Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia

BY

LIM JASON

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfilment of the requirements

for the degree of

BACHELOR OF INFORMATION SYSTEMS (HONOURS)

INFORMATION SYSTEMS ENGINEERING

Faculty of Information and Communication Technology

(Kampar Campus)

JAN 2022

UNIVERSITI TUNKU ABDUL RAHMAN

REPORT STATUS DECLARATION FORM

Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia

Academic Session: JAN 2022

I _____LIM JASON_____

(CAPITAL LETTER)

declare that I allow this Final Year Project Report to be kept in

Universiti Tunku Abdul Rahman Library subject to the regulations as follows:

1. The dissertation is a property of the Library.
2. The Library is allowed to make copies of this dissertation for academic purposes.

Verified by,

_____ (Author's signature)

_____ (Supervisor's signature)

Address:

_43, Jalan Suria 7_____

_Taman Suria_____

_81100 Johor Bahru_____

Date: __21/04/2022_____

___Su Lee Seng_____

Supervisor's name

Date: ___21/04/2022_____

FACULTY/INSTITUTE* OF Information and Communication Technology

UNIVERSITI TUNKU ABDUL RAHMAN

Date: **21/04/2022**

SUBMISSION OF FINAL YEAR PROJECT /DISSERTATION/THESIS

It is hereby certified that **Lim Jason** (ID No: ***18ACB02103***) has completed this final year project/ dissertation/ thesis* entitled "**Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia**" under the supervision of **Mr. Su Lee Seng** (Supervisor) from the Department of **Digital Information Technology**, Faculty/Institute* of **Information and Communication Technology**.

I understand that University will upload softcopy of my final year project / dissertation/ thesis* in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

_____

(*Lim Jason*)

DECLARATION OF ORIGINALITY

I declare that this report entitled "**Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia**" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : _____

Name : **Lim Jason**

Date : **24/08/2021**

ACKNOWLEDGEMENTS

I want to express my sincere thanks and appreciation to my supervisor, Mr Su Lee Seng, who has offered me support and believing in me. This is the third blockchain application I have completed, but this is also the most complex and biggest project I have developed.

Furthermore, I would like to thank UTAR for providing me with the fundamental knowledge I needed to take on this project. I would also like to thank Udemy and Coursera for providing quality courses where I learnt most of my skills to complete this project. Finally, I must thank my family for their love, support and continuous encouragement throughout the course.

ABSTRACT

Healthcare has always been substantial to a country and its economy. It signifies the strength and stability of a country, and without proper healthcare, the country will not be as efficient and successful. Hence, the medical record systems have to be remodified and improved for healthcare services to be efficient. In this project, blockchain technology and smart contracts will be the proposed method to solve issues with current medical record systems. Blockchain technology and smart contracts are nascent but rapidly growing technologies. These technologies can provide drastic improvements to solve key issues faced by almost every traditional medical record system. By utilizing blockchain to store medical records, we can leverage the benefits of blockchain, such as immutability, security, and decentralization. Next, smart contracts are the fundamental part of integrating any applications with the blockchain. It allows the automation of manual tasks that normally require manual labour, significantly reducing hospital labour costs. In this report, issues faced by traditional medical record systems are discussed, and each problem can be solved by implementing a blockchain medical record system. The developed system solves all of the key issues mentioned in the problem statement and achieves all of the objectives stated, proving that blockchain truly is the next big step forward in medical record systems.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

EMR	Electronic Medical Record
EHR	Electronic Health Record
PHI	Patient Health Information
SHA256	Secure Hash Algorithm 2
HIPAA	Health Insurance Portability and Accountability Act
IC	Identification Card
IOS	iPhone Operating System
BMI	Body Mass Index
SDLC	Software Development Life Cycle
CASE	Computer-Aided Software Engineering
IDE	Integrated Development Environment
NPM	Node Package Manager

Chapter 1: Introduction

1.1 Project Background

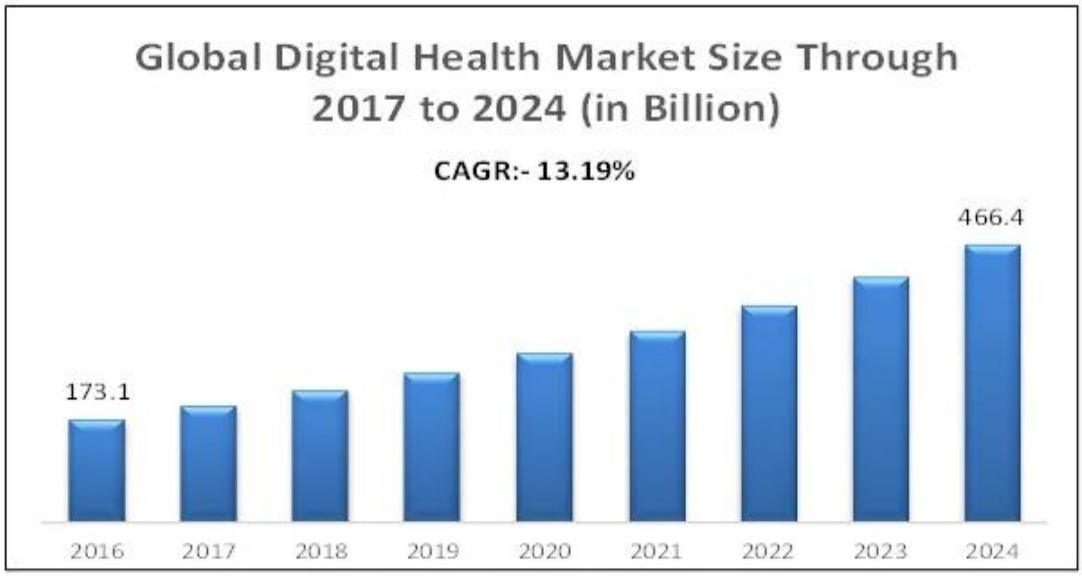


Figure 1.1: Global Market for Healthcare Statistics [1]

Healthcare is the single most crucial aspect of ensuring the well-being of the citizens of a country and the stabilization of the country's economy. As seen by the statistics above, global healthcare spending is expected to reach $10.059 trillion in 2022. Healthcare is also especially significant because of the recent COVID-19 pandemic that took the world by storm, and only countries with efficient and effective healthcare systems will prevail. Therefore, to ensure that the healthcare of a country is running efficiently and smoothly is the obligation of the Ministry of Health. Based on [2], the role of the Ministry of Health in Malaysia is to ensure that the healthcare system in Malaysia is constantly improved with updates to the policy and to regulate the health sector. The Ministry of Health is also in charge of upgrading information and communication technology and medical records systems to maintain efficient health information management.

Electronic medical record (EMR) is a record of a patient's health data and personal details that is created and kept by the hospitals throughout the patient's lifetime and spread among multiple hospitals, clinics, and health providers to ensure each patient gets the right prescription and treatment. EMRs contains sensitive information of each patient that is used during diagnosis and treatment in a hospital. To make the sharing of healthcare data seamless and accurate is a crucial part of an efficient and effective healthcare system.

Next, to understand how blockchain technology can improve EMR, the core concept of blockchain has to be understood. As [3] defines, the definition of blockchain is that blockchain is a public electronic ledger built around a peer-to-peer system that is openly shared among stakeholders of the transaction. This will create an unchangeable record of transactions that can only update when consensus is achieved between stakeholders of the system. Once new data enters the blockchain, it cannot be erased. This implies that if somebody changed one block in the blockchain, it would be immediately apparent it had been tampered with and can be seen by all stakeholders involved. If hackers wanted to corrupt a blockchain system, they would have to change every blockchain chain across all the distributed versions of the chain, making it technically impossible because every blockchain is encrypted with the SHA256 algorithm, meaning that there are 2^{256} combinations. These traits make blockchain have specific features such as being transparent, decentralized and highly secured. Hashing and Cryptography, Immutable Ledger, Consensus Protocol, Mining and Distributed Peer-to-peer Network are just a few of the technologies and services that power the Blockchain [14], which we'll go over in more depth below:

- Hashing and cryptography: The SHA256 hash is used to add transactions to a blockchain. This is a 64-character code produced by the National Security Agency. One-way cryptography, determinism, rapid computing, the avalanche effect, and the ability to tolerate collisions are all aspects of hash algorithms.

- Immutable ledger: In a blockchain network, each transactions are stored, and the distributed ledger cannot be altered or manipulated.

- Consensus protocol: In a blockchain network, specific individuals have individual access privileges to grant transactions that are updated in the system.

- Mining: Miners on the blockchain network utilize blocks of nonce values to generate cryptographic hashes. This demands high computing speeds in order to accomplish and reap the block reward as an incentive for taking part in this process.

- Distributed Peer-to-peer network: To distribute and update data, all transactions are broadcasted throughout the network to various users.

The characteristics of blockchain make it the best step forward to further improve medical record systems. The key benefits of implementing blockchain medical records solve various issues that the current healthcare sector faces in terms of medical records. Using blockchain medical records ensures patients can have complete control of their data and only share it with anyone through their consensus. This can benefit patients, but it can also ensure that patient's information is updated and synchronized to ensure that they can get proper health treatment when they transfer from an old hospital to a new hospital. Blockchain medical records that return the ownership of medical records to the patient instead of the hospital are highly crucial because of the recent ransomware attacks prevailing in the US. The most recent is the Colonial Pipeline attack. Ransomware attacks on hospitals are also fairly common, and issues like this will put patients' medical records in jeopardy. Using blockchain to store medical records can mitigate these risks entirely due to the nature of blockchains preventing them from being breached or hacked. The problem domain of a blockchain medical record system is the Blockchain technology and hospital medical records of patients.

After understanding blockchain, we now have to look into Smart contracts, which are the fundamental part of integrating any applications with the blockchain. Smart contracts are programs or codes stored on the blockchain that perform certain tasks when predetermined conditions are triggered. A Smart contract can be imagined

as an automated contract that will trigger on its own without the involvement of any intermediary to facilitate the transaction. There are many different use cases for Smart contracts like supply chain management, medical record systems, auction systems, and others. The use of Smart contracts in each use case will remove the involvement of a middleman needed to facilitate the transaction, which can drastically cut the labour cost needed to hire the workers. Smart contracts also improve efficiency and provide transparency which has been a long-running issue of certain industries such as the supply chain and medical industries. The smart contract also brings benefits such as speeding up transactions that previously required a lot more time. As when Smart contract conditions are met, the code/contract will execute immediately without needing to process any paperwork while avoiding any human error that may occur in the process.

1.2 Problem Statement

Mismatch or Unsynchronized Health Record of patients that negatively affects the delivery of effective healthcare

According to the American Health Information Association, in an article by [4], the average duplication rate in a healthcare organization's patient health records is between 8 and 12%. In another article stated by [5], CBMI Director Shaun Grannis said in a statement. Statistics show that one patient record is not accurately matched even within the same health care system out of five patient records. Up to half of the patient records are not correctly matched when data is transferred between health care systems. Based on [6], this is a critical issue in healthcare and can cause patients not to receive the proper treatment. For example, a patient that has been diagnosed with depression in hospital A and has transferred to hospital B and the medical records are mismatched or not in sync, which causes the patient not to get the medication he requires because of this issue. The rate of broken or mismatched records can be seen in figure 1.2 below. Not only that, but mismatched records are also an essential issue in Malaysia. For example, when a patient suddenly decides to go to another hospital instead of the regular hospital that he or she goes to. The new hospital might not have the complete medical record of the patient. This will cause issues such as the patient not being treated with proper medication and causing more harm than good.

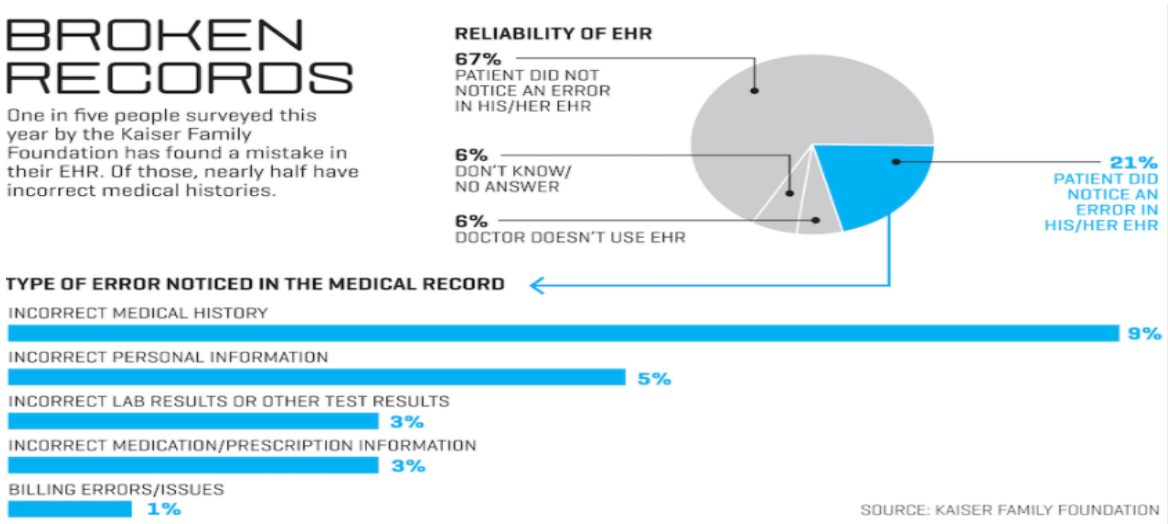


Figure 1.2 Broken or Mismatched Medical Records of Patients

Privacy breach of patient's electronic medical records and private information

Based on [7], Leak of patient's electronic medical records is quite common and a serious issue where the confidential individual records of patients are made available to others without the individual's consent or authorization. Some leak of records is intentional when medical organizations sell patients' medical records to other for-profit organizations. Some leaks of medical records are unintentional where the medical records are accessed and leaked by hackers. As stated by an article by [8], the most recent and severe case of privacy breach was a data leak involving the patient records of 20 thousand Malaysians. He also stated that the United States was most drastically affected. With 13.7 million heath records compromised, including full names of the patient, dates of birth, and medical examination dates, all leaked on the internet and can be accessed by anyone.

Electronic Medical Record System is not intuitive, causing medical personnel to take up too much time to enter or update records of patient

A study by [9] of a community hospital emergency department (ED) found that doctors spent 43% of their time on data entry. Only 28% of the doctors make direct patient contact. They also estimated that the Electronic Medical Record system required 4 thousand mouse clicks in a typical 10-hour shift. Not only that, an article by [10] stated that medical record systems that are over complicated and are not intuitive, resulting in the doctors or nurses having to spend way more time than needed to get their work done. He also stated that some clinics report that users of the system after excessive training still require six to twelve months before they are comfortable with the system, which should not be the case if the medical record system is designed well and intuitive.

Bottlenecks in centralized medical record systems result in a central point of failure

As [11] stated, the authorities know of the risks of losing all of the data of a centralized system if the system is exploiting or destroyed. A centralized medical record system is a vulnerable target for malicious users who wish to destabilize a country by the health system or steal and expose the health record details of the citizens. This issue would

cause the loss of all patients' data and mess up the entire medical record system of the county and cause the country to lose up to millions of dollars for this issue. Furthermore, centralized medical record systems will also have the risk of a breakdown and may lose all its data if the centralized database has problems, meaning that there is a possibility for data wipe of the entire medical record systems, which is very risky and possible to happen.

1.3 Motivation

With the ever-growing importance of the healthcare industry, crucial to weather through the pandemic storm, medical records systems can be seen as an essential part of healthcare. However, medical record system technology has been stagnant for many years and has caused numerous issues to hospitals, doctors, nurses, and patients. Blockchain technology and Smart Contracts should be the best solution to resolve this issue and improve the reliability and security of medical record systems.

Not only that but from the problem statement above, we can see that there is much more evidence that states that the current medical record system is not efficient and has many faults. Therefore, for a country to have a successful healthcare system, the EMR system, which is the backbone of healthcare, should be solved and implemented by creating blockchain EMRs.

Hence, if Blockchain and Smart Contracts are implemented successfully in the EMR systems, it will ensure that patients' medical records are secured and safe. This will also encourage patients to share their medical records seamlessly between hospitals and clinics. Finally, the records' auditability and accountability will be further enhanced because on-chain data on the blockchain can be viewed and audited by anyone to ensure no system issues.

1.4 Project Scope

This project aims to develop and build a blockchain medical record web-based application that allows users to keep their medical records securely. The primary outcome of this project is a web-based decentralized application that utilizes Blockchain technology and Smart Contracts to store medical records of patients. This web-based application will use Smart Contracts and Blockchain to secure the EMR and enable healthcare providers and patients to access these secured EMRs. By having this web-based application, users will be regaining their ownership and privacy of their medical records, which are currently owned by medical organizations instead of patients themselves.

Patient Module

- Allow patients to store demographic data such as name, age, gender, address and etc.
- Patients will be able to view a list of patients that have stored their medical records.
- Patients will be able to search for a specific medical record.
- Allow patients to view, edit and update info of their medical record easily.
- The user will be able to store medications and the medication details, which will allow users to keep track and record their medication for doctors' reference.

Doctor Module

- Doctors will be able to view a list of patients that have stored their medical records.
- Doctors will only be allowed to view the detail of a patient's medical record after permitted by the patient.
- Doctor will be able to search for a specific medical record.

Grant and Revoke Access Module

- Patients can grant access to doctors to view the medical records.
- Patient can revoke access given to doctors or patients to view their medical records.

Appointment Module

- Doctors can set an appointment by setting appointment details like date, time, prescription and etc.
- Patients can view their own appointment in their profile.
- Patient or doctor can update the appointment to change its status to completed.

Dashboard Module

- Both doctors and patient can view the month-over-month patient growth which can greatly help the hospital to plan and optimize strategies to gain and retain their patients.
- Both doctors and patient can view the month-over-month appointment growth to find out whether their actual growth numbers are matching with the hospital's monthly growth expectations.
- Both doctor and patient can view number of patient records and doctors that are stored in the blockchain through the system.
- Both doctor and patient can view number of appointments that the doctors created for the patients.
- Both doctor and patient can view number of permissions granted by patients to allow doctors access to their records.
- Both doctor and patient can view an area chart displaying the number of patients vs doctors in the current year.
- Both doctor and patient can view a line chart visualization displaying number of appointments made in the current year.
- Both doctor and patient can view the number of appointments created per patient.

1.5 Project Objectives

To create a blockchain medical record system that greatly improves the delivery of effective healthcare

With blockchain technologies and smart contracts, common problems encountered in traditional medical record systems could be resolved. For example, problems that stem from interoperability issues, like where different hospitals do not have a fully synced updated copy of the patient's medical record, will be a thing of the past. With a blockchain medical record system, patients that store their records on the blockchain can retrieve them anytime and anywhere. This will drastically improve the quality of healthcare they will be getting, as the patient's record will always be up to date, which allows the patient to get proper treatment. Not only that, by allowing patients to store their own medical records through the blockchain medical record system, medical personnel can spend more time and effort on delivering higher quality healthcare services instead of working on inputting patient records manually, which may even result in human error.

To develop a decentralized application that will reduce the risk of privacy breach by allowing users to take complete control of their medical records

The application will ensure that users can register and input their medical records and store or view them anytime they want without their privacy being invaded or information leaked by medical organizations. Users can share their medical records and use them at any hospital or clinic to grant access to the doctor. This is exceptionally beneficial to solve a significant existing issue that all medical organizations are facing. For example, when the patient is a regular customer of Columbia hospital in Johor Bahru, he will have his medical records stored in all other Columbia hospitals throughout Malaysia. If one day the patient is admitted to a different hospital such as government hospitals or any hospitals overseas and this patient is unconscious, need medical treatment immediately, but the hospital's doctors do not know the diseases and allergies the patient has. This issue might cost the patient's life because of the patient's medical records not being brought around. To prevent this issue, patients should be

given control of their medical records and ensure that the records of each patient are stored securely in the blockchain, which is the concept of decentralized application. It will ensure that patients, even when they are unconscious and sent to a hospital, the doctors will turn on the user's phone and view the patients' medical records.

To study the enhancement of user interface and user experience on reducing the time and effort needed to enter or update patient records

Many information technology healthcare applications, such as electronic medical records, have failed because their user interface is challenging to use [12]. It signifies the importance of an excellent user interface to enable ease of use for all the application users, such as doctors and patients. There are four user interface design principles that can be used to create an easy-to-use interface that will drastically improve user experience. Firstly, is to place users in control of the interface. This can be done by making actions reversible, such as undo and back button, which allows users to change or revert if they made any mistakes.

Furthermore, it will ensure users will not feel stressed out when they made a mistake, such as deleting crucial medical record information. Next, the application design should be designed to make it comfortable for users to interact with the system suitable for all users, including those with no background knowledge of technology. Finally, the user interface design should also be consistent through visual consistency and functional consistency. By following the user interface design principles, the design will be a user-friendly and attractive interface in which users will be more likely to use the application and be more willing to use the application for a long time. Furthermore, by ensuring the user interface is easy to understand, users can use the application even without guidance and save the time needed to adapt to the application and its functionalities.

To evaluate the effectiveness of using blockchain technology and smart contracts on improving the security of electronic medical records and preventing a central point of failure

As stated by the [13], the biggest concern of healthcare is the security of the data. Approximately 193 million personal medical records are leaked in 2015 alone and are

still a prevalent issue even until now. This issue can be combated with the help of blockchain technology, where the technology will be used to store the patients' medical records to ensure that the application would not have a central point of failure. The data will also not have a central point of failure because of the nature of blockchains. Blockchains have these few traits, which are decentralized, immutable and transparent. These characteristics make blockchain perfect for solving issues encountered in traditional electronic medical record systems. If left unhandled, these issues will result in up to millions of dollars in losses. Finally, medical records stored in the Ethereum blockchain will be safe from intruders or hackers who want to destroy or disrupt the medical records as blockchains are unbreachable because of the SHA256 algorithm used to encrypt each block in the blockchain.

1.6 Impacts, Significance and Contribution

The decentralized EMR system can provide users with an efficient and effective way of storing and accessing medical records. Healthcare providers in Malaysia can use this application to improve healthcare services by ensuring the patients' medical records are up to date and synchronized even when used in a different medical organization that prescribes the medications or disease. The significance of this application is that it will return the medical records to their rightful owner as users will then be able to view their medications, medical records history easily without having to visit the hospital for their records. The proposed features and solution to improve electronic medical records using blockchain technology used in this application can help users store medical records more securely and efficiently. With the use of blockchain technology, medical organizations in Malaysia and worldwide can solve the issues as mentioned in the problem statements and improve the quality of healthcare provided in general. With accurate health records of patients, the doctors can efficiently treat the patient based on the symptoms and allergies the patient has through the viewing of the patient's medical records. Not only that, but the Smart contract will help facilitate the hospital appointments between doctor and patient. This will greatly improve the efficiency and transparency of the appointment process of hospitals.

1.6 Report Organization

This report is organized into 6 chapters: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 System Design, Chapter 4 System Implementation and Testing, Chapter 5 System Implementation, Chapter 6 System Evaluation and Discussion, Chapter 7 Conclusion and Recommendation. The first chapter is the introduction of this project which includes framing the problem, explaining the background and motivation of this project, the scope of the project, project objectives that this project aims to achieve, project contribution and report organization. The second chapter is the literature review, exploring multiple traditional medical record systems and also blockchain medical record systems and discuss the strengths and weaknesses of each system in detail. In the third chapter, the overall system design of this project is discussed. The fourth chapter is regarding the details on how to implement the design of the system expressed through diagrams. Next, the fifth chapter details the system implementation and explain in detail about the coding process. The sixth chapter covers system evaluation and discussion. The final chapter covers the conclusion and discusses on the novelties and contributions and recommends how to proceed for future work.

Chapter 2: Literature Review

2.1 Review of Technologies

Type	Name	Description
Blockchain	Rinkeby Network	Test network of Ethereum which simulates the real Ethereum network
Cryptocurrency Wallet	Metamask	To enable the payment of gas fees when storing data in the Ethereum or Rinkeby blockchain
IDE	Remix IDE	Used for initial development and testing of Smart Contract
	Visual Studio Code	Used to code the rest of the blockchain web application from front end to back end
Ethereum API	Infura	To connect the blockchain web application to the web browser seamlessly and easily

Table 2.1: General Technologies

Type	Name	Description
Programming Languages	Solidity	To code the entire Smart Contract
	Javascript	To code the entire front end and back end of the blockchain web application
Front End Framework	React	To create the interaction between the front end and the smart contract of the application
	SemanticUI	To easily create and design the front end
Test Framework	Ganache	Test network that can be used to store the smart contracts and the smart contracts can be interacted through the Windows Terminal
	Mocha	To write tests and test each smart contract functionality to ensure it is working as intended
Other Technologies	Web3	To enable interaction between Metamask with the Smart Contract that has been deployed to the Rinkeby network
	Node.js	To run the application on a localhost web server and allow the use of npm install to install other packages for development.
	Next.js	To handle the front-end of the application and allow navigation from one page to another
	Recharts	Allows the building of interactive charts and visualizations using reusable React components.

Table 2.2: Specific Technologies

2.2 Review of Existing Systems

2.2.1 75Health Web-Based Medical Record System

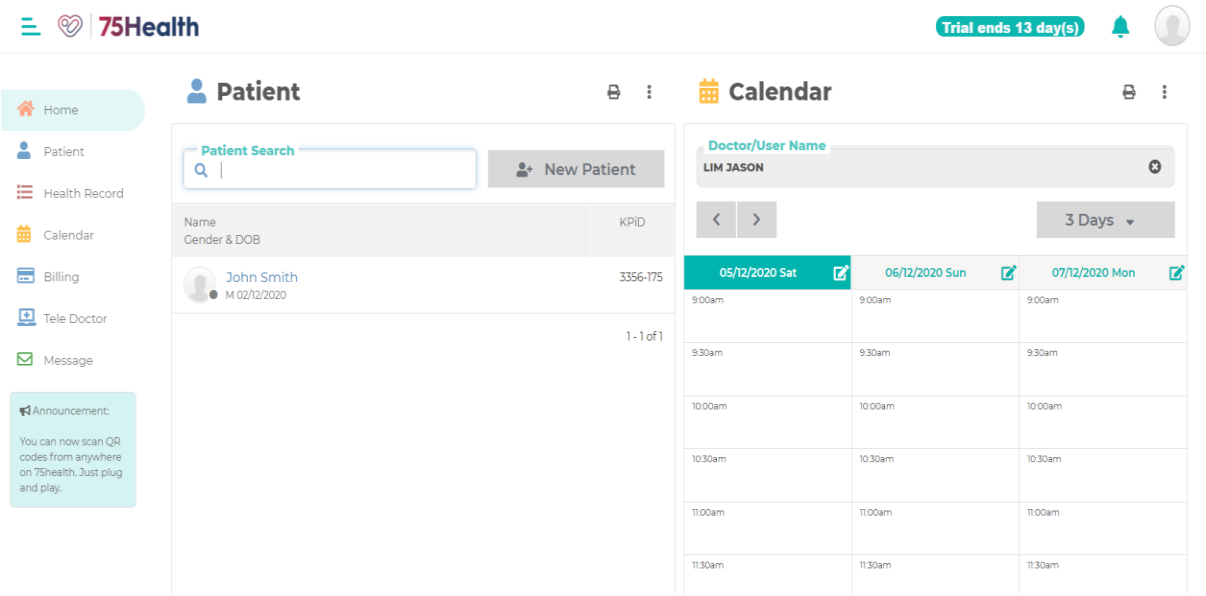


Figure 2.1: Homepage

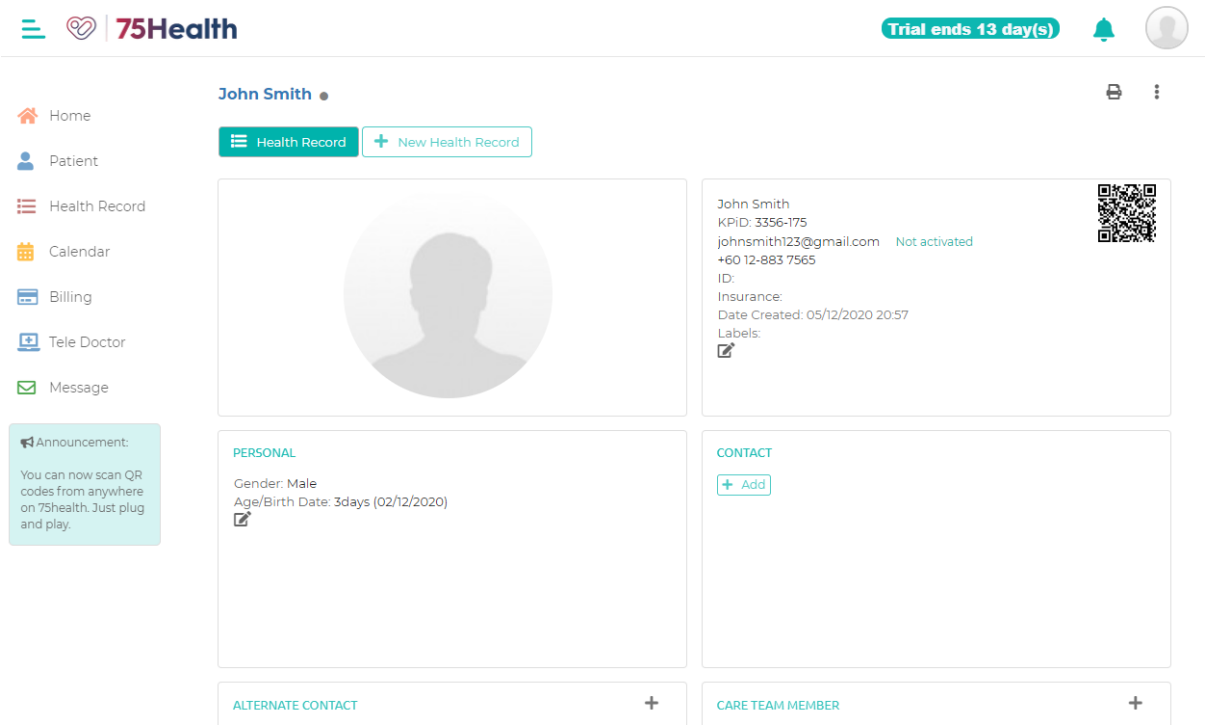


Figure 2.2: Individual Patients Detail Page

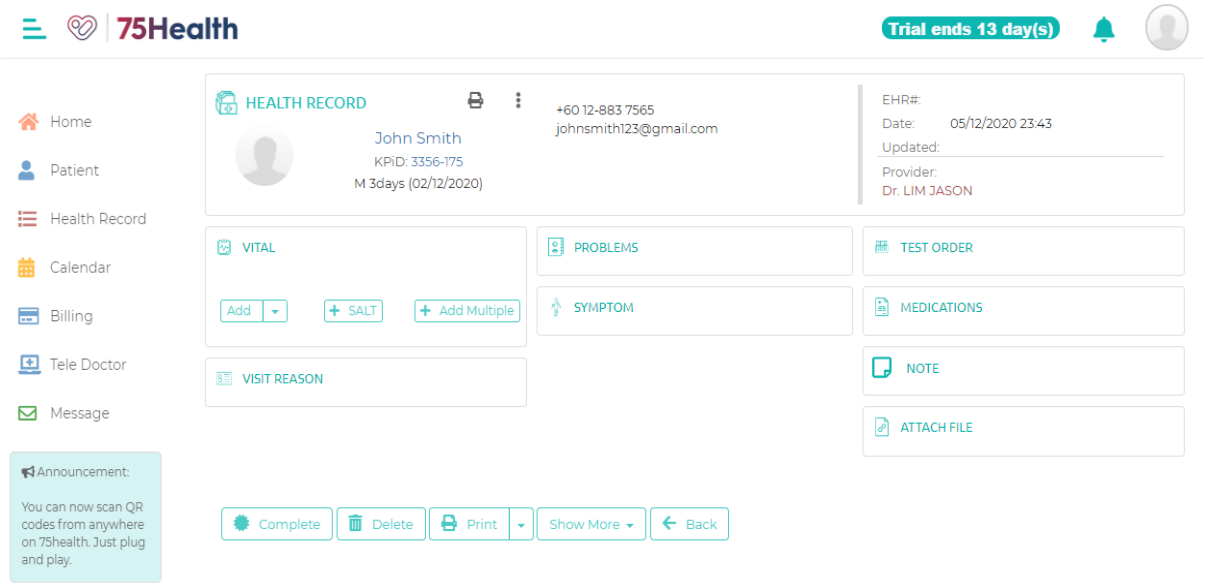


Figure 2.3: Individual Health Records page of patient

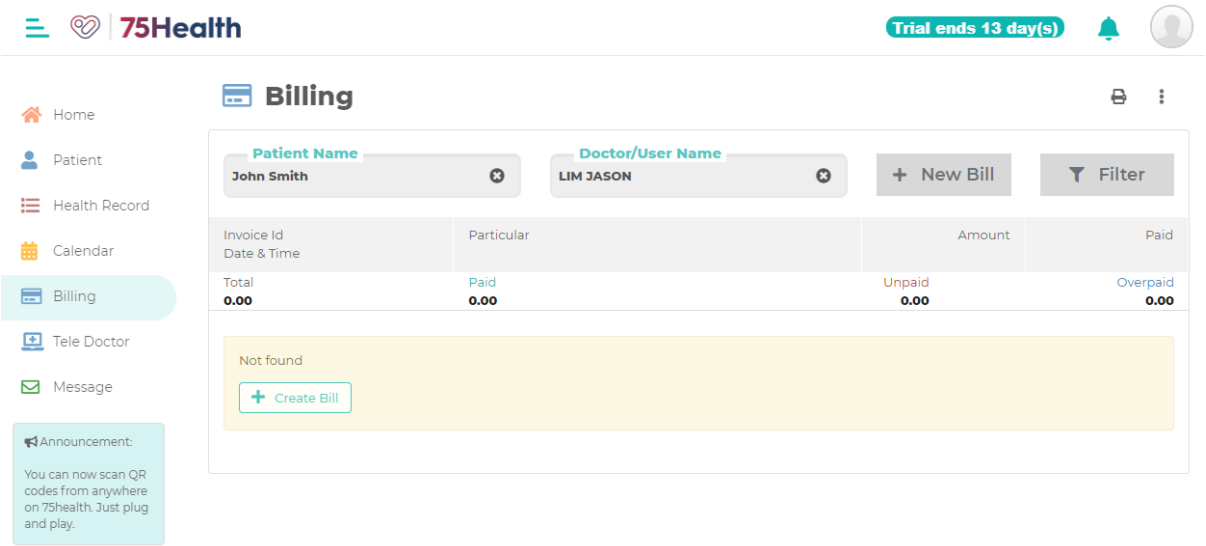


Figure 2.4: Billing page

75Health is a paid medical record system which not only aims to be paperless but also to improve the entire health record data storing process. It is about implementing an intelligent but user-friendly system that assist doctors to ensure they can work efficiently and also improve healthcare service quality. By utilizing cloud-based technology, this system provides a vast array of benefits such as, cost-efficient, fast, and secure. Listed below are the features and also the strengths and weaknesses of the system.

Basic features:

1. Store patient's demographic data such as name, IC, email, phone number and other info.
2. Store health records of patient's data such as medications, problems, symptoms and also file attachment feature are available which allows the doctor to add images of x-ray scans
3. The list of patients in an ordered list arranged in alphabetical order can be seen in figure 2.1.

Special features:

1. As shown in figure 2.3, The health record page allows doctors to input and store user's health records and can generate and print a neat, standardized report that can be used in all hospitals.
2. As shown in figure 2.1, the calendar function allows the doctor to set and schedule patient appointments by setting a time and date, patient name, and description. This feature will allow doctors to create a proper schedule of patients' check-up schedules without clashing between check-up times.
3. As shown in figure 2.4, The Billing feature enables the doctor to enter patients' payment records, including service tax and discount.
4. Tele Doctor service is a new feature that allows doctors to have online calls with patients to ensure that users do not have to go all the way to the hospital to speak to the doctor on any health-related issues.
5. Messages to patients can be sent and stored through the messaging function and receive replies from patients.
6. Supports multiple platforms, including Windows and macOS. In addition, mobile platforms such as Android and IOS are also supported.

