are: usefulness, ease of use, and attitude toward use (Taherdoost 2018). TAM also explains some external variables, like training and involving users in the design process. All the variables mentioned by TAM model will be used in data collection and analysis stage.

2.2.2 The Estonian Experience

Estonia is one of the earlier adopters of blockchain technology. In fact, Estonia is the first country to use the blockchain technology in healthcare on a national level. Estonia completed its EHR project by the end of the year 2008. This project aimed to create a common record for all the patients in the country. One of the other objectives of this project was to provide accurate medical statistics. To make all the patient records secure, the Estonian government started looking for a different option and found blockchain to

be the best technology for the security of these health records. The government partnered with a private company called Guardtime, a blockchain pioneer.

The main reason for using blockchain technology is data integrity. Artur Novek, the foundation's Implementation Manager and Architect, said that the blockchain technology is used as an additional layer for ensuring the integrity of the medical records (Nortal, 2018). The blockchain technology is used for securing the log files which stores all the data processing activities. It is one of the reasons that the Estonian healthcare system is very transparent because every view of the patient's information leaves a trace. All the activities are time-stamped, and the patients can see who has viewed their data. To ensure data integrity, the cryptographic hash function of blockchain creates an unchangeable audit trail; this audit trail can be monitored. It makes it very hard for anyone to manipulate the data; neither the system administrators nor the government can alter the data. Estonia is using blockchain technology in the health sector since 2016, and it has one of the most transparent health record systems.

Estonia is using the KSI blockchain for the integrity of the health records. The KSI blockchain offers the following features:

- Integrity
- Consent
- Anonymization
- Provenance
- Secure Data Exchange

Data integrity is ensured by providing immutability and transparency. Consent means personal control of the data, and the patient can see who has viewed their data. Anonymization of the health record when the data is used for secondary purposes. Provenance is the ability to time-stamp all the activities, and blockchain makes it much easy to exchange data securely (Guardtime, 2018).

3 Case Study Design

In this section of the thesis, the research methodology guiding this study is described in detail. After getting familiar with the topic, it is clear that there is not a lot of information available regarding medical record-keeping in Pakistan, and there is very little material available online. So that is the reason that empirical research needs to be conducted. This chapter focuses on explaining the chosen research method and the steps required for carrying out this research.

This chapter has six sections. The first and most important is section 3.1, which is about the research question. These research questions will help in understanding the current medical record-keeping system in Pakistan and are their shortcomings. Section 3.2 focuses on the case study as well as the motive behind the selection of each case. It explains what a case study research is and what its advantages are. Section 3.3 explains the data collection procedures used for carrying out this research. The different data collection procedures used for this research are interviews and document review. Section 3.3 explains the data analysis procedures while the last section is the summary of the chapter giving a brief overview of the whole chapter.

3.1 Research Questions

The main objective of this study is to find out the best way to implement blockchain in the health sector in Pakistan in order to improve medical records keeping. This thesis has one main question and three sub-questions. These sub-questions are further divided into more questions in order to understand this topic deeply. The main research question is:

RQ1: How can blockchain improve medical record keeping in Pakistan??

The main research question is divided into three sub-questions in order to carry out detailed research. The three sub-questions are:

3.1.1 Sub Questions

SRQ1: How would the Blockchain technology impact medical record-keeping in Pakistan?

SRQ2: How to determine the criteria for measuring the benefits of blockchain technology for medical record-keeping in Pakistan?

SRQ3: How will the adoption of blockchain technology for medical record keeping affect the key stakeholders?

- **SRQ1**

To understand the challenges faced by the current health record-keeping systems in Pakistan, the sub-question one SRQ1 is further divided into three more questions. The question will give us an overview of the shortcomings of the record-keeping system in use and how blockchain can improve these shortcomings. The SRQ1 is divided into the following three questions

- What is the current system in practice for medical records keeping in Pakistan?

- What would be considered as an efficient medical records management system?

- What improvements will blockchain bring to the current system?

- **SRQ2**

To understand the impact of blockchain on record keeping in the health sector, the sub-question two SRQ2 will be divided into three further questions. These questions will help us understand the impact and the importance of blockchain. These questions are:

- What are the criteria to measure the effectiveness of blockchain in medical records keeping and information sharing?

- What are the indicators to measure the efficiency of the proposed system?

- What are the characteristics of an efficient health record-keeping system?

- **SRQ3**

The third sub question will be divided into the following two questions.

- Who are the stakeholders and what is their role?
- What improvement will blockchain bring for the stakeholders?

3.2 Case and Subject Selection

After the research questions, the objective of the thesis is much clearer. The best methodology should be used to reach a constructive outcome. The best methodology for this topic is the case study methodology, which will contribute to the current as well as future research on this subject.

The case study approach is used to get an in-depth understanding of a complicated issue Crowe et al. (2011). According to Stake (1995), it is the study of the complexity of a case, to understand the activity within essential circumstances. The case study helps us in exploring the problem and provides us in-depth and detailed information about a case. A case study is used for generalization, it is the study of a person or unit, and the aim is to generalize a group of people or several units (Gustafsson, 2017). The case study method helps the researcher in narrowing down a broad topic by formulating the right research questions. The researcher gains more knowledge about the selected problem by collecting qualitative or quantitative data. (Yin, 2011) defines the case study as empirical research that investigates and phenomenon in its real-life context when the boundaries are between the context and the phenomenon is not logical.

There are different types of case study research, such as single and multiple case studies. A single case study helps in an in-depth understanding of a single phenomenon. In contrast, multiple case study helps in understanding multiple cases as a unit, by comparing and looking for similarities between the cases. A single case study focuses on parameters, establishments, and objectives of the research. That is is the reason that this research will be adopting a single case study.

