DEVELOPMENT OF A HEALTH INFORMATION SYSTEM FOR MONITORING MEDICATION USE BY HOSPITAL OUT-PATIENTS

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BEING A PROJECT SUBMITTED IN THE DEPARTMENT OF COMPUTER SCIENCE AND MATHEMATICS, COLLEGE OF BASIC AND APPLIED SCIENCES IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE

MOUNTAIN TOP UNIVERSITY, IBAFO
OGUN STATE, NIGERIA

2020

CERTIFICATION

This Project titled, **DEVELOPMENT OF A HEALTH INFORMATION SYSTEM FOR MONITORING MEDICATION USE BY HOSPITAL OUT-PATIENTS,** prepared and submitted by **IPINMOROTI MOYINOLUWA SMART** in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE (Computer Science)**, is hereby accepted.

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DEDICATION

This project is dedicated to God, Almighty.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my deepest appreciation to the Almighty God, for being my rock through this phase of my life. I extend my gratitude to my supervisor Mr J.A Balogun for his time, effort, his advice and guidance throughout the course of the project to ensure the aim of this project is achieved. I appreciate the Dean of CBAS Prof. A.P.Olalusi for his moral support and the Head of Department, Computer Science Dr. I.O. Akinyemi for being a father throughout this project work. I would like to say a big thank you to all staff members of computer science Department: Dr. P. A Idowu, Dr. O. A. Ojesanmi, Dr. F. A Oladeji, Dr. O. B. Okunoye, Dr. B. O. Oladejo, Dr. H. Akewe, Dr. O. S. Odetunde, Dr. O. A. A Akinfenwa, , Dr. H. A. Isede, Dr. F. A. Kasali, Dr. M. O. Adewole, Mr. I. O. Ebo, Mrs. R. Oladokun and Mr. O. Afolabi. My sincere and heartfelt appreciation goes to my parent Mr and Mrs Ipinmoroti for everything because without them I wouldn’t have thought on embarking on this project. I appreciate them for their support spiritually, morally, and financially. Also my brothers for their endless support and encouragement throughout the course of this project, they are indeed a blessing to me

ABSTRACT

This study was aimed at developing a health-based information system that can be used by health officials to monitor the intake of medications prescribed to out-patients by medical doctors remotely. This was achieved by identifying the various requirements of the information system, specifying the design of the information system, implementing the data storage data structure and implementing the information system.

The various requirements of the information system which included the user and system requirements such as the system users alongside their various roles and system functions were elicited from the system users. The system design was specified using unified modeling languages (UML) such as the use-case for user requirements, sequence diagram for operational timing and class diagram for the data model. The database was implemented using JavaScript Object Notation (JSON) on the Mongo DB, the primary system was implemented using the hypertext markup language (HTTP), Cascading Styling Sheet (CSS) and JavaScript for the web application while Swift was used to implement the mobile application for Android OS as the secondary system.

The results of the study showed that the various user and system requirements of the health information system was well captured. The results also showed that the implementation of the database provided a seamless means for the transfer and storage of data across users of the information system. The implementation of the front-end of the web and mobile application for the hospital staff and patients respectively consisted of the various functionalities as required by the system users.

The study concluded that the effective functioning of the mobile app and the web service showed that the information system can be effectively used for the purpose of scheduling appointments for drug prescription and for monitoring the intake of drugs.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The world of medicine has evolved intensely over the past few centuries. From huge CT-scan machines that take x-rays of the body from multiple angles, to several surgical procedures that have been improved through the aid of technology. Before the introduction of technology, medicine was regarded as much more of an art than a science. Doctors used their senses for observations; touch and smell and also an analysis of the patient's environment. It was basically an era of a 'trial & error' system (Campbell, 2012).

Penicillium notatum and its effect on Staphylococcus were observed by Sir Alexander Fleming in 1928, which provided us with our first protection against microbes and other diseases. He has practically begun modern-day medicine with this discovery, which he called Penicillin, which is believed to have saved more than 200 million lives. In clinical medicine, the use of medical instruments and the assistance of technologies has provided a new outlook to the diagnosis, care and monitoring of patients. There are many instances where instruments or medical monitors are attached to a certain part of the body and can be used to monitor the level of sugar, blood pressure, heart rate and other medical signals.. These generally help to prevent emergencies and also monitor the recovery rate of patients even after being prescribed and placed under adequate medications (Campbell, 2012).

Through the use of a cloud-based medication system for medicine intake, the health care sector would be greatly improved. This entails that the hassle of registrations, booking of appointments and also drug prescription and intake can be made a whole lot easier and controlled effectively. Therefore, remotely located patients would have a platform to easily access good, secure and adequate health care resources at their disposal, Furthermore, in a case of an emergency, the information is observed and transmitted to the control center or server and adequate measures would be carried out with immediate effect. The system likewise would also aid the monitoring of user prescribed drugs to avoid abuse and also ensure they are taken at regular intervals. Thus a notification system would suffice to ‘remind’ users of when and which drugs should be take.

1.2 Statement of the Problem

Studies have shown that 20 percent to 30 percent of medication prescriptions are never filled and that approximately 50 percent of medications for chronic diseases are not taken as prescribed. This shows that 50 out of a 100 people misuse drugs prescribed for chronic illnesses thus causing an approximation of 125,00 deaths and at least 10 percent of hospitalization and to cost the American health care system between $100 billion and $289 billion a year. Also, according to results from the 2017 National Survey on Drug Use and Health (NSDUH, 2017), an estimated 2 million Americans misused prescription pain relievers for the first time within the past year which averages to approximately 5,480 initiates per day. Additionally, more than one million misused prescription stimulant, 1.5 million misused tranquilizers and 271,000 misused sedatives for the first time. The reason for the high prevalence of prescription drug misuse varies by age and other factors but basically fueled by ease of access. Besides, lack of information on the addictive nature of some prescription drugs might also be a considerable contributor to the problem.

1.3 Aim and Objectives of the Study

The aim of this project is to design and implement an information system that can be used for monitoring the intake of medication prescribed to patients remotely by medical staff.

The specific objectives are:

i. identify the requirements of the information system;

ii. specify the design of the system based on the requirements identified in (i);

iii. implement the database; and

iv. implement the front-end of the information system.

1.4 Research Methodology

In order to achieve the aforementioned objectives, the following methods were adopted.

a. The user and system requirements were identified from the system users which consisted of the roles of the users and their respective functions alongside the expected system functionalities.

b. The system design was specified using unified modeling languages (UML) such as the use-case for user requirements, sequence diagram for operational timing and class diagram for the data model based on the requirements identified in (a).

c. The database was implemented using JavaScript Object Notation (JSON) on the Mongo DB based on the data model specified in (b).

d. The primary system was implemented using the hypertext markup language (HTTP), Cascading Styling Sheet (CSS) and JavaScript for the web application while Swift was used to implement the mobile application for Android OS as the secondary system.

1.5 Scope and Limitation the Study

In this study, the information system for monitoring the intake of mediation was implemented using the Mountain Top University health center as a case study. A web-based application was implemented for the health center staff while a mobile application was implemented for the patient to be monitored.

1.6 Significance of the Study

This project aims at demonstrating the significance of a managed drug prescription and intake system as an alternative to the traditional way of doing it. The system should be user friendly, respond in a timely manner and in general should he precise as anybody on the platform is assumed to be ill or in a haste. The system should make it as easy and fast as possible. Registration should not be a hassle and should be able to be completed in a reasonable amount of time with adequate information provided and gathered. Patient information should be handled confidentially and with utter most care, Appropriate drugs should be prescribed to the patients with respect to the complained illnesses and prescription should be monitored to avoid abuse and aid regular intake.

1.7 Definition of Terms

Administrator: The Admin has the official power to control the flow of data from one part of the system to another. He has the power to manipulate the access of users data.

Application programming interface (API): A set of software-building definitions, protocols and tools.

Consultation Fee: Consultation fee is the money paid by the patient in question after visiting the doctor and before proceeding to the purchase of relevant medications.

Dental: Dental relates basically to the teeth. The dental section deals with the general dental illness and the overall dental health of the patient. This section also develops an initial treatment plan and refers to specialist when more specialized treatment is required.

Diagnosis: A Diagnosis is a determination of an individual's illness, disease or injury. Made by a health care professional.

Doctor: A doctor is a person with a medical degree who is qualified to treat people who are ill. He is basically a medical practitioner.

Gynecologist: The branch of medicine concerned with the dealing with the health of the female reproductive system**.**

Hospital: A Hospital is an institution that provides the medical services to a patient in question over a given period of time which is basically curative and preventive and is offered in respective units of the hospital; Example; Dental, Laboratory unit etc.

Medical records: Medical records contain sensitive information and increasing computerization and other polices. This section forms an essential part of the patient's present and future health care. It provides the written collection of information about a patient's health and treatment, which are essential for the present and continuity of the patient.

Medicine: Medicine is an applied science or practice of medicine. It encompasses a variety of healthcare practices evolved to maintain and restore health by prevention and treatment of illnesses in human beings.

Monitoring: Monitoring is to keep watch, observe and check the progress or quality of something over time i.e keep under systematic view.

Nursing: Nursing is the protection, promotion and optimization of health and abilities. Nurses are tasked with the duties of caring for patients, communicating with doctors, administering medicine and checking vital signals.

Patient: A patient is a recipient or registered party of health care services performed by health care professionals. The patient is most often ill or injured and in need of treatment by a physician, dentist or other health care provider.

Pharmacy: Pharmacy is the science or practice of the preparation and dispensing of medical drugs. The pharmaceutical section through the nurse gives out the prescribed drugs to the patients. This implies that the patient must have visited the doctor prior to drug prescription and administration.

Prescription: A prescription is an instruction written by a medical practitioner that authorizes a patient to be issued with a medicine or treatment.

User Experience: User experience refers to the overall experience of a person using a product such as a website or computer application, especially in terms of how easy or pleasing it is to use.

Web-based: A web-based application is any program that is accessed over a network connection using Hypertext Transfer Protocol (HTTP), rather than existing within the device’s memory.

CHAPTER TWO

LITERATURE REVIEW

2.1 The History of Cloud Computing

Cloud computing has transformed the way systems and applications are developed, distributed and scaled, and is potentially one of the most important technology developments over the last decade. This technology has enabled individuals and organizations to share a pool of computing, storage and networking resources by enabling the ownership of the underlying hardware needed to run a large part of the Internet while at the same time reducing running costs and complexity. Although the idea is not completely new, the underlying virtualization technology that drives cloud computing can be considered one of the most significant breakthroughs in recent times (García, 2015)**.**

The term *the cloud* has become an everyday word in the modern age of computing as it means saving something or handling a system off a local/physical device. This aids a lot of process and computations as it allows for backup and easy recovery in case of data loss. According to (Bang, 2015), there are 4 types of cloud systems which are: public cloud, private cloud, hybrid cloud and community cloud.