Strengths:

1. Somewhat intuitive and attractive user interface that achieves all the user interface design principles to ensure the best experience for the users.
2. Provide tutorial videos on using the system that guides the doctors using the system for the first time.
3. Many valuable functionalities and features such as storing in depth health records of patients and generating and printing reports for each patient, storing detailed billing records of patients, etc.
4. Able to message patients directly and receive their messages through the system, which saves time on having to use an external messaging app or email to contact patients
5. Data can be exported to other EHR/EMR software, which will ensure the standardization and portability of the medical records can be achieved
6. A centralized application that uses cloud-based technology will ensure that there is no central point of failure as cloud-based storage of information is much more stable and secure as data are stored on multiple servers in different world regions. This will prevent the database from being wiped out due to system failures.

Weaknesses:

1. Only authorized medical personnel such as doctors, nurses, physicians and clerks can access the medical records, which means that patients will not be able to view their own medical records at any time unless they requested from medical personnel and are sent a copy of the records through the messaging feature.
2. Setup and first-time usage are a little complicated due to the vast number of functionalities, and users will have to take some time to explore and get used to what this application has to offer.
3. Security might be an issue because by having the email or ID of the doctor and password, a hacker can alter and delete the data of all the patients, which is a very dangerous problem as hackers nowadays can easily retrieve the email and password of an individual through phishing attacks.

2.2.2 OneTouch Web-Based EMR

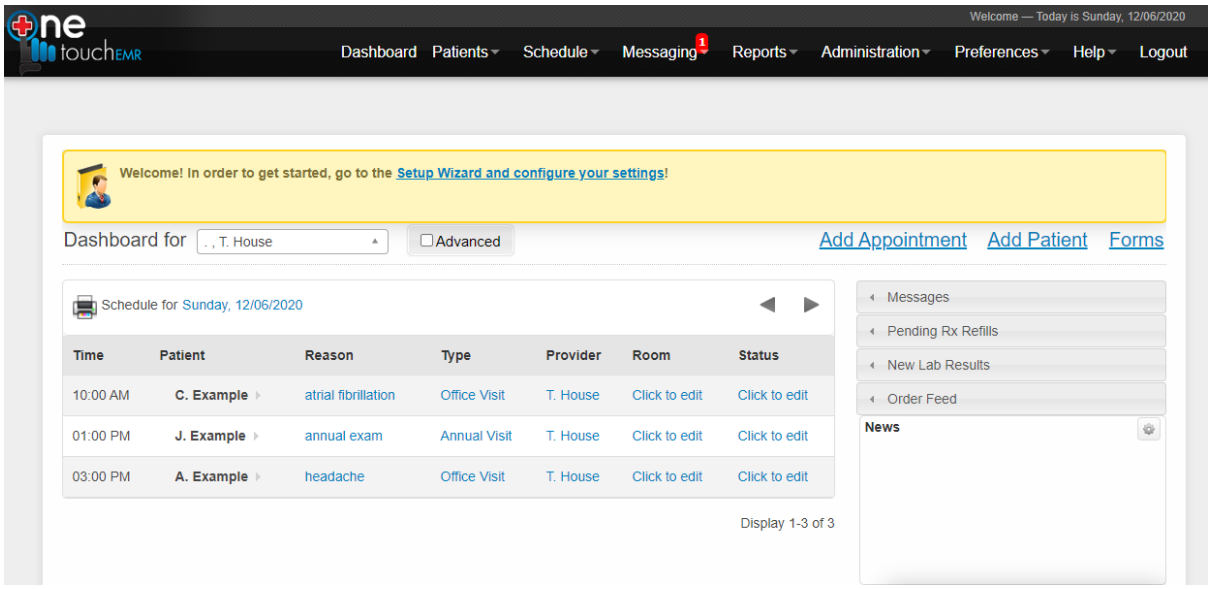


Figure 2.5: Dashboard page

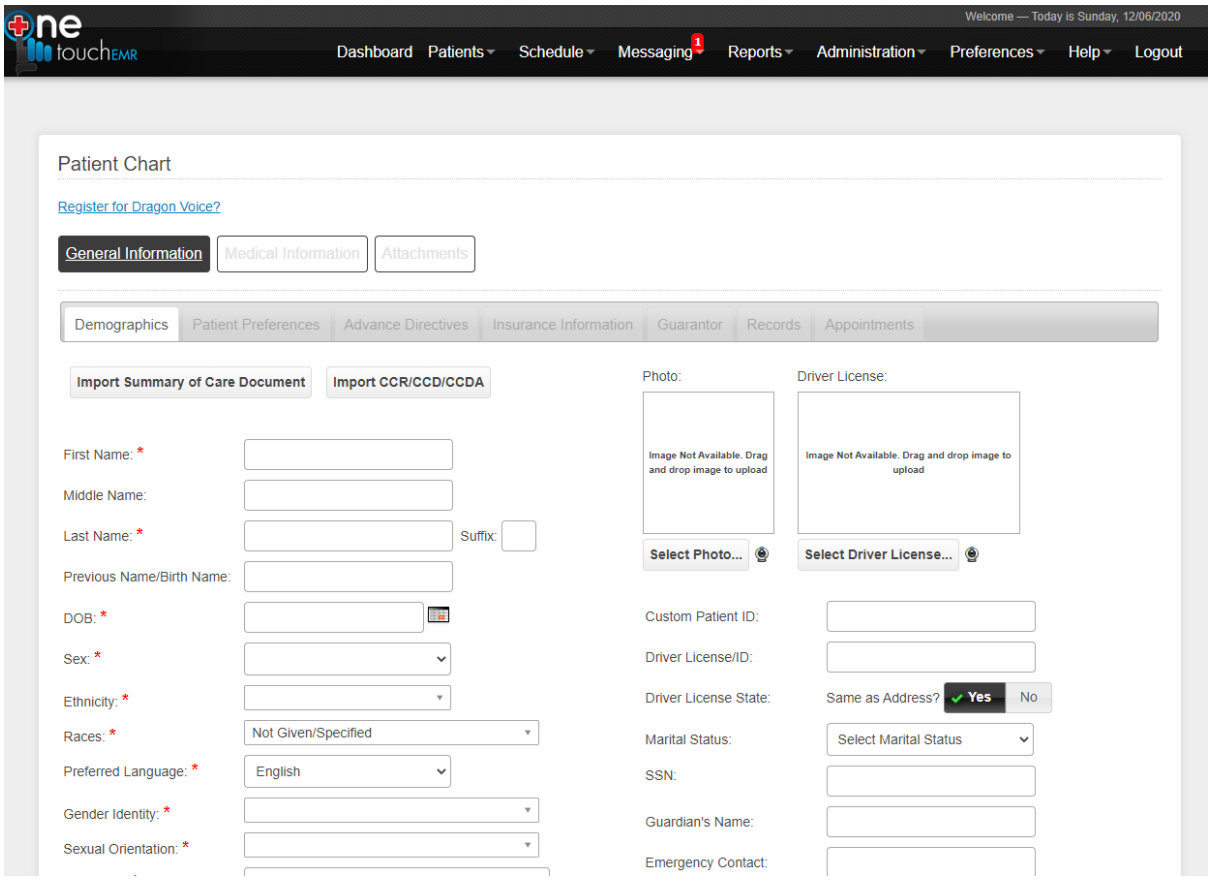


Figure 2.6: Add Patient Details page

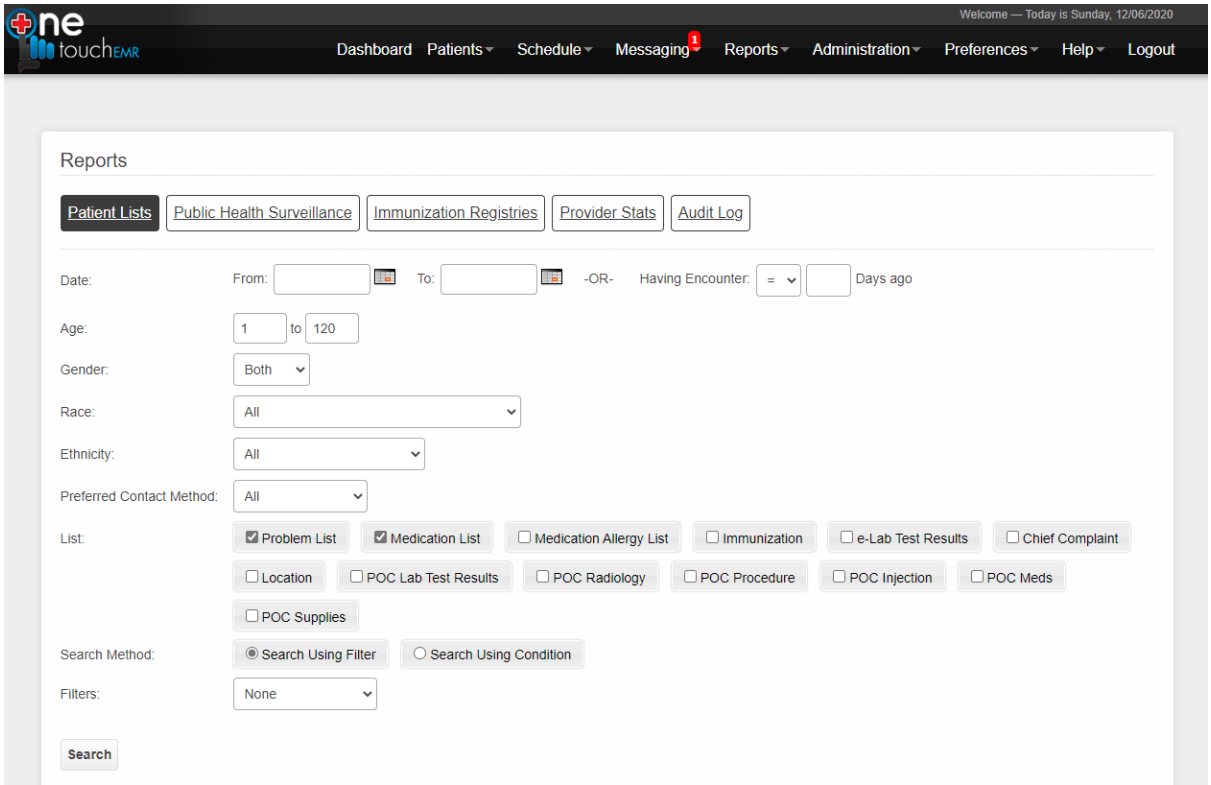


Figure 2.7: Search Medical Reports page

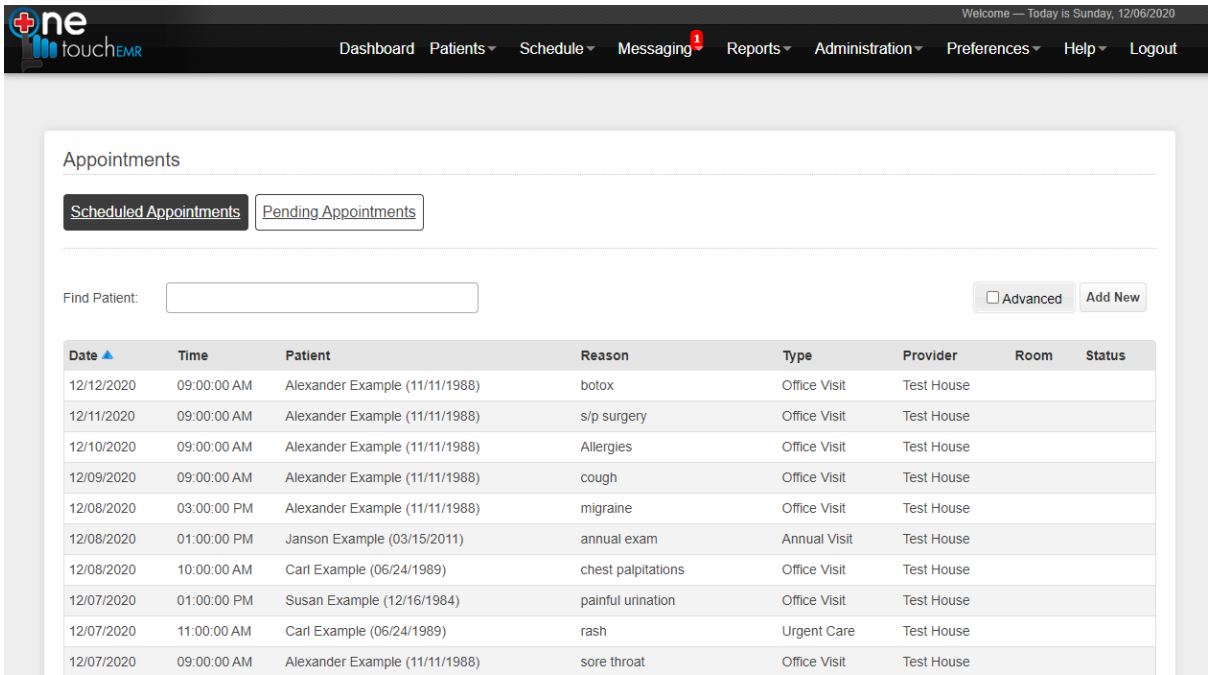


Figure 2.8: Schedule Appointments Page

OneTouch EMR is an open-source medical record system that works rapidly and efficiently. Users can adapt the application to meet the demands of the facility. This application contains a plethora of capabilities that may be used to support a full hospital's operations. Furthermore, with a monthly membership plan, clinicians can use this tool for hospital use.

Basic features:

1. Store detailed patients' demographic data such as name, IC, email, phone number and other relevant data, shown in figure 2.6.
2. Store health records of patient's data such as medications taken, symptoms and also file attachment feature are available which allows doctor to add images of x-ray scans
3. The list of patients in an ordered list arranged in alphabetical order can be seen in figure 2.5.

Special features:

1. Has calendar function that allows the doctor to set and schedule patient appointments. This feature will allow doctors to create a proper schedule of patients' check-up schedules without clashing between check-up times.
2. System Administration functions available where a setup wizard and a video tutorial is available to guide the user on how to set up the system
3. Able to message patients directly and receive their messages through the system, and it will show the priority of the messages received
4. Able to set Appointment reminders for the scheduled appointments to remind doctors of any appointments made with patients, as shown in figure 2.8.
5. Record and view the stocks available for each medication and store the medication orders through the orders page.
6. Supports multiple platforms, including Windows and macOS. In addition, mobile platforms such as Android and IOS are also supported.

Strengths:

1. Provide an in-depth tutorial video and setup wizard, which will guide users on using the system and help the users adapt and understand the system quickly.
2. Has stock checking feature to allow medical organizations to record and store the number of stocks they have for each medication and quickly determine whether they need to restock or not.
3. Stores extremely detailed patient's details such as patient demographics, preferences, insurance information, guarantor, records, and appointments which will ensure the medical organization can provide efficient healthcare services to the patients
4. Able to message patients directly and receive their messages through the system, which saves time on having to use an external messaging app or email to contact patients

Weaknesses:

1. Not intuitive user interface design, which does not satisfy the user interface design principles.
2. Unattractive and dull user interface design due to the overload of words on certain pages, more graphics or images can be used to improve this as an image speaks a thousand words, even a graphic image can allow the user to understand better than reading lengthy text.
3. Only authorized medical personnel such as doctors, nurses, physicians, and clerks can access the medical records, which means that patients won't be able to view their own medical records unless they requested from medical personnel and are sent a copy of the records through the messaging feature.
4. Setup and first-time usage are pretty complicated as the pages are inconsistent, which does not follow the user interface design principles. This will cause the doctor to take a lot of time to enter the records of patients or get any work done.
5. Security could be a concern because by having the email or ID of the doctor and password, a hacker can alter and delete the data of all the patients.
6. A centralized system might cause data wipe if the database is down, which will cause the patients' data and all the organizations' records to be destroyed.

2.2.3 My Health Record

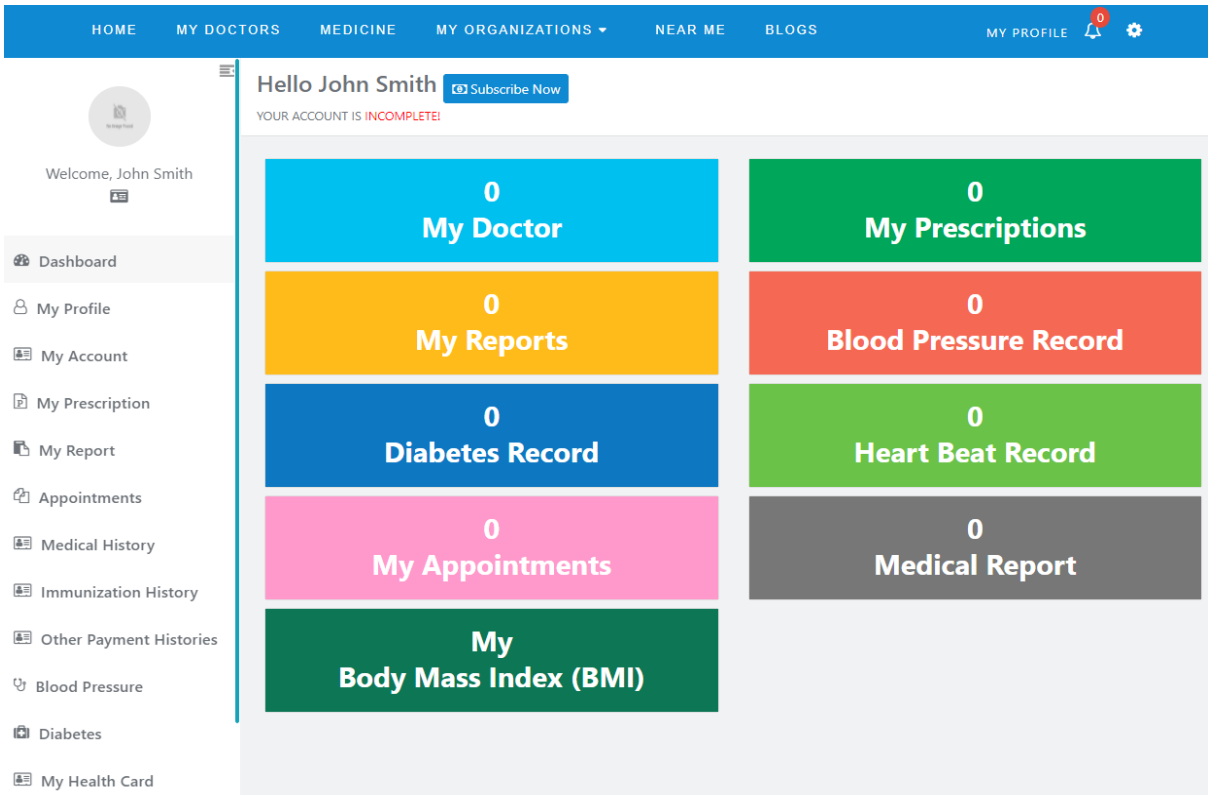


Figure 2.9: Dashboard

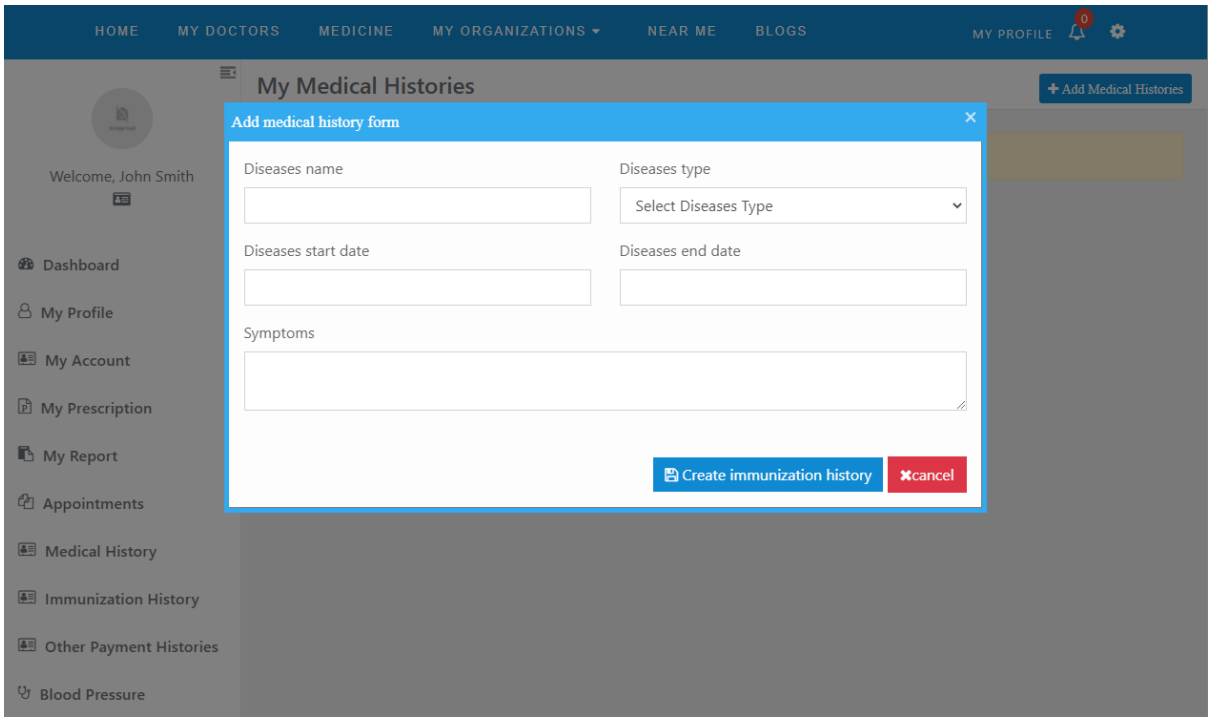


Figure 2.10: Add Medical History

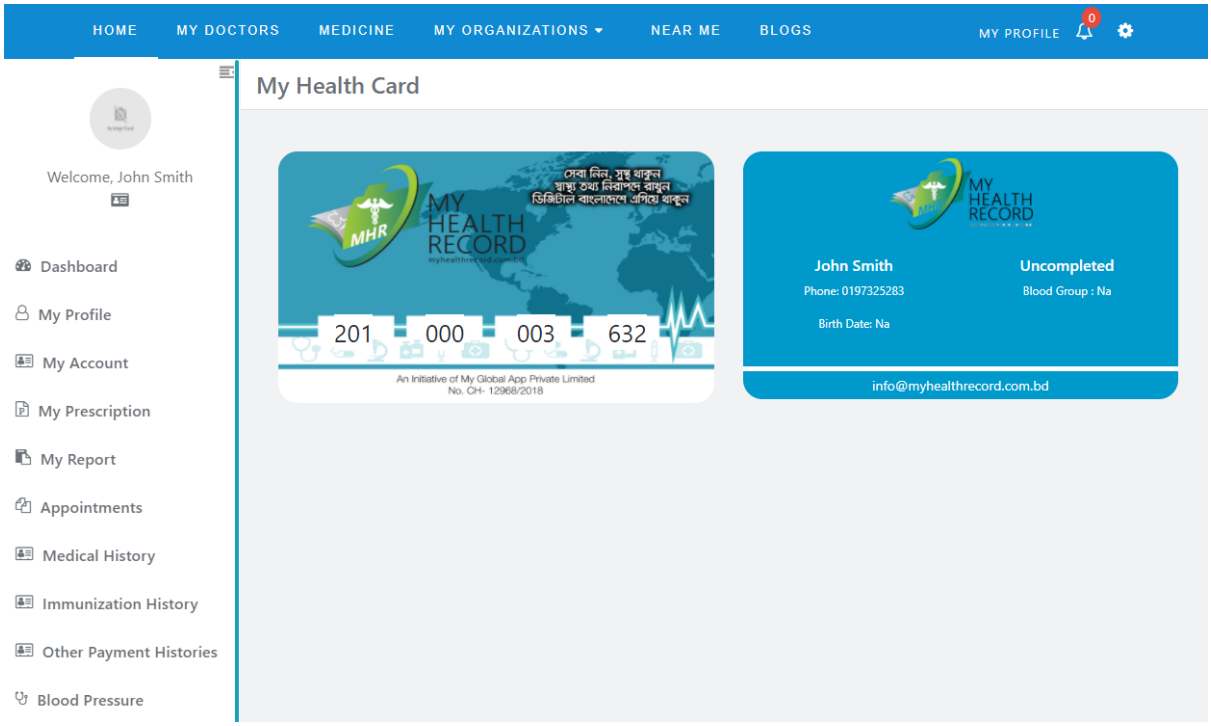
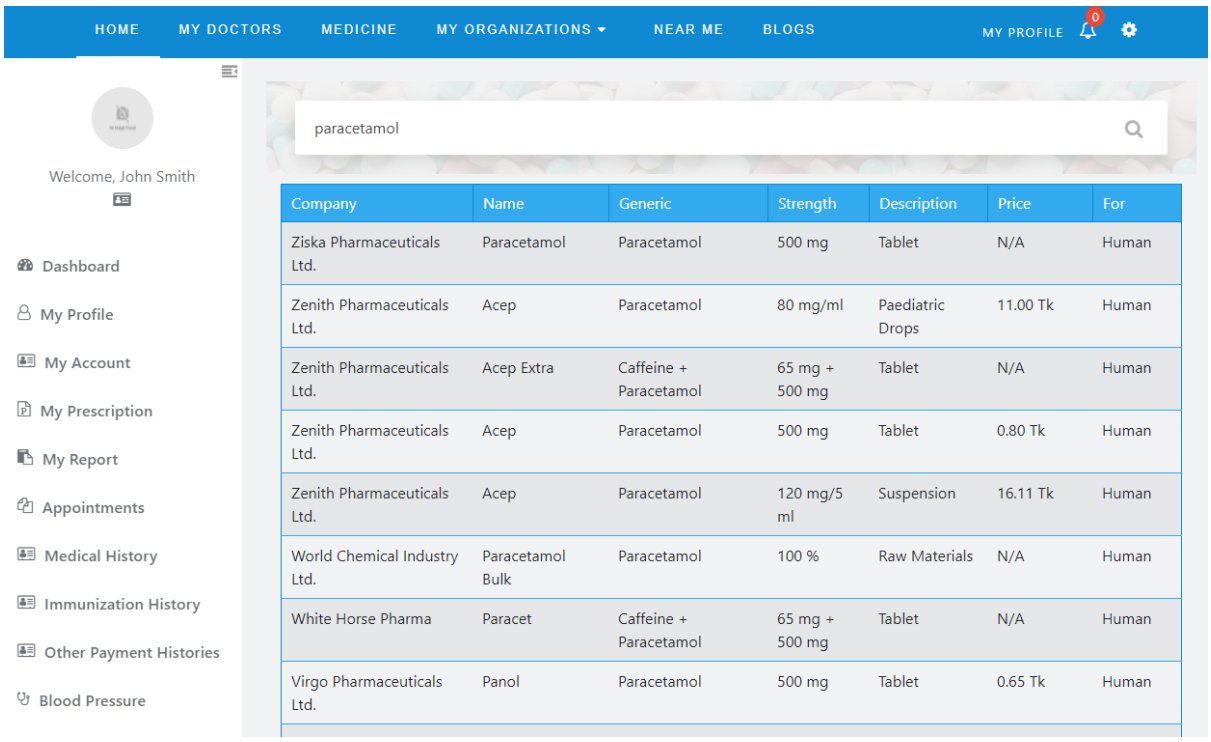


Figure 2.11: View Health Card



Company	Name	Generic	Strength	Description	Price	For
Ziska Pharmaceuticals Ltd.	Paracetamol	Paracetamol	500 mg	Tablet	N/A	Human
Zenith Pharmaceuticals Ltd.	Acep	Paracetamol	80 mg/ml	Paediatric Drops	11.00 Tk	Human
Zenith Pharmaceuticals Ltd.	Acep Extra	Caffeine + Paracetamol	65 mg + 500 mg	Tablet	N/A	Human
Zenith Pharmaceuticals Ltd.	Acep	Paracetamol	500 mg	Tablet	0.80 Tk	Human
Zenith Pharmaceuticals Ltd.	Acep	Paracetamol	120 mg/5 ml	Suspension	16.11 Tk	Human
World Chemical Industry Ltd.	Paracetamol Bulk	Paracetamol	100 %	Raw Materials	N/A	Human
White Horse Pharma	Paracet	Caffeine + Paracetamol	65 mg + 500 mg	Tablet	N/A	Human
Virgo Pharmaceuticals Ltd.	Panol	Paracetamol	500 mg	Tablet	0.65 Tk	Human

Figure 2.12: Medication Search

My Health Record BD has a web-based application that can be accessed through any web browser and a mobile application that can be downloaded through Android Play Store. This application provides an online platform to store and retrieve medical records with just one click. Not only storing and retrieving medical records, but the application also gives reminders on medicine timing to ensure users will be on time with their medication consumption.

Basic features:

1. Store detailed patients' demographic data such as name, IC, email, phone number and other relevant data.
2. Allows the user to store basic medical history and prescription of medications and allow users to check back on their records and generate a report and print out a physical copy.

Special features:

1. The health record page allows doctors to input and store user's health records and generate and print a neat, standardized report that can be used in all hospitals.
2. Allow users to search for any types of medicine that exist and generate the details of the medication found in an organized table form for the user to view and get the details quickly.
3. It has a built-in BMI calculator to allow users to calculate their BMI accurately to determine whether or not they have a healthy BMI.
4. Billing page where users can store the payment history and check on the payment history anytime to verify any payment they have made recently.
5. Can have online consultations with doctors through this application, which allows doctors to have online calls with patients to ensure that users do not have to go to the hospital to speak to the doctor on any health-related issues.
6. As shown in figure 2.11, users can view their medical card, which is automatically generated when users fill in their details. This card can be used in all hospitals to prove that their health records are legit and stored in a legitimate medical records system.
7. This application has multiple platform support on Windows, macOS, and even mobile platforms such as Android and IOS.

Strengths:

1. Quite Intuitive and straightforward user interface design which follows and achieves the user interface design principles
2. Able to set appointment reminders that will ring to remind users on medicine timing to ensure users will be on time with their medicine consumption and prevent users from forgetting to consume their medication which is a common problem with patients.

Weaknesses:

1. The absence of tutorial videos for first-time users might cause problems to users, such as not understanding how to use the application and having a hard time understanding and adapting to the application.
2. A centralized system might cause data wipe if the database is down, which will cause the patients' data and all the organizations' records to be destroyed.
3. It does not store very detailed medical history of patients, which defeats the main purpose of this application: to store detailed medical records of patients used in all hospitals.
4. Certain functions are only allowed in Bangladesh, such as the Near Me function that can be used to display hospitals near the user's current location, which can be seen in the navbar of figure 2.9.
5. Hospital Fees discount only applicable for certain hospitals in Bangladesh as this application is designed and targeted to help the citizens of Bangladesh.

2.2.4 MRT Medical Records Tracker

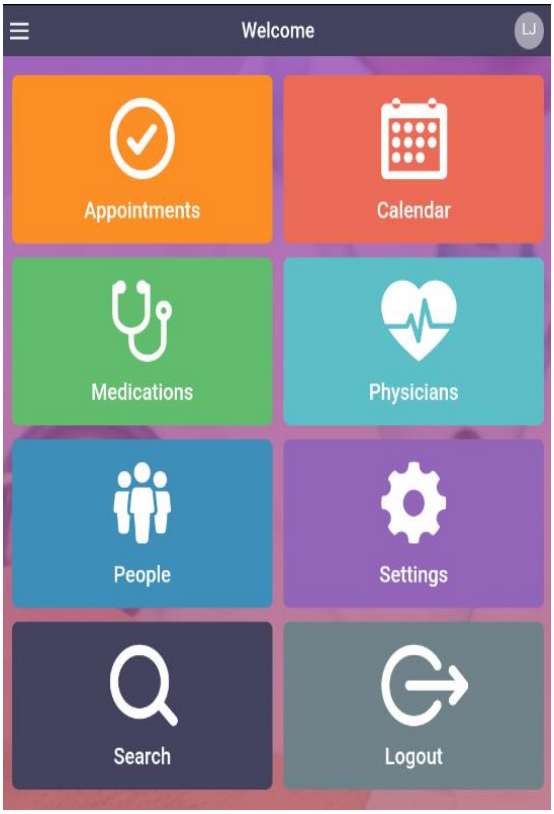


Figure 2.13: Main Menu

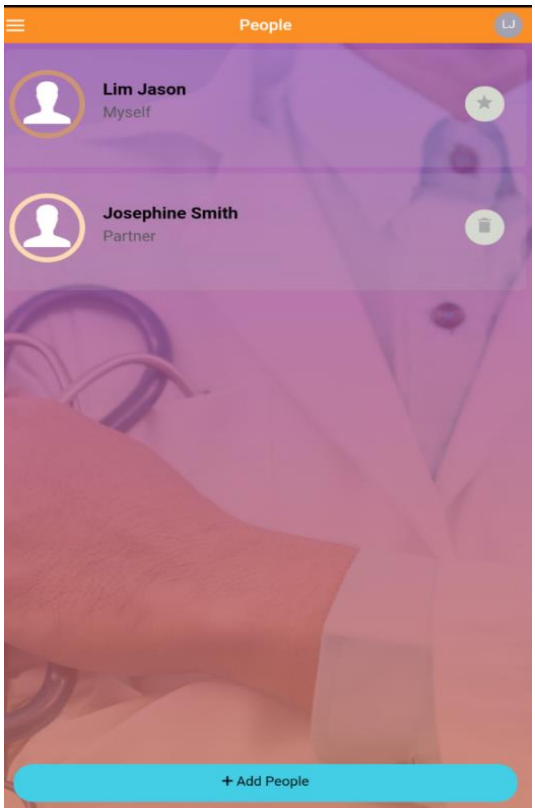


Figure 2.14: Add Family members

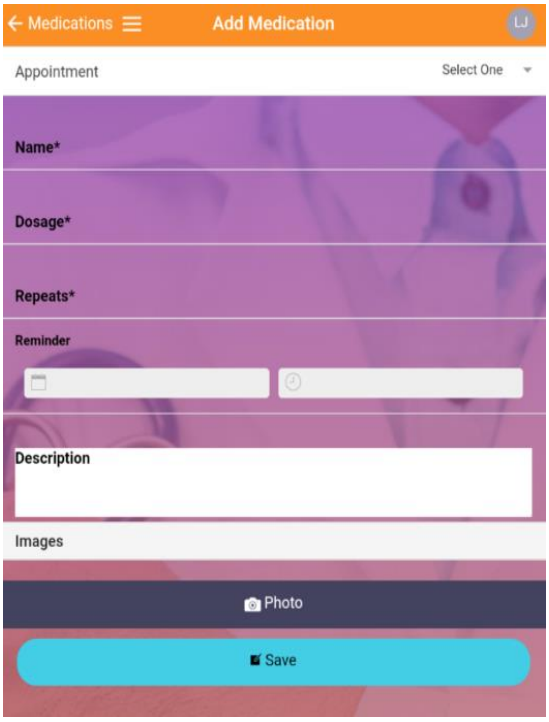


Figure 2.15: Add Medications

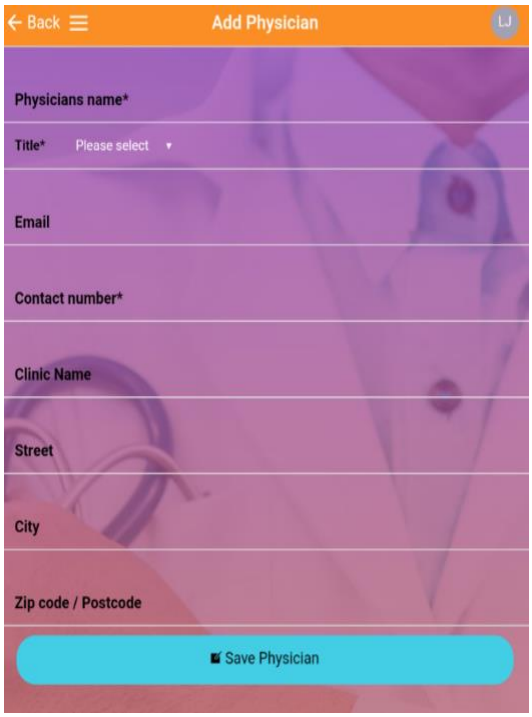


Figure 2.16: Add Physicians

Medical Records Tracker is a free medical records application that enables the user to securely store and organize health records, medication schedules, and medical appointments. This medication tracker application helps ensures the user stays on top of prescriptions, referrals, medical history, blood types, allergies, medications, previous or existing medical conditions, scans, doctor's office addresses, etc.