As a result of the research questions and the decision to undertake a case study research, the hospitals selected. To achieve as considerable variation as possible, attempts were made to make sure that the respondents are selected from different regions of Pakistan. Respondents from different regions of Pakistan would be interviewed for this study. The interviewees will comprise of people who have worked in the health sector and have extensive knowledge about record keeping in the health sector. Moreover, people from the IT sector would also be interviewed to find out the technological barriers and how to resolve them.

3.3 Data Collection Procedures

It is the processing of collecting valuable information, which is a systematic way that will help to answer the research question, test hypotheses, and evaluate outcomes (Kabir, 2016). The main focus is to gather quality data to be analyzed to produce a credible answer to the stated research question. The data collection is the fundamental pillar of any research, as the whole research is dependent on it. There are two main types of data known as qualitative data and quantitative data. Qualitative data is usually non-numerical data, while quantitative data is mostly numerical in nature.

There are two main types of data collection, primary data collection, and secondary data collection. Primary data collection means collecting data for the first time, this type of data is usually not published before and is more reliable, authentic, and objective). The secondary data collection means the collection of already published data, where someone else collected the data and published it (Kabir, 2016).

The various sources of data collection for this research include documents review and interviews.

3.3.1 Document Review

The document review process includes reading of different material and gathering information from these documents. Document analysis is a procedure of analyzing documents by reading and evaluating them. These documents include both electronic and printed documents (Bowen, 2009). These documents include research articles, information published by the government, institutional reports, memoranda, and newspapers to gather information about the research topic.

The document review helps in exploring and understanding the topics that were not covered by the interviews. Document review helps in gathering background information about any phenomenon. The document review is mostly used in qualitative research to produce a detailed description of a single phenomenon (Skate, 1995). Document review cannot be used alone for gathering information about the research topic. As mentioned by Runeson et al. (2012) even if documents are available and the researcher has studied these documents the question is about the quality of the document and whether the interviewee agrees with the content in the document or not

or if these documents are valid or not. That is the reason that interviews will be used to gather empirical data.

3.3.2 Interviews

Interviews help the researcher to gather in-depth information about the research topic. It is the best way to validate the information collected from the document review process. According to Runeson et al. (2012), interviews are an important method of data collection. Interviews are more personal than questionnaires, where the interviewer can ask follow-up questions to gather more information about the research topic. If a topic is susceptible, then interviews are the best way to gather data because sometime the participant may not feel comfortable while talking about a topic openly in a group (Gill et al., 2008).

There are three formats of interviews: structured interviews, unstructured interviews, and semi-structured interviews. The structured interviews consist of predefined interview questions which should be asked in the same order. In unstructured interviews, there are no predefined questions, and the data is collected more informally. In unstructured interviews, the interviewer can ask any questions related to the research topic as there are no predefined questions. While the semi-structured interviews have some predefined questions, and the interviewer can ask additional questions. For this research, the semi-structured approach will be used because it is better suited for exploratory research.

All the interview questions are generated from the main research question and consist of both closed and open-ended questions. Thirteen respondents from different regions of Pakistan will be interviewed for this study. The interviewees will comprise of people who have worked in the health sector and have extensive knowledge about record keeping in the health sector. Moreover, people from the IT sector would also be interviewed in order to find out the technological barriers and how to resolve them. These interviews would help us in understanding the current system, how the patient medical records are stored and how they are shared amongst hospitals. At the end of the interviews, the responses will be transcribed, coded and analyzed using RQDA.[1]

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[1] http://rqda.r-forge.r-project.org

3.4 Data Analysis Procedures

In simple words, data analysis can be defined as the process of analyzing and reducing large chunks of data into small meaningful fragments. The main objective of this step is to extract important and useful information from a large chunk of data. Thematic analysis is the most commonly used form for analyzing the qualitative data gathered from interviews and document review. According to Braun & Clarke (2006), thematic analysis is a method to identify, analyze, and report patterns within the data.

The data collected from the interviewees in this study will be analyzed using the open-source software RQDA. Many researchers commonly use RQDA because of its compatibility with different operating systems, and it integrates with R. According to Braun & Clarke (2006) six steps need to be followed. These steps are:

- Become familiar with the data
- Generate initial codes
- Search for themes
- Review themes
- Define themes
- Write-up

The first step includes reading the data many times in order to get familiar with it and understand it. After getting familiar with the data, the next step is to structure the data into small meaningful fragments systematically. The third step is to look for similar patterns in the data provided by the interviewees. Step four and five consists of reviewing and modifying the themes. The last step is to write a report to present the result in a logical and structured way.

3.5 Validity procedures

The validity of research means how reliable the research results are. Validity procedures need to be applied to the research to ensure that the results of the research are trustworthy and reliable (Runeson et al., 2012). It helps in understanding that the researcher was not based, and the results obtained from the study are reliable. Reliability means that the results are valid and consistent over time. Runeson et al.

(2012) mentioned four types of validity; they are reliability, construct validity, internal reliability, and external reliability.

Reliability means how correct the collected research data is. It ensures that the collected data reflects reality. The reliability test minimizes the biases and errors in the research. In order for this research to be reliable, the interview questions and the transcript are added in the appendices section of this research. If any researcher conducts a similar study in the future by following a similar method, the result of that study will be similar to this research. Construct validity refers to the operational measures that determine how the data is to be collected and which data is to be collected. It ensures that we measure the construct we want to measure. To ensure the construct validity, all the respondents were interviewed similarly so that the operational procedure can resemble each other and it would result in similar results.

3.6 Summary

The focus of the chapter was the provide information about the case study design and the reason behind choosing the case study design for this research. Section 3.3 sheds light on the data collection procedure, such as document review and interviews. The last part of the chapter was focused on data analysis and the reliability of the data. The information provided in this chapter will be used in the next chapter to help in the analysis.

4 Results

4.1 Introduction

This chapter provides a comprehensive explanation of the case selected and analyzed for this research. All the interviews were analyzed using the RQDA software, as previously discussed in section 3.4, and the chapter concludes with a summary.