2.1.1 Public Cloud

This type of cloud enables users to have access to the cloud through interfaces using web browsers. It is basically a pay-per-use service as users only need to pay as they use the system. The major disadvantage of public cloud is security. Public cloud is vulnerable to attacks and the only fix to the issue security checks can be implemented through validation by both sides, by cloud vender as well as client. As well as both parties need to identify their responsibilities within their boundaries of operation. Public cloud is off premise in which varies enterprises can be used to deliver services to user by taking it from third party.

2.1.2 Private Cloud

Private cloud activity is inside an association's inner endeavor server room. The primary preferred position is that it is simpler to oversee security, upkeep and redesigns and furthermore gives authority over organization also, use. It tends to be contrasted with web. As analyzed to public cloud where all assets and application were overseen by specialist co-op, in private cloud these administrations are pooled together and made accessible to client at the hierarchical level. These assets also, applications are overseen by association itself. As just the association's clients approach private cloud the security is improved.

2.1.3 Hybrid Cloud

This model consists of both a public and a private model. Cloud simulations where the cloud processing environment is situated, hosted and managed by a third party a private cloud is connected to this model one or more external cloud providers are available. It's more stable with the way to monitor and make data and applications.

2.1.4 Community Cloud

Requires the cloud storage environment to be used, shared or operated by number of associated organizations. When several companies combine the construction and they share cloud resources, rules, and requirements then a model of this kind is called a community cloud. The cloud infrastructure is host by third party provider or within one of the organizations in the community.

2.2 Sensor App System

Personal mobile computer technology has seen rapid improvement in recent years. Services brought by mobile devices, such as multiple means of contact and consumer apps, host a lot of possibilities. As a result, the mobile app industry has been in the race, including healthcare assistance for elderly patients Specifically, a lot of smartphone and tablet centered applications for adherence to medications in the form of an electronic warning have been created. In this case, the Sensor-App solution incorporates the use of sensor networks and smartphone applications. Approaches for tracking and monitoring of commitment to medications. (Abbey *et al*, 2012). have built a pillbox containing several compartments with an ambient light sensor fixed in each compartment and a link to Wi-Fi. A smartphone app containing the medication schedule has also been created.

2.3 Various drug medication systems

Chen *et al.* (2014), defined a method for tracking the intake of medications by pill bottles. The device utilizes wearable inertial sensors built into the bracelet. Sensors are used to track the motions of the hands and sides. The goal is to establish patterns of signals like the "cap twist" and "arm to mouth”. The problem with communication between the bracelet and a device which sends information about upcoming medication intakes and registration of events about the intake remains unsolved. Hutchinson (2013) developed an automatic drug dosing method with visual feedback for the aged. It consists of an automated prescription dispenser that shows images of loved ones. This method is more focused on psychological status of patients rather than regulating and managing the ingestion of medications.

Mira (2014), developed ALICE a smartphone application that is programmed to help patients remember, distinguish and take the recommended drugs with the right dose. It helps, too, avoiding general use mistakes, possible drug reactions, and giving advice on safe handling and advice from doctors on good habits. This system does not track and regulate the ingestion of medications. McCall *et al.* (2013). proposed a framework for the automatic control of the consumption of drugs. It consists of a spinning platform – a meter, an RFID tag reader, a microcontroller and a UI panel. Medications are placed in various parts of the platform and labelled with RFID tags. As the frame is rotated, the RFID reader reads the sections and decides the correct bits. Then the scale tests the weight of the prescription bottle before and since you took the drug. This decides whether the medication is used and whether the dosage is taken. This method does not help the surveillance and regulation of the intake of drugs. Pak *et al.* (2012), described a medication intake monitoring system – UbiMMS. It consists of drug dispensers connected to a server. They can download medication intake schedules remotely by the server or manually by the user. Through the WEB service, medical staff can monitor patients' intakes. There is no medication intake control implemented in this system.

The most significant drawback of all the systems examined is that none of them has any mechanism for monitoring the ingestion of drugs has been identified. In comparison, the programs are often not equipped to be used for the elderly or individuals with disabilities. Presence of unsolved persons issues require the creation and introduction of a method to ease the prescribing and shift of the consumption of medications as well as regulation of the consumption by prescription. The machine should be low-cost and easy to run with hardware. We need a smartphone application with a clear and intuitive user interface that can be an insightful "assistant" for patient.

The submission should be aware of potential intake(s) of drugs and should be told if the intake has been postponed. Medication identification feature can be introduced so it can be found in all types of packaging – pill tubes, blisters, etc (Ventsislav Venkov, 2016).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The proposed methodology describes the approaches to the earlier stated objectives of the Cloud Based Real Time Medication System. The design of the system was specified using the Unified Modelling Languages (UML) which are the Use Case for user actions, sequence diagrams for timing of operations and class diagrams for the data model of the system. The System was implemented using Hypertext Mark-Up language (HTML) and Cascading Style Sheet (CSS) for the web layout design. The backend of the system was handled using a JavaScript runtime environment; Node.JS and Swift (IOS) handled the design and development of the mobile application.

3.2 Functional and Non-Functional Requirements of System

For the development of a Cloud based real time medication system, a set of requirements must be fulfilled by both users and systems and they are generally classified as functional requirements and non-functional requirements.

3.2.1 Functional Requirement analysis

This is a definition of the basic system behaviour. It is basically an analysis of the systems response to inputs as well as its outputs. The functional requirements for the development of the system are as follows.

a. The system shall control access using a registration format authenticated by google for the mobile application and the nurse (administrator) has access to the web dashboard.

b. The system shall allow performance of various tasks according to assigned roles.

c. The system would allow for the monitoring of drug and dosage of prescription.

3.2.2 Non-Functional Requirement analysis

The non-functional requirements are the basis used to evaluate the specific performance and procedure of the system. It allows the imposition of restrictions on the design of the system across various agile backlogs. Thus, the external system constraints the system should meet include:

a. **Security:** The particular system was designed in such a way that only the system administrator may access system permissions for system data. All system data must be backed up every 24 hours and the backup copies must be kept in a secure location that is not in the same place as the system.

b. **Accessibility:** Accessibility discusses the unequal dimensions of fair customer access for persons with disabilities. It means people with disabilities can perceive, understand and interact equally with websites and tools with regard to web accessibility.

c. **Usability:** Usability is about designing goods that are reliable, efficient and fulfilling. Usability requires functionality for user interface. This can include common factors that concern all and do not concern persons with disabilities disproportionately.

d. **Inclusion**: is about diversity, and ensuring involvement of everyone to the greatest extent possible. In some regions this is also referred to as universal design and design for all.

e. **Authentication**: In computing, authentication is the process of verifying the identity of a person or device. It is used to determine whether someone or something is in fact, who or what it is declared to be.

f. **Reliability**: It is the ability of a system to perform its required functions under stated conditions for a specific period of time

g. **Integrity control: i**ntegrity in term of data and network security, is the assurance that information can only be accessed by those authorized to do so.

h. **Confidentiality**: is the degree to which the software system protects sensitive data and allows only authorized access to the data.

i. **Dependability**: the dependability of a computing system is the ability to deliver service that can justifiably be trusted by users.

3.2.3 Hardware Requirements

For the effective and reliable operation of the project, such hardware specifications must be fulfilled which are as follows: a web server with a significant volume of RAM and hard disk, an Intel i5 Windows 7 operating system and 4 GB ram size, a wireless Internet access card, a wireless router or an alternative Internet service provider (ISP) and an Uninterrupted Power Supply (UPS) or an Inverter.

3.2.4 Software Requirements

In order to allow flexible and productive use of the system over the Internet, a network operating system must be running on a network server, a windows operating system on a client computer, and a browser on a client computer to boost the internet connectivity. The software requirements include: Operating system adopted was Windows 7, Web user Interface language is HTML and Bootstrap 4, Mobile user Interface was Google material design & responsive design, Client-side Scripting language was the Vanilla JavaScript, Mobile Client-side Scripting language was

Kotin, Server-side Scripting language was Nodejs, Database was implemented using Firestore while the Web Server adopted was Netifly.

3.3 Method of Software Development

Extreme programming (XP) is probably the best known and commonly used agile approaches. In extreme programming, specifications are expressed as cases (called user stories) that are explicitly implemented as a series of tasks. Programmers are working in pairs and designing tests for each task before writing the code. All checks must be carried out successfully when the new code is implemented into the system. There is a limited time period in system launches.

3.3.1 System Analysis and Design

System review is the method of documenting and analyzing information, diagnosing concerns, and using the evidence to suggest system upgrades. Device design requires the study and modification of the hardware and software elements used to support the architecture of the solution. The design stage translates the detailed specifications of the description stage into a full, detailed device specification. Many of this phase's most relevant events include:

a. Pointing out the all required data that will be needed in handling the immunization record system and performing all the necessary activities that are required by the user of the system;

b. Characterization and documentation of all related entities that exist in the immunization information system is performed.

c. Designing the components of the system: unified modelling language (UML) diagram that shows the relationship that exists between entities in the immunization record system, the database structures, inputs, outputs, internal processing, manual procedures, system interfaces, technical environment, and overall system architecture;

d. Carrying out walkthroughs of the design to ensure that it is programmable and technically complete and beginning development of approaches to user support and system maintenance afterwards

3.3.2 Use Case diagram

The goal of the case diagram for use is to capture the complex nature of a structure. This diagram is used to compile the parameters of a device, including internal and external variables. These specifications are often specifications for architecture. Therefore, usage cases are planned and actors are identified while a system is examined to collect its features. The usage case diagram was used to explain the system's roles that generate a visible outcome for multiple actors interested in the use of the system, such as health professionals and public health workers who are the system's key consumers. The recognition of actors and use cases contributes to the concept of the system boundary, which is to distinguish the tasks performed by the system and the tasks performed by its environment. A summary of the actors alongside their respective operations using the suggested method is seen in the use-case diagram shown in Figure 3.1.

a. **System Administrator:** The System admin is the person responsible for maintaining, configuring and efficiently running computer systems, in particular multi-user computers such as servers. He / She is responsible for maintaining an authenticated user's access to the device. In this case, the role of the system administrator rests solely in the hands of the Nurse. Their primary responsibilities include: handling consultation data that includes date, time and supposed illness to the doctor, scheduling medication periods for patients, and handling and viewing patient information.