Basic features:

1. Store detailed patients' demographic data such as name, IC, email, phone number and other relevant data.
2. As shown in figure 2.15, users are allowed to store medication details such as medication name, dosage, repeats, reminders, and description.
3. As shown in figure 2.16, users can add physicians or doctor's information consisting of the physician's name, title, email, contact number, etc. This function is vital because if emergency help is needed from the doctor or physician, the contact can be found through this page.

Special features:

1. Able to set appointment reminders that will ring to remind users on medicine timing to ensure users will be on time with their medication consumption and never forget to consume their medication.
2. Can set reminders to remind the user on medical check-up dates to make sure the user does not forget about their appointment with their doctor.
3. As shown in figure 2.14, users can store and manage entire family medical records through the application, which will ensure that all family members' health records and details can be easily accessed.
4. Add custom notes and attachments of documents such as images of the medication package to keep a clean record of the medication details.
5. The search function is to search for medication details that can be accessed through the main menu, as shown in figure 2.13.
6. Can store medical records locally and securely where users are allowed to use the mobile application even without internet connection and will be able to store the records.

Strengths:

1. Has search function to easily search for stored data, as can be seen in figure 2.13. This search function can allow for quick retrieval of data when family members data are stored and when the user wants to look for a specific medication from the list.
2. Able to store and manage entire family medical records through the application makes for a good medical records application for prominent families. The parents can help store their children's medical records and easily present this record to clinics or hospitals to get medicine, etc.

Weaknesses:

1. Bad colour selection and unattractive user interface might cause eye strain for users over long periods as the colours of the fonts, buttons, and background do not contrast well.
2. Not intuitive user interface design due to the application not following the UI design principles of consistency as shown in figure 2.15 and figure 2.16, where the save buttons of the pages are different. This should not be the case as consistency will help the user adapt quickly and not get confused.
3. Lack of the feature allows users to store the disease history of patients, which is essential if users want to keep track of the recovery period of certain diseases and check for symptoms for any other diseases.
4. It does not have a web-based application as this application only supports mobile platforms.
5. It is not a decentralized application, which means that there is a chance that hackers can access user's information can alter or use the information for ill purposes.

2.2.5 Multi-Profile Medical Records

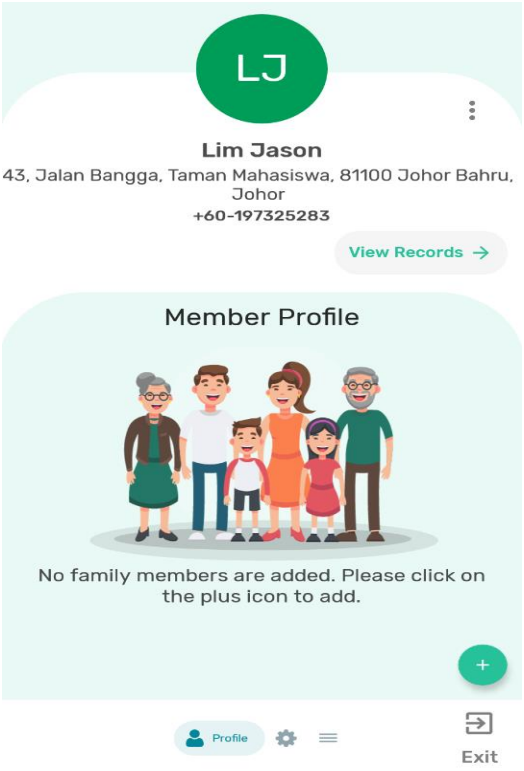


Figure 2.17: Main Menu

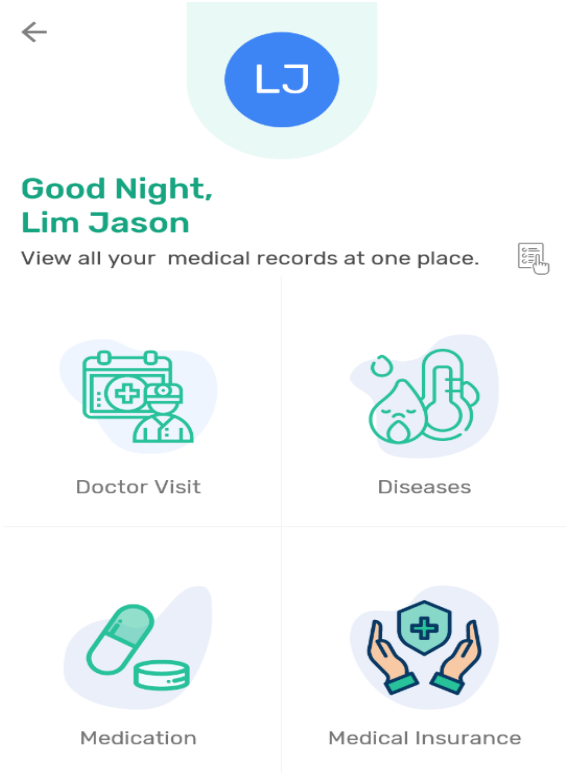


Figure 2.18: Personal Records

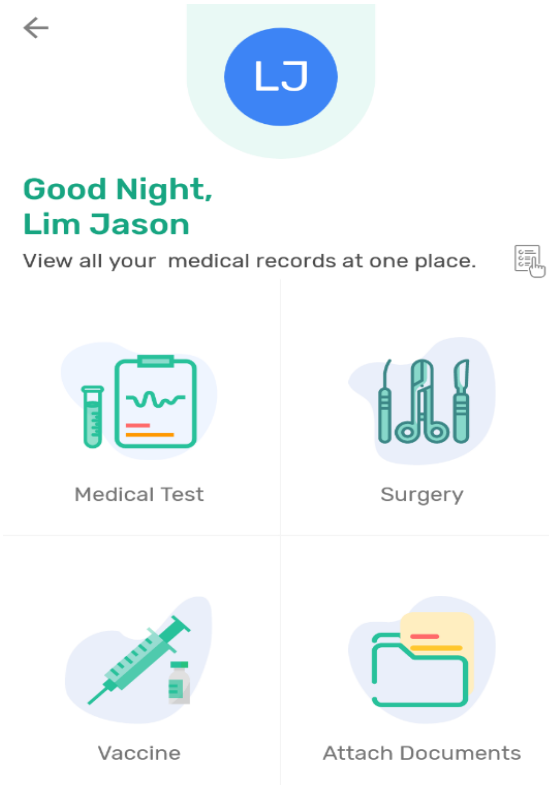


Figure 2.19: Personal Records

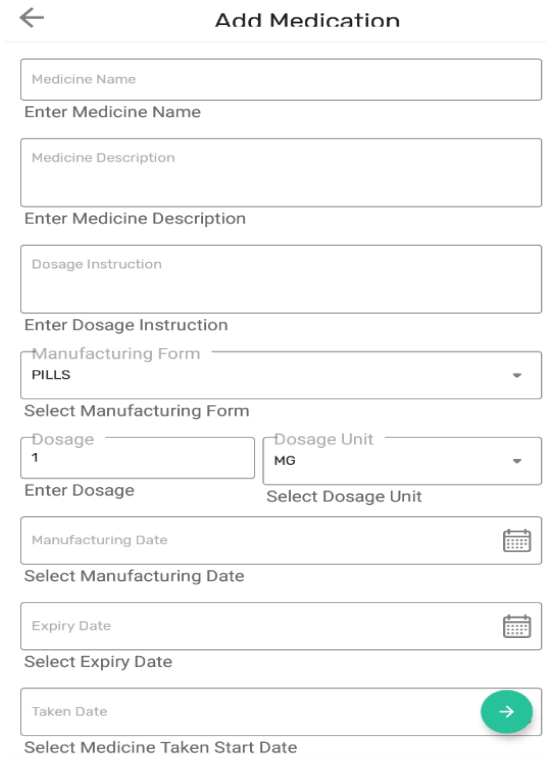


Figure 2.20: Add Medication

Multi-profile medical records are an innovative and practical application for managing and storing the health data of the entire family. With this application, one can easily save medical records and history, and the health status of the entire family and view all of the medical records easily through the application.

Basic features:

1. Store detailed patients' demographic data such as name, IC, email, phone number and other relevant data. This data will then be displayed on the main menu after users fill up their basic information, as shown in figure 2.17.
2. Store user's disease history can then later be viewed by doctors to know a brief history of diseases the patient so that the doctor can provide better and more effective healthcare to the user.
3. As shown in figure 2.20, users are allowed to store medication they are currently taking, which helps the user keep track of the medication amount and the expiry date to ensure they will not consume medication that passes the expiry date.

Special features:

1. Has security mechanisms such as application lock, which will lock the application if the user is idle for more than 2 minutes. The other security mechanism is security questions in which users can choose the question and set an answer. These will help ensure that malicious users will not access the user's account and is much safer than the traditional email and password on most medical record systems.
2. As shown in figure 2.17, users can store and manage entire family medical records through the application, which will ensure that all family members' health records and details can be easily accessed.
3. Can attach medical records in images or documents to ensure that old paper-based medical records can be stored by snapping a picture and storing it without wasting time and retype everything.
4. Able to generate a report in pdf format of any medical record user selects and can be presented to any medical organizations to get treatment directly without having the hospital clerk to fumble and search upon hundreds of paper-based records or electronic records in the hospital system.

Strengths:

1. It is a very intuitive and attractive user interface design that achieves all the user interface design principles to ensure the users' best experience and allow users to navigate through the system and complete their tasks efficiently.
2. As shown in figure 2.17, users can store and manage entire family medical records to organize entire family records straightforward.
3. Security will not be a problem as this is a decentralized application built on the STEEM blockchain with all the characteristics that all decentralized applications would have, such as transparency, security, and immutable.
4. It is a decentralized application which means that users data will not be accessible by a central organization, so privacy breaches will not be an issue.

Weaknesses:

1. It does not provide video guidance for first-time users that will cause users to have to test out the application themselves, which might waste time.
2. It is only supported on mobile platforms as it does not have a web-based application as it is only downloadable through Google Play Store and IOS App Store.

2.2.6 Decentralized Medical Records

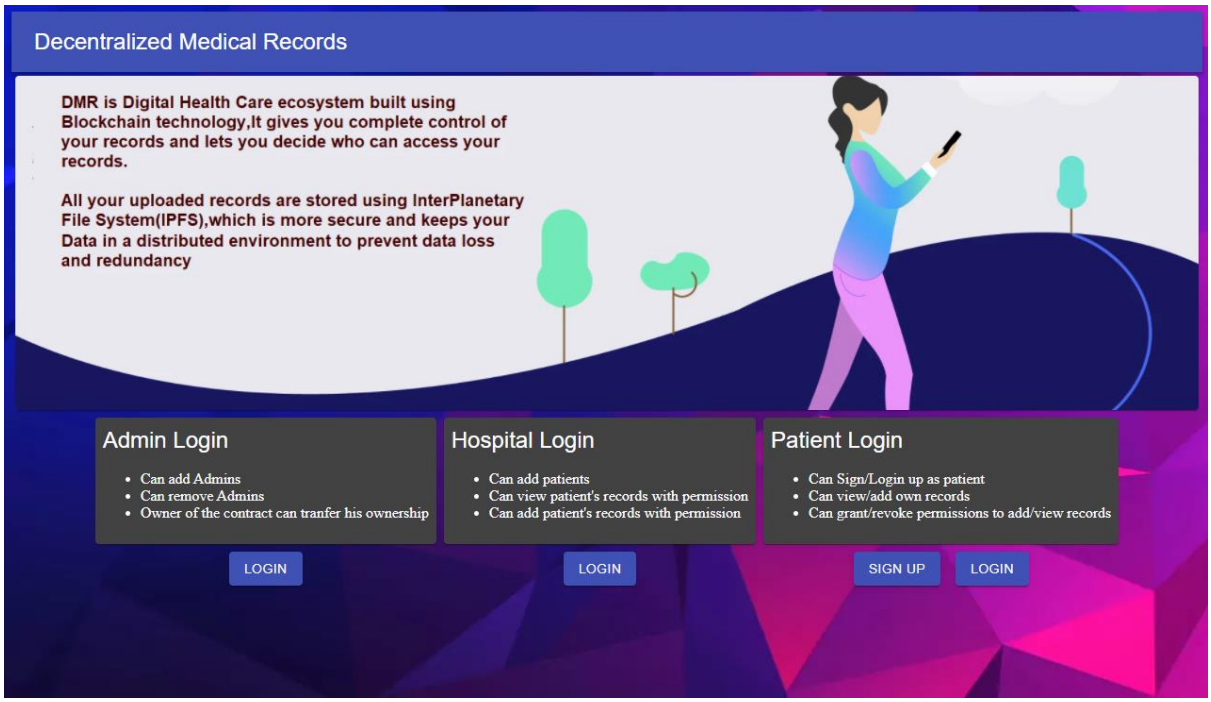


Figure 2.21: Menu Interface

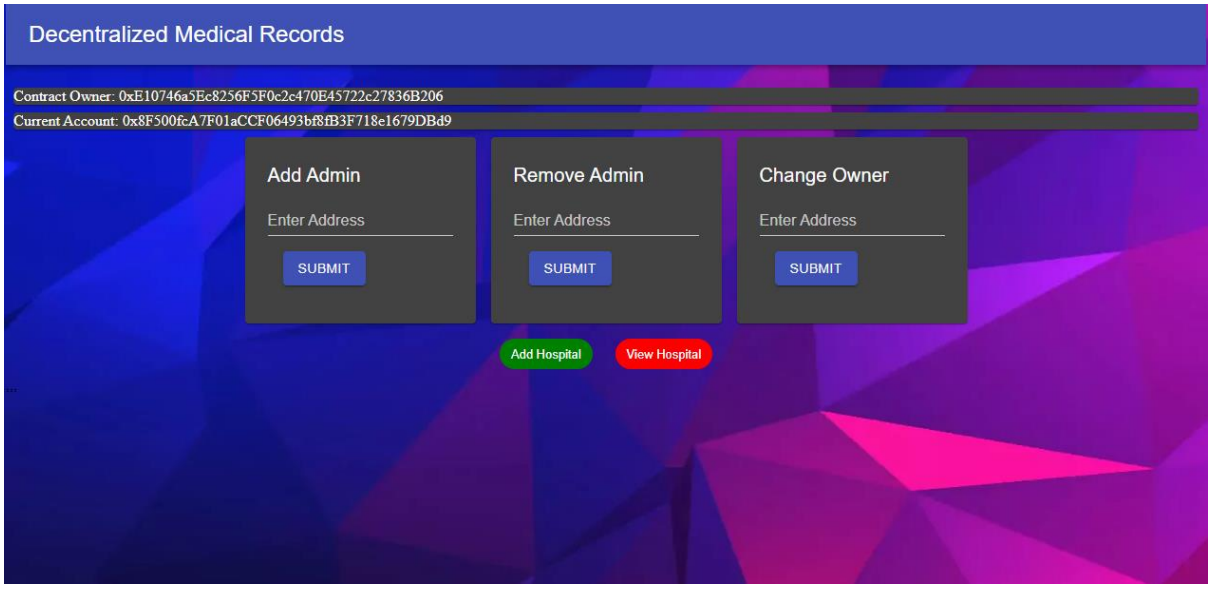


Figure 2.22: Admin Module

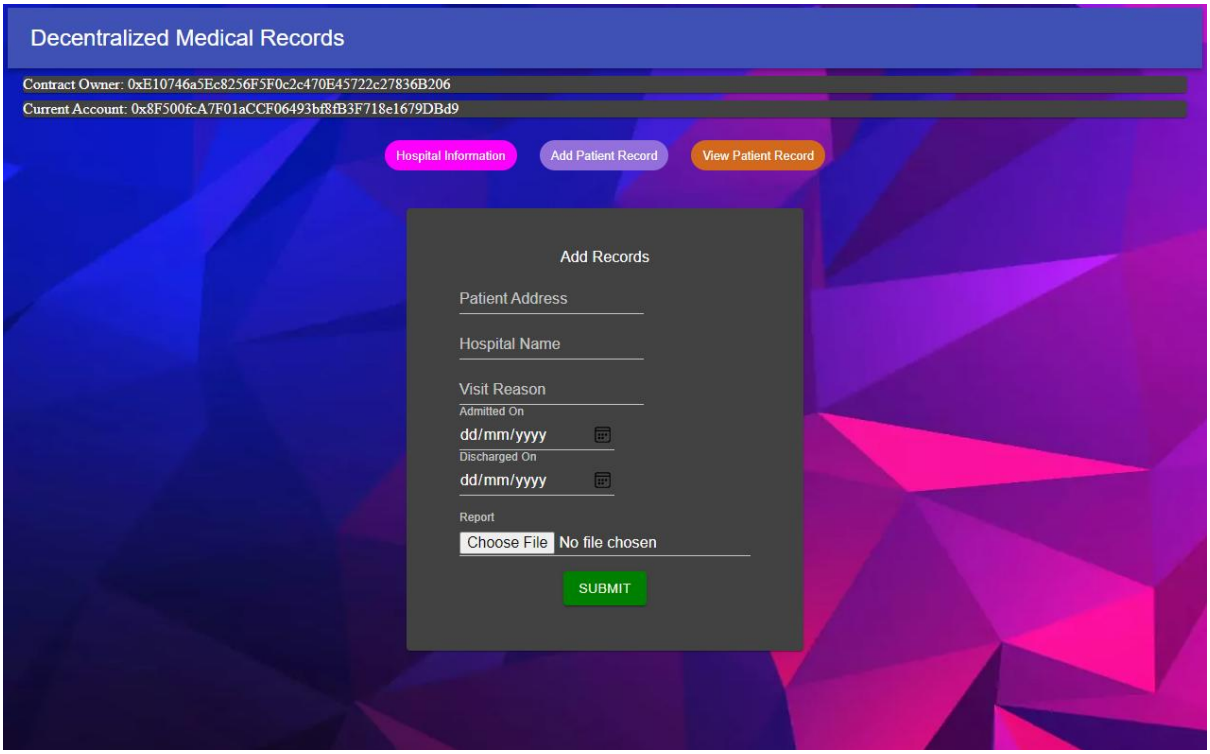


Figure 2.23: Hospital Module

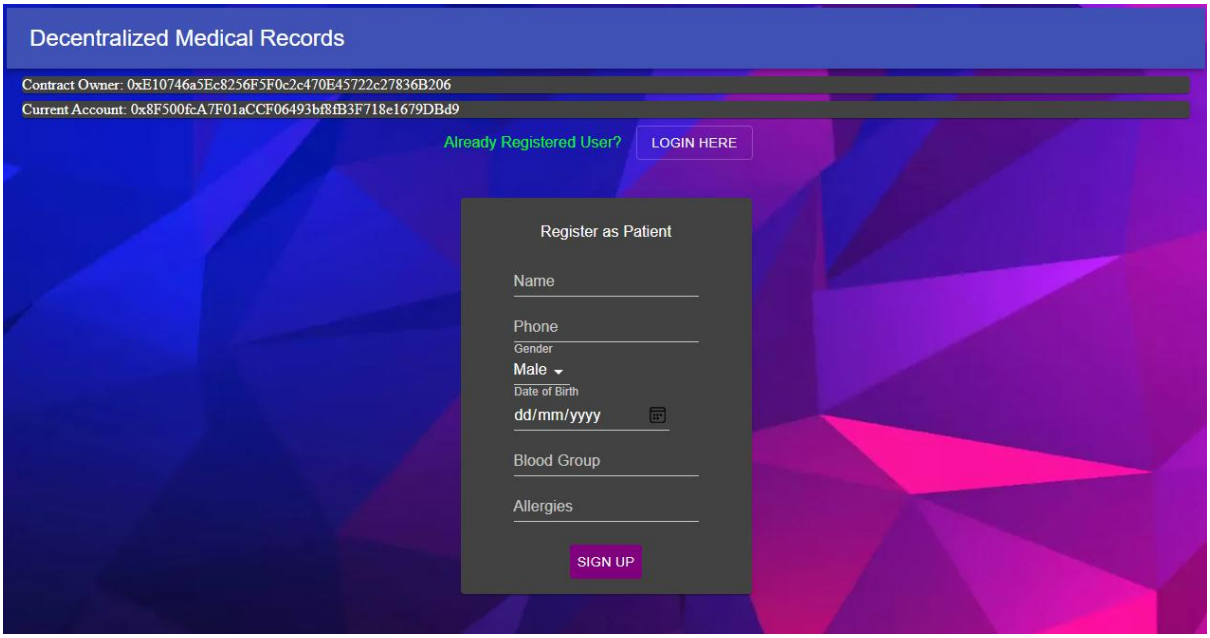


Figure 2.24: Patient Sign Up Module

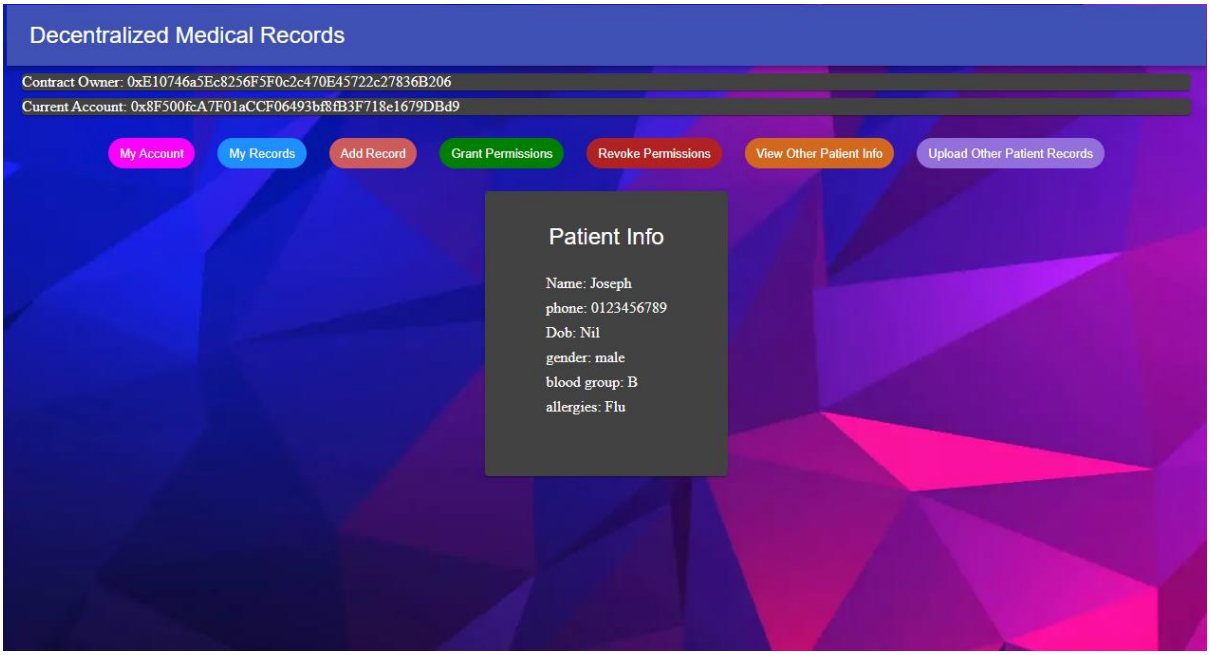


Figure 2.25: Patient Log In Module

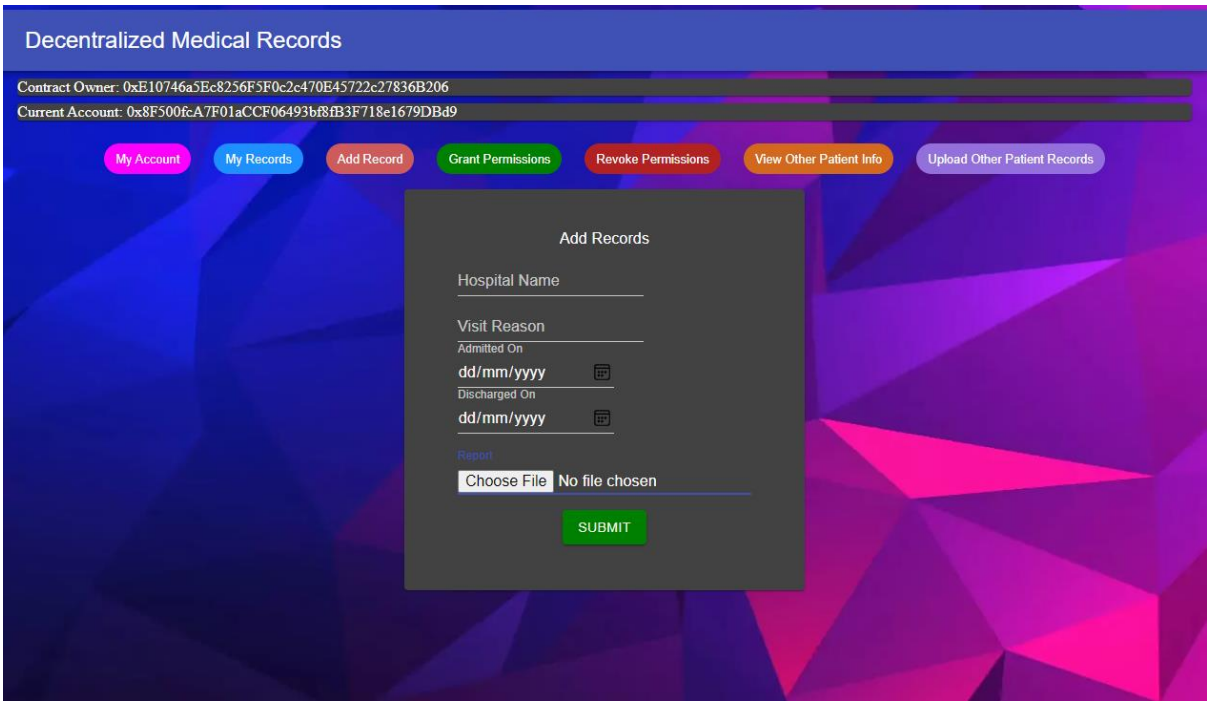


Figure 2.26: Patient Add Records Module

Decentralized Medical Records is a simple medical record application on the blockchain that has a wide array of functionalities. This application is deployed on the Rinkeby test network and requires Rinkeby network Ether to perform certain tasks in the application. In general, there are four main modules in this application which are owner, admin, hospital, and patient.

Basic features:

1. Doctor can view hospital information
2. Doctor can add new patient records
3. Doctor can view patient's record with permission from the patient
4. Patient can sign up and login
5. Patient can add new medical records
6. Patient can grant and revoke permission to hospital to allow the viewing of medical record

Special features:

1. Admin can change ownership and pass it to someone else
2. Admin can add new hospital
3. Patient can upload images or documents to be stored along in the medical record
4. Patient can search for other patients' info
5. Patient can upload record of other patients

Strengths:

1. The medical record is stored in the blockchain which makes it decentralize and secure.
2. Patient has full control of their own medical record and doctors will be allowed to access the patients' medical records only after the patient has given access permission.
3. Patient records are stored in InterPlanetary File System(IPFS) which is much more secure and stores the data in a distributed environment to prevent data loss and redundancy.

Weaknesses:

1. Not very intuitive interface design might have a little trouble navigating for the first time.
2. The user of the system has to have Metamask extension on their browser, if not the application cannot be used.
3. User needs basic knowledge in Ethereum and Metamask to be able to use the application without needing guidance.
4. No guide on how to use the application, user has to experiment by trial and error on their own.

2.2.7 Comparison Table

Table 2.3 Comparison between similar applications

Application Name	Functionality	Security	Reliability	Intuitive	Blockchain Technology
75Health Web-Based Medical Record System (kaaspro, 2020)	5	3	4	5	X
OneTouch Web-Based EMR (One Touch EMR, 2020)	4	2	3	3	X
My Health Record bd (My Health Record, 2020)	3	2	3	2	X
MRT Medical Records Tracker (Damien, 2019)	4	1	3	4	X
Multi-Profile Medical Records (Techxonia Inc., 2020)	4	5	5	5	✓
Decentralized Medical Records (Jayateertha G., 2020)	5	5	3	3	✓

5 – Excellent 4 – Good 3 – Average 2 – Bad 1 - Poor

Chapter 3: System Methodology

3.1 System Design Diagram

3.1.1 System Architecture Diagram

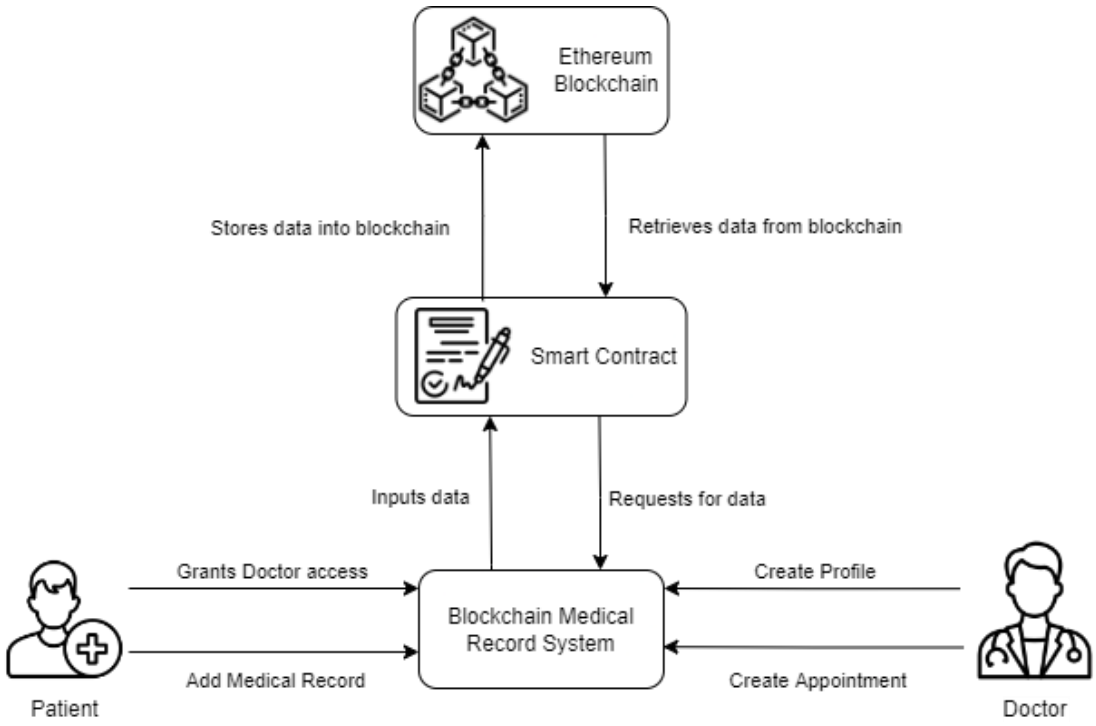


Figure 3.1: System Architecture Diagram

3.1.2 Use Case Diagram and Description

Figure 3.2: Use Case Diagram

Use case	Create New Medical Record
Purpose	Patient can fill up their medical record details such as name, date of birth, height, weight, and others.
Actor	Patient
Trigger	When user hovers over and clicks on Register Patient button on the Menu Bar
Main flow	1. Click on Register Patient and type in patient details 2. Click Create button
Alternate flow	None

Table 3.1: Use Case Description: Create New Medical Record

Use case	Edit Medical Record
Purpose	Users can edit and update any of their medical record data
Actor	Patient
Trigger	When user hovers over and clicks on Patient Edit Profile button on the Menu Bar
Main flow	1. Click on Edit Patient and type in patient details 2. Click on Edit Button
Alternate flow	None

Table 3.2: Use case description: Edit Medical Record

Use case	Approve Doctor to View Record
Purpose	Give doctor or patient approval to view the medical record of a patient
Actor	Patient
Trigger	When patient enters doctor address and click approve
Main flow	1. Go to Patient and click Allow Access 2. Enter doctor or patient address 3. Click revoke
Alternate flow	None

Table 3.3: Use case description: Approve Doctor to View Record

Use case	Revoke Access to View Record
Purpose	Revoke access of doctor or patient to view the medical record of a patient
Actor	Patient
Trigger	When patient enters doctor address and click revoke
Main flow	1. Go to Patient and click Allow Access 2. Enter doctor or patient address 3. Click Revoke
Alternate flow	None

Table 3.4: Use case description: Revoke access to View Record

Use case	View entire list of medical records
Purpose	Doctor and patient can view the full list of medical records but can only view details of the records after being authorized.
Actor	Patient, Doctor
Trigger	Click on Records List on Menu Bar
Main flow	1. Go to Records List on the Menu Bar
Alternate flow	Display “No Permission” error

Table 3.5: Use case description: View entire list of medical records

Use case	Display “No Permission” error
Purpose	Show error if doctor or other patient try to access a patient record without permission
Actor	Patient, Doctor
Trigger	When user clicks on a record detail without being approved
Main flow	1. View details of medical record 2. Display error if user does not have permission
Alternate flow	None

Table 3.6: Use case description: Display “No Permission” error

Use case	View Medical Record Details
Purpose	Show details of the medical record
Actor	Patient, Doctor
Trigger	1. When user clicks on View Profile on Patient tab in the Menu bar 2. When user clicks on View Record on Record List page
Main flow	1. View details of medical record
Alternate flow	None

Table 3.7: Use case description: View Medical Record Details

Use case	View Appointment Details
Purpose	Patients can view the details of the appointment including date of appointment, prescription, diagnosis and etc.
Actor	Patient, Doctor
Trigger	1. When user clicks on View Profile on Patient tab in the Menu bar 2. When user clicks on View Record on Record List page
Main flow	1. View details of appointment
Alternate flow	None

Table 3.8: Use case description: View Appointment Details

Use case	View Dashboard
Purpose	All users can view and interact with a series of statistics and visualizations including area charts, line charts and etc.
Actor	Doctor
Trigger	When user clicks on Dashboard on the Menu Bar
Main flow	1. Go to dashboard page
Alternate flow	None

Table 3.9: Use case description: View Dashboard

Use case	Create New Profile
Purpose	To allow doctors to create their own profile
Actor	Doctor
Trigger	Click on Register Doctor on the register tab on the Menu Bar
Main flow	1. Fill up Doctor details 2. Click create profile
Alternate flow	None

Table 3.10: Use case description: Create New Profile

Use case	Edit Profile
Purpose	To allow doctor to make changes to their existing profile
Actor	Doctor
Trigger	Click on Edit Profile on the Doctor tab on the Menu Bar
Main flow	1. Fill up Doctor details 2. Click edit profile
Alternate flow	None

Table 3.11: Use case description: Edit Profile

Use case	Create Appointment
Purpose	Doctor can create an appointment with patient
Actor	Doctor
Trigger	When user clicks on create appointment button
Main flow	1. Go to create appointment page 2. Fill up appointment details 3. Click create appointment
Alternate flow	none