4.2 Case and Subject Description

The health sector of Pakistan can be divided into two main categories, the public sector and the private sector. The public sector serves 30% of the population; the private sector serves 70% of the population. State Healthcare Service delivery is being organized through a three-tiered Healthcare delivery system (Hassan, Mahmood & Buksh, 2017). The primary care mainly deals with rural areas and consists of Rural Health Centers (RHCs) and Basic Health Units (BHUs). The secondary care deals with small towns and consists of Tehsil Head Quarters (THQs) and District Head Quarters (DHQs). While tertiary care mainly deals with big cities and consists of different teaching hospitals (Hassan, Mahmood & Buksh, 2017).

According to the constitution of Pakistan, the provincial governments are responsible for the healthcare provision in their provinces, while the federal government is responsible for federally administered areas. Due to the 18th Amendment, the health sector was devolved to the provinces, and funds are allocated through the NFC award. The government is trying third to improve the healthcare services by hiring medical staff like doctors and nurses and constructing new hospitals.

Healthcare Facilities							
Health Manpower	2011	2012	2013	2014	2015	2016	2017
Registered Doctors	152,368	160,880	167,759	175,223	184,711	195,896	208,007
Registered Dentists	11,649	12,692	13,716	15,106	16,652	18,333	20,463
Registered Nurses	77,683	82,119	86,183	90,276	94,766	99,228	103,777
Population per Doctor	1,162	1,123	1,099	1,073	1,038	997	957
Population per Dentist	15,203	14,238	13,441	12,447	11,513	10,658	9,730
Population per Bed	1,647	1,616	1,557	1,591	1,604	1,592	1,580

Table 2: Statistics of Pakistan's healthcare facilities   Source: (www.finance.gov.pk)

The table above shows that the health sector is continuously improving as the population per bed, and population per doctor has dropped significantly. The health sector has made a significant improvement in the last few years. In Pakistan, more and more public services are getting digitalized, such as e-visa, citizens portal, and the recent use of telemedicine due to the coronavirus pandemic. Despite these advancements, the country still lacks behind when it comes to the proper management of the patient's health information.

The majority of the hospital, both public and private, in the rural areas are using paper-based record management of the patients. This is one of the reasons that healthcare facilities are considered to be inadequate. The paper-based health record-keeping creates many problems for the healthcare providers such as missing health records, delays in the retrieval of patient health history, delays in patient's treatment.

Proper management of patient's health records not only helps the hospital staff but also provides statistics about different diseases. It will provide the healthcare provider an idea about the statistics of different diseases in the country. So, if these records are adequately managed, it will help in increasing the quality of healthcare services rendered. This research was carried out to find out the major issues faced by healthcare providers regarding patient health records management and how blockchain technology can solve these problems.

As mentioned earlier, this research was conducted using interviews to properly understand the case being studied and also to have direct contact with different healthcare providers from all over Pakistan to record their views. The respondents were selected from different parts of the country to understand the common problem faced by all the healthcare providers. The interviews were conducted with different healthcare providers like nurses, general practitioners, registrars, paramedics to get their views about the current system and what do they think of a blockchain-based system.

4.3 Presentation of Findings

This section of the thesis is directed to describe and examine the findings generated by analyzing the data gathered. For data collection, interviews were conducted with different healthcare providers. The interview was divided into different sections, with the first section gathering information about the interviewer and their work situation. The next section was about Understanding the respondents' knowledge base of the

technology in order to measure the validity of their answers. Furthermore, it was important to know about the availability and accessibility of a patient's health record and KPIs for effectiveness and efficiency. Data collected during the interviews were transcribed to text so it can be analyzed with RQDA. Different codes were generated in RQDA from the transcribed interviews. Moreover, a set of categories linked to the research questions were developed, and the similar codes were categorized together. The categories from this research are highlighted below:

- Current Record Keeping System in Pakistan
- Current Information Sharing/Retrieval System
- Shortcomings of the current Record Keeping System
- Features of Efficient Record Keeping System
- Improvements that Blockchain technology will bring
- Barriers in Implementing Blockchain Technology
- How to mitigate the barriers
- KPIs for Efficiency and Effectiveness
- Blockchain Impacts on Stakeholders

4.3.1 General Description of the respondents

This section provides details of the respondent selected for the interviews. Total thirteen respondents were interviewed, 8 of them were related to healthcare sector and 4 of them were from the IT sector, while one was a member of the standing committee on governance. The main reason to interview people from the healthcare sector was to understand the current work flow and the limitations of the current system and what could be done to resolve those issues. The eight respondent that were interviewed had extensive knowledge about the healthcare sector. The majority of the respondents were doctors having different duties like ENT specialist, Anesthesia specialist, general practitioners. Some of the respondent were nurses while one respondent was working as a registrar. The majority of the respondents had more than 5 years' experience with one respondent having 32 years of experience.

Four respondents from the IT sector were interviewed to understand the technological barriers in implementing the blockchain technology in healthcare and what could be done to mitigate those barriers. All the respondent had over fiver years of experience in

the IT sector and one respondent had twelve years of experience. Lastly, a member of the standing committee on governance was interviewed.

4.3.2 Impact of blockchain on health record keeping in Pakistan

One of the main objectives of this research is to find out how blockchain technology would impact health record-keeping in Pakistan. This section answers the sub research question one: How would Blockchain technology impact medical record-keeping in Pakistan? This question was divided into a further three sub-question to provide a more in-depth explanation. The first question is, "What is the current system in practice for medical records keeping in Pakistan?" The answer to this question will help us in understanding the current system being used in different parts of Pakistan and also the shortcomings of the current systems. The second question is, "What would be considered as an efficient medical records management system?" and the third question is, "What improvements will blockchain bring to the current system?" Interviews were conducted to find out the answers to these questions.