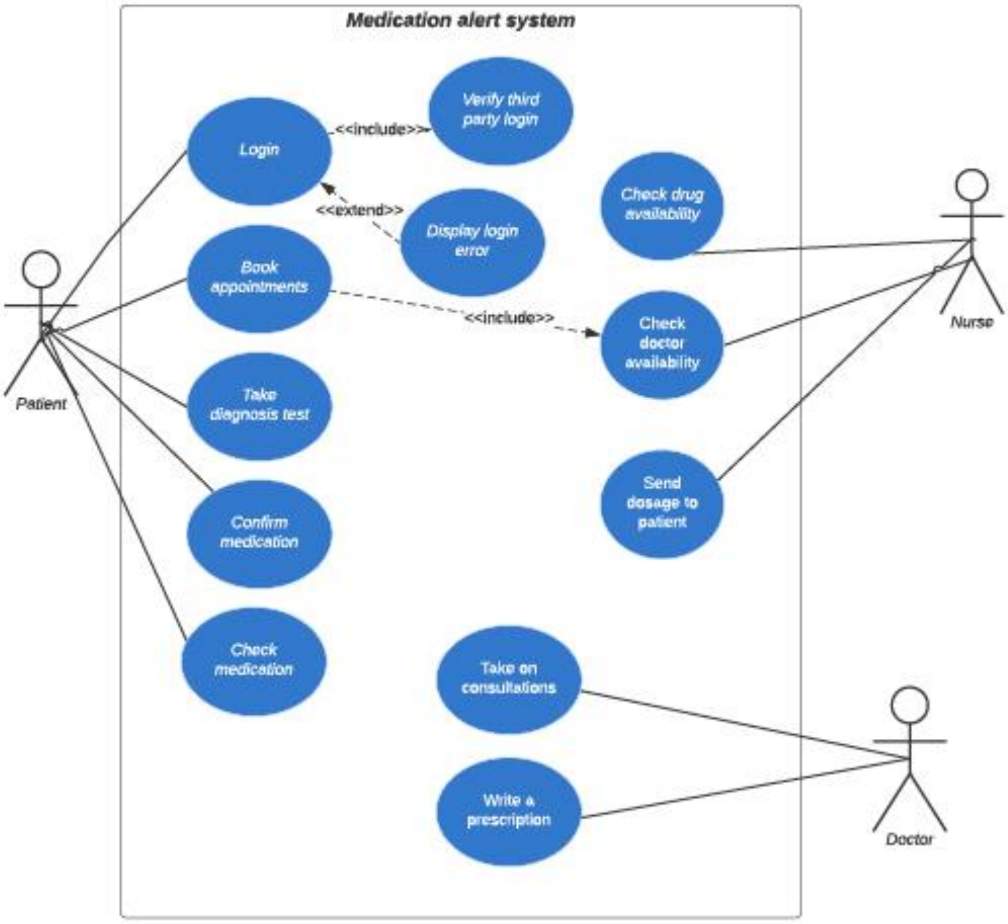


Figure 3.1: Use Case Diagram.

b. **Doctor:** The Doctor is a user of the system that is tasked with the responsibility of handling consultations with patients and writing of prescriptions directly to the system administrator for further admittance of the said or required drugs through the mobile app.

c. **Patient:** The patients aim on the system is the use of the mobile appp tp book for appointment based on ailments or complaints as the case may be to specialized doctors and receiving medication alerts on prescribed drugs and dosage after consultation with the doctor.

3.3.3 Class Diagram

The class diagram outlines a class's characteristics and operations and the limits placed on the system as well. In the diagram seen in Figure 3.2, it was used in the context of the suggested scheme to describe the different categories of classes, objects and their corresponding instances alongside their relationships. The framework has a key class called System User, which decides whether a user is an administrator of the system, a nurse, or a basic user.

3.3.4 Activity Diagram

One of the most important modeling artifacts used in UML is Activity Diagrams which is used to model the sequence of actions as part of the process flow as shown in Figure 4.3. It is used to model the sequence of actions to capture the actions of the process flow and its effects. It focuses on the work performed in the implementation of an activity (a method) and on the activities performed in a case-by - case application or in an object.

3.3.4 Sequence Diagram

A Sequence diagram focuses on time-sequencing or time-ordering of messages or the order in which messages are sent. The focus in these diagrams is on what happens first,

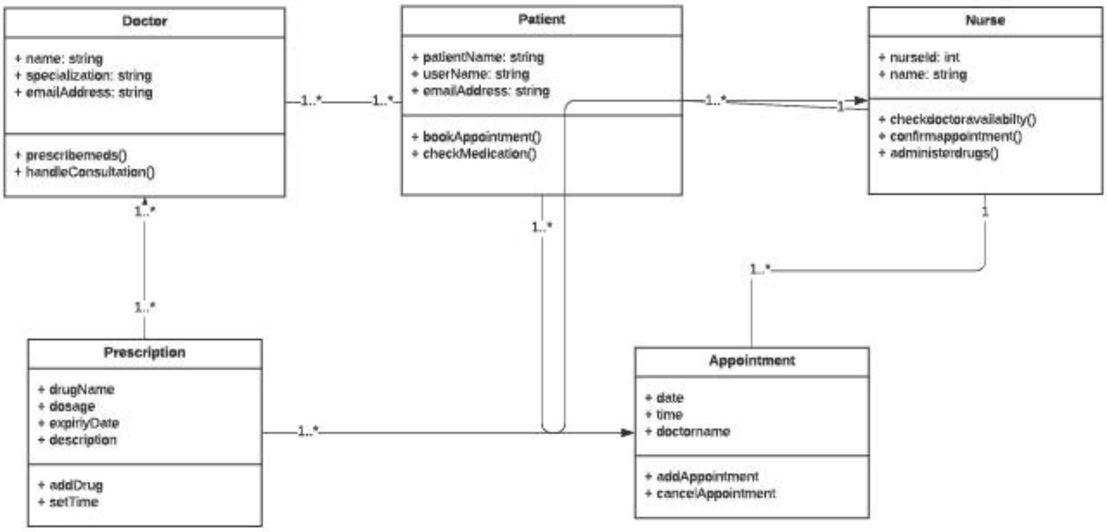


Figure 3.2: UML Class Diagram.

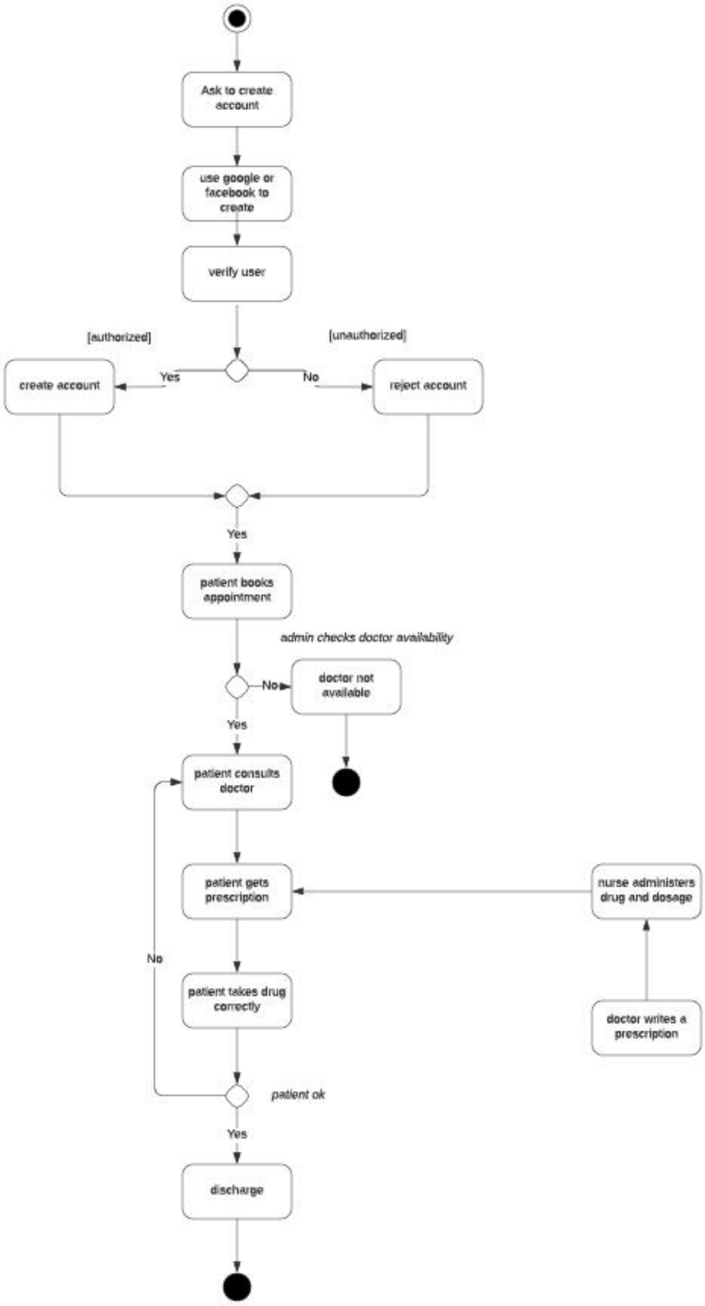

Ask to create account
use google or facebook to create
verify user
[authorized]
[unauthorized]
Yes
No
create account
reject account
Yes
patient books appointment
admin checks doctor availability
No
doctor not available
Yes
patient consults doctor
patient gets prescription
nurse administers drug and dosage
No
patient takes drug correctly
doctor writes a prescription
patient ok
Yes
discharge

Figure 3.3: Activity Diagram.

second, and so on. They graphically reflect the passing of time. The schematic structure and the notation of a medication alert system shown in Figure 3.4.

3.4 System Development Tools

These are tools that enable the implementation of the proposed system. These tools include: Hypertext Preprocessor, Cascading Stylesheet, Node.Js and Swift (IOS).

3.4.1 Nodejs

As an asynchronous event-driven JavaScript running time, Node.js is built to construct scalable network applications. Node.js is close in architecture to and inspired by frameworks such as Ruby's Event Machine and Python's Twisted. Node.js is pushing the event concept a little further. It introduces an event loop as a runtime construct instead of a library. There is often a blocking call in other systems to launch the event-loop. Usually, the behaviour is described by callbacks at the beginning of the script, and at the end the server is initiated by a blocking call such as EventMachine::run). There is no such start-the-event-loop call in Node.js. Node.js would simply enter the event loop after running the input script. Node.js will exit the event loop when there are no more callbacks to perform. This action is like a JavaScript browser — the case loop is concealed from the user.