Table 3.12: Use case description: Create Appointment

Use case	Update Appointment
Purpose	Doctor can update appointment and make changes to existing appointment
Actor	Doctor
Trigger	When doctor clicks on update appointment in the Doctor tab on the Menu Bar.
Main flow	1. Fill up appointment form 2. Click on update appointment
Alternate flow	none

Table 3.13: Use case description: Update Appointment

3.1.3 Activity Diagram

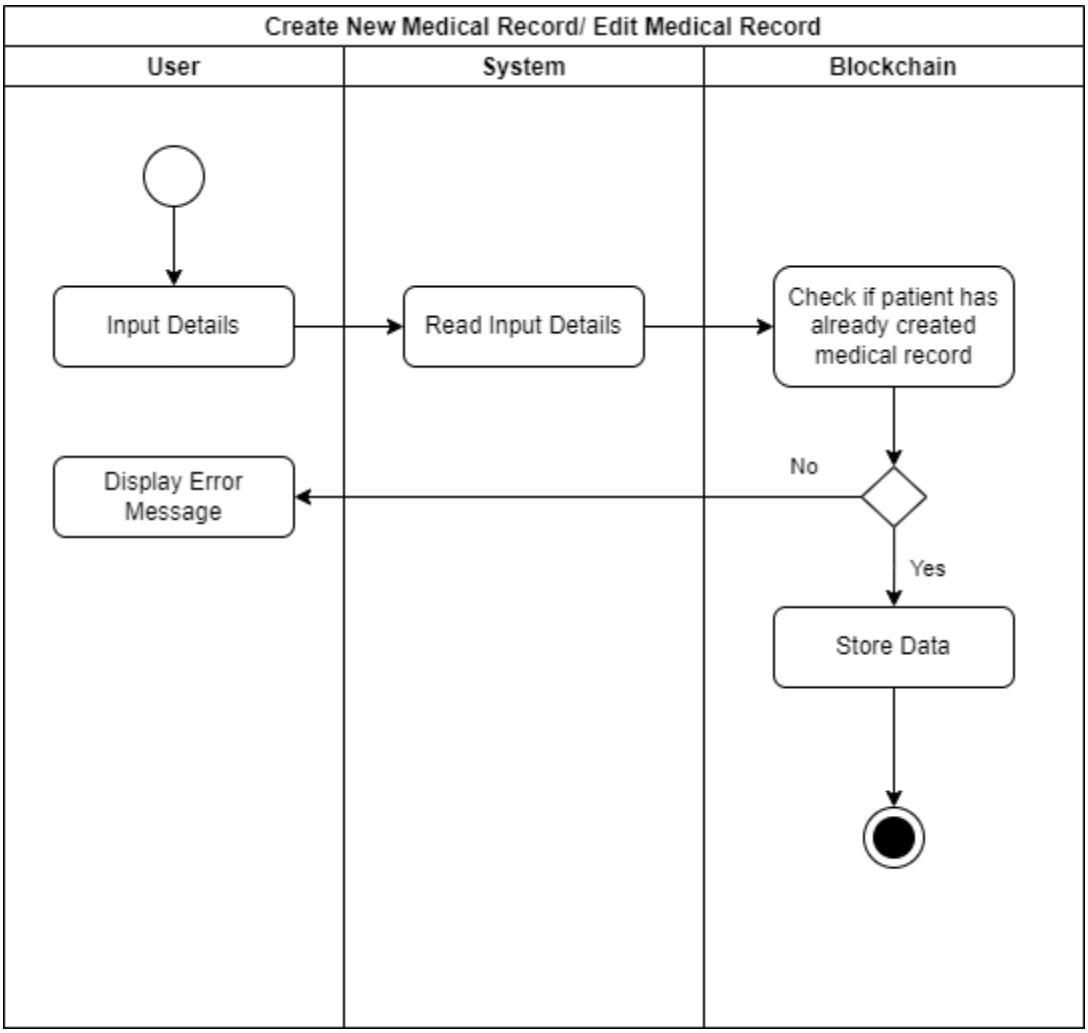


Figure 3.3: Activity Diagram: Create New Medical Record/ Edit Medical Record

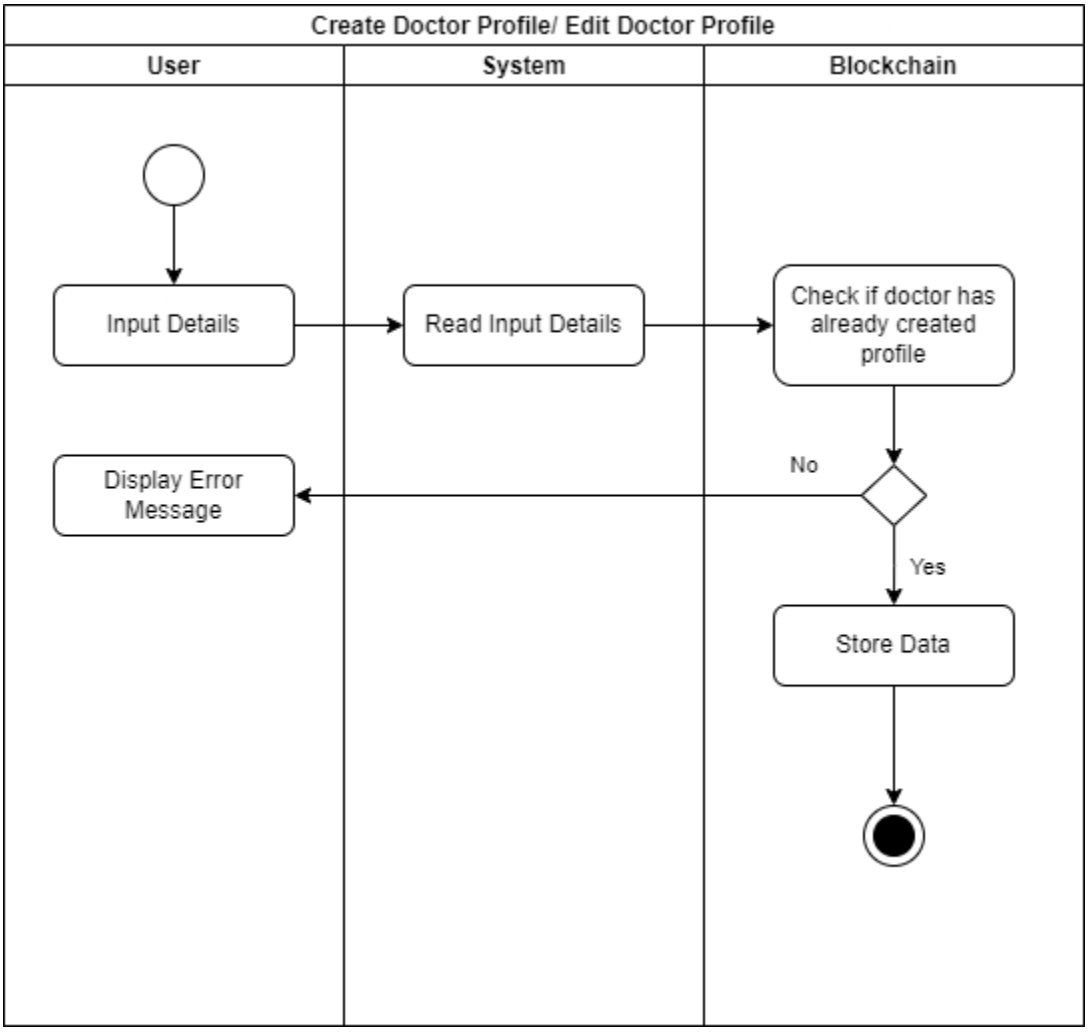


Figure 3.4: Activity Diagram: Create Doctor Profile/ Edit Doctor Profile

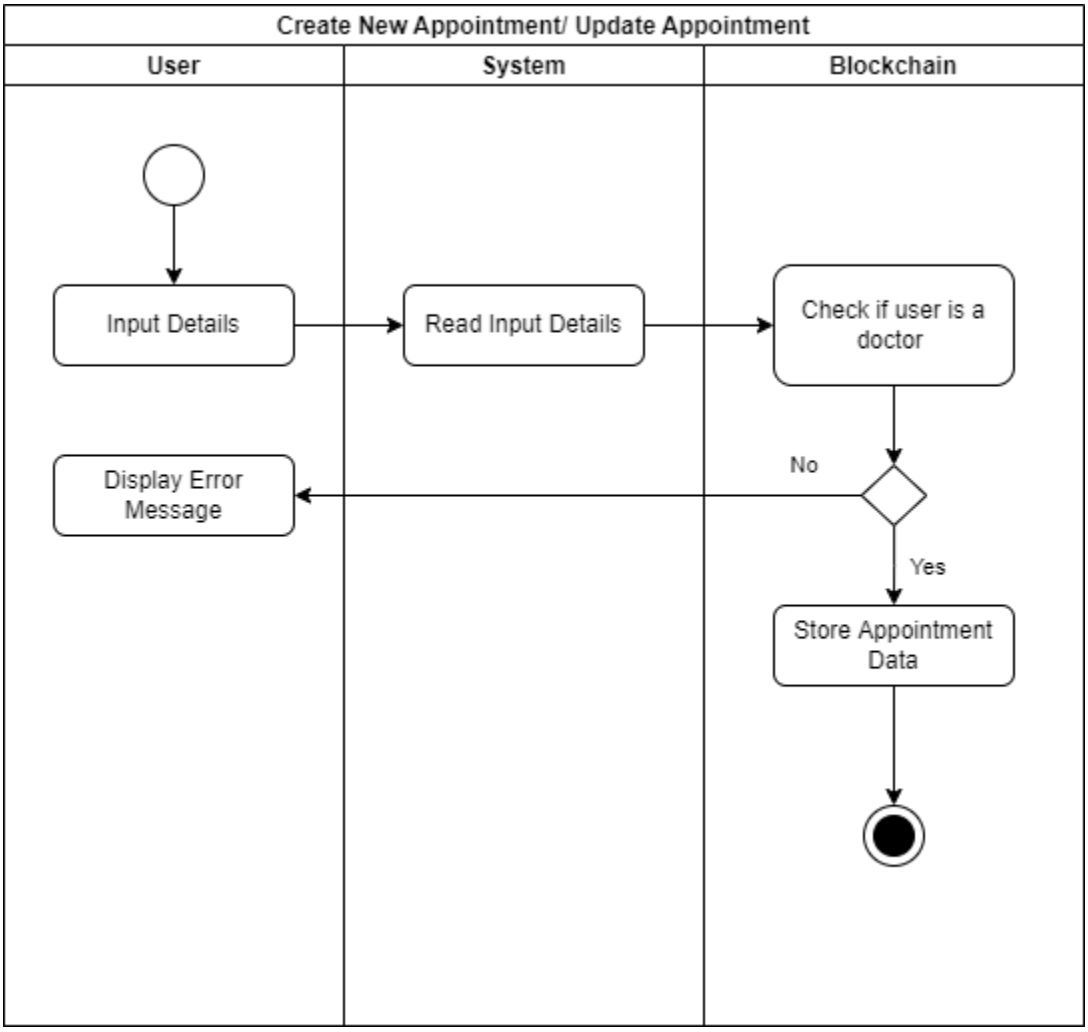


Figure 3.5: Activity Diagram: Create New Appointment/ Update Appointment

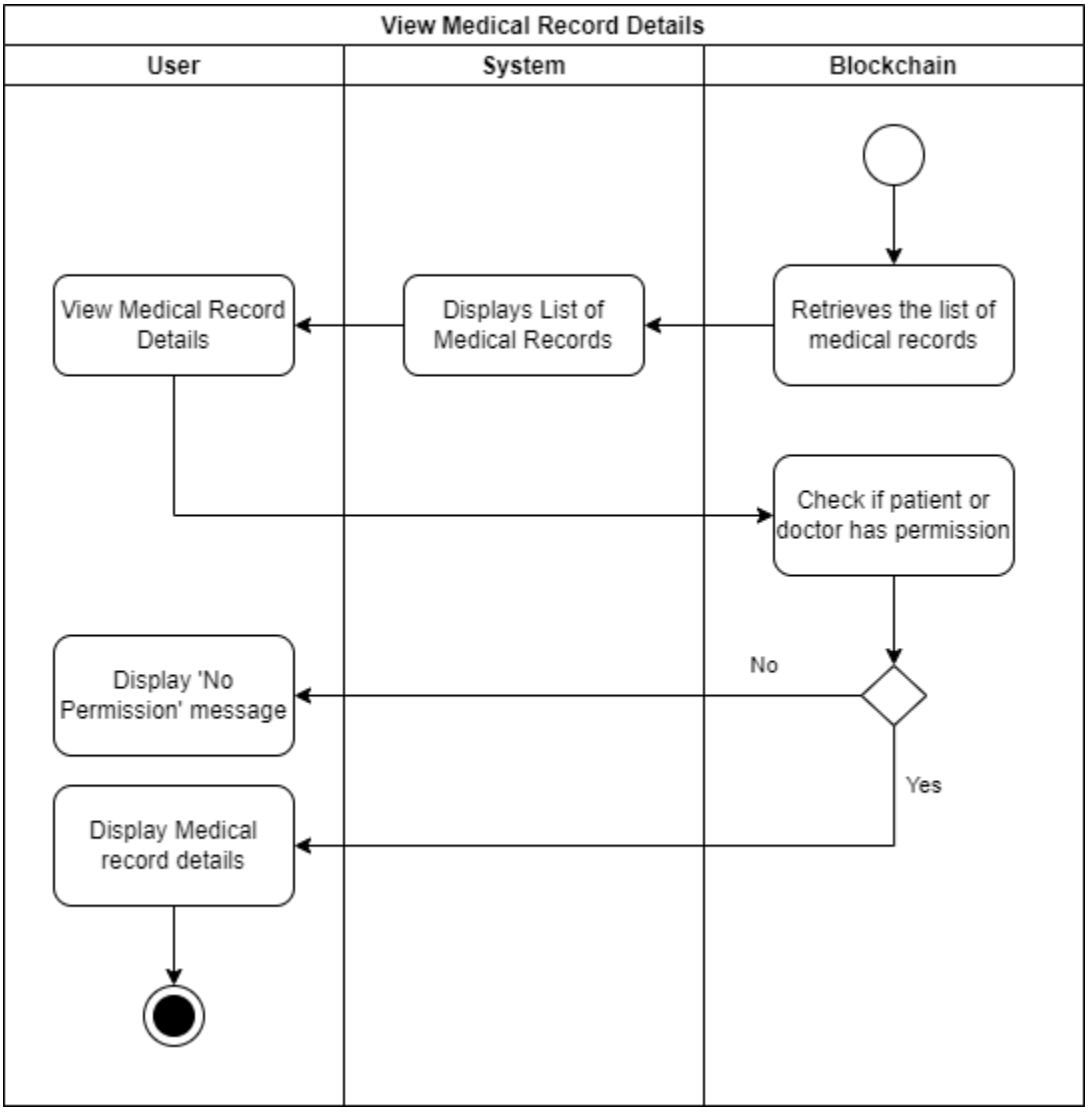
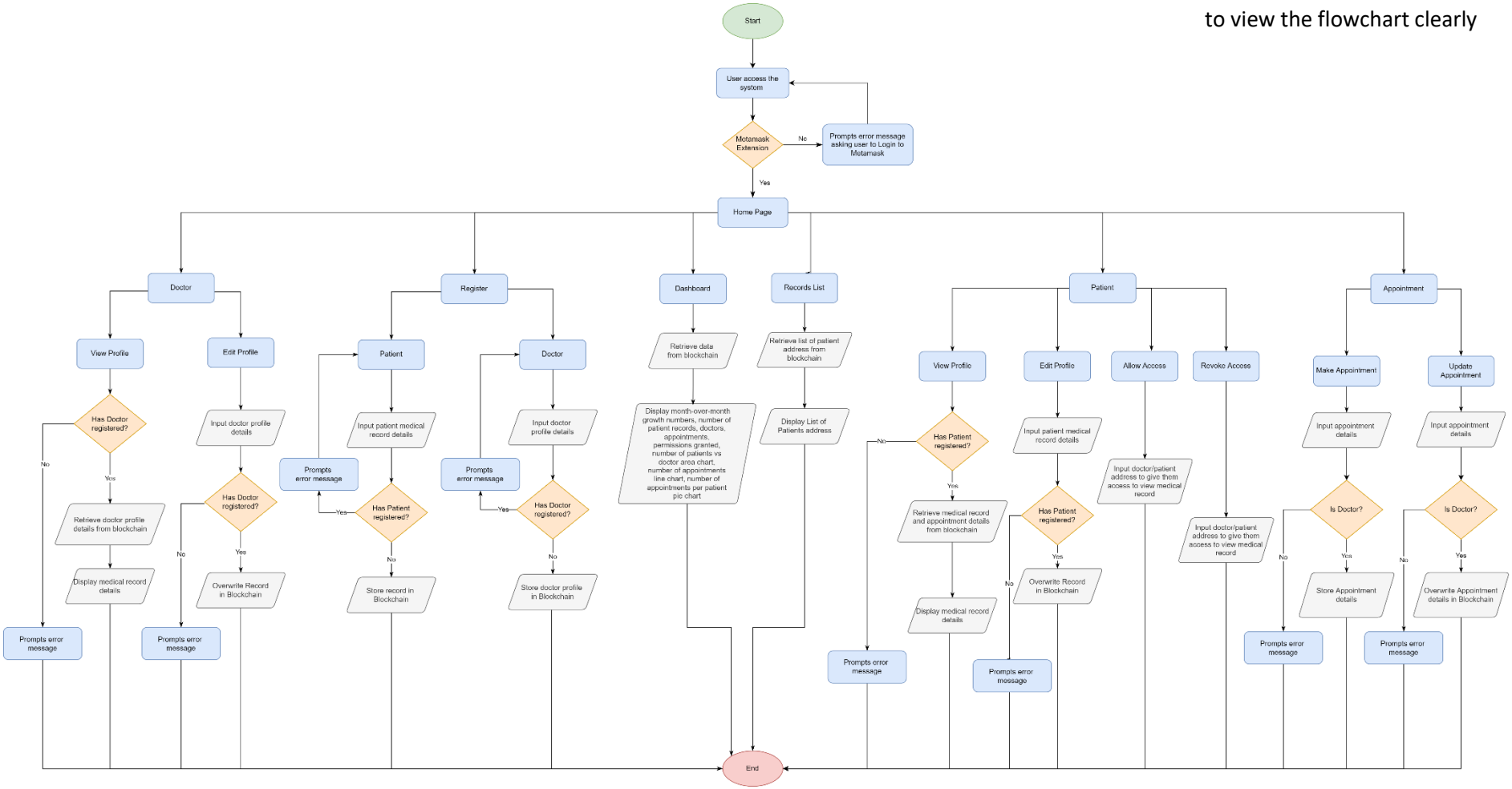


Figure 3.6: Activity Diagram: View Medical Record Details

Chapter 4: System Design

4.1 System Flowchart

Note: Zoom (Ctrl + scroll) in to view the flowchart clearly



4.2 Flowchart Description

4.2.1 Home Page

When users first access the system, they have to login to Metamask. Otherwise, they will not be allowed to access any other part of the system. This is because Metamask is essentially the key component facilitating the back end of any blockchain system. To be more exact, Metamask injects a global API into websites visited by users. This API then allow websites to request users' Ethereum accounts, read and write data to and from the blockchain, and facilitates the transactions. After ensuring Metamask is installed and signed in, users are then greeted by the home page which they are then free to click on any on any button on the menu bar.

4.2.2 Register Patient

By hovering over and clicking on the register patient button, user will be redirected to the page. Patient will then fill up their medical record details in each section of the form. After that, patient will click create and a Metamask transaction message will pop up displaying the gas price needed to add this medical record into the blockchain. The patient can then decide to click Confirm or Reject, if patient clicks Confirm, the amount of Ether will be deducted from the Metamask wallet of the patient. Ether is the cryptocurrency needed to interact with the Ethereum blockchain. Reading data from the blockchain does not require any Ether payment but writing data to the blockchain does. In the case of registering patient, we are storing the medical record data to the blockchain. Hence, payment is needed. After payment, there is a 30 second to 1 minute wait for the data to be included into the blockchain. This wait time is also called block time, which signifies the time taken in seconds for a block to be included into the Ethereum blockchain. According to [15], the average block time is 15 seconds. Throughout the project, the Rinkeby blockchain is used, which is a test net of the Ethereum blockchain. Hence, the concepts and the way it runs is similar to the Ethereum blockchain. The function of this test net is to allow the use of Ether that does not cost real money for development. After the block has been added to the blockchain,

an alert will be displayed to the user notifying that the medical record has been created successfully.

4.2.3 Register Doctor

Registering doctor technically works the same as registering patient. The doctor will fill up his or her details, then click create button. Then, the Metamask transaction message will pop up and the doctor can click confirm. After waiting for a couple seconds to a minute, an alert message will be displayed to the doctor indicating that his profile details have been stored in the blockchain successfully. In the smart contract, there are certain code that I have added that will check for whether the doctor has already created an account or not. It only allows for doctor to create one and only one account. If they have already created an account and try to create again, it will prompt an error message.

4.2.3 Patient Module

For the patient module there are two features in total. The first and main feature is the view profile feature. The patient can access his or her profile in two ways, one is through the view profile feature and the other is by clicking on view record of their own record through the medical records list. After patients clicks on the view profile button, the function in the smart contract will be triggered which checks whether the patient has registered and only if the patient has registered, then the data will be retrieved from the blockchain and displayed in a neat form to the user. Otherwise, if the patient has not registered, an error message will be prompt to request the user to create their medical record first, before proceeding.

For the edit profile feature, patients will be allowed to input their patient medical record details through the neat form that is segmented by sections. After inputting and clicking edit, the patient will then be prompted with a Metamask transaction message.

If the user has not registered and proceeds to edit record, it will show an error message and recommend that you not proceed as there is an error that has been triggered in the smart contract. This is due to the smart contract function for the edit record feature undergoes a check to determine if the patient that has registered. Patients are only allowed to edit record only after they have registered. This edit record feature is impossible in blockchain systems as blockchain data is technically immutable (data stored is not removable) but due to my commitment of making a great UI and UX experience, I came up with the idea to implement this feature and it is discussed in the later section, which is Chapter 5: System Implementation.

4.2.4 Grant and Revoke Access Module

There are two features in this module but we will get into the allow access feature first. This feature allows patients to grant doctors access to their medical records which is the only way doctors will be allowed to access the records of the patient. This is the main feature that allows patients to take full control of their data and can give this control to any doctor or patients at their own will. Whenever, patient enters the doctor address and clicks send, the doctor will be automatically granted permission through the smart contract.

The next is the revoke access feature. This feature revokes the access given to patients or doctors to view your medical records, which ensures you gain back full rights to your own medical records. This feature is not only crucial to achieving the objectives of this project but is also revolutionary in terms of medical record systems. The way this works is exactly the same as the grant access feature but in terms of the smart contract code, it is slightly different.

4.2.5 Doctor Module

The doctor module consists of two features which are view profile and edit profile. The first feature which is view profile works the exact same way in terms of technicality to the patient view profile feature. The doctor will click on the view profile and the smart contract will automatically check if the doctor has already registered. If the doctor is already registered, then the page with the details will render. Otherwise, an error message will prompt asking the doctor to go create a profile first.

The second feature is the edit profile feature. This feature allows doctor to correct any mistakes he or she made to their profile. This feature is achieved by the technique that I mention in the edit patient profile feature. It will let doctor fill up their details and the smart contract will check if the doctor has already registered. If the doctor has already registered, it will overwrite the record in blockchain. Otherwise, it will prompt an error message asking doctor to register first.

4.2.6 Appointment Module

The appointment module consists of two features which are make appointment and update appointment. The first feature which is make appointment will require the doctor to input the details of the appointment first. Then, the doctor can click the create button which will prompt a Metamask transaction message. Then, the smart contract is triggered to check whether the user is registered as a doctor. If the user is a doctor, then the user can click on the Approve Metamask transaction button to proceed. Otherwise, Metamask will show an error stating that this transaction may fail.

The second feature is the update appointment feature. This feature allows doctors to update the status of the appointment after it is done or make amendments if there is any error in the appointment. It will let doctor fill up their details and the smart contract will check if the doctor has already registered. If the doctor has already

registered, it will overwrite the appointment details in the blockchain. Otherwise, it will prompt an error through the Metamask transaction.

4.2.7 Medical Records List Module

The medical records list module will automatically retrieve the patients address from the blockchain and displayed them here in an organized list. This list of patient addresses are stored in an array inside the smart contract. Patients can also access their medical records here by clicking on the View Record button below their address. Doctors can also view this page but are not able to view the records of any patients without being granted permission. Doctors after clicking on the View Record button without permission will be greeted with an error message stating that you cannot view this medical record without permission.

4.2.8 Dashboard Module

The final module is the dashboard module which takes the data from blockchain and visualizes it into interesting and insightful statistics and visualizations. Users will click on the dashboard button on the navigation bar and will load into the dashboard. Both patient and doctor can access this dashboard as we want analytics to not only be accessible to hospitals and doctors but also the patients as well. Patients will be greeted by an array of key metrics and also graphs and charts, which will be covered in the next section through screenshots and in-depth explanations on each visualization and metric.

Chapter 5: System Implementation

5.1 System Methodology

In this project, the proposed methodology that will be used to develop the decentralized web-based medical record application will be the prototyping model. The prototyping model mentioned is a type of software development model. By using the prototyping model, developers need to build a prototype, and the prototype can be tested and modified based on user's feedbacks repeatedly until all user requirements are achieved. Hence, this will be a faster way to get user feedback more often to detect the issues with the system and solve it as soon as possible. For example, shown in figure 4.1 below are the phases of the six Prototyping Model:

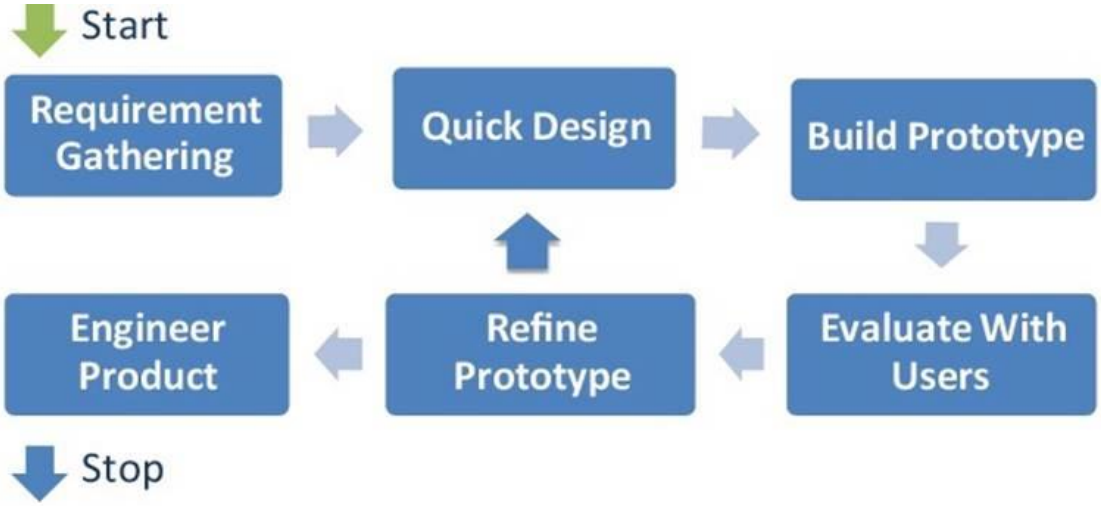


Figure 5.1: Prototyping Model Phases

Phase 1: Requirements gathering and analysis

The first step includes the planning and analysis of the system. We will collect the user requirement and analysed the data gathered throughout this process. This process can help us gauge the user needs and wants of the system. By letting users fill up a survey, we can generally know the user's expectations of the system and the requirements. Then, this data will be analysed using quantitative data such as graphs and charts to ease the visualization of the data.

Phase 2: Quick design

In the second phase, a preliminary design or a quick design of the system should be produced. A simple system design will be created in this phase using CASE tools such as Visual Paradigm to create use-case diagrams, flow diagrams etc. The system's design will be according to the data gathered in the first stage. The simple design of the system will be given out some idea for the user and also helping the developer in developing the prototype of the system.

Phase 3: Build a prototype

In this phase, a prototype will be built according to the requirements gathered and analysed and also according to the design in the quick design phase. This prototype is an incomplete but runnable system that is very likely to have bugs and errors.

Phase 4: Initial user evaluation

In this phase, the proposed prototype of the system will be proposed to the users for testing. The user will test the system and give feedback or evaluation on parts where the system can be improved. Through this phase, the strengths and weaknesses of the prototype system can be determined. Users are also allowed to give constructive criticism or suggestions to further improve the features and functionalities of the system.

Phase 5: Refining prototype

Suppose there are any comments or criticism from the user after the initial user evaluation phase. In that case, the developers will need to improve and alter the prototype based on the user's feedback. After that, the prototype will be refined and honed based on the user's feedbacks repeatedly until all problems are solved and all user requirements are achieved. Finally, when the user is satisfied with the system, the final prototype will be the system published to the market for everyone to use.

Phase 6: Implement product and maintain

In this phase, the final prototype will be implemented and deployed to production as the final system. The system will have to undergo maintenance regularly to minimize system failures and fix bugs not found in the prototype.

5.2 Project Timeline

Activity	Period													
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1.INTRODUCTION														
Motivation and Problem Statement														
Project Scope														
Project Objectives														
Impact, Significance and Contribution														
Background Information														
2. LITERATURE REVIEW														
Fact Finding														
Compare Existing Systems														
3. PROPOSED METHOD/ APPROACH														
Design Specifications														
System Design														
Implementation Issues and Challenges														
Timeline														
4. CONCLUSION														
5. SYSTEM DESIGN														
Design Prototype														
Test Prototype														
Debug Prototype														
Finalize Prototype														

Table 5.1: Gantt Chart

5.3 Settings and Configuration

5.3.1 Design of Smart Contract (Solidity)

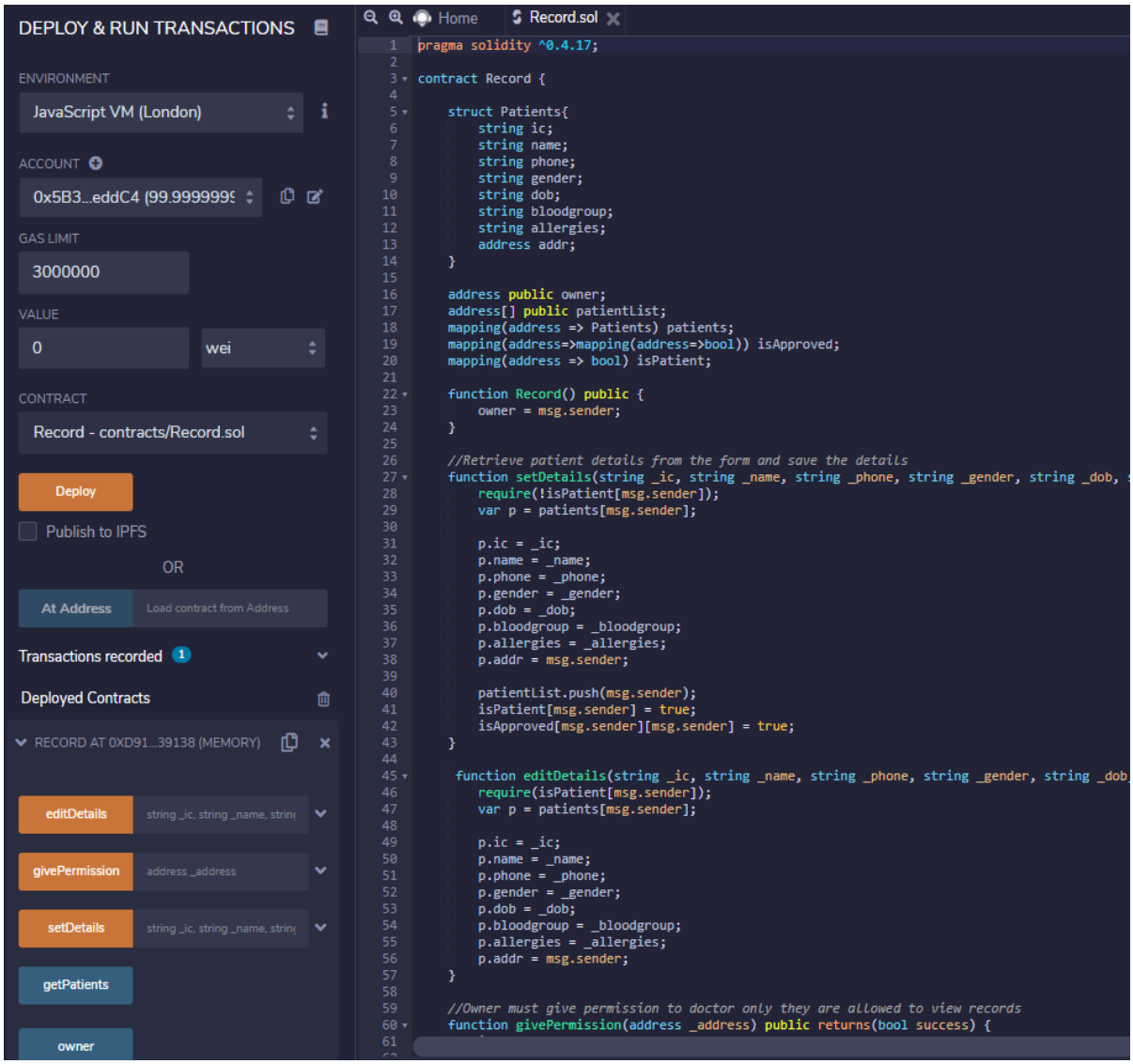


Figure 5.2: Initial Design in Remix IDE

The initial implementation of the smart contract is designed and tested in the Remix IDE. The IDE provides tools to easily compile, deploy and test the smart contract even before creating a front-end and back-end to work with the smart contract. This will ensure that the contract can be tested like in a real network but without any hassle of writing anything other than the smart contract. In addition, any bugs and errors found in the initial implementation are fixed immediately, reducing the errors we have to solve in the later phase. This version of the contract can then be moved directly into the project folder.

5.3.2 Install the needed packages and dependencies (Node.js)

```
{} package.json > {} dependencies
1   {
2     "name": "medicalrecord",
3     "version": "1.0.0",
4     "description": "",
5     "main": "index.js",
      ▷ Debug
6     "scripts": {
7       "test": "mocha",
8       "dev": "next dev"
9     },
10    "author": "",
11    "license": "ISC",
12    "dependencies": {
13      "@artsy/fresnel": "^1.9.0",
14      "fs-extra": "^10.0.0",
15      "ganache-cli": "^6.12.2",
16      "mocha": "^8.4.0",
17      "next": "^8.1.0",
18      "next-routes": "^1.4.2",
19      "prop-types": "^15.7.2",
20      "react": "^17.0.2",
21      "react-dom": "^17.0.2",
22      "semantic-ui-css": "^2.4.1",
23      "semantic-ui-react": "^2.0.3",
24      "solc": "^0.4.17",
25      "truffle-hdwallet-provider": "0.0.3",
26      "web3": "^1.3.6"
27    }
28  }
29
```

Figure 5.3: Dependencies and Frameworks used

Many packages have to be installed and ensure that they are compatible with every other framework. This process is extremely tedious as after coding with a certain framework, certain features might be deprecated or cause errors with other frameworks. When this occurs, the code has to be fixed or remove entirely and reinstall the dependency and recode the entire feature. Not only that, but many of the blockchain technologies like solc, web3, truffle cause many issues as it is a very new technology. These dependencies are updated very often and may cause older versions to be incompatible. Whenever incompatible dependencies are used, they might not work as intended with the other frameworks and may cause a whole suite of errors. Hence, a lot of time was spent on setting up the right version to ensure every dependency works together with each other seamlessly.