4.3.2.1 Current Record-Keeping System in Pakistan

This section will provide an answer to the question, "What is the current system in practice for medical records keeping in Pakistan?" It was imperative to know the current system being used for record-keeping in different regions of Pakistan. The existing literature already shows that the paper-based health record-keeping is mostly in practice in many regions in Pakistan, the evidence from the interviews also support this fact that paper-based record-keeping is mostly in use not only in rural areas but also in many urban healthcare units. Evidence also supports the fact that more and more hospitals are moving from paper-based to electronic form of health record keeping. For instance, one of the respondents mentioned that "*currently we are using the electronic form of record keeping and the recently moved to the electronic record keeping system. The current government helped us in moving from paper-based to electronic health record system*" while another respondent mentioned that "*we mainly use paper-based record keeping but we use some kind of software as well*".

The majority of the healthcare providers use paper-based health record keeping while the electronic health records system is an emerging technology. It was very important to know the how information is shared between hospitals. Most of the respondent answered that currently there is no proper channel of sharing information sharing

between hospitals and the only way is that the patient themselves have to bring their medical files from the previous hospitals. For instance, one respondent said that "*we don't share data with other hospitals, only it is given to the patient if the patient requests for it and then the patient themselves have to take it to other hospitals*" while another respondent went on further to explain the difficulties in data sharing by saying that "there is no way that we can directly get the patient information from other hospitals. The patient needs to go and request for their record, and they get it if the hospital approves giving that information. Or maybe someone on behalf of the patient can request like a relative or friend".

It was also very important to find out the shortcoming of the current system and the difficulties that the healthcare providers are facing because of the traditional paper-based record keeping system. Almost all of the respondent mentioned that in case of the paper-based record keeping most of the times the records are incomplete because sometimes the patient doesn't have their medical records at all and it creates a lot of difficulties for the doctors. One respondent mentioned that "*50 to 60 percent of the patient doesn't have their old health record. Most of the times these files are mis managed and in result in losing of important health history of the patient.*" Another respondent mentioned a very important point that "*when the patient is brought to the emergency room then the only way to know about their medical history is that we have to ask the patient if the patient is conscious and most of the time ask their relatives/friends or whoever came with the patient. But if there is no one to ask then we have to take risk and start treating the patient without knowing their medical history*". It means that in case of emergency the doctors are dependent on the information provided by the patients themselves or their relatives who came with them. Another respondent mentioned that the room where all the medical records are kept is locked during the night and is not accessible at that time. The respondent further explained that if a patient wants to get their medical record files, then the permission from the Medical Superintendent (MS) of the hospital is needed, and it takes at least one day. One respondent pointed out that paper-based record keeping is inadequate because the data can be manipulated, and it can create many problems for the healthcare providers. All the respondent agreed the healthcare providers should move from paper-based to the electronic form of record-keeping.

4.3.2.2 Efficient Record-Keeping and Information Sharing System

This section of the thesis was directed to find out what the respondent thinks an efficient record keeping and information sharing system should be. This section provides the answer to the question, "What would be considered as an efficient medical records management system?"

The result gather from the interview indicates that there are two most important features that an efficient record keeping and information sharing system should have; first, it should be accessible all the time, and the second that it should be easy to use. The respondent mentioned that it should be easy to retrieve the patient medical history and the retrieval of information should be fast so they can take the right decisions based on the medical history of the patient. One respondent mentioned that "*It should be easy to use and should be accessible by the doctor and it should be secure because the health data is very private information and the system should provide privacy to all the patient's health data. Not everyone should have access to this system and only if the patient allows only that authorized person can have access to that patient data. It would make the record secure and that there will be privacy as well and the record can be accessed by multiple healthcare providers.*" Another respondent mentioned that "*Firstly, it should be easy to understand and operate. Then its availability should be 24 hours and the record should be easily retrieved whenever needed. It definitely has to be implemented country wide to be properly efficient.*"

Almost all of the respondents mentioned the fact that the system should be easy to use because it will make the adoption of the technology fast. The respondents also pointed out the fact that the system should be secure and the health data is very sensitive, so the system should be able to protect the data from unauthorized users. So, an efficient system would be such a system that would be easy to use by the healthcare providers and the data should be easily retrieved and only authorized individuals should have access to it.

This section of the thesis was directed to find out what the healthcare providers think of an efficient system for record-keeping in the health sector. The result indicates that the respondent considers two important feature that an efficient record keeping and information sharing should have. The first one is that the system is easy to use and the second is that information should be retrieved easily.

4.3.2.3 Improvements that blockchain technology will bring to record keeping

This section of the thesis was directed to find out the answer to the sub research question "What improvements will blockchain bring to the current system". It was very important to know what the respondent thinks of the use of blockchain technology for medical record keeping and what improvement could this system bring. Some of the improvements that the respondents mentioned are:

- Sharing of information between healthcare providers
- Quick retrieval of information
- Increase in the quality of healthcare service provided
- No need for a physical visit to the record room
- Transparency and less corruption

Once respondent mentioned that "*there is a lot of corruption specially in government hospitals as there is no proper record of medicines, where was the medicines consumed. As everything is paper-based so there is no transparency but if we move to a digital system where all the records of the patients are stored then it will increase transparency and corruption in the hospitals will decrease.*" Another respondent said that "*This surely will improve record system in Pakistan. Delay in starting treatment and risks of treatment hazards can be avoided. If this system is implemented fully and properly then it will definitely benefit patients and health care providers.*"

Furthermore, it was also important to know the barriers in implementing such a system in Pakistan. It was very necessary to know what the respondent thinks will be the barriers in implementing a blockchain based record keeping system. The respondent mentioned a number of barriers that will limit the implementation of the blockchain technology in Pakistan. Some of the most important barriers are:

- Availability of internet
- Availability of computer systems in all healthcare units
- Lack of training
- Less funding
- Lack of rules and regulations
- Will of the government
- Poor IT infrastructure