3.4.2 Cascading Style Sheets

CSS is designed to allow the separation of presentation and content, including style, colors and fonts. This separation will increase content usability, offer greater consistency and autonomy in the selection of presentation characteristics, allow different web pages to share formatting by defining the related CSS in a separate.css file that reduces complexity and repeatability in a separate.css file. Separation of formatting and material often allows it possible to view the same markup page in

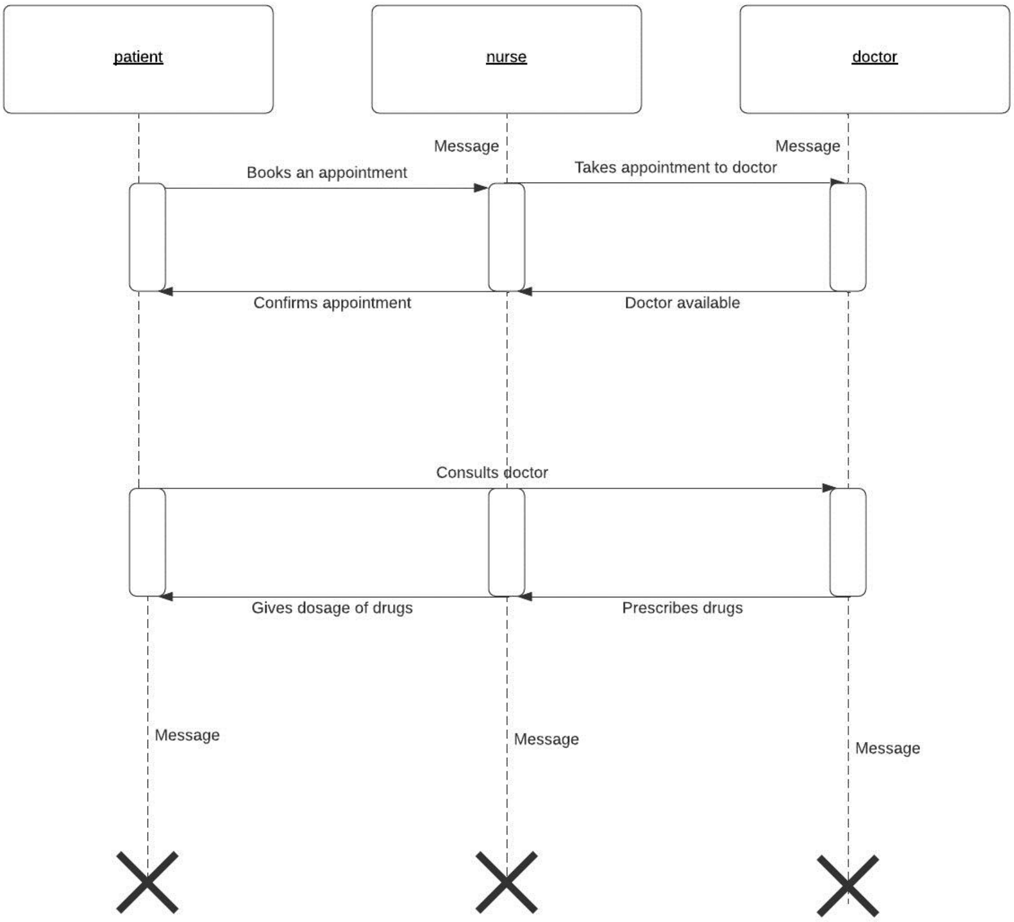


Figure 3.4: Sequence Diagram.

various formats for different rendering methods, such as on-screen, print, voice (via speech-based browser or screen reader) and Braille-based tactile devices. CSS also has guidelines for alternative formatting if content is read on a mobile device. The name cascading is derived from the stated priority scheme to decide which type of cascading is needed.

3.4.1 Swift

Kotlin is a cross-platform, statically typed, general-purpose programming language with type inference. Kotlin is programmed to completely interface with Java, and the JVM implementation of Kotlin 's standard library relies on the Java Class Library, but the type inference enables the syntax to be more succinct. Kotlin primarily targets JVM, but also compiles JavaScript (for example. frontend web applications using React) or native programming (via LLVM), e.g. native iOS apps sharing business logic with Android apps. Language creation expenses are shared by JetBrains, while the Kotlin Foundation protects Kotlin's trademark. On 7 May 2019, Google announced that Kotlin's programming language is now the chosen language for Android app developers. Since the introduction of Android Studio 3.0 in October 2017, Kotlin has been used as an alternative to the mainstream Java compiler.

3.4.1 Hypertext Markup Language (HTML)

HTML consists of a set of short codes that the author of the web typed in a text-file — these are marks. The text is then stored as an html file and accessed using a window such as Internet Explorer or Netscape Navigator. This browser reads the file and converts the text into a visible form, ideally making the website as expected by the author. Writing your own HTML requires the proper use of tags to build your vision. You can use anything from a rudimentary text editor to a versatile graphic editor to create HTML pages.

CHAPTER FOUR

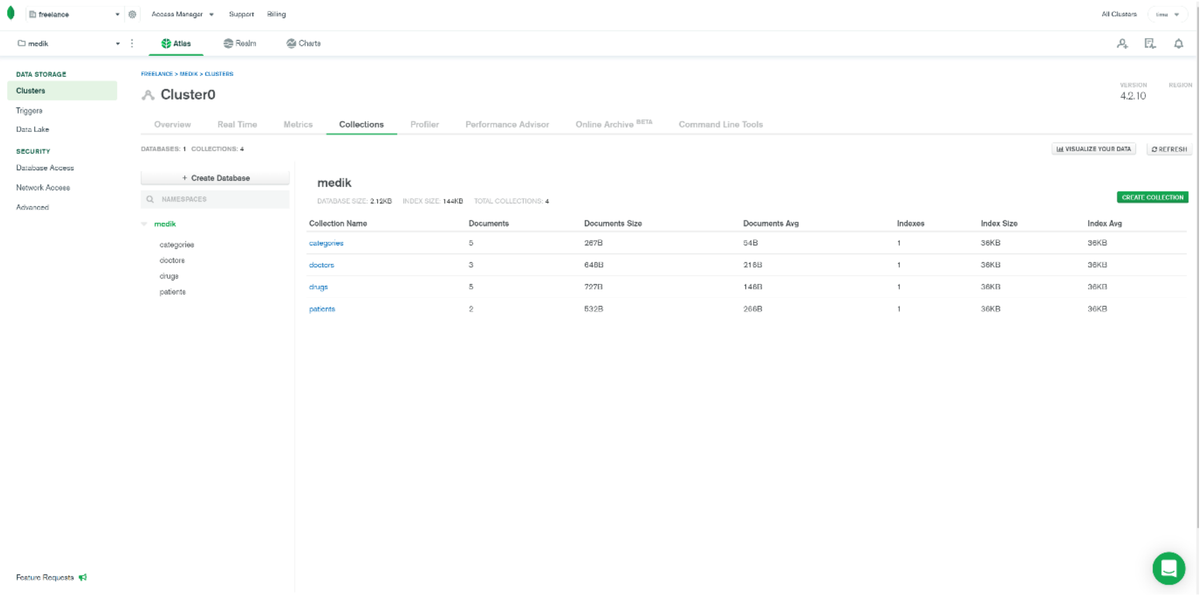
IMPLEMENTATION AND RESULT

4.1 Introduction

This section presents the findings and discussions of this study, which involved the design and implementation of a real time medication system. The chapter introduces the system database that has been implemented using JavaScript Object Notation (JSON) alongside the system interface that has been implemented using web-based application technologies such as HTML , CSS and JavaScript for the development of the system interface. The secondary user machine interface that is of a patient has been introduced using the mobile technology called as Kotlin. Testing and evaluation of device preformation was also an important part of this portion.

4.1.1 Implementation of System Database for Medication System.

Figure 4.1 shows a description of the database that was implemented for this study in order to store and retrieve information required by the proposed system. As a result of this, a database was implemented called the medik which consists of three (3) database collections which were required for managing the various types of information stored and manipulated by the system. The results of the implemented collection courses as shown in Figure 4.2 was used to manage information about the various components of the system as regards the roles they play. The collection holds an array of documents, a document in mongodb is a data structure composed of field and value pairs. The values of fields may include other documents, arrays and arrays of documents. A document in the categories collection had values and keys such as: _id, a unique id for each document, name, the name of the doctor.



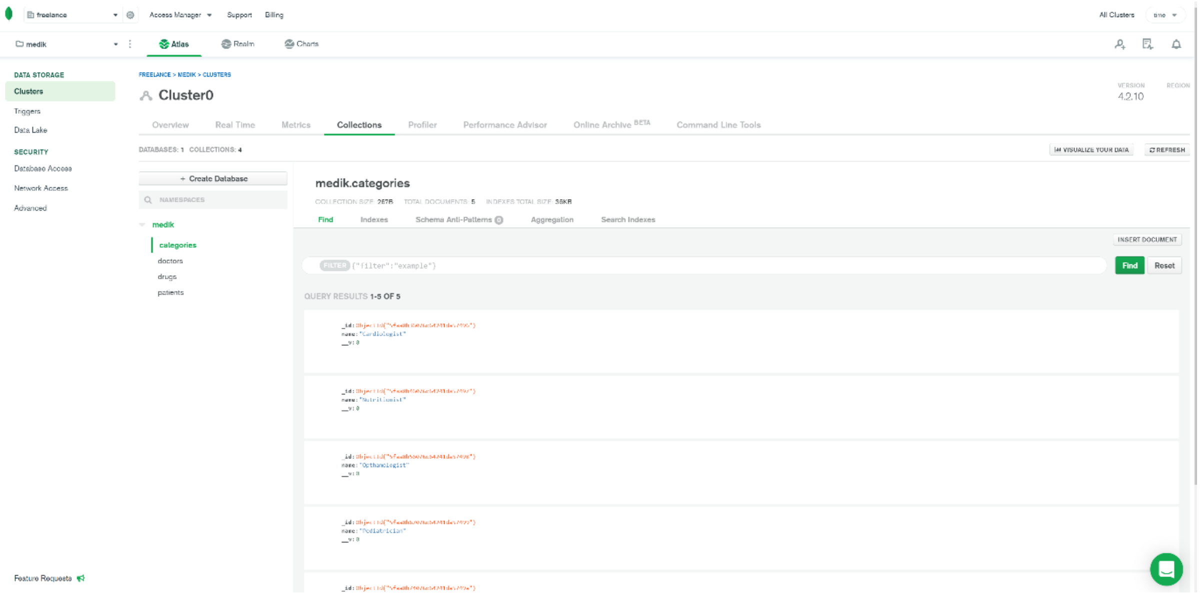
DATABASES: 1 COLLECTIONS: 4

medik

DATABASE SIZE: 2.12KB INDEX SIZE: 144KB TOTAL COLLECTIONS: 4

Collection Name	Documents	Documents Size	Documents Avg	Indexes	Index Size	Index Avg
categories	5	267B	54B	1	36KB	36KB
doctors	3	648B	216B	1	36KB	36KB
drugs	5	727B	146B	1	36KB	36KB
patients	2	532B	266B	1	36KB	36KB