5.3.3 Design of Smart Contract Integration Scripts (web3)

```
const path = require('path');
const solc = require('solc');
const fs = require('fs-extra');

const buildPath = path.resolve(__dirname, 'build');
console.log('Deleting build folder...');
fs.removeSync(buildPath);

console.log('Getting contract by path...')
const campaignPath = path.resolve(__dirname, 'contracts', 'Record.sol');
const source = fs.readFileSync(campaignPath, 'utf8');

console.log('Compiling contract...');
const output = solc.compile(source, 1).contracts;

fs.ensureDirSync(buildPath); //recreate build folder

for (let contract in output) {
    fs.outputJsonSync(
        path.resolve(buildPath, contract.replace(':', '') + '.json'),
        output[contract]
    );
}
```

Figure 5.4: Compile Script

The back end consists of the compile, deploy, instance and web3 scripts. The compile script takes the Solidity code (the code written in Remix) and then compiles it into a JSON file.

```
    const accounts = await web3.eth.getAccounts();

    console.log('Attempting to deploy from account', accounts[0]);

    //Deploy contract to rinkeby network
    const result = await new web3.eth.Contract(JSON.parse(compiledRecord.interface))
        .deploy({ data: compiledRecord.bytecode })
        .send({ gas: '5000000', from: accounts[0] });

    //Display the address of the contract
    console.log('Contract deployed to', result.options.address);

    //Always go to record.js after updating solidity code
};

deploy();
```

Figure 5.5: Deploy Script

The deploy script takes the JSON interface created by the compile script and deploys it to the Rinkeby Network by utilizing Infura. After running the script, the smart contract will be deployed to the Rinkeby Blockchain, but it will require up to 30 seconds of waiting.

```
import web3 from './web3';
import Record from './build/Record.json';

const instance = new web3.eth.Contract(
    JSON.parse(Record.interface),
    '0xaFEe66f47EB7c8Bf6b903f54DA13262AF4BDb056' //Deployed Contract Code //Everytime contract code is changed,
);

export default instance;
```

Figure 5.6: Instance Script

The instance script takes in the deployed contract address and JSON interface. This will create an instance of the smart contract that can then be interacted with by implementing a front and back end.

```
import Web3 from 'web3';

let web3;

if(typeof window !== 'undefined' && window.web3 !== 'undefined') {
    //We are in the browser AND metamask is running
    async () => {await window.web3.currentProvider.enable();}
    web3 = new Web3(window.web3.currentProvider);
} else {
    //We are on the server OR the user is not running metamask
    const provider = new Web3.providers.HttpProvider(
        'https://rinkeby.infura.io/v3/cae3e4c525ba4a75b6ae9ffe89ca6160'
    );
    web3 = new Web3(provider);
}

export default web3;
```

Figure 5.7: Web3 Script

The web3 script serves the purpose of allowing users to interact with the smart contracts through the Metamask extension on the web browser. Users who do not have Metamask will be requested to log in or install a Metamask account to use the application.

5.4 System Operation

5.4.1 Home Page

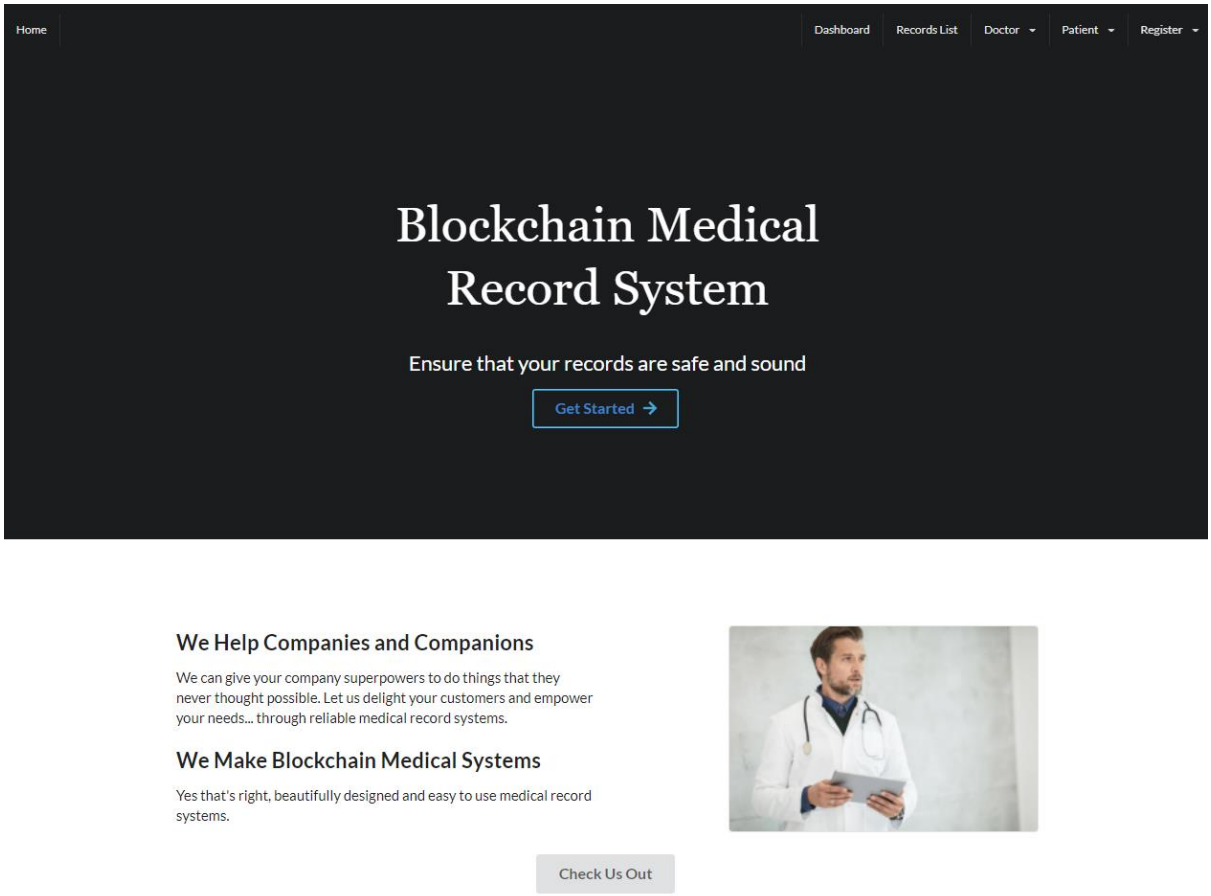


Figure 5.8: Home page

The system's home page allows users to check out some customer reviews, articles about the system and case studies. It mainly serves as a welcome screen with no other features. Users can click on the 'Get Started' button to proceed to the dashboard page.

5.4.2 Register Patient Medical Records

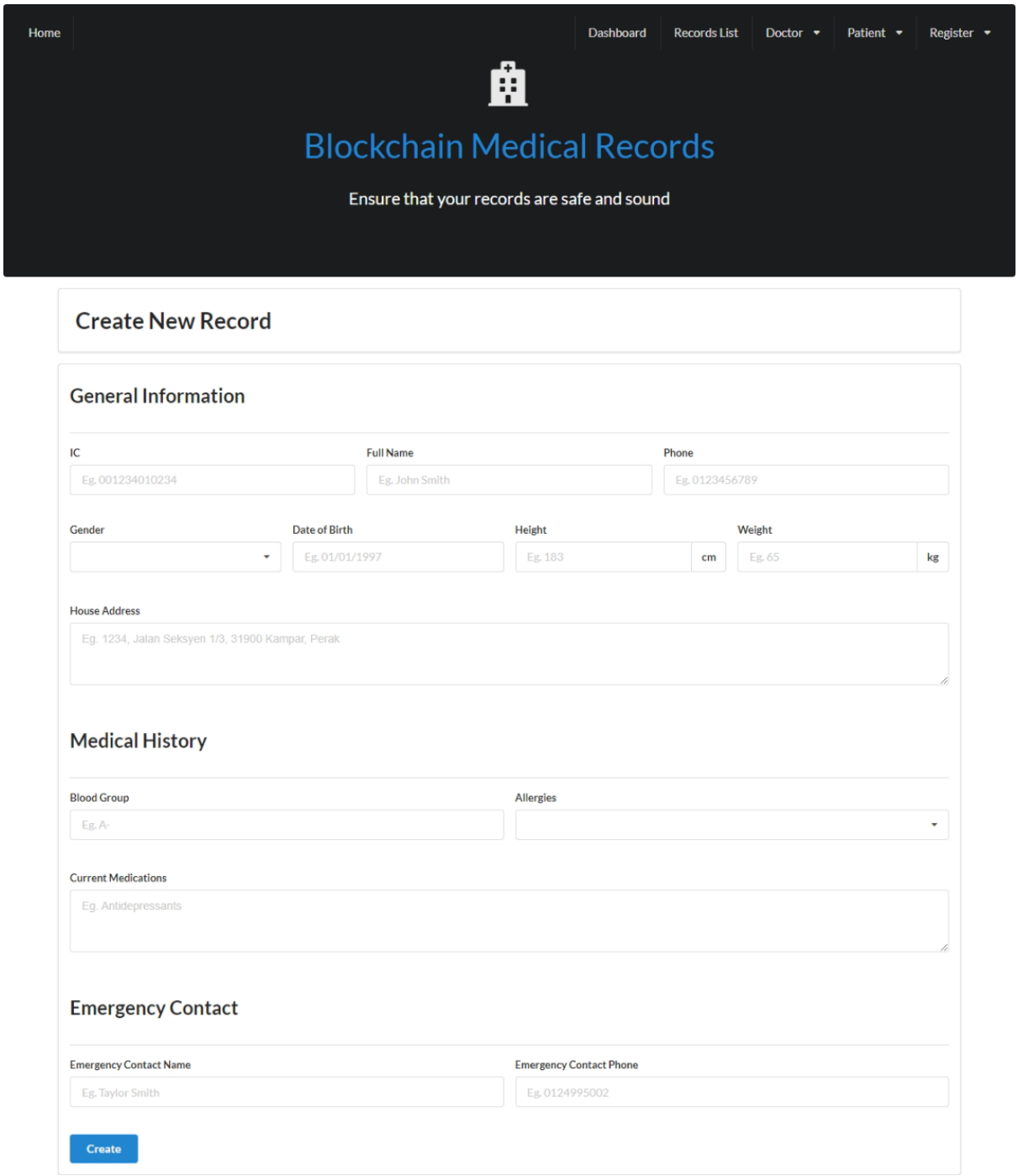


Figure 5.9: Register Patient/Create New Record Page

Users can access this page by hovering over the Register button on the Navigation Bar and click on 'Patient' on the navigation bar. Users can fill up their details according to each section then proceed to click create.

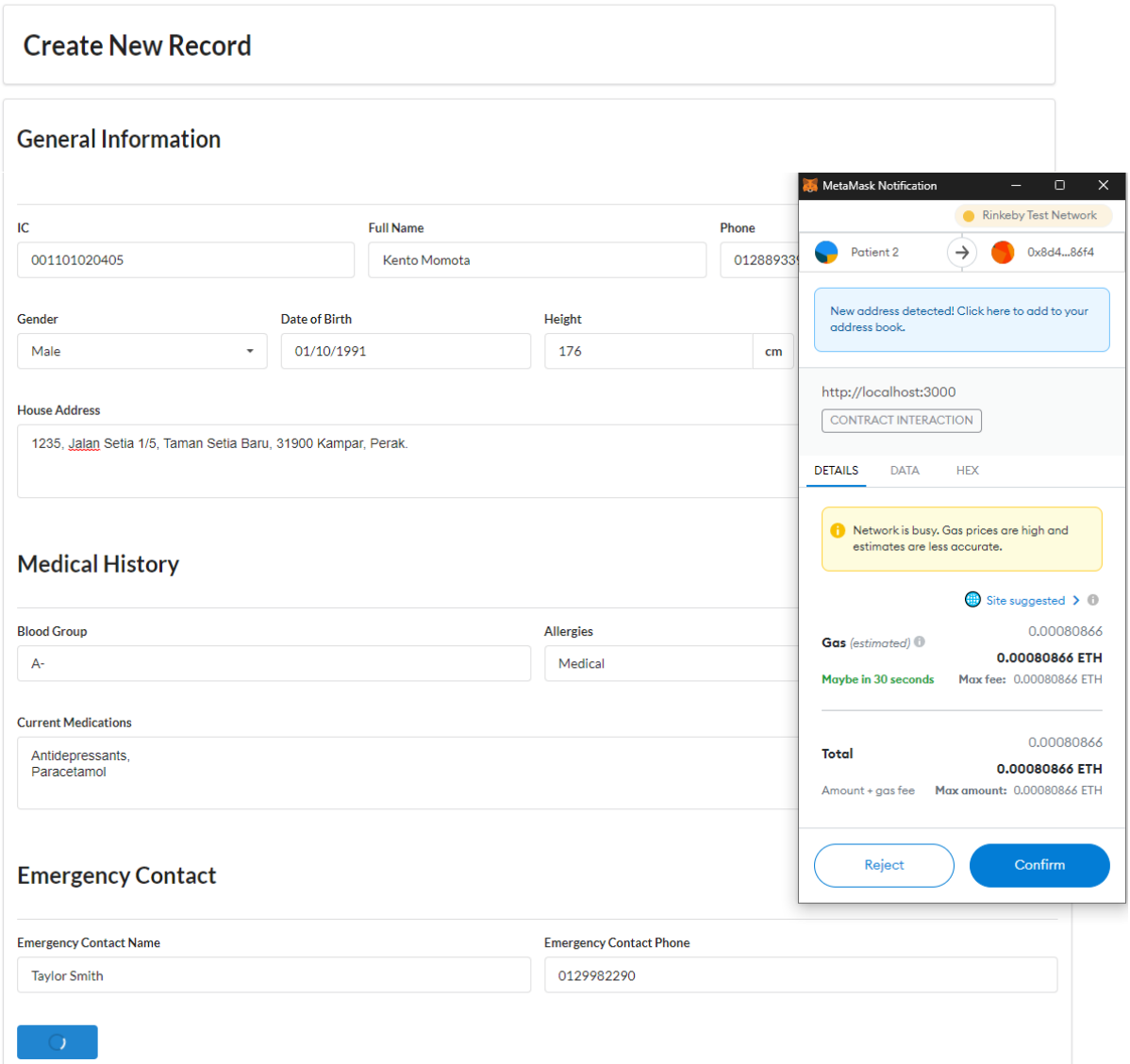


Figure 5.10: Metamask Transaction

As can be seen in figure 5.10, a Metamask transaction will pop up to request the user to confirm or reject the transaction. After clicking confirm, Metamask will load for thirty seconds to a minute and then a confirmation message will appear signalling to the user that the patient medical record has been created and stored successfully on the blockchain.

5.4.3 Register Doctor Profile

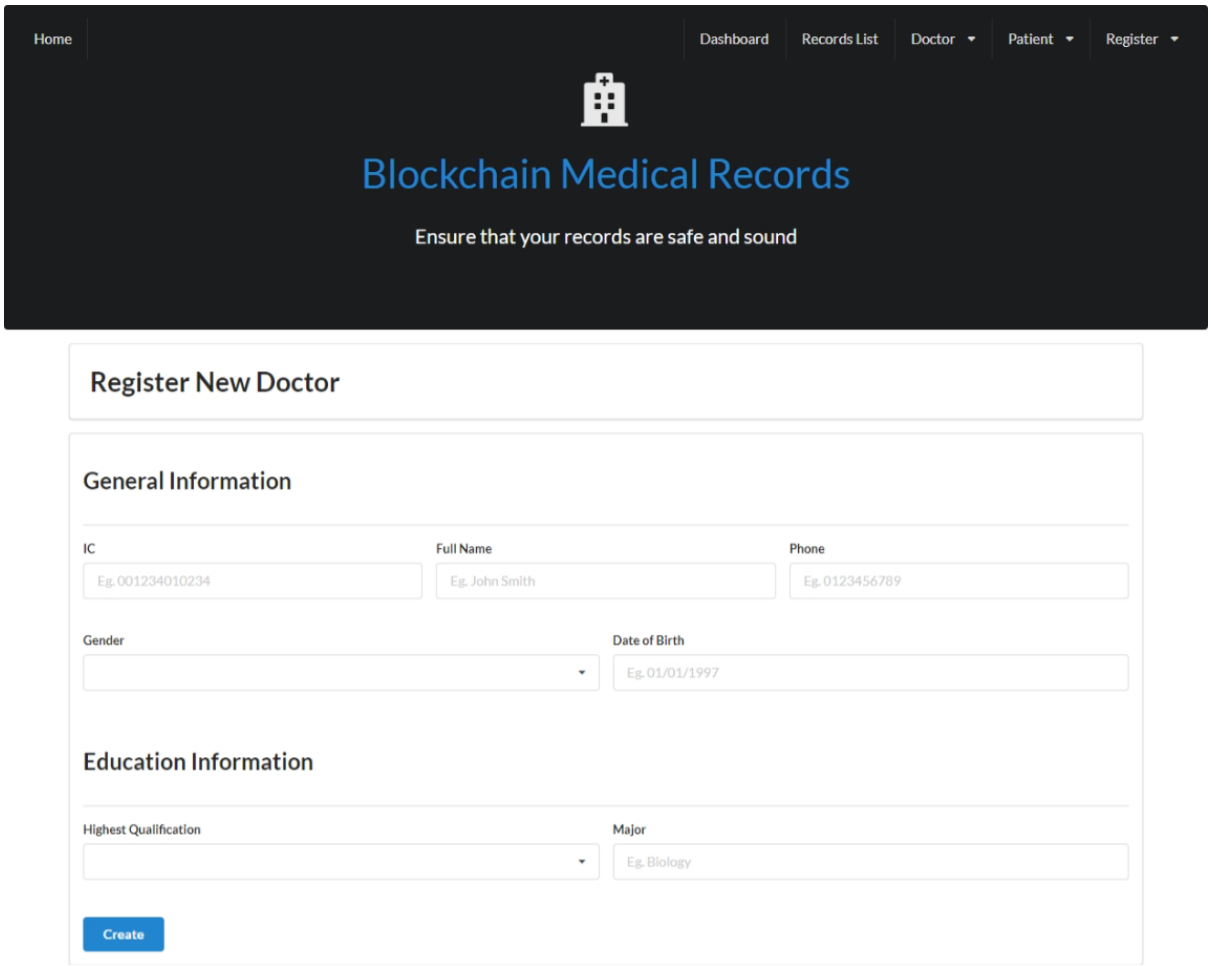


Figure 5.11: Register Doctor Page

The register doctor page is almost same with the register patient page in terms of the design and look and feel of the page. It serves the purpose of letting doctors to store their personal details and create their own profile.

5.4.4 Patient – View Profile

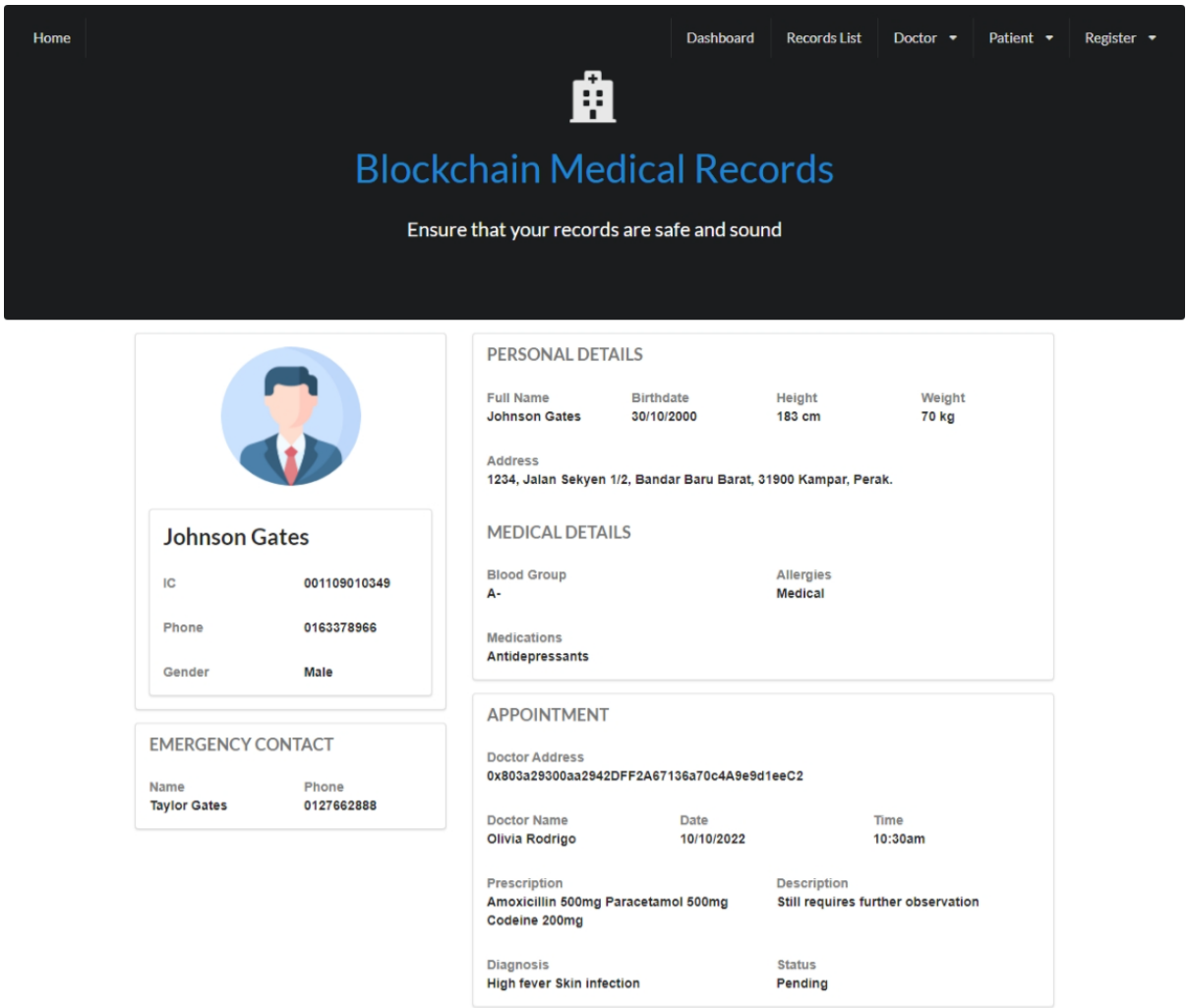


Figure 5.12: View Patient Profile Page

The View Patient profile page splits the patient's medical record details into neat and organized boxes to ease of the viewing of details. The profile picture on the medical record will change according to the gender that user input into the patient registration page. Below the personal details and medical details section is the appointment details. The appointment will be covered later, but the data from the appointment will be displayed here, in the patient's profile. Emergency Contact details is also an important addition to the medical records in case the patient is in an unconscious state and may require medical attention immediately and may need consent from the next of kin, the doctor can then contact this emergency contact person. Users can also view medical records that belong to other people only with their approval. This ensures that the medical record truly belongs to the user and other users will only be allowed to view their records with consent.

5.4.5 Patient – Edit Profile

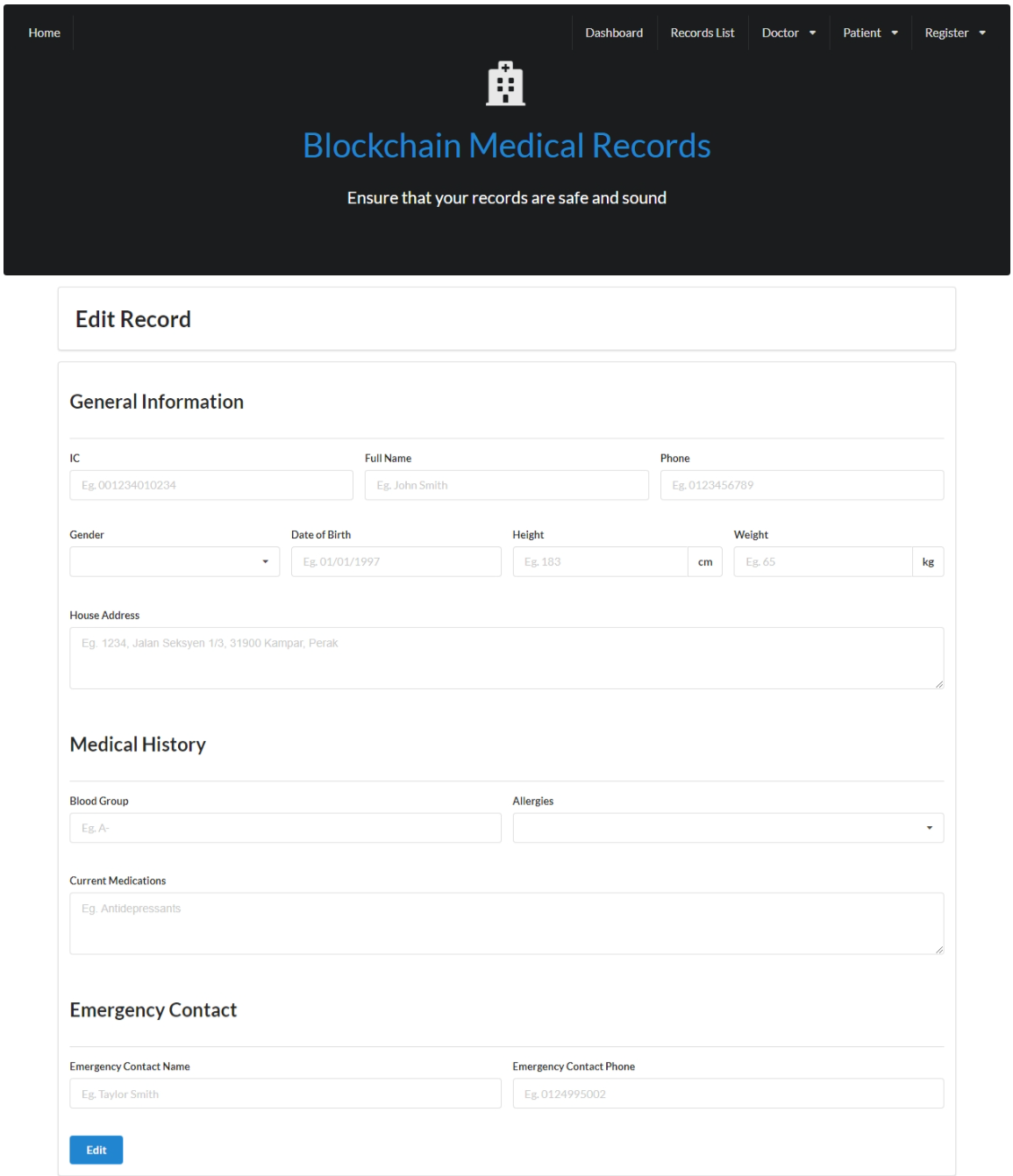


Figure 5.13: Edit Patient Profile Page

Patients can freely edit their existing records if they want to update their records or find any error and fix it. However, users can only edit the record if they have already created one, or they will be shown an error. In traditional blockchain applications and the concept of blockchain, data stored inside blockchain applications are not allowed to be changed. This rule

still holds, but by implementing this feature, I implemented some clever code in the smart contract to allow users to seem as though they have changed their existing records that are stored in the blockchain. However, the data that was stored in the blockchain was not removed nor changed fundamentally. Instead, it was in a way overwritten. This feature will prove extremely useful and accomplishes the objective of making the user interface much more user-friendly to improve the user experience, which improves the efficiency of the healthcare service they will be receiving.

5.4.6 Patient – Allow Access

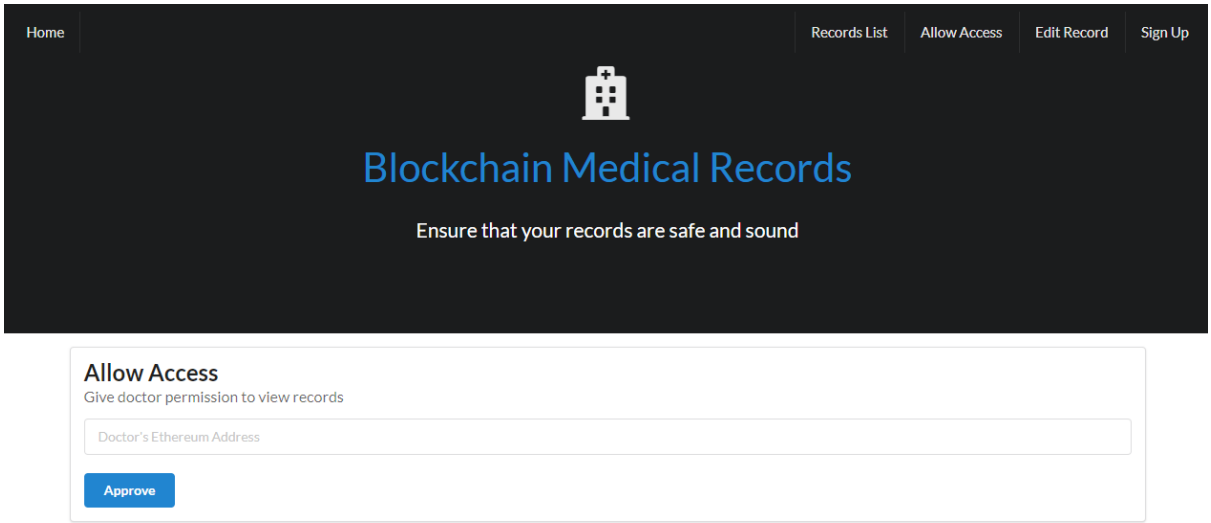


Figure 5.14: Patient Allow Access Page

As shown in figure 5.14, users can enter a doctor's address or any other patient's address and grant that patient or doctor the permission to view their medical record details. In addition, the users that have been allowed access can freely view and edit that patient's record. This feature is important as patient's should give close family members access to their medical records to avoid the scenario where the patient is in the hospital in a coma and the doctor nor the close family members have access to the patient's medical records. The patient may lose their life because the doctor may not know about the allergies or the medical history of the patient. Hence, this feature cannot be understated.

5.4.7 Patient – Revoke Access

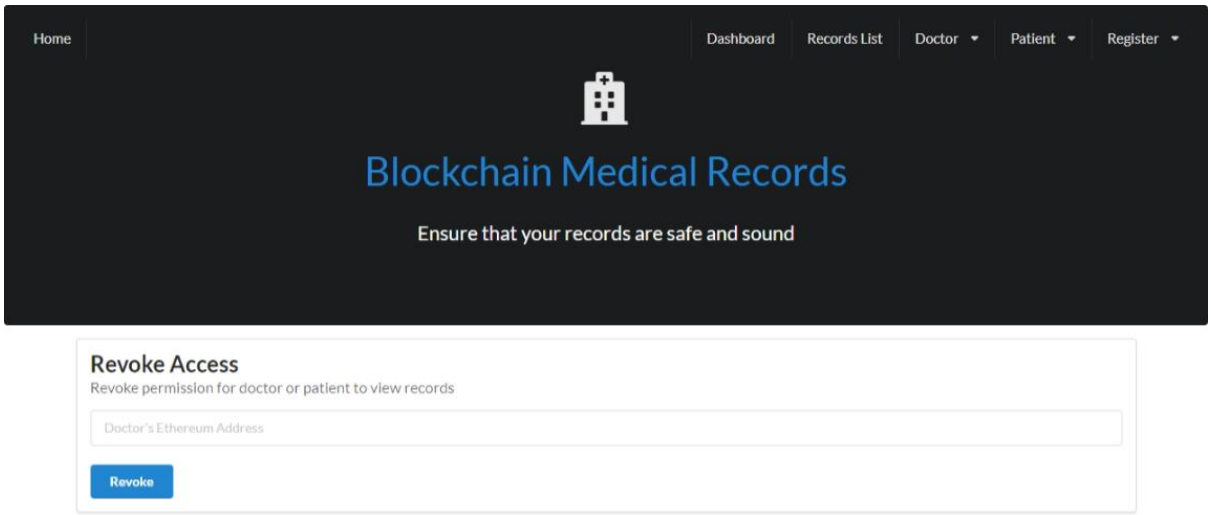


Figure 5.15: Patient Revoke Access Page

As shown in figure 5.15, users can enter a doctor's address or any other patient's address and revoke access of patient or doctor to view their medical record details. This feature allows patients to regain full rights to their medical records after leaving the hospital or after completing the treatment session in a said hospital. The patient may no longer want to visit this hospital for some time and want to prevent the doctors or hospital personnel from misusing the data of the patient, they can easily revoke the access to their medical records through this feature. This feature is not only crucial to achieving the objectives of this project but is also revolutionary in terms of medical record systems. As no medical record systems before blockchain medical record systems are allowed to grant and revoke access to others to view our own medical records.

5.4.8 Doctor – View Profile

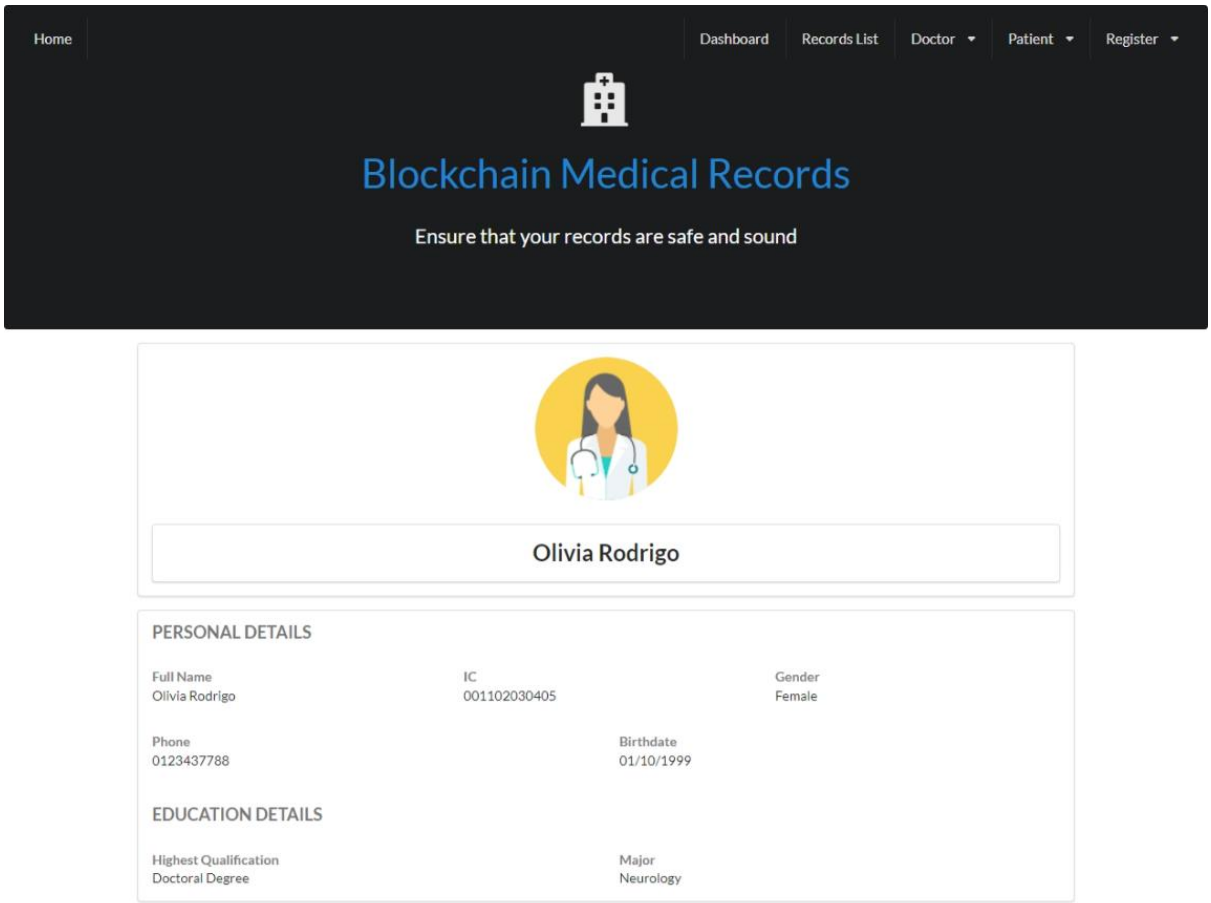


Figure 5.16: View Doctor Profile Page

The View Patient profile page splits the patient's medical record details into two organized boxes to ease of the viewing of details. The profile details of the doctor is split into personal details and education details. The profile picture on the medical record will change according to the gender that user input into the doctor registration page. As in this case, the doctor is female, which is why the profile picture is of a female doctor. These details are retrieved from the blockchain and displayed in the front end.