These are the barriers mentioned by the respondents. The respondents mention that in order to implement an efficient record keeping and information sharing system there is a need to address these barriers first. Because without addressing these barriers it would be impossible to implement a blockchain based medical record system in Pakistan. One respondent mention that "*problems in implementing this system in Pakistan can be Government permission, providing enough resources, so that it is implemented country wide and electricity shortage problems. Also, training of the staff.*" Another respondent said that "*it is not hard to implement such a system in Pakistan; it can be implemented in Pakistan but the government isn't willing to do it. Because if such system is implemented then the corruption of the people sitting in government hospitals will be exposed. Because of the paper-based system there is no transparency like there is no proper record of the medicine, how much medicine was used.*"

The respondents mentioned that if the government is willing then such a system can be implemented in the whole country. It just depends on the will of the government; the respondent also mentioned an important point that since we have a shortage of electricity in Pakistan then alternative power supply resources should be provided to the healthcare units for the system to work efficiently. Moreover, the respondent mentioned that as it has to be implemented in the whole country so it is very important to provide internet to even the remote areas of Pakistan.

The IT infrastructure of Pakistan needs to be improved to implement a blockchain for medical record keeping. Pakistan also needs more blockchain developers to enhance the use of blockchain technology in different projects. One of the respondents said that "*we need to upgrade the IT infrastructure of the country and the other issue is that we have very few blockchain developers in Pakistan. As far as I have heard there are one or two companies in Islamabad that are working on blockchain technology. We need more blockchain developers.*" The public and the private sector need to work together to make people aware of blockchain technology by starting blockchain courses in universities and colleges.

Moreover, we will need proper legislation on National and Provincial levels to ensure data exchange amongst private and public hospitals. One of the respondents mentioned that "*The coordination between private hospitals and public hospitals and make them work together is a big problem. The coordination between provinces and coordination with the federal government. For example, the Khyber Pakhtunkhwa is a separate entity*

and we have the problem of coordination with other provinces like Sindh and Punjab. The patients aren't restricted to get treatment form other provinces, they can move freely and can get treatment from any province. The main problem would be data transfer between provinces and these problems needs to be resolved". Public-private partnerships should be encouraged and the government should focus on building trust between the public and private hospitals and bring such legislation through which all the healthcare institutes are made responsible to share patient data with other healthcare institutes.

The respondent further said that to mitigate these barriers there is a need for a pilot project "*the easiest way to implement this project and eliminate the barriers would be to start a pilot project on a district level. Like we have started a pilot project in Mardan district (for digitalization of land records system), although it's not related to blockchain still it's a good example*".

This part of the research was directed toward finding out the improvements that the blockchain technology will bring to medical record keeping. Furthermore, it provided us the information about what the healthcare providers think could be the barriers in implementing a blockchain-based health record-keeping and information sharing system and how these barriers can be avoided.

4.3.3 KPI's determining the effectiveness and efficiency of adopting blockchain technology for medical records keeping in Pakistan

Another important of the research was to find out the criteria that demonstrate the successful adoption of blockchain technology for health record-keeping and information sharing between hospitals. This is why it was important to find out the answer to the research question, "How to determine the criteria for measuring the benefits of blockchain technology for medical record-keeping in Pakistan?" This research question was further divided into sub-questions "What are the criteria to measure the effectiveness of blockchain in medical records keeping and information sharing?", "What are the indicators to measure the efficiency of the proposed system?" and "What are the characteristics of an efficient health record-keeping system?" In order to find an answer to these questions, interviews were conducted with healthcare providers. The data gathered from the respondents indicate the following KPI for determining the effectiveness and efficiency of adopting blockchain technology for medical records keeping in Pakistan.

- Time taken to access patients records
- Availability of the system
- Patients satisfaction
- Affordability of the technology
- Ease of use

These are the KPI mentioned by the respondents which will determine how effective and efficient the system is. One respondent mentioned that "*the most important factors is how affordable the technology is. As you know that Pakistan is a developing country so we don't have much money to spend on the new technology. So, I think the most important factor would be the affordability of the technology. If we can't afford it then it is of no use to us*". Another respondent highlighted the fact that the technology should be easy to use, the respondent said that "*If we want to implement such a technology in the whole country then it should be easy to use because you know that the people in the primary healthcare units have no knowledge of computer. So, the technology should be easy to use so they people in the primary healthcare units can also use it*".

However, most of the respondent were concerned with the availability of the system and how fast the retrieval of information is. The respondent also mentioned that the health sector really needs a system through which healthcare providers can share information amongst each other's.

4.3.4 Effects of Blockchain Technology on the Activities of Stakeholder in Healthcare Sector

This section aimed to find out an answer to the research question, "How will the adoption of blockchain technology for medical record-keeping in Pakistan affect the key stakeholders?" This question was further divided into two more questions, "Who are the stakeholders and what is their role?" and "What improvement will blockchain bring for the stakeholders?". To find an answer to these questions, interviews were conducted with healthcare providers. The aim was to find the effect of the blockchain technology on the healthcare providers, what benefits could blockchain technology bring for the healthcare providers.

The majority of the respondents were doctors, while some were nurses and registrars. The majority of the respondent had over five years' experience in the healthcare sector,

with one respondent having 32 years of experience. Most of the respondents had similar duties like taking care of the patients admitted in different wards or taking care of critical patients in the Intensive Care Unit (ICU) or attending to emergencies.