Figure 4.1 Database of medik showing its collections



```
{"filter":"example"}
```

```
_id:ObjectId("5fea8b3e07e6e4241de57496")
name:"Cardiologist"
__v:0

_id:ObjectId("5fea8b4e07e6e4241de57497")
name:"Nutritionist"
__v:0

_id:ObjectId("5fea8b5507e6e4241de57498")
name:"Opthamologist"
__v:0

_id:ObjectId("5fea8b6707e6e4241de57499")
name:"Pediatrician"
__v:0

_id:ObjectId("5fea8b7407e6e4241de5749a")
```

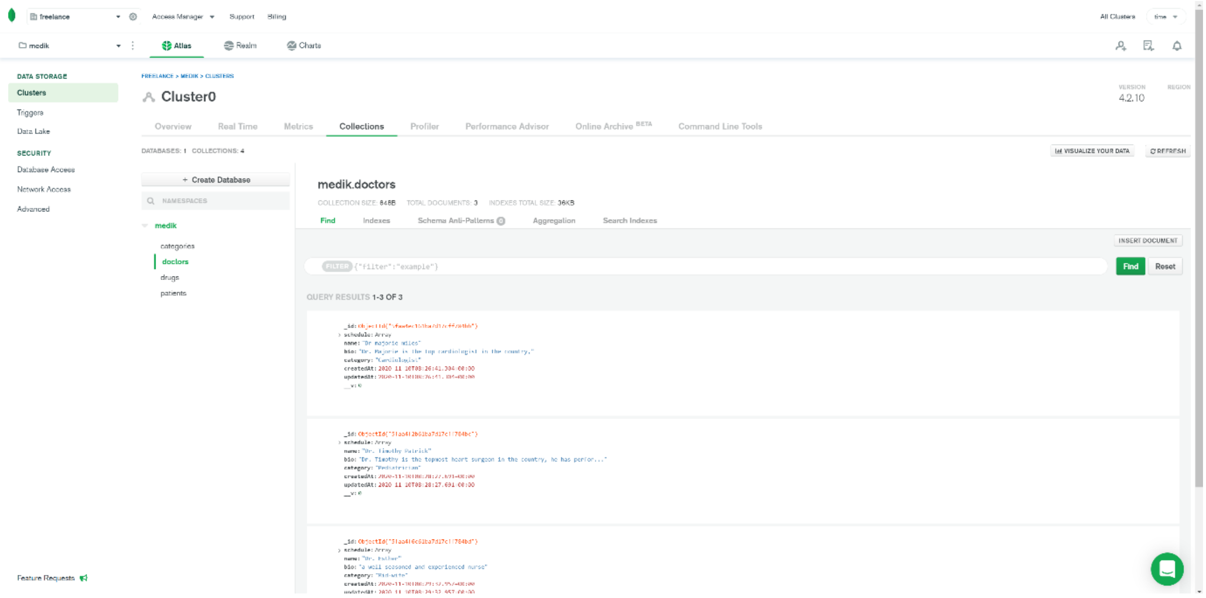
Figure 4.2 Collection medik.categories showing the list of courses and attributes

The results of the implemented medik,doctors collection as shown in Figure 4.3 was used to manage information about the doctors that are registered on the system. A document in the doctor's collection has values, and keys such as: _id, schedule, name, bio, category, createdAt, and updatedAt. The results of the implemented medik.drugs collection as shown in Figure 4.4 was used to manage information about the drugs available in the system. A document in the drug's collection has values, and keys such as: name, description, expiryDate, createdAt, and updatedAt. Figure 4.5 shows the result of the implementation of medik.patient collection which was used to manage information about the patients registered on the system. A document in the patient collection has values and keys such as: _id, name, email, homeAddress, gender, language, phone_no, blood_type, medical_history, createdAt, updatedAt.

4.3 Result of the User Interface of System of Implementation

Following the presentation of the results of the implementation of the system database using Monogdb the results of the implementation of the system using web-based technologies are presented. Figure 4.6 shows the system dashboard of the hospital administrator (Nurse).The results of this interface shows the different information stored on the system so far such as number of patients, recent activity, upcoming appointments, real-time calendar and many more. Figure 4.7 shows the results of the interface when an administrator views the upcoming appointments in the system.

Figure 4.8 shows the result of the interface when the system administrator is about to schedule an appointment for a patient to a specialized doctor. Hence, the shows the requisition of details such as the patients name, date of birth, phone number, location of the hospital the patient would like to take such appointment, date and time of appointment, examination/diagnosis type, specialist to whom to see, and any other extra



DATABASES: 1 COLLECTIONS: 4

medik.doctors

COLLECTION SIZE: 848B TOTAL DOCUMENTS: 3 INDEXES TOTAL SIZE: 36KB

{"filter":"example"}

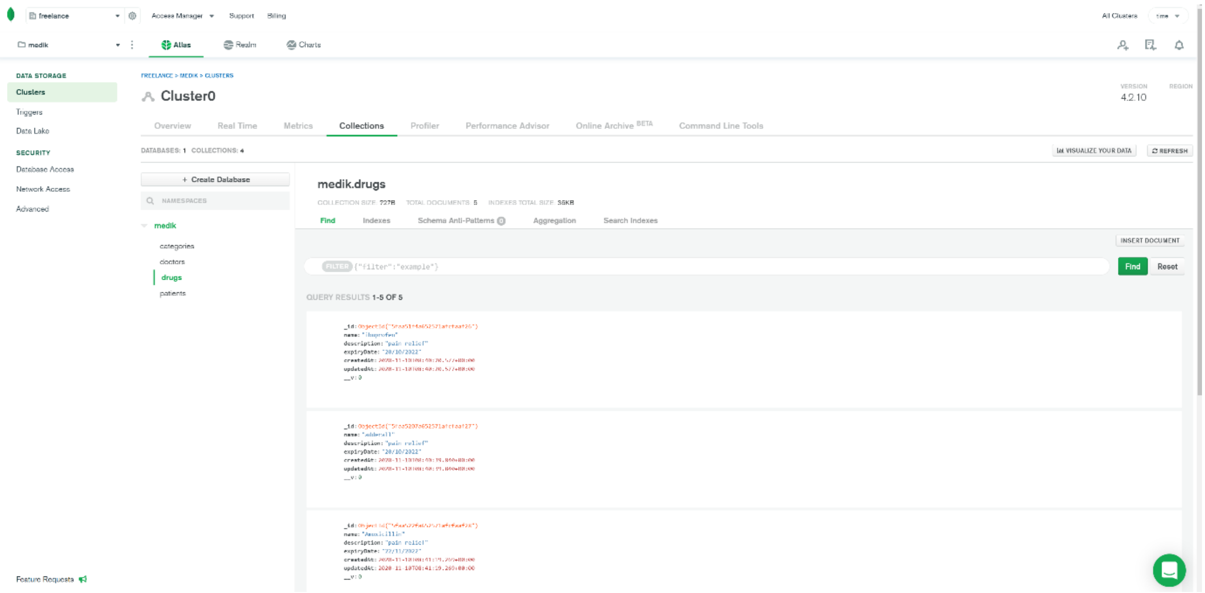
QUERY RESULTS 1-3 OF 3

```
  _id: ObjectId("5faa40c161ba7d17cff784bb")
> schedule: Array
  name: "Dr majorie miles"
  bio: "Dr. Majorie is the top cardiologist in the country,"
  category: "Cardiologist"
  createdAt: 2020-11-10T08:26:41.304+00:00
  updatedAt: 2020-11-10T08:26:41.304+00:00
  __v: 0
```

```
  _id: ObjectId("5faa412b61ba7d17cff784bc")
> schedule: Array
  name: "Dr. Timothy Patrick"
  bio: "Dr. Timothy is the topmost heart surgeon in the country, he has perfor..."
  category: "Pediatrician"
  createdAt: 2020-11-10T08:28:27.691+00:00
  updatedAt: 2020-11-10T08:28:27.691+00:00
  __v: 0
```

```
  _id: ObjectId("5faa416c61ba7d17cff784bd")
> schedule: Array
  name: "Dr. Esther"
  bio: "a well seasoned and experienced nurse"
  category: "Mid-wife"
  createdAt: 2020-11-10T08:29:52.957+00:00
  updatedAt: 2020-11-10T08:29:52.957+00:00
```