5.4.9 Doctor – Edit Profile

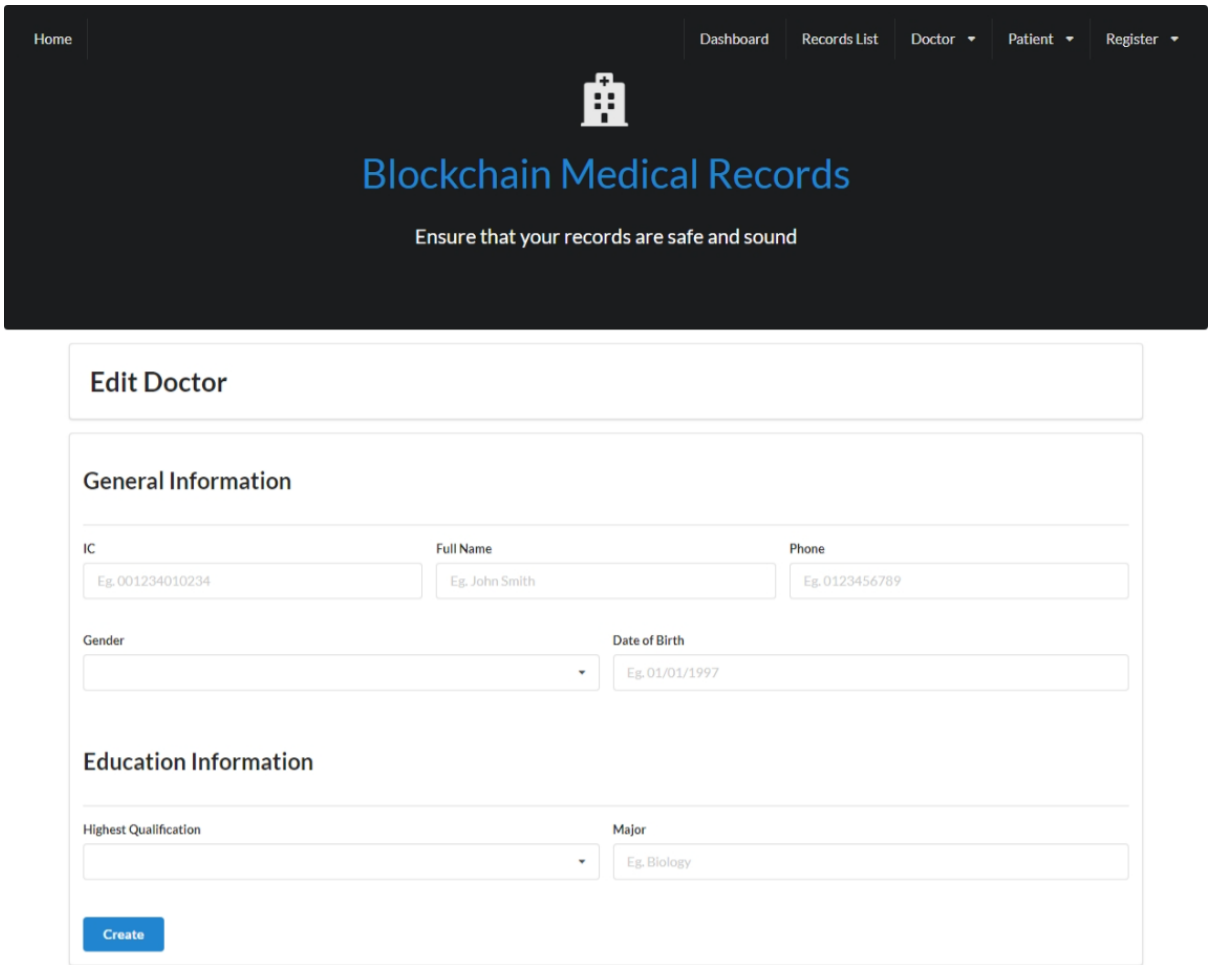


Figure 5.17: Edit Doctor Page

Doctors can freely edit their existing records if they want to update their records or find any error and fix it. However, users can only edit the record if they have already created one, or they will be shown an error. The way the edit doctor feature is explained in the edit patient part, it is using the exact same technique. Also, this feature will prove extremely useful and accomplishes the objective of making the user interface much more user-friendly to improve the user experience, which improves the efficiency of the healthcare service the patients will be receiving.

5.4.10 Doctor – Make Appointment

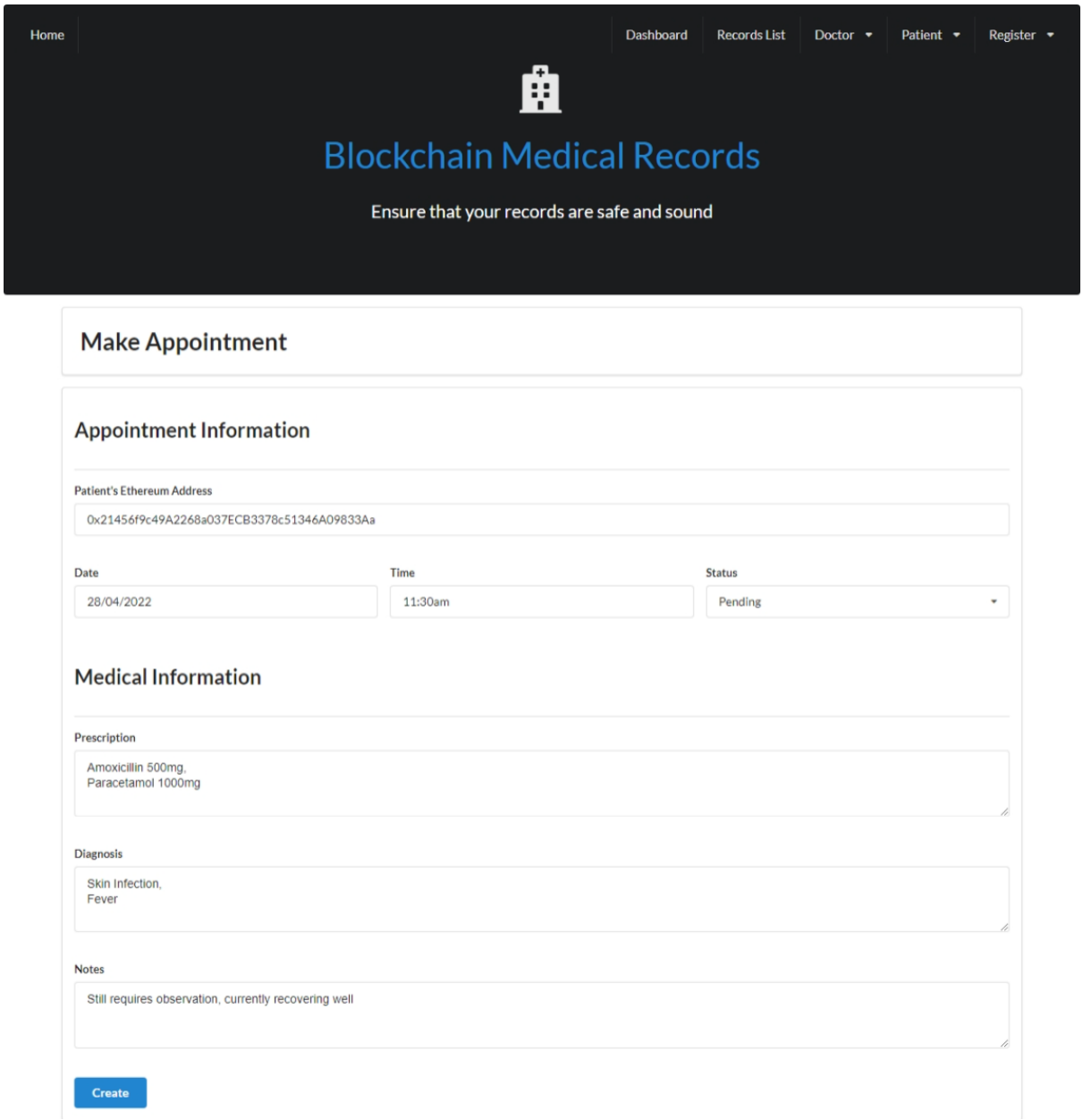


Figure 5.18: Make Appointment Page

The make appointment page allows doctor to fill up details for the appointment to make booking with the patient. It only requires the patient's Ethereum address to make booking, which ensures anonymity and ensures the patients privacy is not violated. After making appointment, the details of the appointment will then be displayed on the patient's medical record/ profile. The make appointment module is only specifically for the doctor because this will avoid the patient from abusing the system and making multiple appointments and not attending.

5.4.11 Doctor – Update Appointment

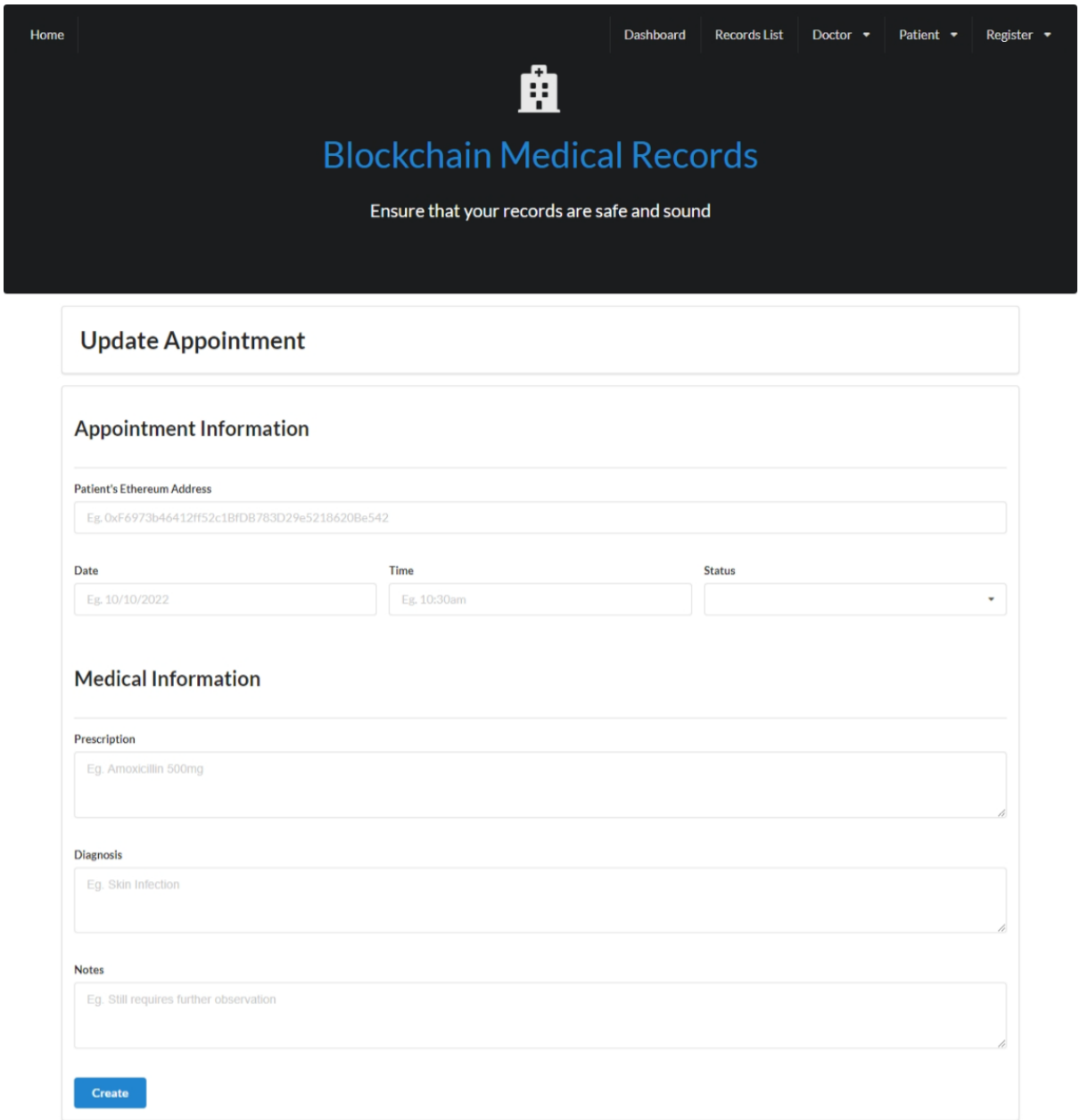


Figure 5.19: Update Appointment Page

Doctors can update the appointment after they completed it and change its status to completed. The way the update appointment feature is explained in the edit patient and edit doctor part, it is using the exact same technique. This feature is key to ensuring the appointment module works, otherwise, the appointment will forever be showing that it is in pending status.

5.4.12 Records List Page

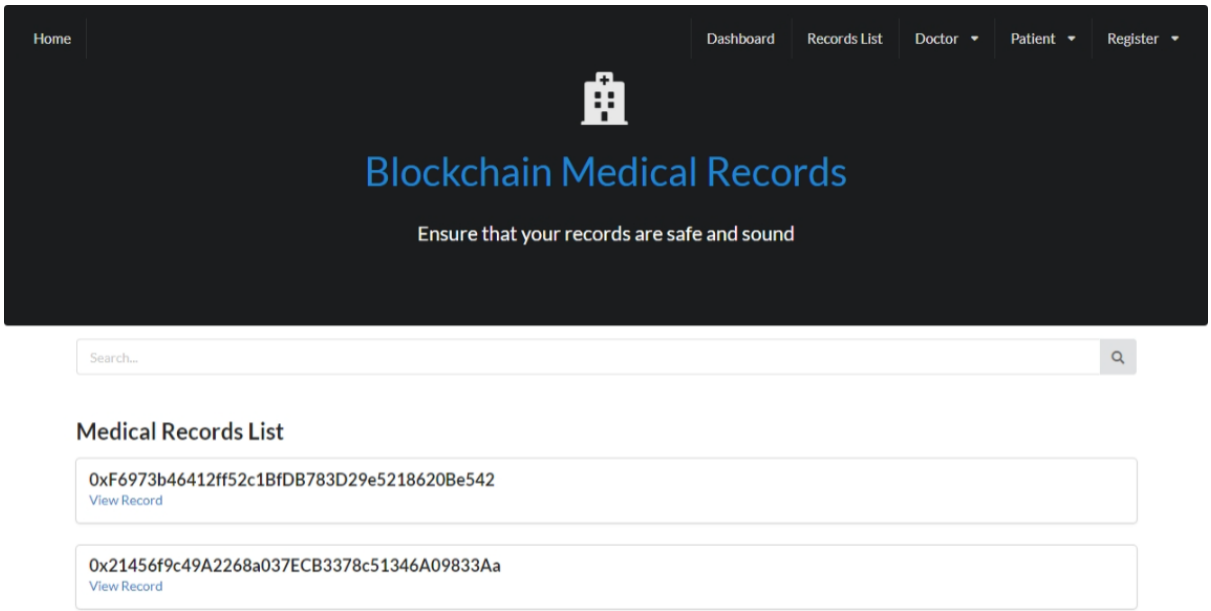


Figure 5.20: Medical Records List Page

Users can view a list of medical records that are created. In addition, users can click on view record to view details of the medical record. However, if users are not authorized to view the record, they will receive a message saying, 'You don't have permission to view this account.' If the user is authorized, the user can proceed to view the medical record detail page. In addition, the search bar above the text 'Medical Records List' can be used to search for specific addresses. Users can type their own Metamask address or another user's address to view their medical record details.

5.4.13 Dashboard Page

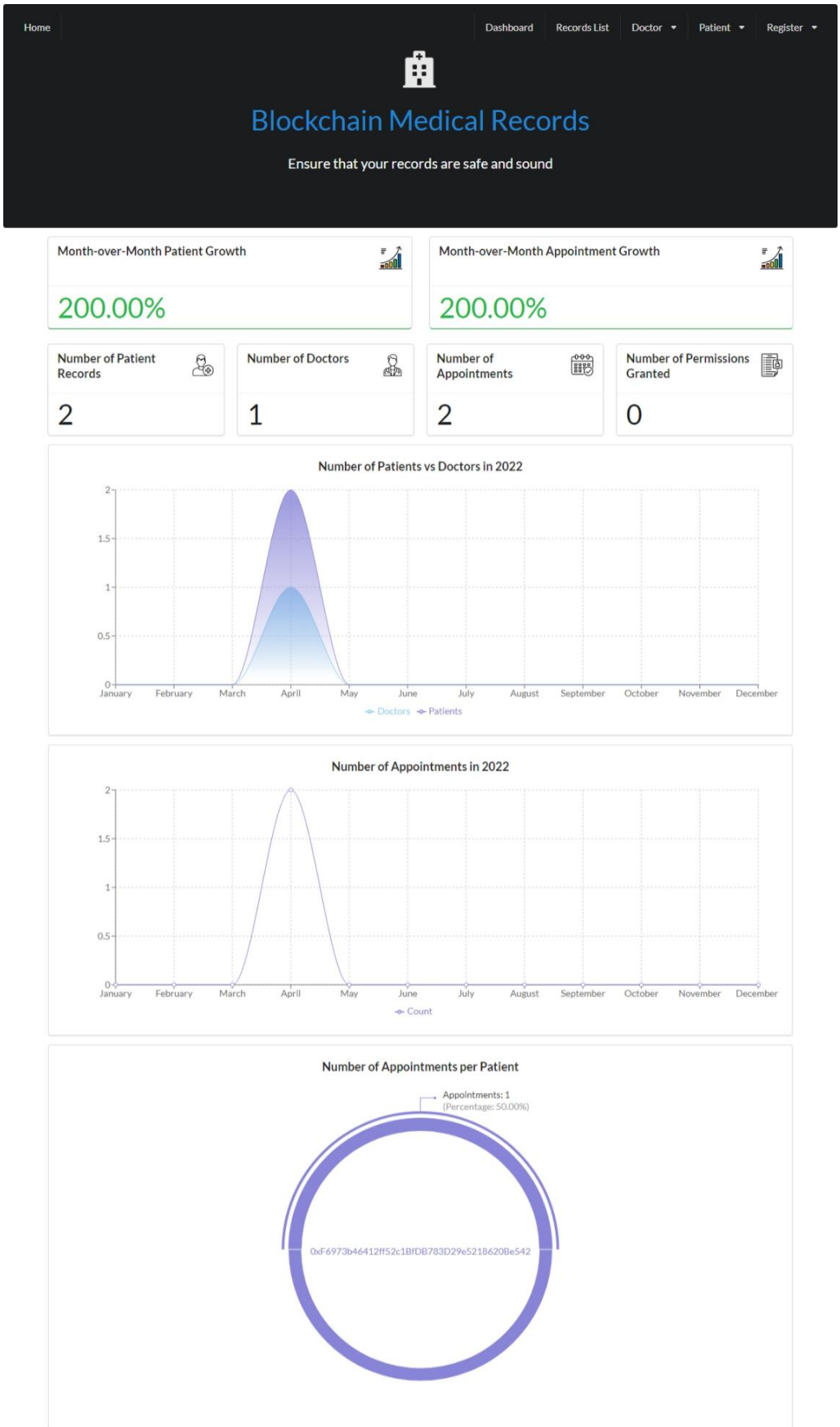


Figure 5.21: Dashboard Page

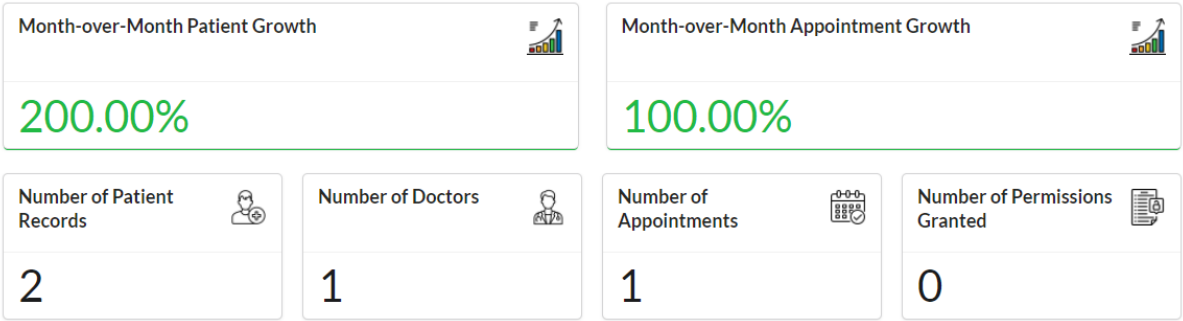


Figure 5.22: Growth numbers and insightful statistics

The dashboard will be broken down into each individual components and explained separately. All of the data on this dashboard page are retrieved from the blockchain and created into key metrics and visualizations which is much easier to consume and understand. The highlights of the statistics would be the two growth numbers. Month-over-month growth numbers is an important indicator of whether the hospital can make a profit this month according to the number of patients that have registered through the system and also the number of appointments made this month. The growth numbers flash red when the growth is 0% or a negative value. This indicates that the previous month has a higher patient or appointment number than this month. The rest of the statistics provide an insight as to in total how many patients, doctors and appointments have been made.

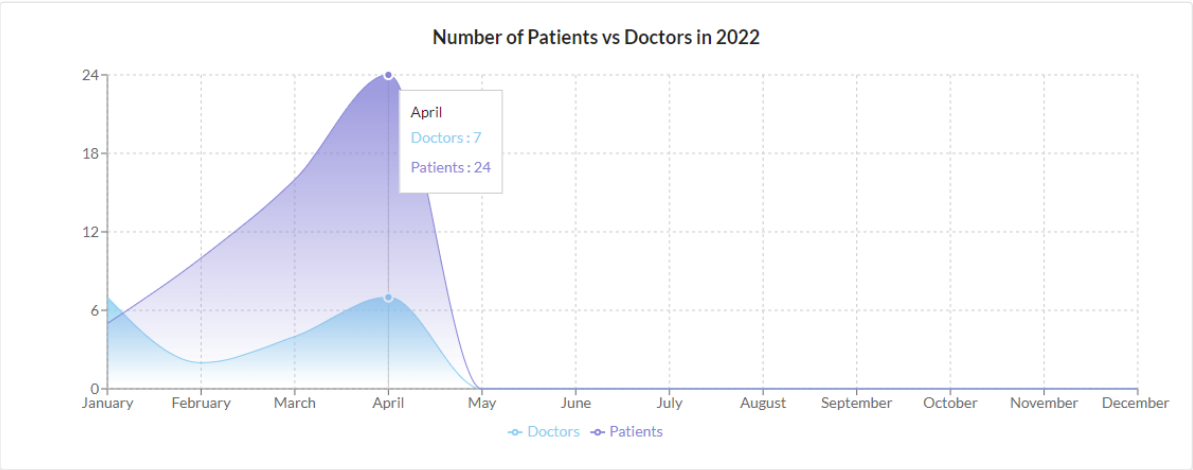


Figure 5.23: Number of Patients vs Doctors in 2022

This visualization indicates the number of patients vs doctors in the entire year. From this area chart, we can view the entire trajectory of patients and doctor acquisition for the year 2022. This can help the hospital employed data analyst to analyse the month's where performance has been declining and find out the reason why growth has been declining for that month. This visualization is very important for the hospitals to understand the user growth per month, which can help ensure that the hospitals are profitable and could upgrade their facilities and services to give a better experience to patients.

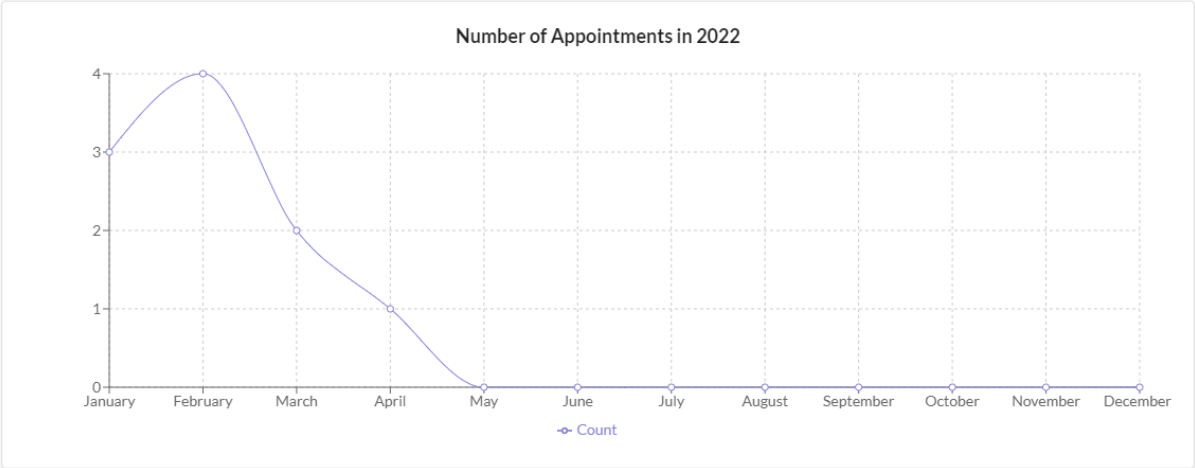


Figure 5.24: Number of Appointments in 2022

This visualization indicates the number of appointments made in the entire year. From this line chart, we can view the entire trajectory of appointments made for the year 2022. This can help the hospital employed data analyst to analyse the month's where number of appointments have been declining and explore reasons as to why this is happening. This visualization is a good complement to the Month-over-Month Appointment growth metric as the metric only shows the growth percentage, we can then identify exactly how much has the appointments count drop or rise through this graph.

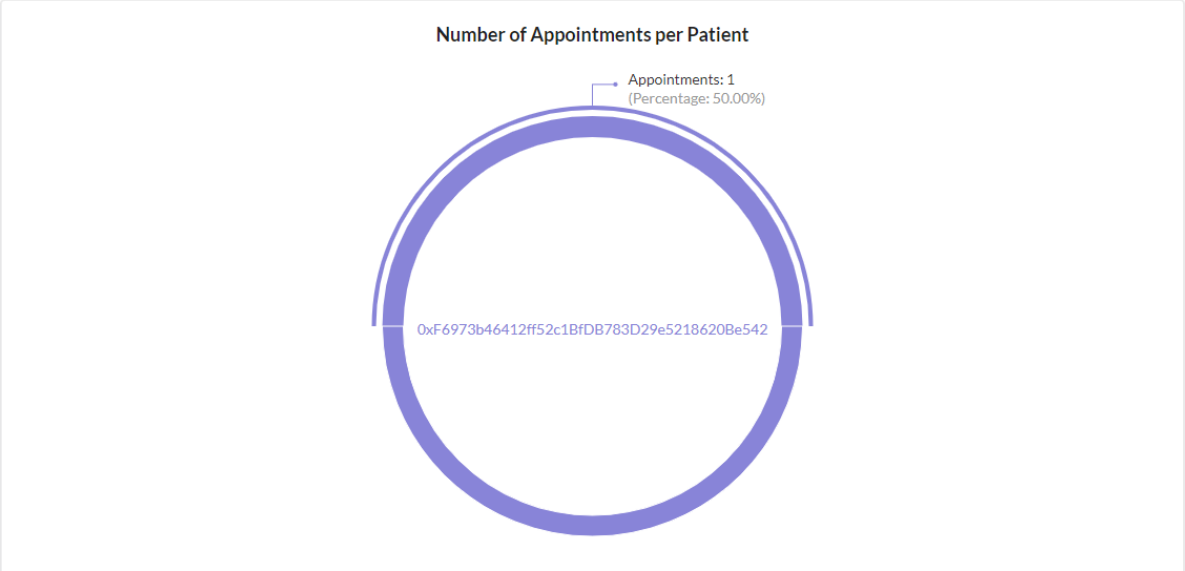


Figure 5.25: Number of Appointments per Patient

This visualization indicates the number of appointments made per patient in total. Through this interactive pie chart, we can view the distribution of each patient's appointment count. This can be a useful visualization when the c suite of the hospital wants to know which are the patients that made the most number of appointments, and how many appointments has that patient made. Notice that it only displays the patient's address in the centre of the pie chart, as this is to ensure that the privacy of the patient is withheld while providing insightful visualizations to the hospital management.

5.5 Concluding Remark

All of the modules that have been suggested in the project scope have been achieved through this system as can be seen from the previous section. Throughout the system, the privacy of patients has been kept as much as possible. This ensures the safety and privacy of the patients and also avoids privacy breach issues. User interface and user experience is also designed to be simple and very forgiving, which ensures that patients and doctors can use the system without a second thought and be able to navigate through the system easily. This will then improve the delivery of effective healthcare which was also one of the objectives of the system. Overall, all modules are implemented successfully and are able to run without issues.

Chapter 6: System Evaluation and Discussion

6.1 Testing Setup and Result

test > Record.test.js > describe('Records') callback > it('can create appointment using doctor account') callback

```
1  const assert = require('assert');
2  const ganache = require('ganache-cli');
3  const Web3 = require('web3');
4  const web3 = new Web3(ganache.provider());
5
6  const compiledRecord = require('../ethereum/build/Record.json');
7
8  let accounts;
9  let record;
10
11 beforeEach(async () => {
12     accounts = await web3.eth.getAccounts();
13
14     record = await new web3.eth.Contract(JSON.parse(compiledRecord.interface))
15         .deploy({ data: compiledRecord.bytecode })
16         .send({ from: accounts[0], gas: '5000000' });
17 });
18
19 describe('Records', () => {
20     it('can deploy record contract', () => {
21         assert.ok(record.options.address);
22     });
23
24     it('can add record', async () => {
25         await record.methods.setDetails(
26             '001107020345', 'John', '0123456789', 'Male', '07/22/2222','183', '75', '1234,
27         ).send({ from: accounts[0], gas: '5000000' });
28     });
29
30     it('can retrieve all record address', async () => {
31         await record.methods.setDetails(
32             '001107020345', 'John', '0123456789', 'Male', '07/22/2222','183', '75', '1234,
33         ).send({ from: accounts[0], gas: '5000000' });
34
35         const allRecords = await record.methods.getPatients().call();
36
37         const owner = await record.methods.owner().call();
38
39         assert.equal(allRecords, owner);
```

Figure 6.1: Mocha Test Scripts utilizing Ganache Blockchain

This is the second time where testing occurs. The first test is through Remix, where initial tests are done to find and fix minor bugs. The second test, which uses Mocha and the Ganache Blockchain, simulates the real blockchain environment. Any minuscule errors or edge cases can be tested before the actual deployment to the real network. Testing is done twice because errors in blockchain applications will result in real user funds getting stolen or lost due to an error in the code. This scenario should be avoided at all costs. Therefore, rigorous testing should be done before deploying to the actual blockchain.

```
Records
  √ can deploy record contract
  √ can add record (969ms)
  √ can retrieve all record address (1126ms)
  √ can search for a patient (1142ms)
  √ can create patient using multiple accounts (1871ms)
  √ can create appointment using doctor account (2370ms)
  √ can count number of records created by patient (1071ms)


7 passing (10s)
```

Figure 6.2: Mocha Test Results

These are the results of the mocha test after running the code 'npm run test' which runs the mocha test script. After running the test script, it will execute each test in the test script one by one starting from 'can deploy record contract'. The ticks indicate that the tests are running without any issues. The red bracket indicates the time needed to execute each test. If a test does not pass, it will prompt an error and continue to execute the remaining tests. At the end of each test case, an assert equal statement is used to test that the results that have been outputted will be equal to our expected value. Since we can see that all of the tests are passing, we can then safely assume that our code is running on the Ganache Blockchain without any issues.

6.2 Project Challenges

As Blockchain technology and Smart contracts are still very nascent, the tools and technologies used to develop Blockchain applications are constantly being improved and redesigned. Unfortunately, this makes it extremely tedious to keep up to date on the latest development trends in creating these applications. Not only that, but some technologies might have deprecated code and features, which makes it even more of a hassle as when this happens, the version has to be updated to the latest. Otherwise, the code will be removed. Furthermore, to update to the latest version, the entire code, including the smart contract written in Solidity, the front-end code in React, and many other parts, must be changed to accommodate some new changes. Hence, blockchain app development in such an early phase of the technology is really challenging.

Another technical issue faced during the development of blockchain applications is that the documentations are not user-friendly. The full stack blockchain application development process is not very well documented. Developers who want to debug specific issues they face while using the technology have no choice but to try their best to understand the documentation. If this does not resolve the issues, developers can always go to StackOverflow to look for answers. However, given that this technology is still in its early phase, few developers can help answer these questions. Hence, many questions are left unanswered, and the people facing these problems may give up and scrap their projects.

6.3 Objectives Evaluation

There were in total four objectives that were stated at the previous sections and throughout the implementation of the system, I ensured that the objectives were met by designing the system to meet the objectives as closely as possible. The objectives serve as a mental guidance for the implementation of the system and some sort of benchmark to evaluate the success of the system. Therefore, we will be looking into each of the objectives and discuss whether these objectives are met.

For the first objective, I aim to create a blockchain medical record system that greatly improves the delivery of effective healthcare. This objective is successfully achieved through the implementation of a blockchain medical record system that is interoperable between multiple different hospitals all across the country. This system easily accommodates the massive scale of medical records that is needed to be stored and can easily ensure that server or storage space issues are a thing of the past. This will ensure that hospitals can focus more on improving the quality of healthcare. Not only that, by implementing an easy-to-use create new medical record feature that will allow patients to store their own medical records through the blockchain medical record system, medical personnel can spend more time and effort on delivering higher quality healthcare services instead of working on inputting patient records manually, which may even result in human error.

For the second objective, I strive to develop a decentralized application that will reduce the risk of privacy breach by allowing users to take complete control of their medical records. By ensuring privacy is the main priority throughout the development of the system, I created features that will not put the privacy of patients and doctors through unnecessary risk. For example, patients name and details are never shown anywhere, including at the medical records list and the dashboard, only when patient authorize access to the doctor can the doctor view their medical records. Hence, patients own full control of their own medical records and are free to act on their own accord. This completely eliminates the risk of privacy breaches as hospitals would not be the owner of our medical records and do whatever they want with the rights over our records.

For the third objective, I aim to make enhancement on the user interface and user experience(UI & UX) which will indirectly reduce the time and effort needed to enter or update patient records. I closely followed user interface design principles when designing the front end of the system as I know the importance of a good UI and UX experience can ensure that users will never get lost navigating the system and it will improve the efficacy of the system. Examples of these UI and UX improvements include creating prompt error messages, edit feature for any form, easy to navigate menu bar and many others. The edit feature was actually impossible with Blockchain systems as Blockchain at its core is immutable in nature, but through some clever code in the smart contract, I managed to allow users to seem as though they have changed their existing records that are stored in the blockchain. However, the data that was stored in the blockchain was not removed nor changed fundamentally. Instead, it was in a way overwritten. This feature will prove extremely useful and accomplishes the objective of making the user interface much more user-friendly to improve the user experience, which improves the efficiency of the healthcare service they will be receiving.

For the final objective, I am to evaluate the effectiveness of using blockchain technology and smart contracts on improving the security of electronic medical records and preventing a central point of failure. By utilizing the core security features blockchain like decentralization, immutability and interoperability, any system that is built on the blockchain will automatically gain these features which makes a blockchain system to be not only efficient but also extremely secure.