The respondent mentioned that if the hospitals have such a system where the healthcare providers can share patient information and easily retrieve patient medical history, then it would make their job very easy. They would be able to attend to the patients and provide them immediate care. One respondent mentioned that "*It would definitely help us such as the whole medical history of the patient will be Infront of me. I wouldn't have to leave my office to collect the patient files from any other departments. Everyone would have a computer from where they can retrieve the patient health records and we wouldn't need to physically visit the record room*". Another respondent said "*we want the patient to quickly recover, to provide quick and efficient treatment to the patient. For that we need to have the medical history of the patient to know about any kind of allergy or other diseases. If the patient medical files are in another hospital then we have to wait until the patient bring these files.*"

It is very clear that the current system of record keeping in healthcare has a lot of problem. One respondent mentioned that in 50 to 60 percent cases the patients have incomplete files of their medical history that is one of the reasons of delayed treatment of the patient. The respondent agreed that the implementation of a blockchain based system will help them in taking care of the patient efficiently.

4.4 Summary

This chapter started with a concise introduction, followed by the case and subject selection. Further on, the chapter provided an analysis of the information gathered from the respondents. Section 4.3 was related to the presentation of the findings, followed by a brief description of the respondents. Furthermore, the answer to the research questions is explained in the subsections of 4.3.

Research Questions	Findings from the interviews
SRQ1: How would the Blockchain technology impact medical record-keeping in Pakistan?	
What is the current system in practice for medical records keeping in Pakistan?	**Paper based** in most of the hospitals with store room for storing medical records. - Informational retrieval is very difficult - In emergency case the doctors ask the patient or the patient's attendants about the patient medical history - Record rooms are mostly locked during the night - Incomplete records - Records are lost **Electronic health records system** in some hospitals but information is not shared with other hospitals
What would be considered as an efficient medical records management system?	- Available all the times - Less waiting time - Easy to use - Easy information sharing - Privacy of the health records - Quick retrieval of information
What improvements will blockchain bring to the current system?	- Transparency - No need to visit the record rooms - Quick access to the patient health records - Easy Information sharing amongst healthcare providers

Blockchain technology	Barriers:
	- Less funding
	- Poor IT infrastructure
	- Lack of training
	- Power supply issues
	- Resistance to adopt new technology
	Resolution:
	- Increase the budget
	- Improve IT infrastructure
	- Train the staff
	- Power supply backup
	- Need of proper legislation

SRQ2: How to determine the criteria for measuring the benefits of blockchain technology for medical record-keeping in Pakistan?	
What are the criteria to measure the effectiveness of blockchain in medical records keeping and information sharing? What are the indicators to measure the efficiency of the proposed system?	- Affordability - System's availability - Patient's satisfaction - Ease of use - Time taken to retrieve the medical records.
What are the characteristics of an efficient health record-keeping system?	- Privacy of the health records - The patient's records are easily accessible

SRQ3: How will the adoption of blockchain technology for medical record keeping affect the key stakeholders?	
Who are the stakeholders and what is their role?	- Patients - Paramedics - Nurses - radiographers

What improvement will blockchain bring for the stakeholders?	• Increased productivity • Quick treatment • Less time consuming

Table 3: Summary of findings, source: author.

5 Conclusions and Future Work

5.1 Introduction

The previous chapter indicates that the respondent healthcare providers support the adoption of blockchain technology for record-keeping and information sharing. The subsection of 4.3 also showed that there are many barriers in implementing blockchain technology in Pakistan. If these barriers are not removed, then it will be tough to implement the blockchain technology in Pakistan successfully. In this chapter, we propose a framework for the successful adoption of blockchain technology in the healthcare sector in Pakistan. Furthermore, we have discussed the implications, limitations and future work.

5.2 Summary of Findings and Recommendations

For the successful implementation of blockchain technology for medical records keeping in Pakistan the researched proposed a framework which will in guiding and avoiding the barriers mentioned earlier. See figure 6 for the successful adoption of blockchain technology in Pakistan.
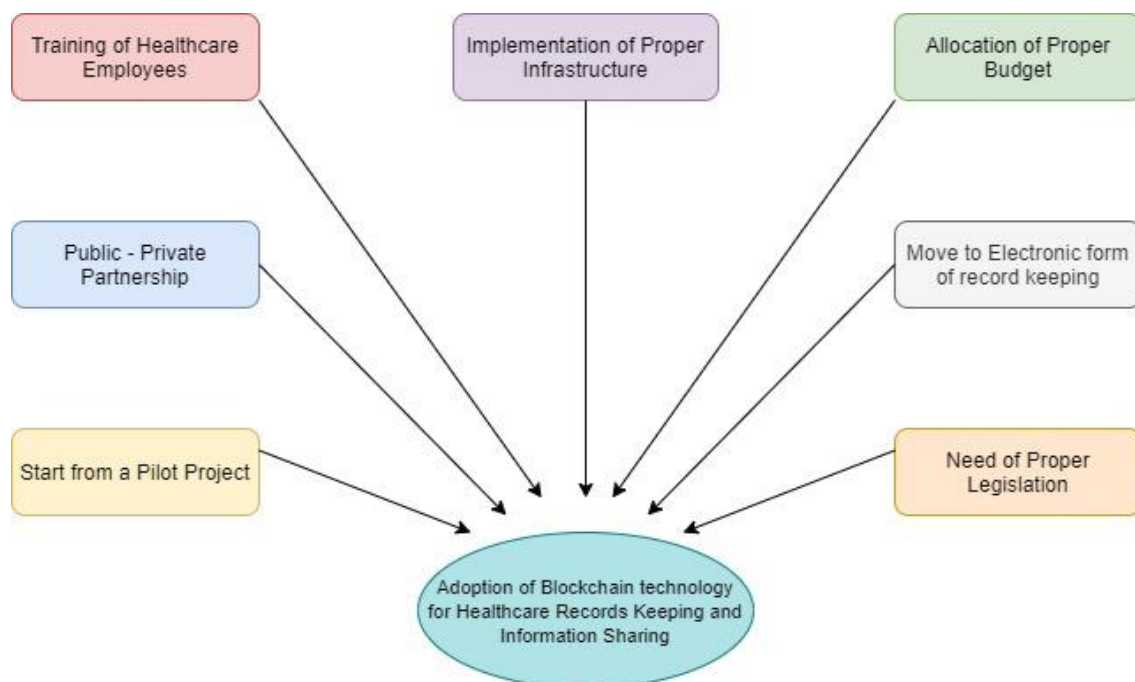