Figure 4.3 Collection medik.doctors showing the list of doctors and attributes

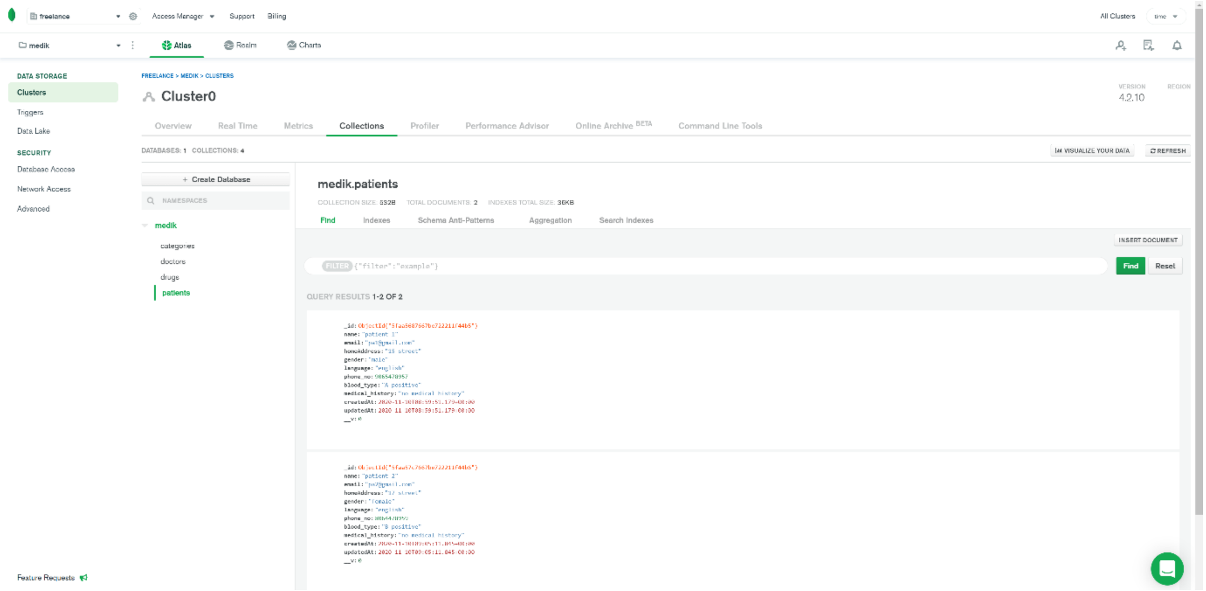


```
_id: ObjectId("5faa51f4a652571afcfaaf26")
name: "ibuprofen"
description: "pain relief"
expiryDate: "28/10/2022"
createdAt: 2020-11-10T08:40:20.577+00:00
updatedAt: 2020-11-10T08:40:20.577+00:00
__v: 0
```

```
_id: ObjectId("5faa5207a652571afcfaaf27")
name: "adderall"
description: "pain relief"
expiryDate: "28/10/2022"
createdAt: 2020-11-10T08:40:39.840+00:00
updatedAt: 2020-11-10T08:40:39.840+00:00
__v: 0
```

```
_id: ObjectId("5faa522fa652571afcfaaf28")
name: "Amoxicillin"
description: "pain relief"
expiryDate: "22/11/2022"
createdAt: 2020-11-10T08:41:19.269+00:00
updatedAt: 2020-11-10T08:41:19.269+00:00
__v: 0
```

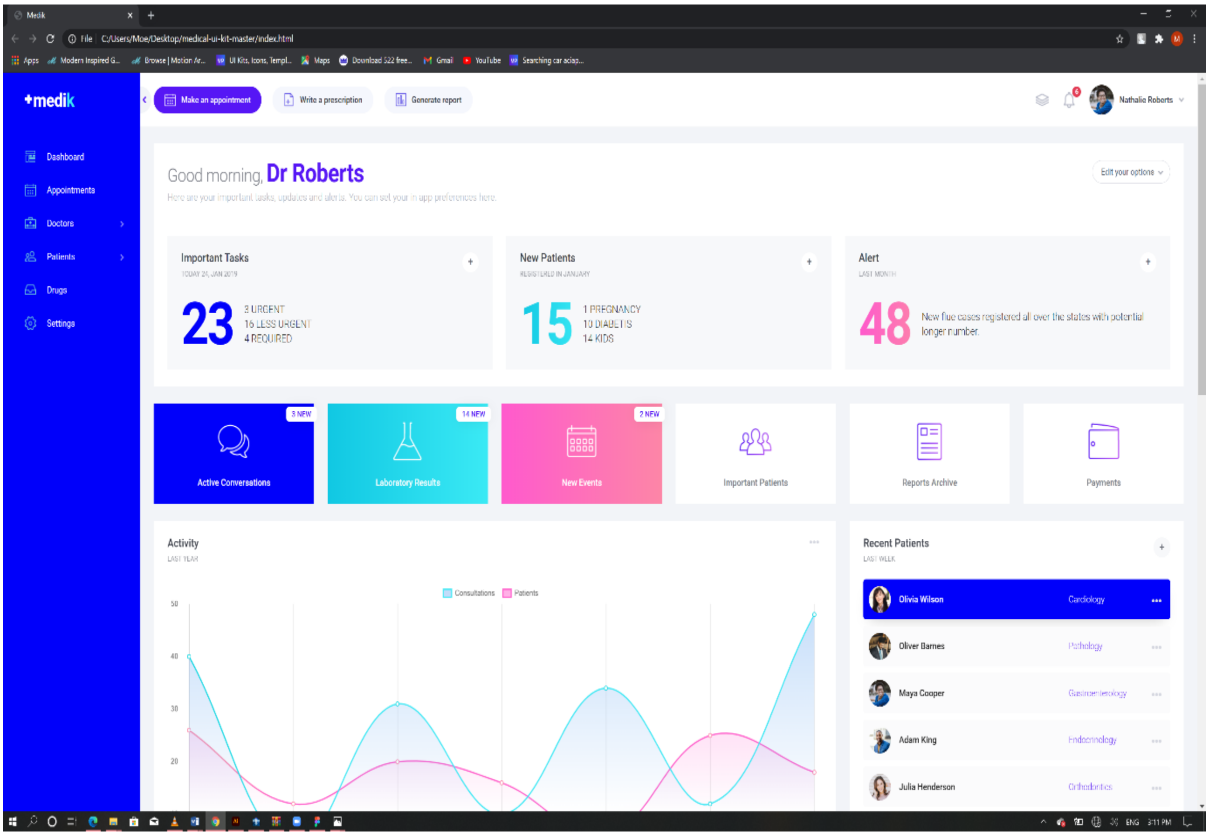
Figure 4.4 Collection medik.drugs showing the list of drugs and attributes



```
_id: ObjectId("5faa5687667be722211f44b5")
name: "patient 1"
email: "pa1@gmail.com"
homeAddress: "15 street"
gender: "male"
language: "english"
phone_no: 9865478957
blood_type: "A positive"
medical_history: "no medical history"
createdAt: 2020-11-10T08:59:51.179+00:00
updatedAt: 2020-11-10T08:59:51.179+00:00
__v: 0
```

```
_id: ObjectId("5faa57c7667be722211f44b6")
name: "patient 2"
email: "pa2@gmail.com"
homeAddress: "17 street"
gender: "female"
language: "english"
phone_no: 9864478959
blood_type: "B positive"
medical_history: "no medical history"
createdAt: 2020-11-10T09:05:11.845+00:00
updatedAt: 2020-11-10T09:05:11.845+00:00
__v: 0
```

Figure 4.5 Collection medik.patients showing the list of patients and attributes



Good morning, Dr Roberts

Here are your important tasks, updates and alerts. You can set your in app preferences here.

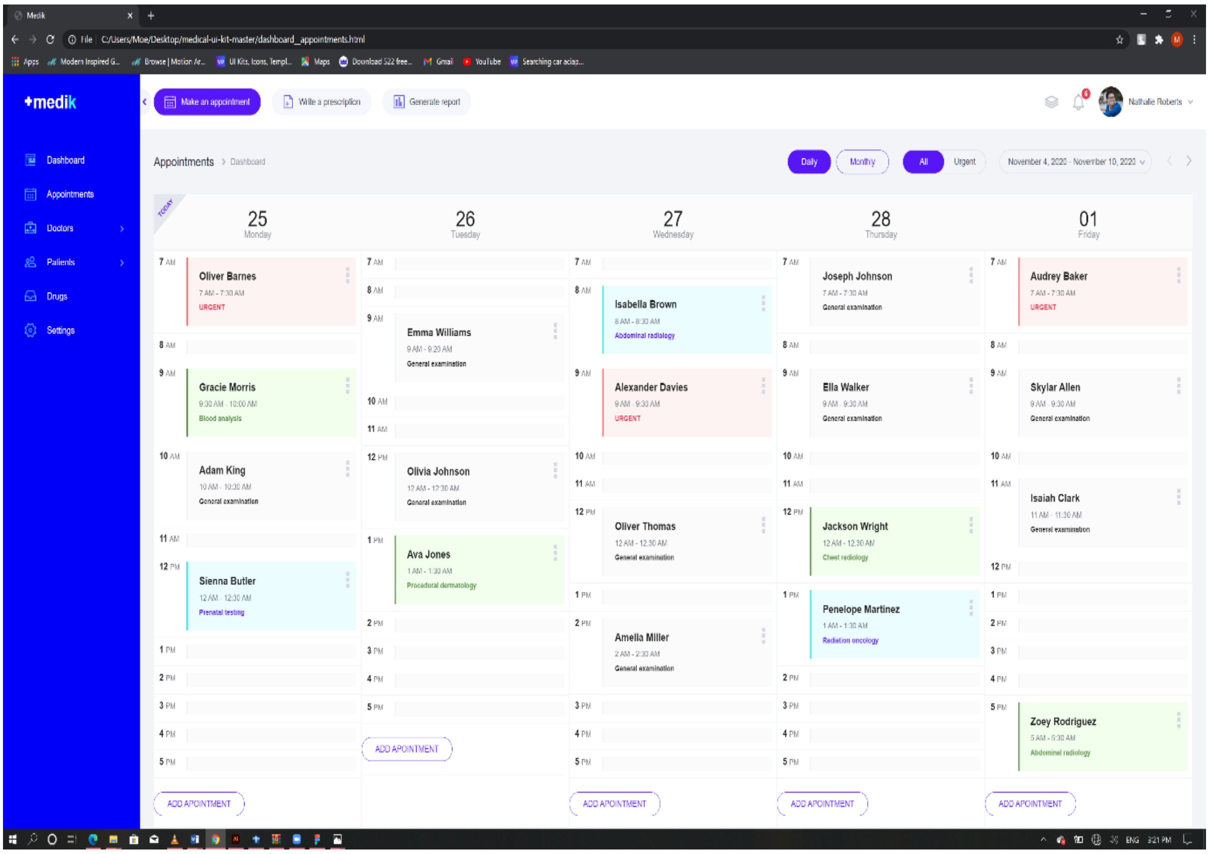
Important Tasks
TODAY 24, JAN 2019
23 3 URGENT
16 LESS URGENT
4 REQUIRED

New Patients
REGISTERED IN JANUARY
15 1 PREGNANCY
10 DIABETIS
14 KIDS

Alert
LAST MONTH
48 New flue cases registered all over the states with potential longer number.

Olivia Wilson	Cardiology
Oliver Barnes	Pathology
Maya Cooper	Gastroenterology
Adam King	Endocrinology
Julia Henderson	Orthodontics

Figure 4.6: Screenshot of System Admin dashboard.