6.4 User Evaluation Survey

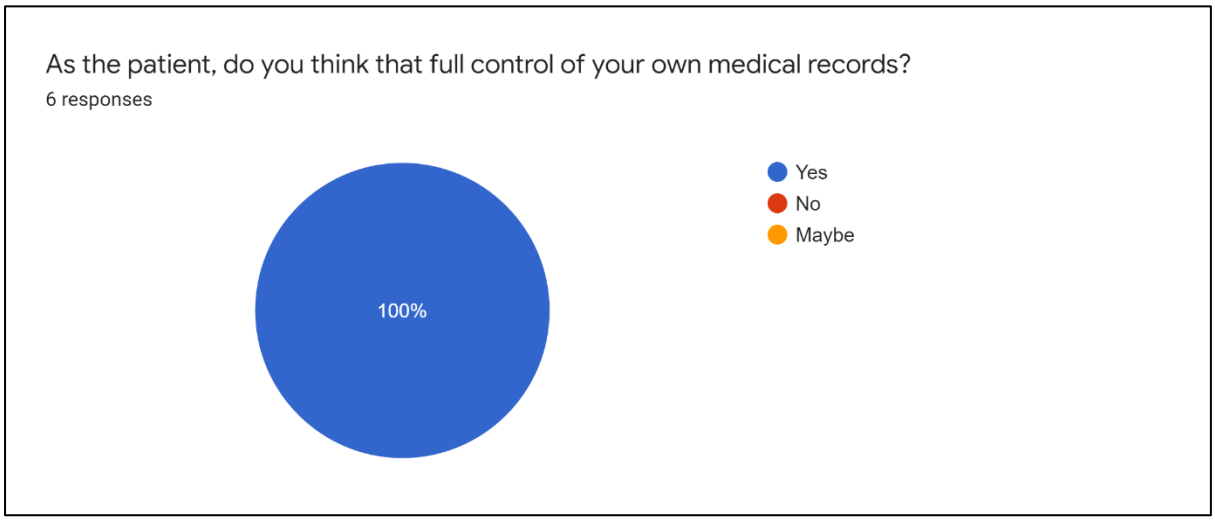


Figure 6.3: Question 1

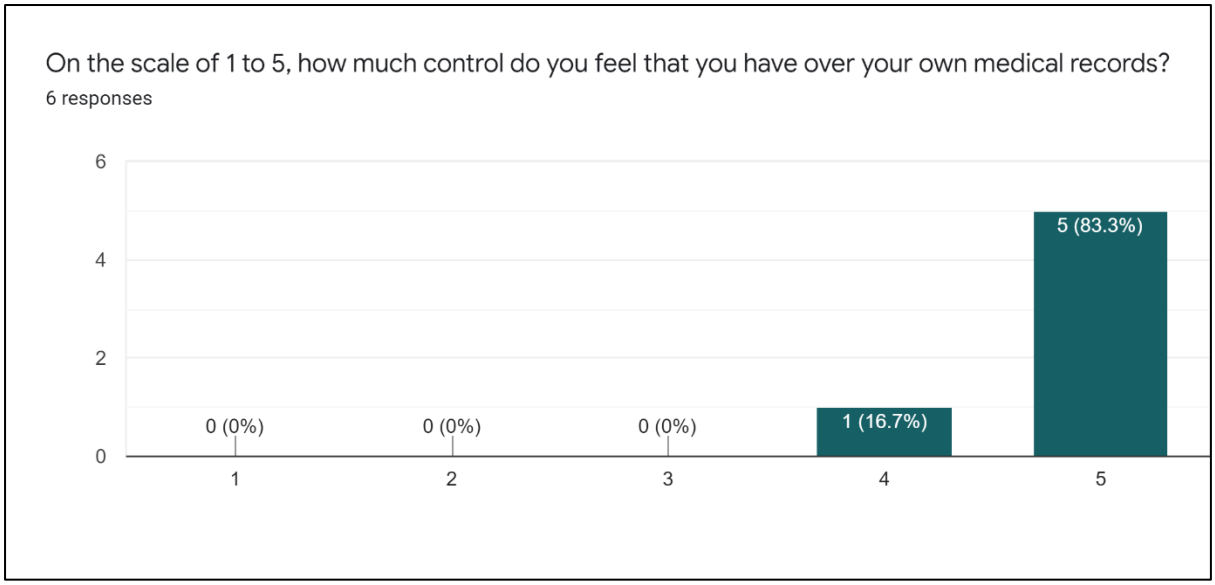


Figure 6.4: Question 2

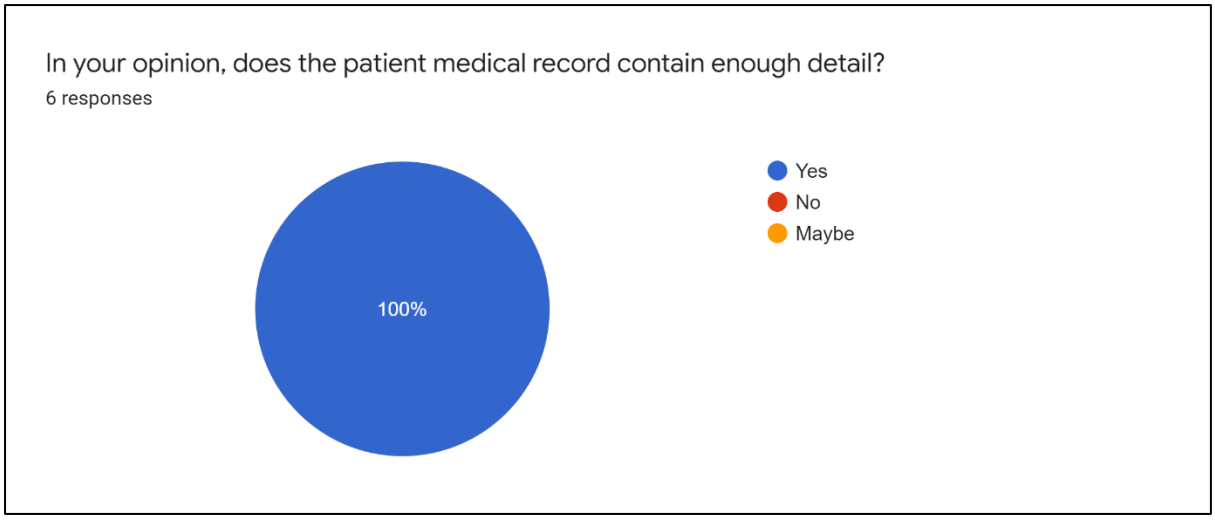


Figure 6.5: Question 3

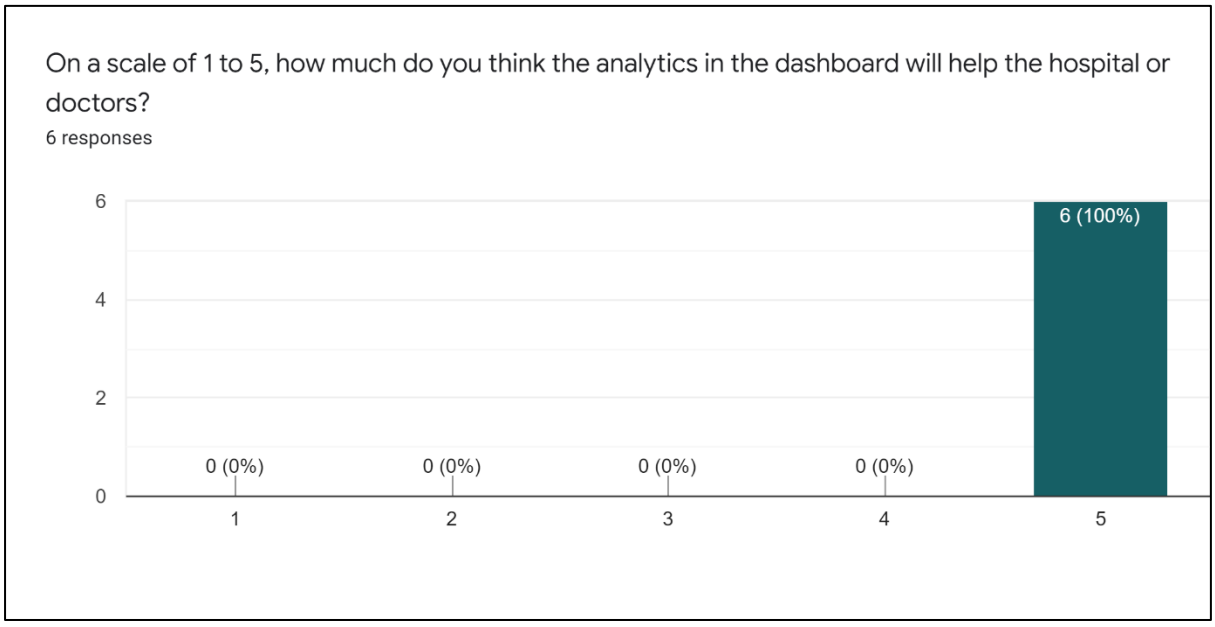


Figure 6.6: Question 4

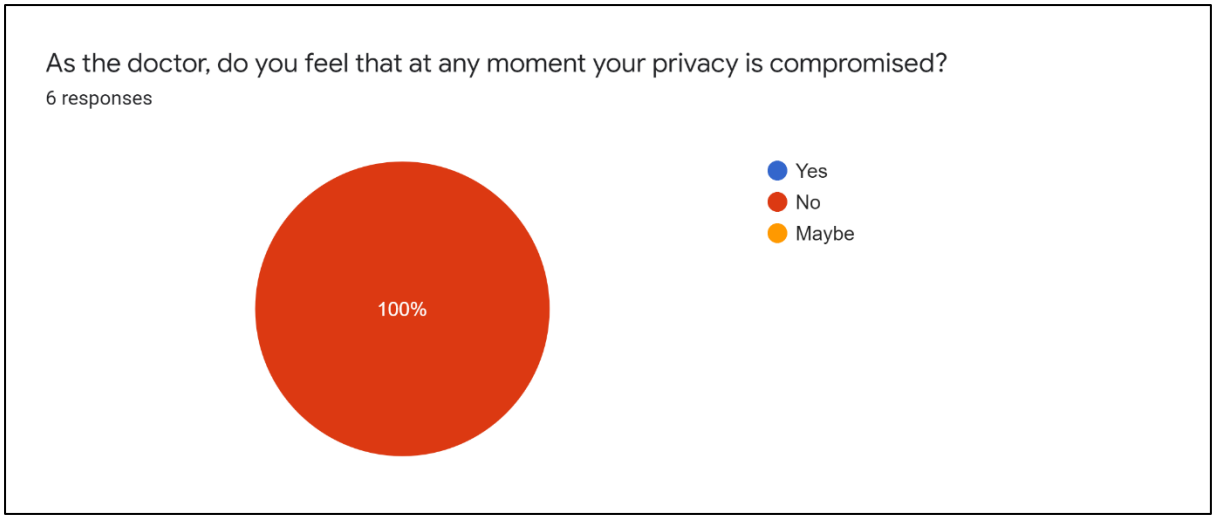


Figure 6.7: Question 5

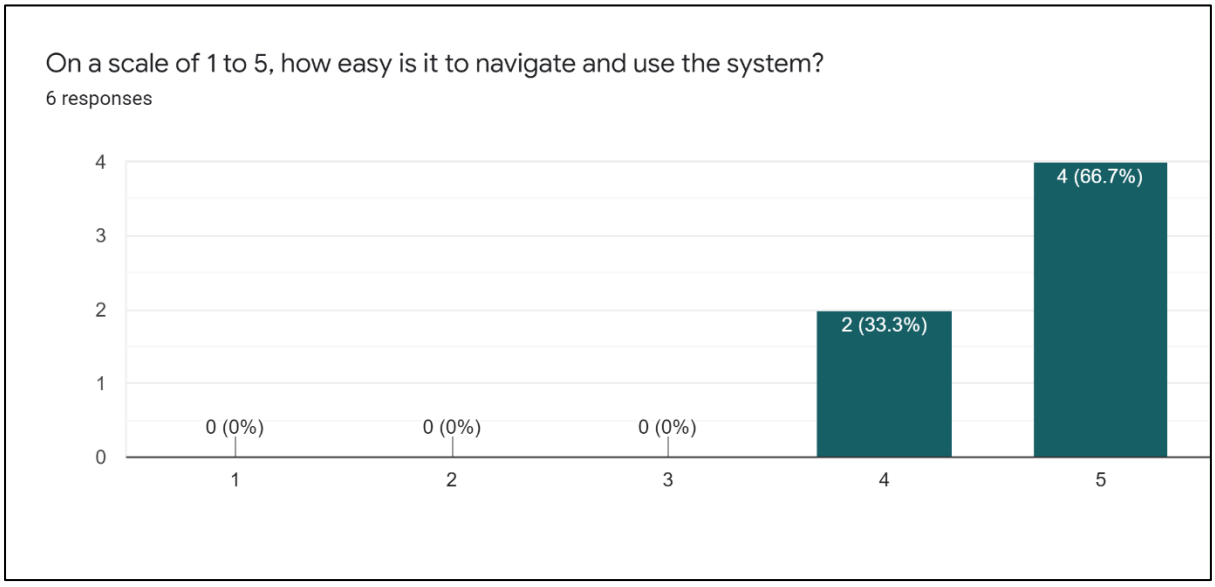


Figure 6.8: Question 6

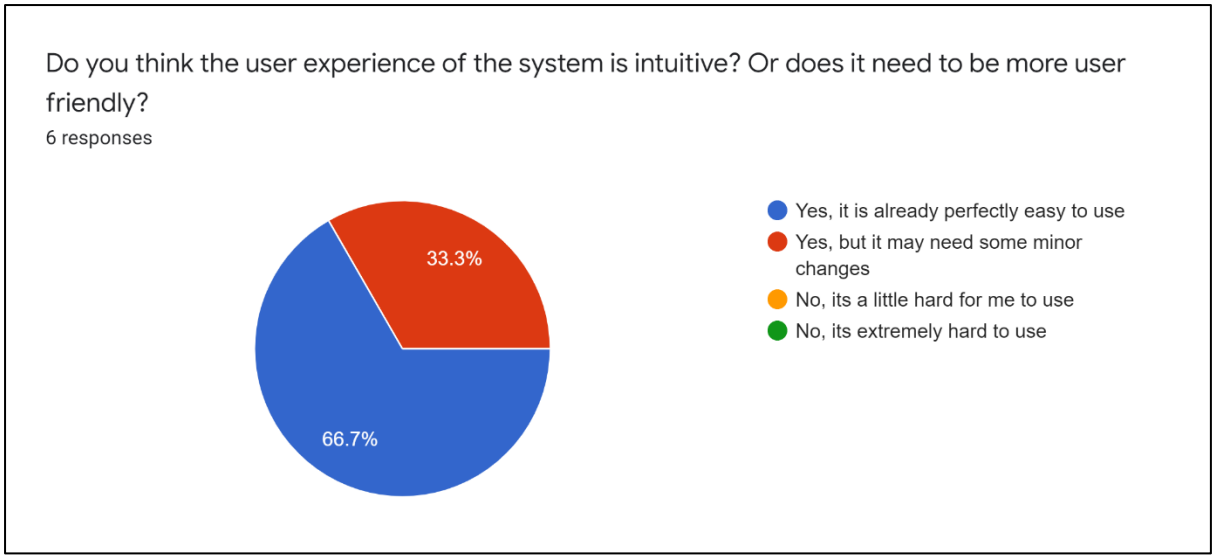


Figure 6.9: Question 7

The user evaluation survey serves the purpose of finding out whether the system achieves the goals and objectives that I have set out for this project. Upon evaluating the response of the survey, it seems that all of the users are satisfied with the system in general. Through this user evaluation process, we can conclude that upon trying out the system, users are satisfied with the system which may indicate that a blockchain medical record system would truly be possible and should be researched upon further in the hopes of reaching full implementation to the regular consumers in the future.

Chapter 7: Conclusion and Recommendation

7.1 Conclusion

With the ever-growing importance of the healthcare industry, crucial to weather through the pandemic storm, medical records systems can be seen as an essential part of healthcare. However, medical record system technology has been stagnant for many years and has caused numerous issues to hospitals, doctors, nurses, and patients. Blockchain technology and Smart Contracts should be the best solution to resolve this issue and improve the reliability and security of medical record systems.

Not only that, but from the stated problem statement, we can see that there is much more evidence that states that the current medical record system is inefficient and has many faults. Therefore, for a country to have a successful healthcare system, the medical record system, which is the backbone of healthcare, should be solved and implemented by creating blockchain medical record systems.

Through this project, the blockchain medical record system developed in this project has further reinforced the point that blockchain technologies and smart contracts are the right step forward for medical record systems. Each problem stated in the problem statement is solved through the blockchain medical record system that was implemented. Furthermore, each project objective has been successfully achieved through the blockchain medical record system developed in this project. Therefore, every feature stated in the project scope serves a key role in solving the problems encountered when using the medical record systems that are widely used today.

However, we should not ignore the challenges faced in implementing blockchain systems in general. As Blockchain technology and Smart contracts are still in their early phases, the tools and technologies used to develop Blockchain applications are constantly being updated and redesigned on a weekly basis by the Ethereum core development team. This makes

it extremely difficult to keep up to date on the latest development trends in creating these applications. Unfortunately, some updates may even incur massive changes, and it may take many hours or days to restructure the entire system code to accommodate the new changes.

Not only that, but the documentation for blockchain application development is not user-friendly and are made for advanced developers that have years of experience. The full-stack blockchain application development process is not very well documented since this technology is incredibly new. Developers who want to debug specific issues they face while using the technology have no choice but to try their best to understand the documentation. If this does not resolve the issues, developers can always go to online coding forums to find answers. However, given that this technology is still in its early phase, few developers can help answer these questions. Hence, many questions are left unanswered, and the people facing these problems may give up and scrap their projects.

In summary, the disadvantages of blockchain technologies and smart contracts pale in comparison with the vast array of advantages these technologies bring. The advantages greatly outweigh the disadvantages, as has been proven throughout this project. Nevertheless, blockchain technologies represent a new way for medical record systems to ensure interoperability without compromising security while also ensuring the data is decentralized and cannot be taken advantage of by third parties. This is an unprecedented change from what current medical record systems provide, and blockchain medical record systems could become a new norm for medical record systems in the future. Finally, healthcare service quality and the population's life expectancy may also greatly increase from the mass adoption of blockchain medical record systems, which will bring all of the advantages mentioned throughout this report.

7.2 Recommendation

The blockchain medical record system that is currently created can still be improved into a more full-fledged medical record system which includes tele-doctor feature, e-appointment feature and so on. As Blockchain technology is still fairly new, I had many limitations in implementing this system but in the future, there may be more updates and improvements made to the technology which makes it much easier to use and setup. The front-end design of the system could still be further improved as the package I had to work with for the development of the front end is powerful yet easy to use but there were no readily available templates for me to use. Hence, the somewhat simpler looking design.

Furthermore, new features like adding images or documents to the system would be a wonderful addition as well. Currently, the technology is still pretty limited and only IPFS which stands for Interplanetary file system is available to implement this feature, but due to time constraints for this project, I had to drop this feature entirely. Finally, a payment module would also be a good addition to the system, but it requires thorough planning as there are many moving parts in a payment system including recording receipts, setting the prices of each medication and appointment, insurance claims and etc. Payments can get very messy in online systems which is why services like Stripe which offers online payment processing API that makes it easy for developers to add a payment feature into any web application. For blockchain systems, there are no such services, which is why implementation can be a bit tricky.

References

[1] "How to build an electronic medical record secured by Blockchain?," *DevTeam.Space*, 29-Nov-2021. [Online]. Available: https://www.devteam.space/blog/how-to-build-an-electronic-medical-record-secured-by-blockchain/. [Accessed: 01-Apr-2022].

[2] "Role of ministry of health in Malaysia," *Bartleby*. [Online]. Available: https://www.bartleby.com/essay/Role-of-Ministry-of-Health-in-Malaysia-FK8HDNZ8JKDW#:~:text=The%20Ministry%20of%20Health%27s%20role,regulations%20and%20be%20the%20regulator. [Accessed: 01-Apr-2022].

[3] L. Mearian, "FAQ: What is Blockchain and how can it help business?," *CSO Online*, 24-Apr-2017. [Online]. Available: https://www.csoonline.com/article/3191619/faq-what-is-blockchain-and-how-can-it-help-business.html. [Accessed: 01-Apr-2022].

[4] B. Siwicki, "Chime Drops National Patient ID Challenge," *Healthcare IT News*, 16-Nov-2017. [Online]. Available: https://www.healthcareitnews.com/news/chime-drops-national-patient-id-challenge. [Accessed: 01-Apr-2022].

[5] "Enhanced patient matching is critical to achieving full ...," *PEW*. [Online]. Available: https://www.pewtrusts.org/-/media/assets/2018/09/healthit_enhancedpatientmatching_report_final.pdf. [Accessed: 01-Apr-2022].

[6] T. Walker, "Why mismatched patient records are a problem," *Managed Healthcare Executive*, 12-Nov-2020. [Online]. Available: https://www.managedhealthcareexecutive.com/view/why-mismatched-patient-records-are-problem. [Accessed: 01-Apr-2022].

[7] N. Jamshed, F. F. Ozair, A. Sharma, and P. Aggarwal, "Ethical issues in electronic health records: A general overview," *Perspectives in Clinical Research*, vol. 6, no. 2, p. 73, 2015.

[8] S. Habibu, “Health Ministry investigating leak of Patient Records,” *The Star*, 19-Sep-2019. [Online]. Available: https://www.thestar.com.my/news/nation/2019/09/19/health-ministry-investigating-leak-of-patient-records. [Accessed: 01-Apr-2022].

[9] R. G. Hill, L. M. Sears, and S. W. Melanson, “4000 clicks: A productivity analysis of electronic medical records in a Community Hospital Ed,” *The American Journal of Emergency Medicine*, vol. 31, no. 11, pp. 1591–1594, 2013.

[10] N. Brown, “Driving EMR adoption: making EMRs a sustainable, profitable investment.,” *Health management technology*, pp. 47–48, May 2005.

[11] C. Quantin, D.-O. Jaquet-Chiffelle, G. Coatrieux, E. Benzenine, B. Auverlot, and F.-A. Allaert, “Medical record: Systematic centralization versus secure on demand aggregation,” *BMC Medical Informatics and Decision Making*, vol. 11, no. 1, 2011.

[12] K. Zheng, D. A. Hanauer, R. Padman, M. P. Johnson, A. A. Hussain, W. Ye, X. Zhou, and H. S. Diamond, “Handling anticipated exceptions in clinical care: Investigating clinician use of ‘exit strategies’ in an electronic health records system,” *Journal of the American Medical Informatics Association*, vol. 18, no. 6, pp. 883–889, 2011.

[13] M. Staff, “Why data security is the biggest concern in healthcare,” *ClassAction.com*, 03-Dec-2020. [Online]. Available: https://www.classaction.com/news/data-security-in-healthcare/#:~:text=Your%20protected%20health%20information%20is,a%20hot%20commodity%20for%20hackers. [Accessed: 01-Apr-2022].

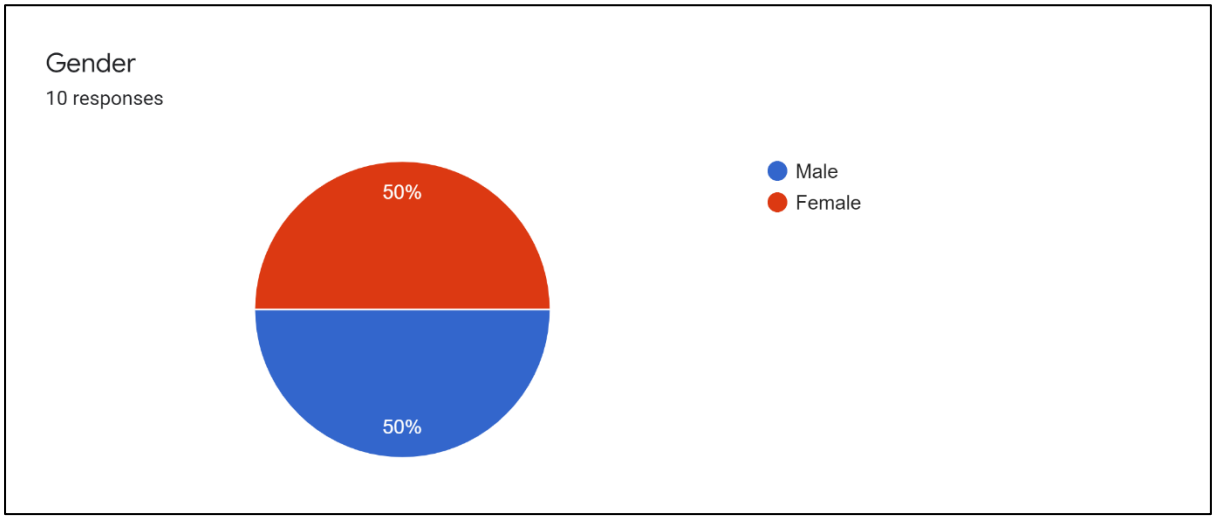
[14] S. Tanwar, K. Parekh, and R. Evans, “Blockchain-based Electronic Healthcare Record System for healthcare 4.0 applications,” *Journal of Information Security and Applications*, vol. 50, p. 102407, 2020.

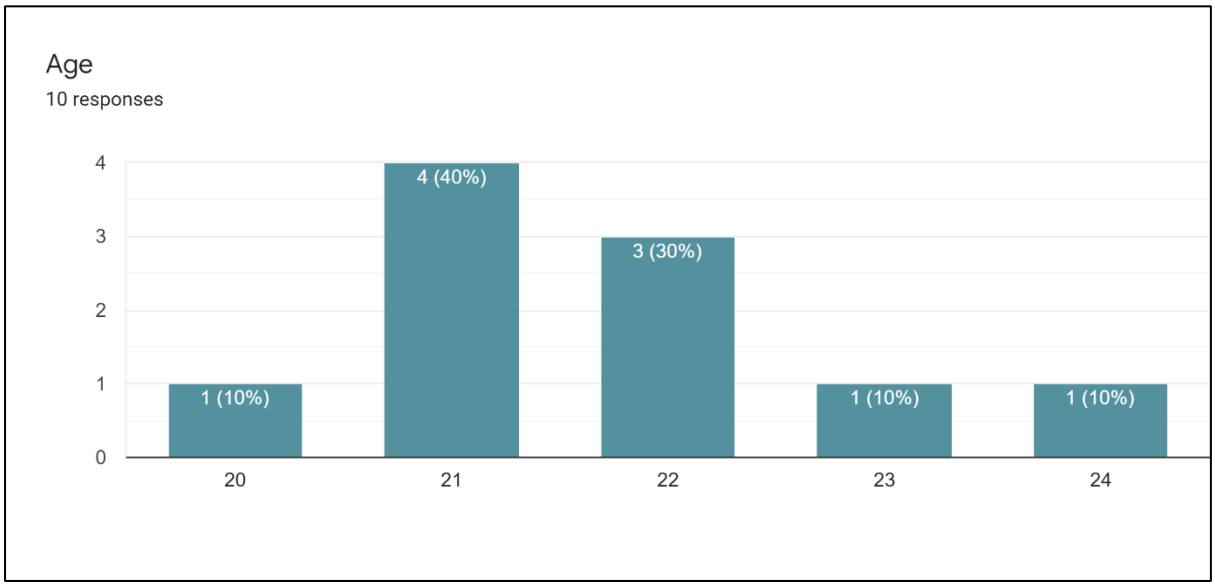
[15] “Ethereum Average Block Time Chart | Etherscan.” [Online]. Available: https://etherscan.io/chart/blocktime. [Accessed: 20-Apr-2022].

Appendix

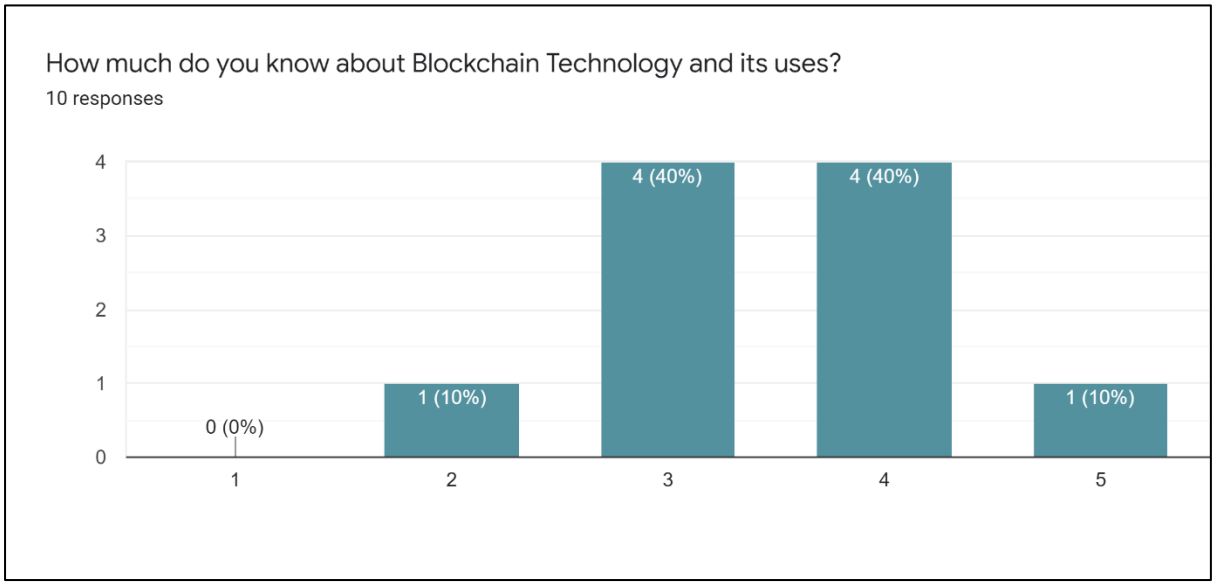
A.1 System Requirements Survey

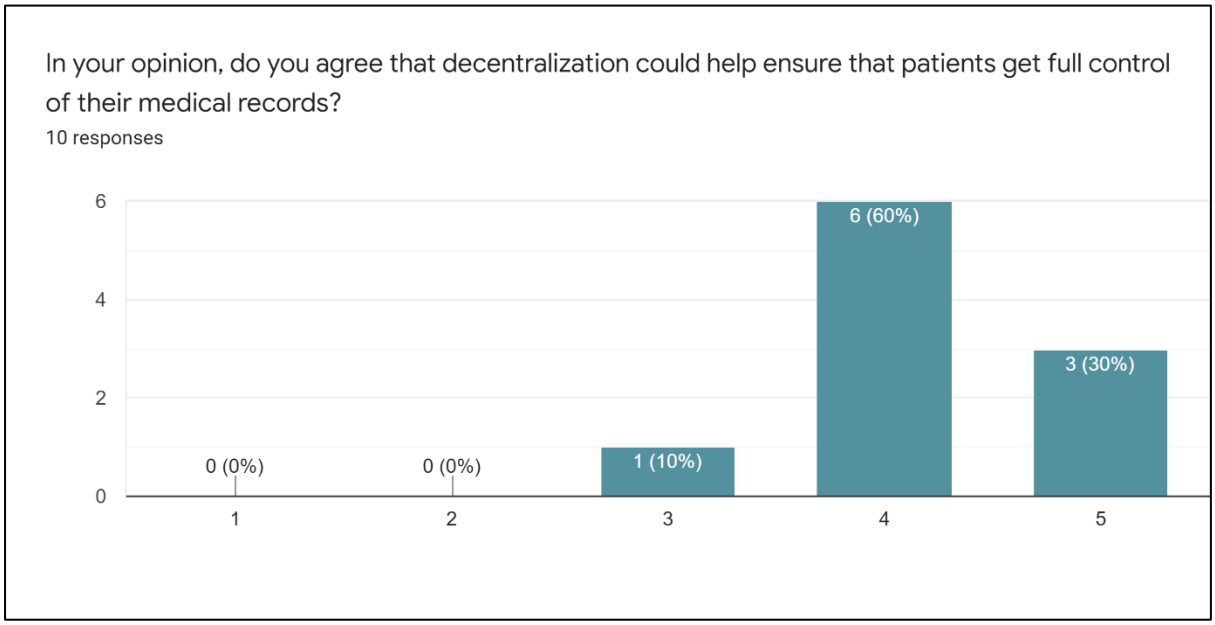
Demographics





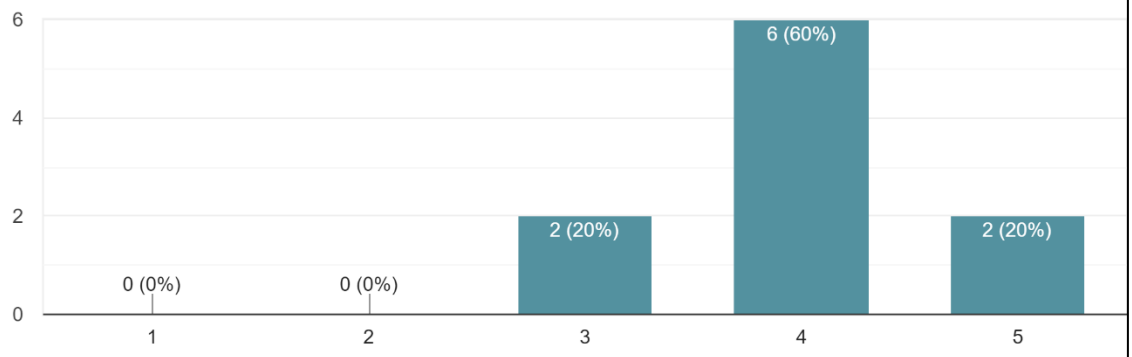
Blockchain Knowledge





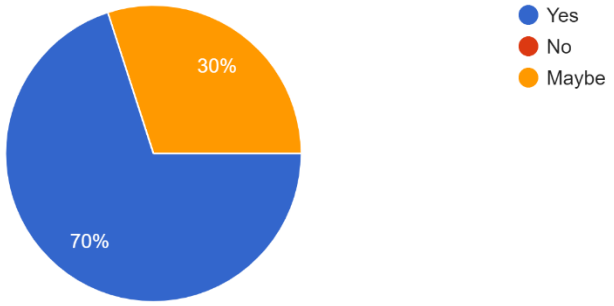
How much do you trust the security of Blockchain?

10 responses



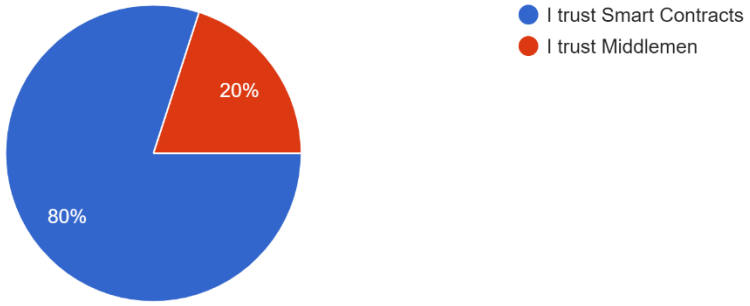
Do you know the impacts that Blockchain can bring towards our digital life?