Figure 6: Framework for the adoption of Blockchain technology for medical records keeping and information sharing in Pakistan, Source: (Author)

5.2.1 Training for Healthcare Providers

As the majority of the respondents mentioned that the system should be easy to use and training should be provided to the healthcare employees. It is clear that without proper training and education, the blockchain-based system for record-keeping and information sharing would not be successful. As this system is to be implemented in the whole country, so it means that everyone working in the healthcare sector, even in Basic Health Units (BHUs), should be able to use it. This is why it is very important to provide training to all the existing employees as well as the new employees joining the healthcare sector. Moreover, the system should be easy to use, and healthcare providers should be involved in the design process of the system. The system should be developed, keeping in mind the healthcare providers in rural areas such as Rural Health Centers (RHCs) and Basic Health Units (BHUs). The healthcare providers in these units do not have much knowledge about technology, so the system should be easy to use for them, and they should be given proper training before implementing this technology.

5.2.2 Allocation of Proper Budget

The health budget of the federal government Pakistan for the year 2019 - 2020 was just 13 Billion Rupees, which was less compared to last year's budget. For decades, the country has been spending less than one person of the total GDP on health (Pakistan Today, 2019). Pakistan ranks 152 out of 189 countries in terms of the Human Development Index (HDI). Similarly, health expenditures by federal and provincial governments of Pakistan during the year 2018-2019 increased to Rs 203.74 billion (Pakistan Today, 2019). The government should allocate proper health budget, so a project like the adoption of blockchain technology for record-keeping is easy to implement. Provision of funds for providing computers and power supply alternatives is very important and that is why the government needs to allocate proper budget for this project. The government should also allocate budget for training of the employees.

5.2.3 Implementation of Proper Infrastructure

One of the main problems in the adoption of the blockchain technology for medical record keeping and information sharing is the need for proper infrastructure. Most of the RHUs and BHUs do not have computer systems, and that is why it would be very hard to implement blockchain technology in the health sector throughout the whole

country. The federal and provincial governments need to make sure that every health unit has a computer system available. The federal and provincial governments need to allocate budget for providing a computer system to every healthcare unit in the country.

The other main problem in Pakistan is the power supply. Currently, Pakistan is facing a huge energy crisis, and the country has an electricity shortage. That is why in the rural areas of Pakistan is has massive load shedding (no electricity available) hours. Especially in summer, there is no electricity in some rural areas for up to 12 hours. In this case, the government will need to provide alternative power supply recourses to all the health units so the system can work efficiently. In alternative power supply resources are not provided, then the system will be useless as no one will be able to use the system when there is no electricity available for 6 to 12 hours.

Another issue would be the provision of the internet to all the healthcare units. The government needs to make sure that all the healthcare units have a working internet connection; this is how healthcare providers will be able to add or retrieve records. For this purpose, even the health units in the remote areas must have a working internet connection.

5.2.4 Move to Electronic form of record keeping

To implement blockchain technology in the health sector, the first thing that Pakistan needs is to move to the electronic form of record keeping. All the healthcare providers in the country should stop using a paper-based record keeping system and should adopt the electronic health record system. Once all the healthcare providers move to the electronic form of record-keeping, then it will be very easy to implement the blockchain technology for record-keeping.

5.2.5 Public – Private Partnership

Just like Estonia, the government needs to collaborate with the Private sector in order to implement the blockchain technology in Pakistan. The government should encourage the private sector so they can play their role in the adoption of blockchain technology. The government should also encourage startups working on blockchain based solution and should encourage such courses in different public and private universities. Continuous research on technology will be another very important aspect.

Moreover, the government of Pakistan needs to collaborate with countries like Estonia, which is already using a blockchain-based health record-keeping system. Estonia is already ahead of all the countries when it comes to the adoption of blockchain in the health sector. The government of Pakistan can learn a lot from the Estonian experience of blockchain, and the government of Pakistan needs to partner with Estonian public and private companies like Guardtime.

5.2.6 Start from a Pilot Project

To implement blockchain technology in the health sector, the best recommendation would be to start from a pilot project and once the pilot project is implemented the performance of the pilot project should be evaluated. Once the pilot project is evaluated only then the project should be implemented nationally or provincially. Just like the pilot project for the digitalization of land records systems, the digitalization of the medical records should also start from a pilot project. During the pilot phase the medical records of three hospital should be fully digitalized and the data should be shared amongst these three hospitals. This pilot project should be evaluated and all the shortcomings of the system should be addressed. Once the pilot project is successful then more hospitals should be connected to these three hospitals.

5.2.7 Need of Proper Legislation

The implementation of the blockchain technology in health care sector would need proper legislation to ensure medical records sharing amongst hospital. Currently the hospitals are reluctant in sharing patients' medical records with other hospitals so these legislations should obligate the hospitals to share patients' medical records with other health institutes. These legislations are not only needed on National level but also on provincial levels. New legislation in the health sector is the need of today. The legislator should coordinate with care providers and bring new legislations. The main focus of these legislations should be data security and dating sharing between healthcare institutes.