25 Monday

7 AM Oliver Barnes 7 AM - 7:30 AM URGENT

9 AM Gracie Morris 9:30 AM - 10:00 AM Blood analysis

10 AM Adam King 10 AM - 10:30 AM General examination

12 PM Sienna Butler 12 AM - 12:30 AM Prenatal testing

26 Tuesday

9 AM Emma Williams 9 AM - 9:20 AM General examination

12 PM Olivia Johnson 12 AM - 12:30 AM General examination

1 PM Ava Jones 1 AM - 1:30 AM Procedural dermatology

27 Wednesday

8 AM Isabella Brown 8 AM - 8:30 AM Abdominal radiology

9 AM Alexander Davies 9 AM - 9:30 AM URGENT

12 PM Oliver Thomas 12 AM - 12:30 AM General examination

2 PM Amelia Miller 2 AM - 2:30 AM General examination

28 Thursday

7 AM Joseph Johnson 7 AM - 7:30 AM General examination

9 AM Ella Walker 9 AM - 9:30 AM General examination

12 PM Jackson Wright 12 AM - 12:30 AM Chest radiology

1 PM Penelope Martinez 1 AM - 1:30 AM Radiation oncology

01 Friday

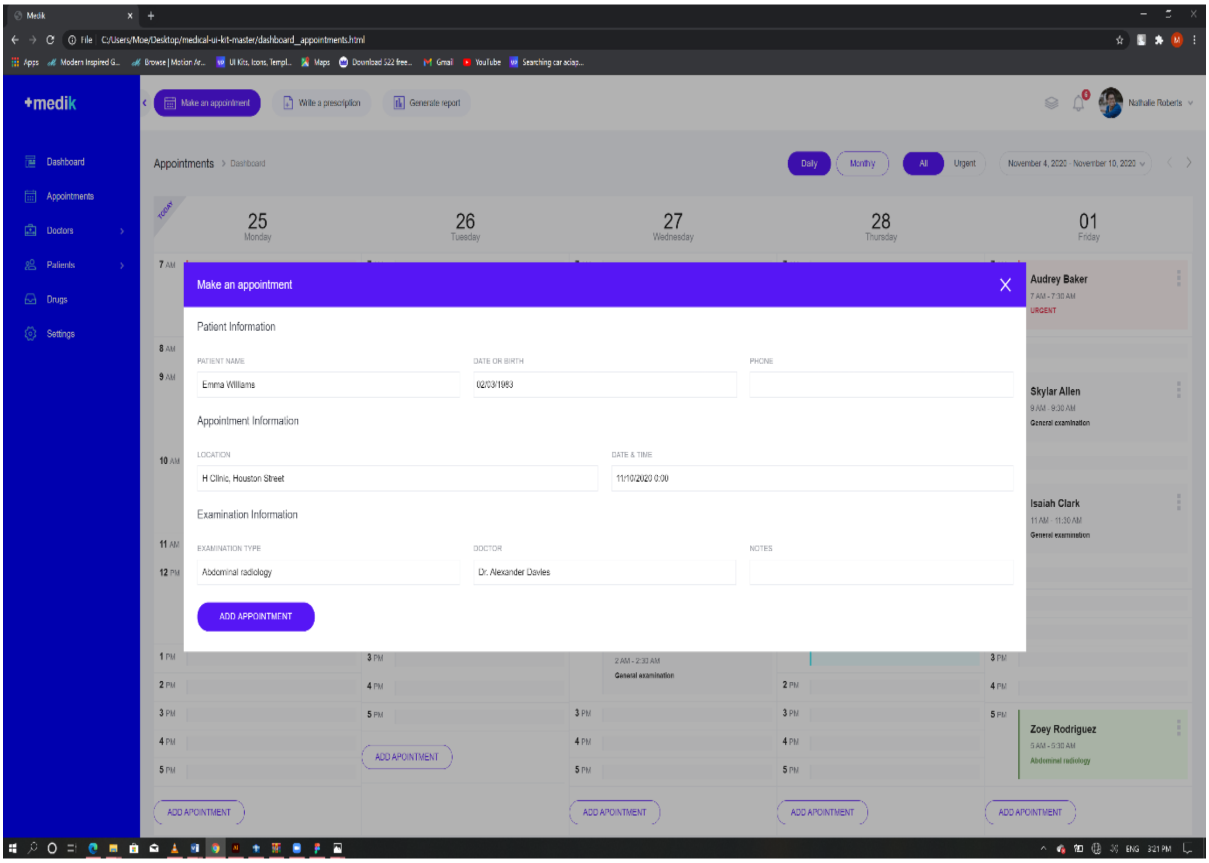
7 AM Audrey Baker 7 AM - 7:30 AM URGENT

9 AM Skylar Allen 9 AM - 9:30 AM General examination

11 AM Isaiah Clark 11 AM - 11:30 AM General examination

5 PM Zoey Rodriguez 5 AM - 5:30 AM Abdominal radiology

Figure 4.7: Screenshot of Admin Interface for viewing appointments.



Make an appointment

Patient Information

PATIENT NAME: Emma Williams

DATE OR BIRTH: 02/03/1983

PHONE:

Appointment Information

LOCATION: H Clinic, Houston Street

DATE & TIME: 11/10/2020 0:00

Examination Information

EXAMINATION TYPE: Abdominal radiology

DOCTOR: Dr. Alexander Davies

NOTES:

ADD APPOINTMENT

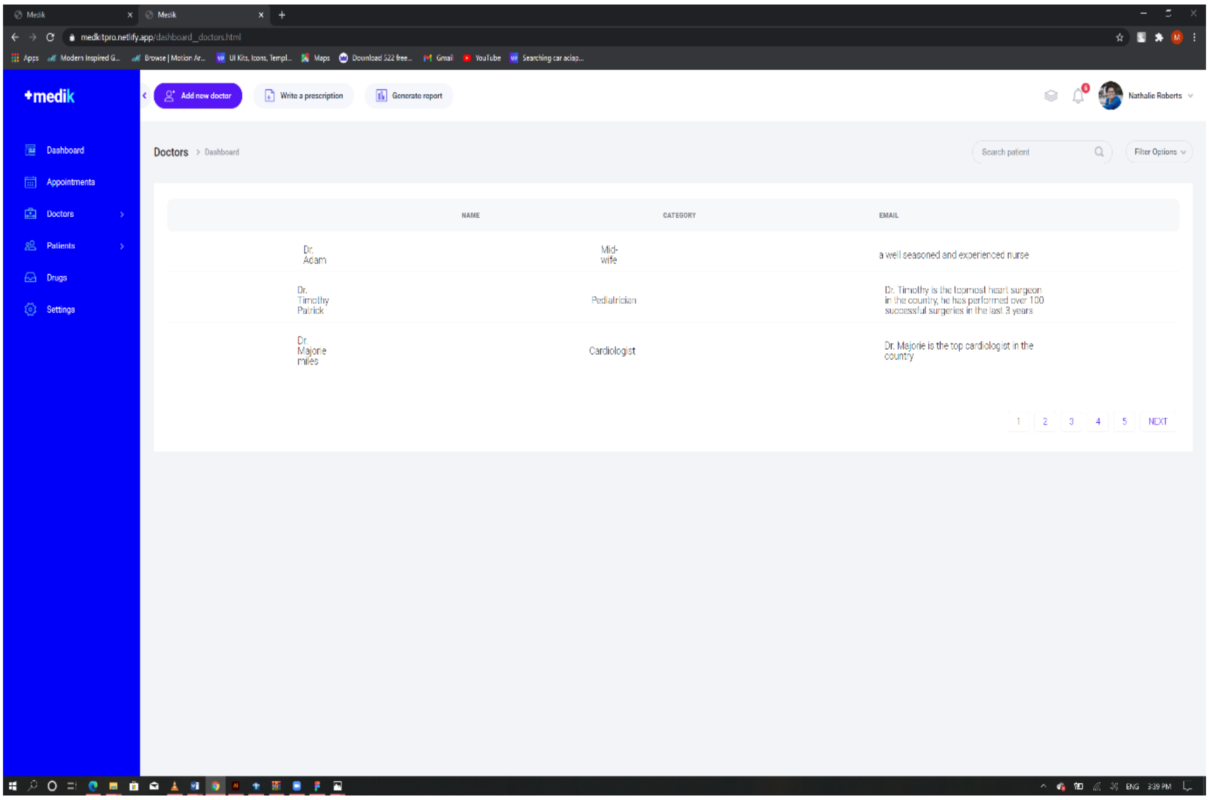
Figure 4.8: Screenshot of Admin Interface for adding appointments.

notes. Figure 4.9 shows the results of the interface when an administrator views the available doctors in the system. On clicking the ‘appointment’ button, it opens the earlier stated appointment screen. Figure 4.10 shows the result of the interface for adding/registering a new doctor manually into the system. Thus, this interface shows the requirement of details such as first name, last name, picture, email address, phone number, gender, date of birth, address, specialization, educational history and period of study.

Figure 4.11 shows the results of the interface when an administrator views the available patients that have been registered in the system. On clicking the ‘appointment’ button, it opens the earlier stated appointment screen. Figure 4.12 shows the result of the interface for adding/registering a new patient manually into the system. Thus, this interface shows the requisition of details such as first name, last name, email address, picture, phone number, gender, date of birth, address, known diseases, family history. Figure 4.13 shows the results of the interface when an administrator views the available drugs in the system as well as their availability, expiry dates and description. Figure 4.14 shows the results of the interface when an administrator is to add a new drug to the list of drugs available in the system. Hence, this interface shows the requisition of details such as drug name, expiry date and description.