10 responses

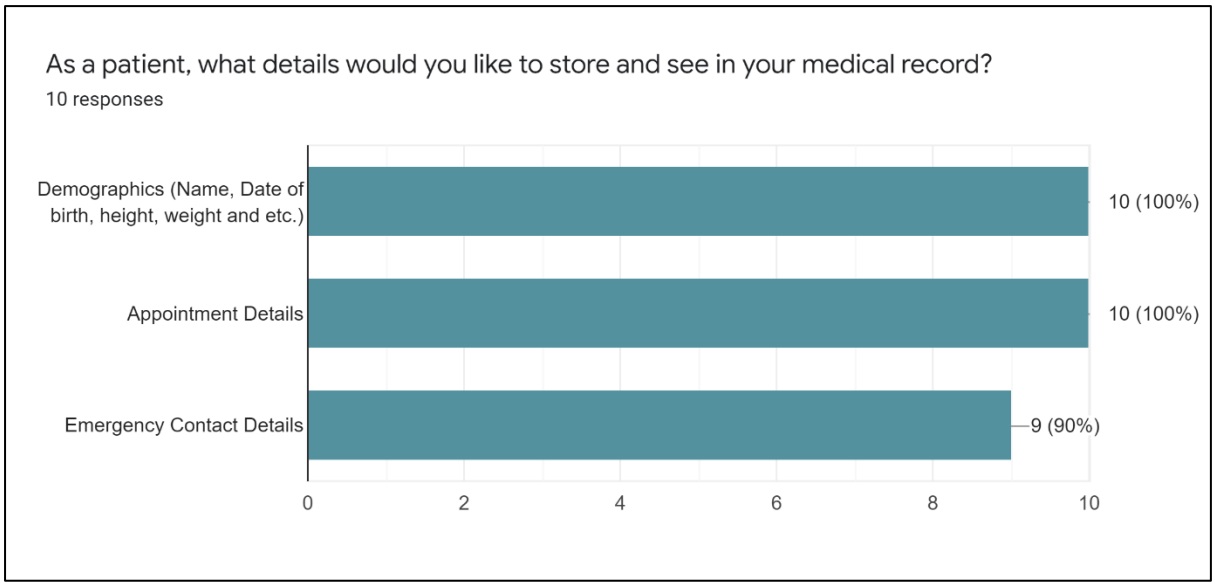


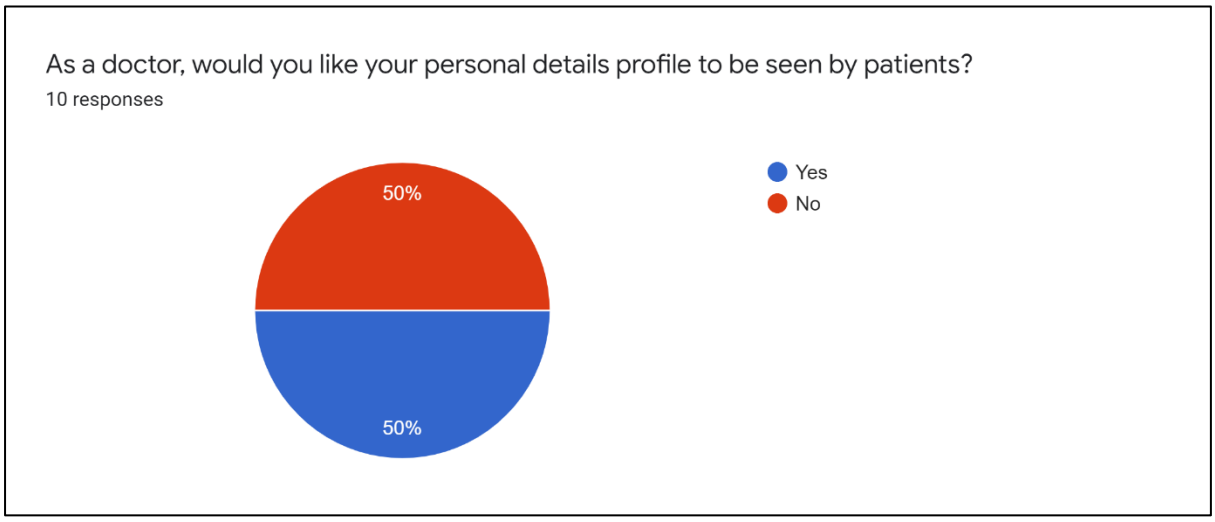
Do you put trust in Smart Contract or middlemen that profits off helping you complete certain processes?

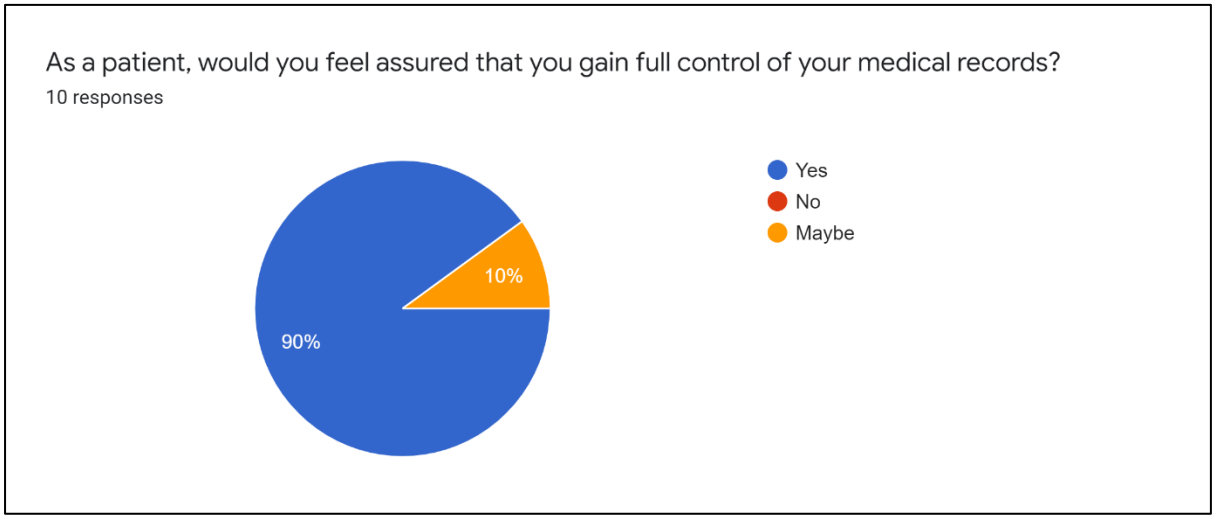
10 responses



System Requirements

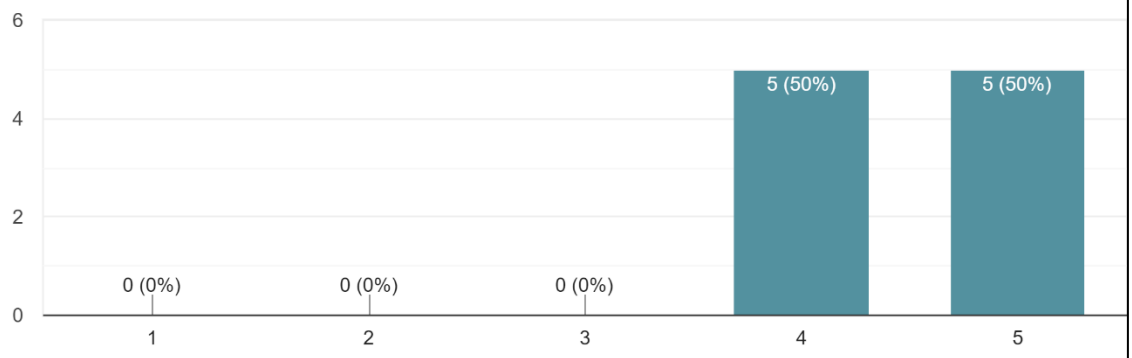






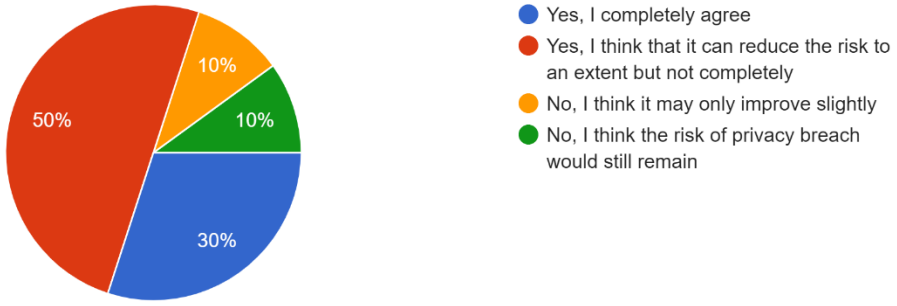
Do you think improvements in User Interface and User Experience (UI & UX) of the system will result in an improvement of the efficiency of healthcare services?

10 responses



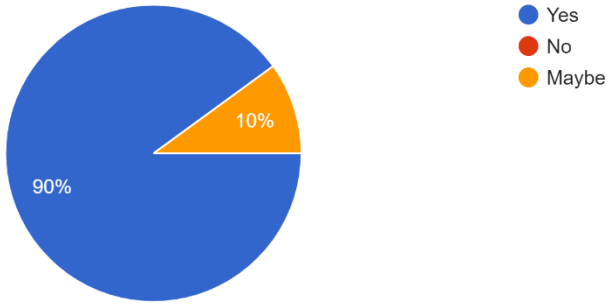
In your opinion, do you think that patients taking control of their own medical records can completely reduce the risk of leaked medical records?

10 responses



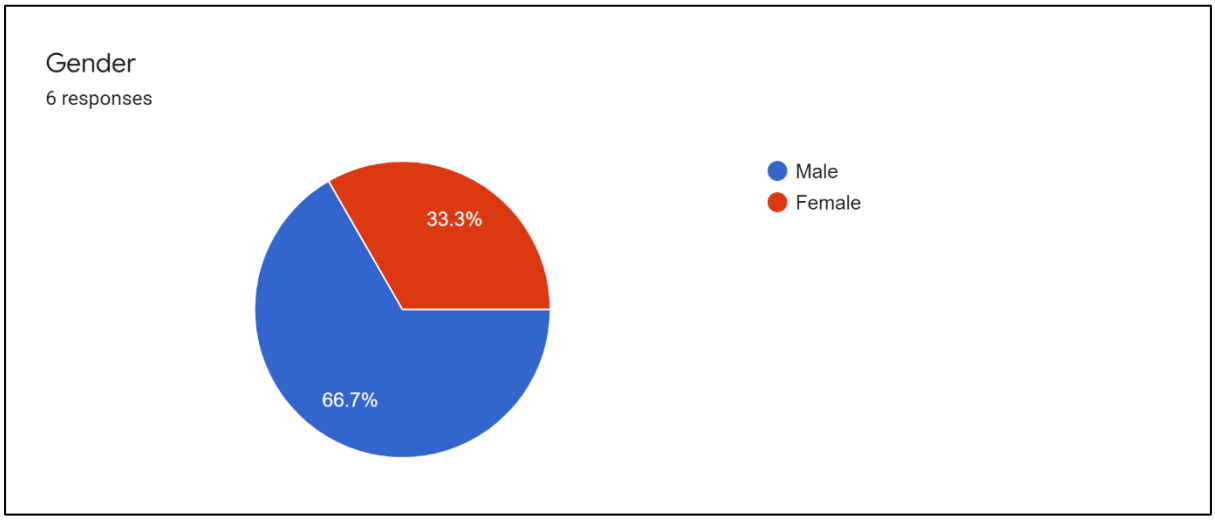
Do you think a dashboard that shows analytics and statistics that are retrieved from the blockchain would be helpful for the doctors and hospitals in understanding their business?

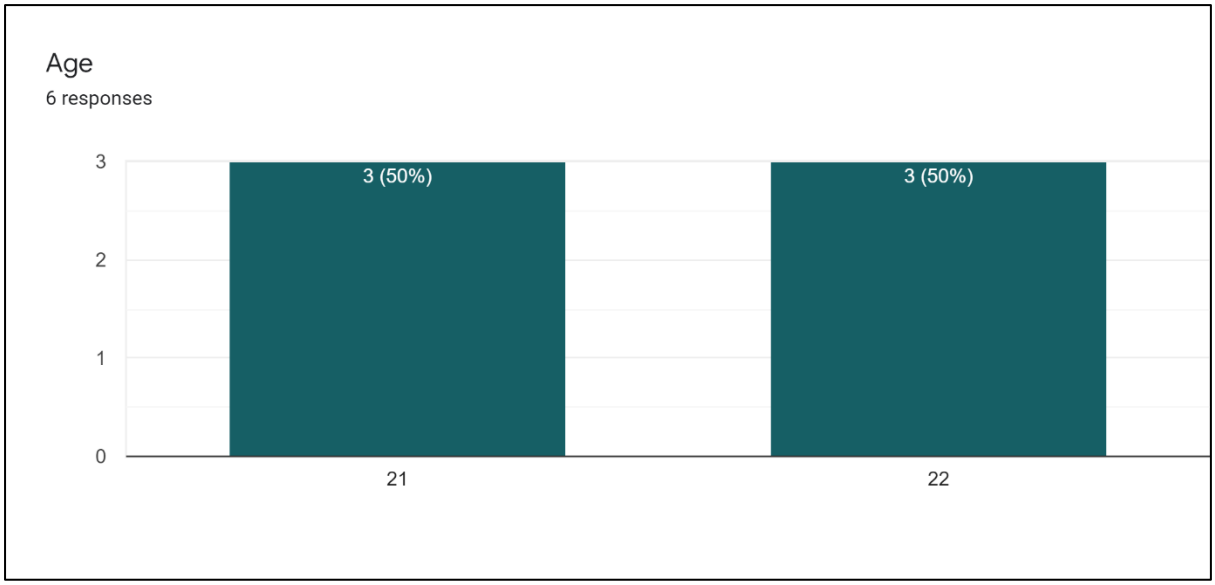
10 responses



A.2 User Evaluation Survey

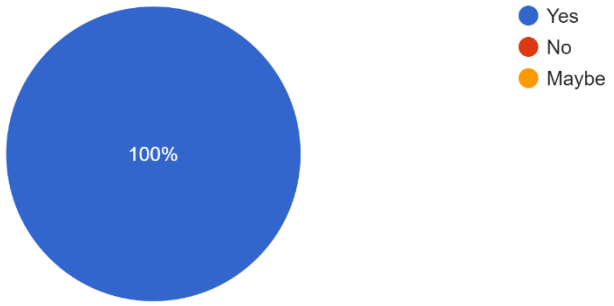
Demographics





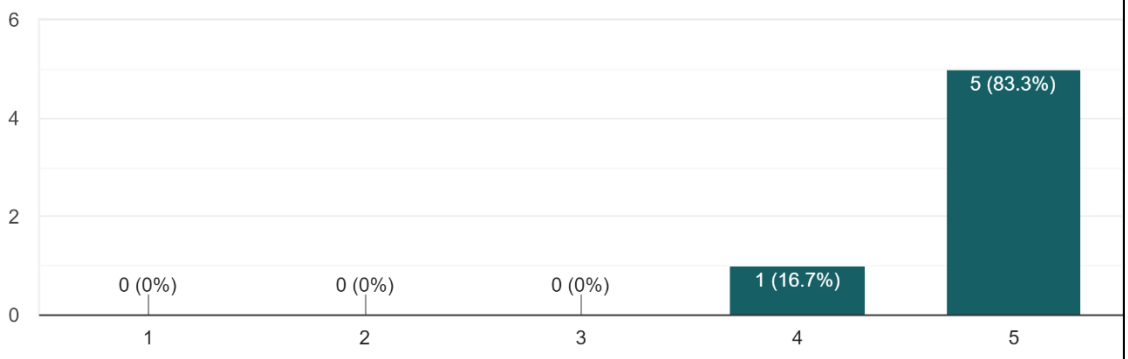
As the patient, do you think that full control of your own medical records?

6 responses



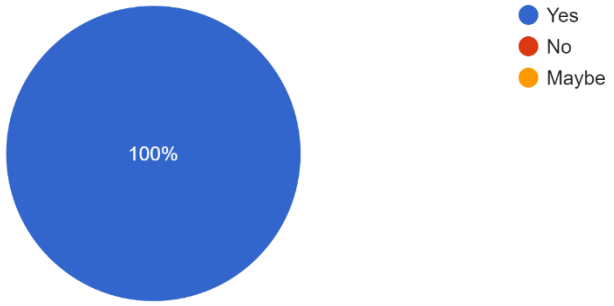
On the scale of 1 to 5, how much control do you feel that you have over your own medical records?

6 responses



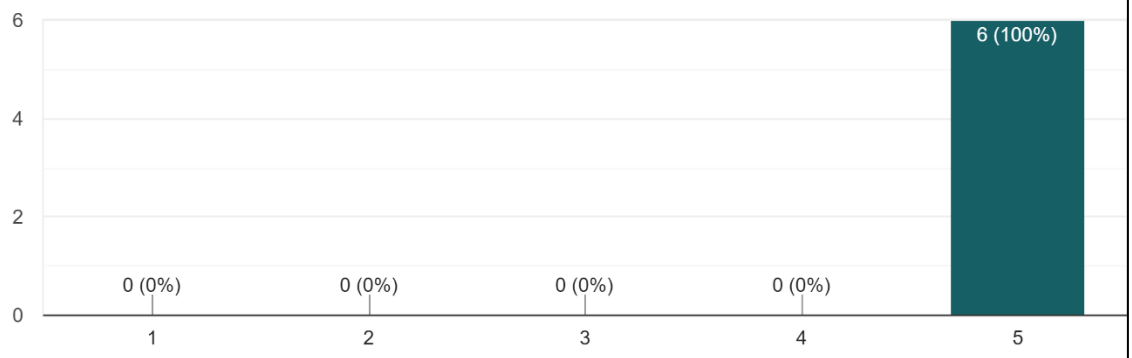
In your opinion, does the patient medical record contain enough detail?

6 responses



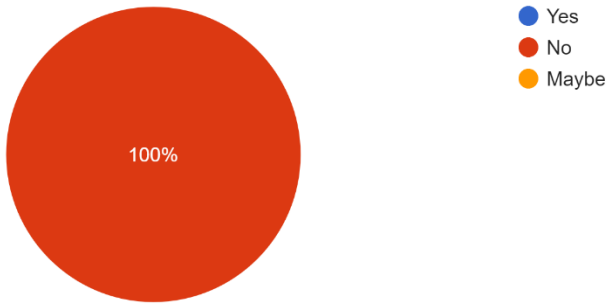
On a scale of 1 to 5, how much do you think the analytics in the dashboard will help the hospital or doctors?

6 responses



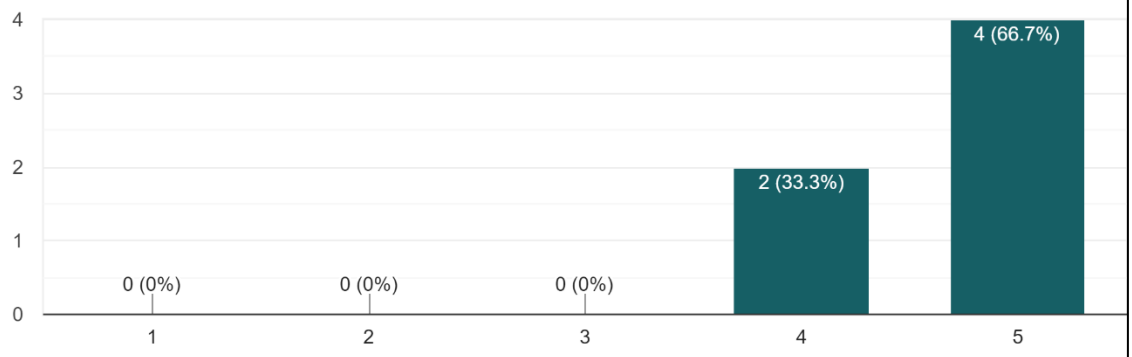
As the doctor, do you feel that at any moment your privacy is compromised?

6 responses



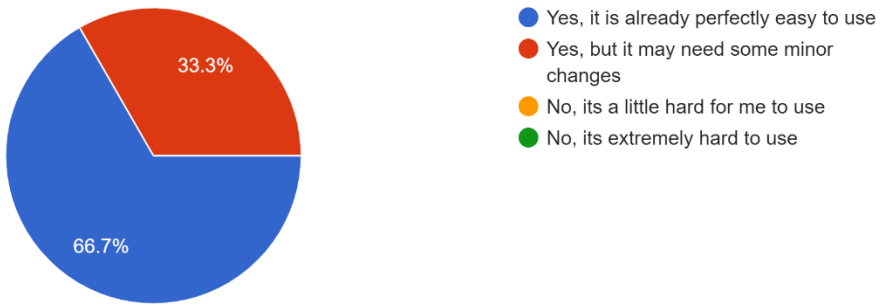
On a scale of 1 to 5, how easy is it to navigate and use the system?

6 responses



Do you think the user experience of the system is intuitive? Or does it need to be more user friendly?

6 responses



Weekly Log

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 1**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Finish revising and created blockchain application as side project during semester break and this week.
- Produce the background of the project.
- Determine the problem statement and objectives of the project.

2. WORK TO BE DONE

- Complete Project motivation
- Complete Project scope
- Complete impacts, significance and contribution

3. PROBLEMS ENCOUNTERED

- Thinking of ideas on how I should implement and develop the application

4. SELF EVALUATION OF THE PROGRESS

- Progress for report is good but need to start development of the project in week 3

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 2**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Completed the project motivation
- Complete project scope
- Complete impacts, significance and contribution

2. WORK TO BE DONE

- Do literature review
- Sketch use case diagram

3. PROBLEMS ENCOUNTERED

- Need to start development as soon as possible

4. SELF EVALUATION OF THE PROGRESS

- Progress also good and have an idea on how to implement and design the application

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 3**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete literature review
- Sketch use case diagram and complete use case descriptions
- Develop smart contract in Remix IDE
- Test and redesign smart contract in Remix IDE

2. WORK TO BE DONE

- Install dependencies needed using node package manager
- Design smart contract integration scripts

3. PROBLEMS ENCOUNTERED

- Ran into quite a lot of problems with the initial smart contract prototype but managed to solve all the issues by the end of the week

4. SELF EVALUATION OF THE PROGRESS

- Smart contract development was successful and progress is still good

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 4**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Download dependencies using node package manager(npm)
- Redownload dependencies to versions that are compatible
- Create smart contract integration scripts
- Debug any problems with the smart contract integration scripts

2. WORK TO BE DONE

- Write tests using Mocha and Ganache to test smart contract
- Import front end frameworks
- Create front end for the application

3. PROBLEMS ENCOUNTERED

- Finding the proper versions for the dependencies took a few days because problems won't arise only until its too late and the entire dependency has to be replaced with another version

4. SELF EVALUATION OF THE PROGRESS

- Still on track but a lot of time was spent on finding the right dependency

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 5**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Write tests using Mocha and Ganache to test smart contract
- New issues with the smart contract should be debugged immediately
- Import front end frameworks like next.js, next-routes, semantic-ui-react and others
- Create a very simple front end for the application

2. WORK TO BE DONE

- Ensure the front end can connect to the smart contract and interact with it

3. PROBLEMS ENCOUNTERED

- Front end is still very unattractive, need to redesign it, but it is not the main priority yet

4. SELF EVALUATION OF THE PROGRESS

- Project progress is good but report hasn't had any progress in these few weeks

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 6**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete compile and deploy the smart contract to the Rinkeby Blockchain
- Completed the 'add medical record' feature
- Implemented 'view medical record list' feature but encountered bug

2. WORK TO BE DONE

- Debug and fix 'view medical record list' feature

3. PROBLEMS ENCOUNTERED

- Encountered a bug where every medical record that is displayed in medical record list have the same Metamask address

4. SELF EVALUATION OF THE PROGRESS

- Encountered an error that hinders progress

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 7**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Successfully fixed the 'view medical record list' feature
- Developed the 'view record details' feature front end but have yet to ensure it is fully working

2. WORK TO BE DONE

- Complete debugging and developing 'view record details' feature

3. PROBLEMS ENCOUNTERED

- 'View record details' feature encountered some problems with the smart contract code and have went to Stack Overflow for help but could not get any help

4. SELF EVALUATION OF THE PROGRESS

- Development progress starting to plateau as many different errors are encountered

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 8**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete debugging 'view record details' feature
- Successfully developed a Search feature on medical record list page
- Implemented 'register doctor' feature
- Implemented 'Edit doctor' feature

2. WORK TO BE DONE

- Need to develop 'Grant access to doctor' feature
- Ensure that 'Grant access to doctor' feature does not have any errors

3. PROBLEMS ENCOUNTERED

- Search feature had some errors in the back-end code initially and the back-end code had to be redesigned to fit the feature

4. SELF EVALUATION OF THE PROGRESS

- Good progress in development but still need to decorate the application because the user interface looks very dull and unattractive

SuLee

Supervisor's signature

JS807

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 9**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Successfully develop 'verify permission' feature
- Successfully developed 'Grant access to doctor' feature
- Successfully developed 'Revoke access to doctor' feature
- Debug and solve any issue that arise
- Complete design specifications in report
- Complete implementation issues and challenges
- Complete timeline

2. WORK TO BE DONE

- Chapter 4 and 5 of report still not completed
- Have yet to redesign the application user interface

3. PROBLEMS ENCOUNTERED

- 'Verify permission' feature had a few issues with the smart contract and had to redesign the smart contract in Remix IDE and recompile and redeploy the smart contract on Rinkeby network

4. SELF EVALUATION OF THE PROGRESS

- Progress quite on track

SuLee

Supervisor's signature

JS807

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 10**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Implemented 'Edit record' feature
- Redesign UI of certain pages of the application

2. WORK TO BE DONE

- Complete 2 sections of the report

3. PROBLEMS ENCOUNTERED

- Redesign of the UI took more time than expected as a lot of code had to be changed to redesign the entire look of the application
- Back-end code also has to be redesigned to make it work with the UI changes

4. SELF EVALUATION OF THE PROGRESS

- FYP1 project for this semester is complete but report is not done yet

SuLee

Supervisor's signature

JSON

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 11**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete Chapter 4 by drawing the different types of diagrams
- Complete Chapter 6 by screenshotting and explaining each section

2. WORK TO BE DONE

- Might want to add more features to the system

3. PROBLEMS ENCOUNTERED

- No issues

4. SELF EVALUATION OF THE PROGRESS

- Report progress quite good but still need to complete chapter 5 and chapter 7

SuLee

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 12**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Complete Chapter 5 and 7
- Implemented 'Dashboard' feature and incorporate multiple different visualizations
- Completely redesign the entire UI of all the pages of the system
- Finalize the report

2. WORK TO BE DONE

- Final checking on the system and report

3. PROBLEMS ENCOUNTERED

- Redesign of the entire UI took more time than expected as a lot of code had to be changed to redesign the entire look of the application
- Back-end code also has to be redesigned to make it work with the UI changes

4. SELF EVALUATION OF THE PROGRESS

- Very pleased with the dashboard feature
- Satisfied with the new look of all of the pages of the system

SuLee

Supervisor's signature

JSon

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 13**
Student Name & ID: Lim Jason 18ACB02103	
Supervisor: Mr. Su Lee Seng	
Project Title: Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Final Checking on the system
- Complete poster
- Finalize the report

2. WORK TO BE DONE

- Submit FYP2 report

3. PROBLEMS ENCOUNTERED

- No issues

4. SELF EVALUATION OF THE PROGRESS

- FYP2 report and project is completed

SuLee

Supervisor's signature

Student's signature

Poster

Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia

Introduction

6 200 133
medical records
were exposed in the US during January-May 2019**

77%
of all data breaches in 2019
were caused by healthcare providers**

Healthcare has always been substantial to a country and its economy. It signifies the strength and stability of a country. Hence, the medical record systems have to be improved for healthcare services to be efficient.

What is Blockchain?

Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network.

What is a Smart Contract?

Smart Contracts are simply programs stored on a blockchain that run when predetermined conditions are met.

Problem Statement

- Mismatch or Unsynchronized Health Record of patients that negatively affects the delivery of effective healthcare.
- Privacy breach of patient's electronic medical records and private information.
- Medical Record System is not intuitive, causing medical personnel to waste a lot of time.
- Bottlenecks in centralized medical record systems result in a central point of failure.

Methodology

Prototyping Model

Phase 1: Requirements gathering and analysis
Phase 2: Quick design
Phase 3: Build a prototype
Phase 4: Initial User evaluation
Phase 5: Refining prototype
Phase 6: Implement product and maintain

Project Objectives

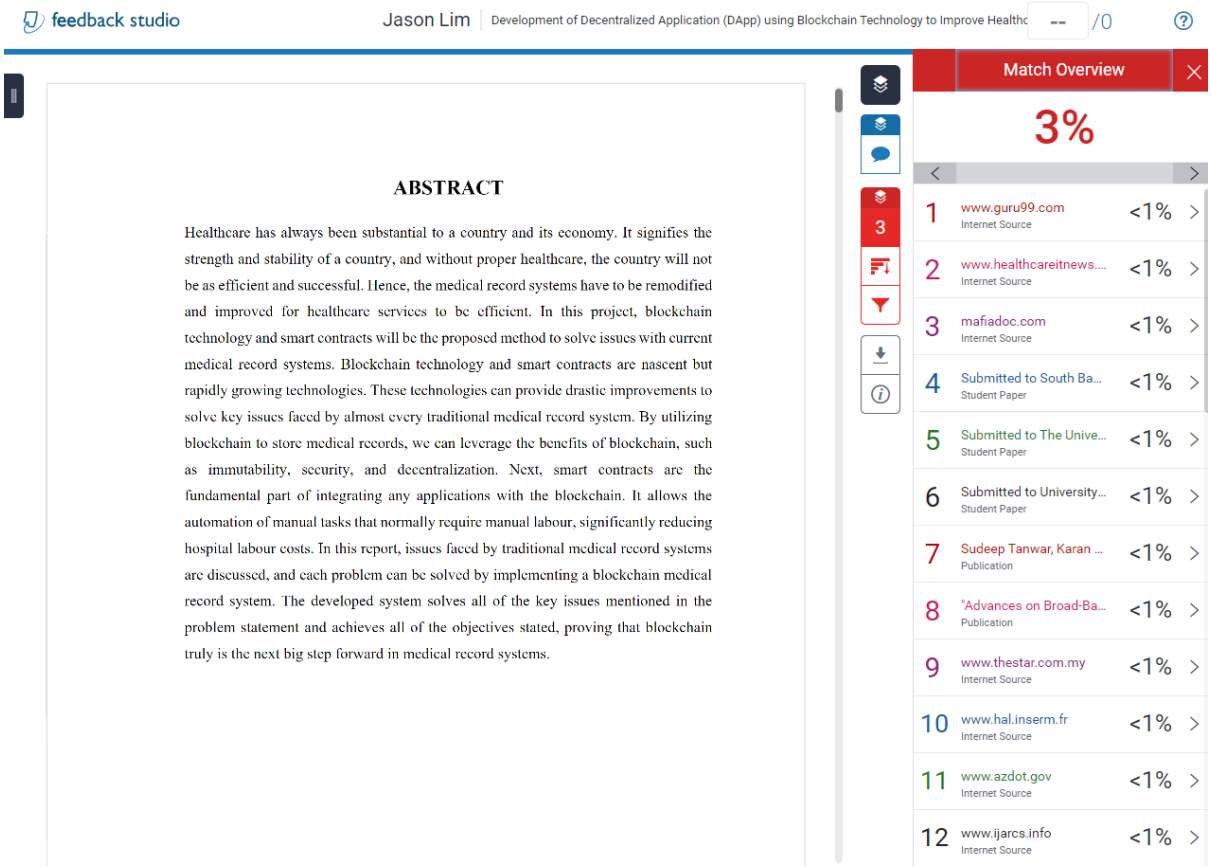
- To create a blockchain medical record system that improves the delivery of effective healthcare.
- To develop a system that reduces the risk of privacy breach.
- To study the enhancement of user interface and user experience on reducing the time and effort needed to use the system.
- To evaluate the effectiveness of using blockchain technology on improving the security.

Conclusion

Throughout the report, issues faced by traditional medical record systems are discussed, and each problem can be solved by implementing a blockchain medical record system.

The developed system solves all of the key issues mentioned in the problem statement, proving that blockchain truly is the next big step forward in medical record systems.

Plagiarism Check Result



ABSTRACT

Healthcare has always been substantial to a country and its economy. It signifies the strength and stability of a country, and without proper healthcare, the country will not be as efficient and successful. Hence, the medical record systems have to be remodified and improved for healthcare services to be efficient. In this project, blockchain technology and smart contracts will be the proposed method to solve issues with current medical record systems. Blockchain technology and smart contracts are nascent but rapidly growing technologies. These technologies can provide drastic improvements to solve key issues faced by almost every traditional medical record system. By utilizing blockchain to store medical records, we can leverage the benefits of blockchain, such as immutability, security, and decentralization. Next, smart contracts are the fundamental part of integrating any applications with the blockchain. It allows the automation of manual tasks that normally require manual labour, significantly reducing hospital labour costs. In this report, issues faced by traditional medical record systems are discussed, and each problem can be solved by implementing a blockchain medical record system. The developed system solves all of the key issues mentioned in the problem statement and achieves all of the objectives stated, proving that blockchain truly is the next big step forward in medical record systems.

Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia

ORIGINALITY REPORT

3%	2%	1%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.guru99.com Internet Source	<1%
2	www.healthcareitnews.com Internet Source	<1%
3	mafiadoc.com Internet Source	<1%
4	Submitted to South Bank University Student Paper	<1%
5	Submitted to The University of Law Ltd Student Paper	<1%
6	Submitted to University of Greenwich Student Paper	<1%
7	Sudeep Tanwar, Karan Parekh, Richard Evans. "Blockchain-based electronic healthcare record system for healthcare 4.0 applications", Journal of Information Security and Applications, 2020 Publication	<1%

8	"Advances on Broad-Band Wireless Computing, Communication and Applications", Springer Science and Business Media LLC, 2020 Publication	<1 %
9	www.thestar.com.my Internet Source	<1 %
10	www.hal.inserm.fr Internet Source	<1 %
11	www.azdot.gov Internet Source	<1 %
12	www.ijarcs.info Internet Source	<1 %
13	Reyhane Attarian, Sattar Hashemi. "An anonymity communication protocol for security and privacy of clients in IoT-based mobile health transactions", Computer Networks, 2021 Publication	<1 %
14	ebin.pub Internet Source	<1 %
15	Submitted to University of Northumbria at Newcastle Student Paper	<1 %
16	tind-customer-agecon.s3.amazonaws.com Internet Source	<1 %

Universiti Tunku Abdul Rahman			
Form Title : Supervisor's Comments on Originality Report Generated by Turnitin for Submission of Final Year Project Report (for Undergraduate Programmes)			
Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1of 1

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Lim Jason
ID Number(s)	18ACB02103
Programme / Course	IA
Title of Final Year Project	Development of Decentralized Application (DApp) using Blockchain Technology to Improve Healthcare and Medical Record Systems in Malaysia

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceeds the limits approved by UTAR)**
Overall similarity index:___3___% **Similarity by source** Internet Sources:___2___% Publications: ___1___% Student Papers:___1___%	
Number of individual sources listed of more than 3% similarity: _____	

Parameters of originality required and limits approved by UTAR are as Follows:

(i) Overall similarity index is 20% and below, and
(ii) Matching of individual sources listed must be less than 3% each, and
(iii) Matching texts in continuous block must not exceed 8 words

Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8

Note Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

SuLee

Signature of Supervisor

Name: Su Lee Seng

Date: 21/04/2022

Signature of Co-Supervisor

Name: _____

Date: _____

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY
(KAMPAR CAMPUS)

CHECKLIST FOR FYP2 THESIS SUBMISSION

Student Id	18ACB02103
Student Name	Lim Jason
Supervisor Name	Su Lee Seng

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
	Front Plastic Cover (for hardcopy)
√	Title Page
√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
	List of Symbols (if applicable)
√	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
√	Appendices (if applicable)
√	Weekly Log
√	Poster
√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)
√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

*Include this form (checklist) in the thesis (Bind together as the last page)

I, the author, have checked and confirmed all the items listed in the table are included in my report.

_____

(Signature of Student)
Date: 21/04/2022