The table below summarizes the findings and recommendations

Name	Description	Reason
Training of healthcare Providers	Proper training of the healthcare workers is needed so they can use the system easily and efficiently	The respondents mentioned that due to the lack of training the healthcare providers will not be able to use the system properly.
Allocation of Proper Budget	Allocation of proper budget is needed in order to implement the blockchain technology for record keeping and information sharing.	To provide computer and internet to all the healthcare providers, the government needs to allocate proper healthcare budget.
Proper Infrastructure is Needed	Provision of internet, computer systems, power supply resources is important.	The main problem is that most of the hospitals don't have computer system or an internet connection. The power supply issues will be a main problem in the whole country.
Move to Electronic Record Keeping	To make the implementation of the blockchain technology easy, it is very important that all the hospitals in Pakistan should start using Electronic health records system.	Paper-based record keeping is mainly used for record keeping. The paper-based system has many shortcomings and cannot meet the needs of the modern world.
Public – Private Partnership	The government of Pakistan needs to partner with different private companies and encourage startups working on blockchain technology. Research on the technology should be encouraged and blockchain	Public private partnership will make the adoption of blockchain technology easy. Countries like Estonia also partnered with private companies to implement blockchain technology in the health sector.

	courses should be introduced.	
Start from a Pilot Project	To implement this project on National it is very important to start it as a pilot project in one district. The pilot project should be evaluated and all the shortcomings should be addressed. Once the pilot project is successful then more hospitals should be linked to this pilot project.	Pakistan is a country with over 212 million population so it is much better to start this project as a pilot project in one district. This way all the shortcoming of the projects could be addressed.
Need of Proper Legislation	To ensure data sharing amongst hospitals, proper legislations on National and Provincial level is needed. The hospitals should be obligated to share patient date with other healthcare institutes.	Currently the hospitals are reluctant in sharing patient's data with other hospitals. SO proper legislation is needed to resolve this issue.

Table 4: Summary of recommendations, source: author

5.3 Impact/Implications

This research explored the current medical record-keeping system in Pakistan and how information is shared between healthcare providers. The research identified the main issues and challenges faced by healthcare providers due to the current system. The research further provided details on how these challenges can be mitigated and how blockchain technology can help in record keeping and information sharing.

The study provides details on how information is shared between healthcare providers and the issues with current information-sharing methods. This research will help other researchers exploring this topic and will open a new perspective on how information

should be shared between healthcare providers and how the health care records can be made more secure.

5.4 Limitations

The main limitations of this study will be related to the limitations of the single case study. One of the main limitations of the case study design is the limitation in generalizability. According to Hyde et al., (2012), the case study research design is used for proving and theory and not to generalize the findings. The critics argue that the case study research design is meant to prove a theory and not to generalize findings.

Other critics argue that one interview with the respondent is not enough to have a clear picture of their understanding. The critics further argue that the case study methodology may result in a biased outcome (Krusenvik, 2015). According to Yin (2003), many times, the investigator is sloppy, and there are biased views that influence the directions of the conclusions. Although efforts were made to collect data from different sources but the limitations highlighted here cannot be ignored.

5.5 Future Work

This study only provides a direction for some more in-dept analysis of the research problem. Further research can be done on this topic involving more respondents from other cities of Pakistan specially the remote areas to get their perspective on this issue. Both qualitative and quantitative methods can be used in order to get more appropriate results.

Further research on the design of the system and also the patient view about the system should be conducted. The work done through this research will offer a guide to further research on medical record keeping in Pakistan.

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Appendix 1 – Interview Guide

Step 1: Introduction

Interviewer presents the research topic and explains the goal of the interview.

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

- Do you work in a private hospital or government hospital?
- What is your role (doctor, nurse or something else)?
- For how long you have been working in this hospital?
- What are your main duties?
- Can you explain how patient's health records are currently stored in your hospital?
- Can you briefly describe how information about the patient's medical history is accessed or shared with other hospitals?

Step 3: Understanding the respondents' knowledge base of the technology

- What do you know Electronic Health Records system?
- How would you rate your computer knowledge?
    - If Yes, how would you describe your computer skills? Basic (), Average (), Experienced ()
    - if Yes, were you given any computer training?
    - If No, do you have any plans to learn computer skills?
- Do you use any ICT in your responsibilities? YES / NO
    - if YES, what program (Software) do u use?
- What do you know about blockchain technology?
- Do you think using a blockchain based system for medical records keeping will be beneficial? YES/NO
    - If YES, please explain how it will improve the current health records keeping?
    - If NO, please give reasons why do you think it will not improve the current health records keeping.
- What is your opinion on moving from the paper-based form of record keeping to the use of a blockchain based record keeping and information system?

- What do you think could be the main problem implementing blockchain technology in the health sector in Pakistan?
- How can these problems be resolved?

Step 4: 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 information about the patient do you need to know before starting the treatment?
- At what stage do you need to know the patient's medical history?
- Why do you need to know the patient's medical history?
- How do you get patient's health records from other hospitals?
- Can you start patient's treatment without knowing their medical history?
- What do you think are the shortcomings of the current system used in your hospital?
- What should be done in order to overcome these shortcomings?
- What is the view of the patient about the current system in use for health record keeping?
- What features do you think an efficient health records keeping system should have?
- What do you think are some challenges currently experienced while using the current system?
- What are the steps being taken to address the challenges in the current system?

Step 5: Questions on the measuring criteria for effectiveness and efficiency in the system

- Do you have standards for measurement of success of the current system for the treatment of patients?
- Do you have standards for measurement of productivity in using the current system for the treatment of patients?
- What improvement do you think a blockchain based system will bring to health records keeping and information sharing?
- How do you think the quality of service can be measured after using a blockchain based system?

Step 6: Questions related to the roles of stakeholders in the system

- Do you think that by using a blockchain based system your productivity will increase and it will be beneficial for you?
    - o IF Yes, explain why?
    - o IF No, explain why?
- Will a blockchain based system bring any ease or benefits for the patients?
    - o If Yes, What kind of benefits?
    - o If No, why?
- Do you think that a blockchain based system will improve the overall record keeping in the health sector?

Appendix 2 – Additional Materials

Link to the thesis materials

https://drive.google.com/drive/u/1/folders/1XKTYTKESR6K0-uM_W9Rugjcmo_uOyhho

Appendix 3 – Thematic Map of All Categories and Codes