Figure 4.15 shows the result of the interface for a doctor on the mobile application. The first user interface screen shows the distinction between a patient and a doctor. When a doctor comes on the app, he moves to the next screen which would be the

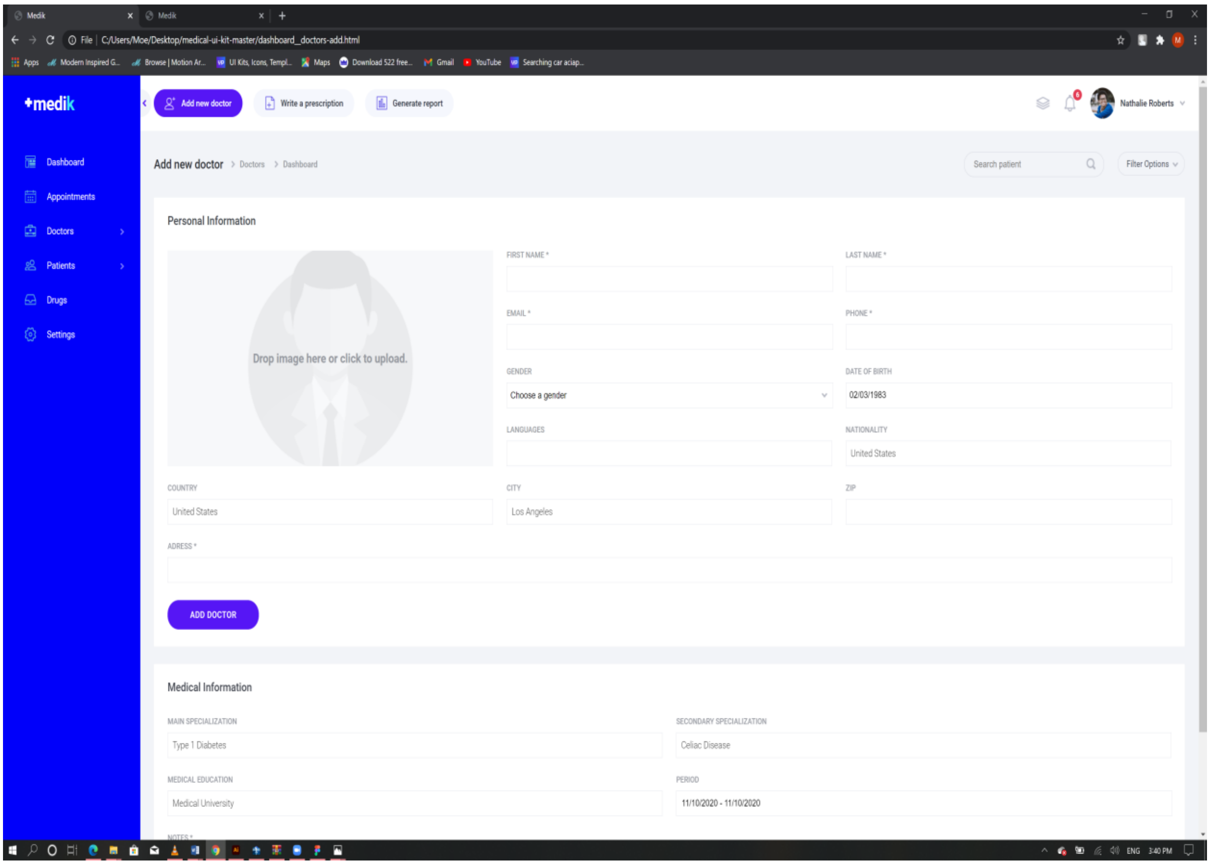
Signup screen for first time users. This screen uses verification from Google or the users’ Facebook account. The third screen shows a dropdown menu and an upload form for choosing specialty and uploading credentials respectively. The fourth screen is the homepage for



Doctors > Dashboard

NAME	CATEGORY	EMAIL
Dr. Adam	Mid-wife	a well seasoned and experienced nurse
Dr. Timothy Patrick	Pediatrician	Dr. Timothy is the topmost heart surgeon in the country, he has performed over 100 successful surgeries in the last 3 years
Dr. Majorie miles	Cardiologist	Dr. Majorie is the top cardiologist in the country

Figure 4.9: Screenshot of Admin Interface for viewing available doctors.



Personal Information

FIRST NAME *

LAST NAME *

EMAIL *

PHONE *

GENDER: Choose a gender

DATE OF BIRTH: 02/03/1983

LANGUAGES

NATIONALITY: United States

COUNTRY: United States

CITY: Los Angeles

ZIP

ADRESS *

Medical Information

MAIN SPECIALIZATION: Type 1 Diabetes

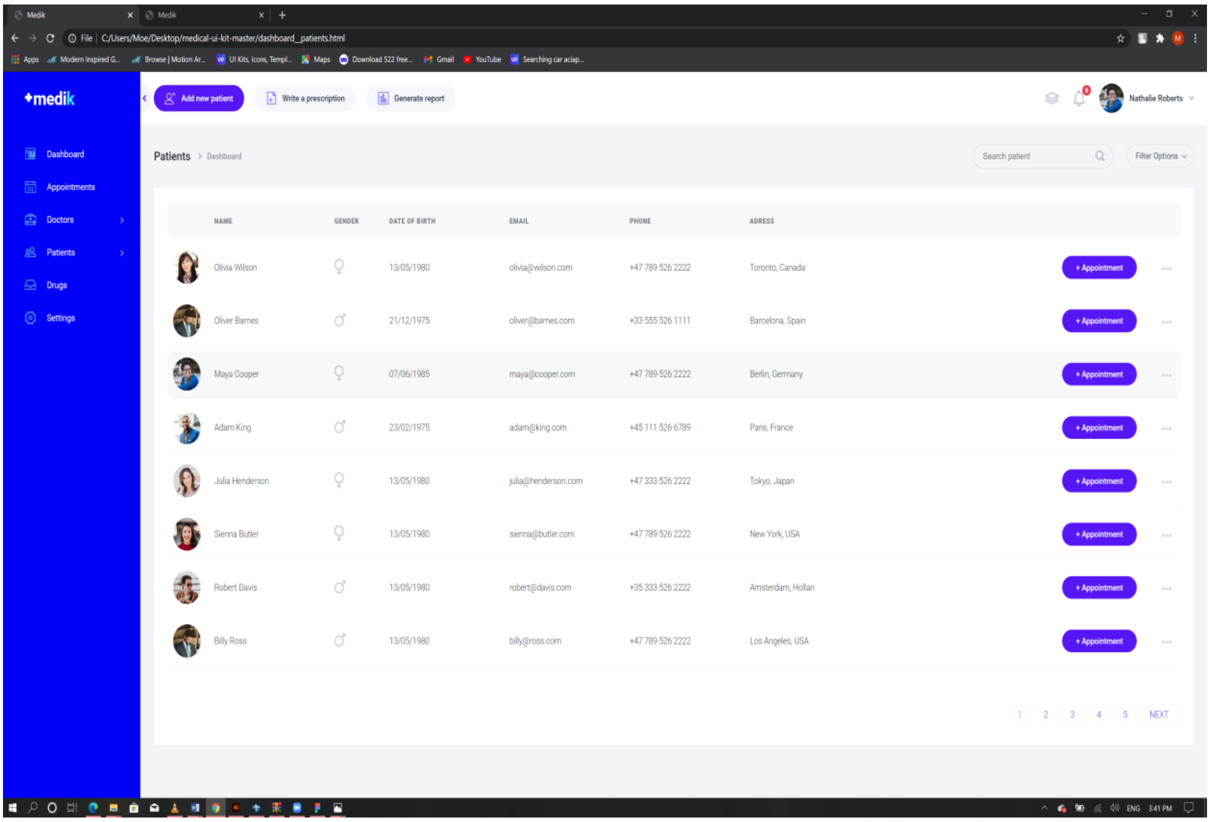
SECONDARY SPECIALIZATION: Celiac Disease

MEDICAL EDUCATION: Medical University

PERIOD: 11/10/2020 - 11/10/2020

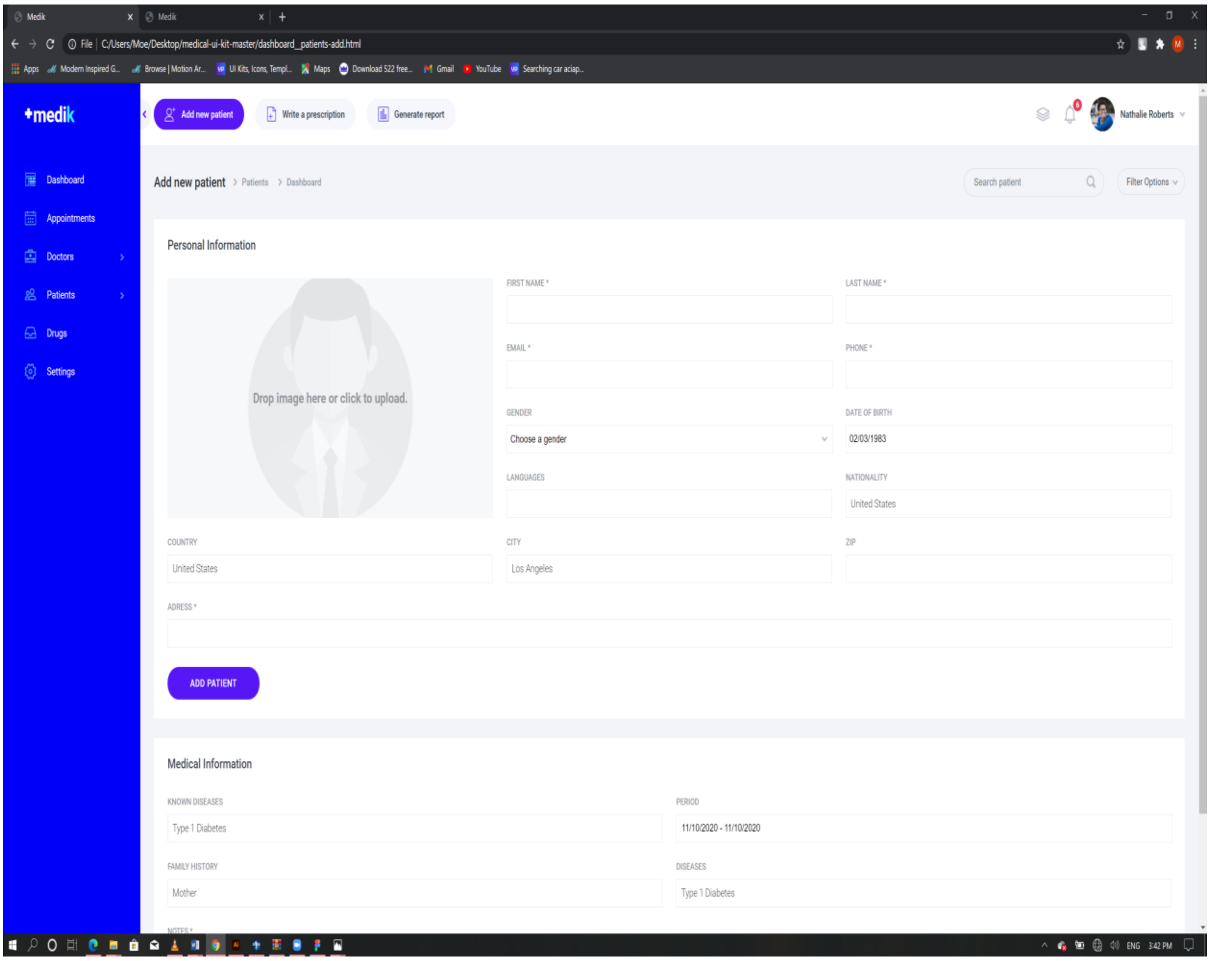
NOTES *

Figure 4.10: Screenshot of Admin Interface for adding a new doctor.



NAME	GENDER	DATE OF BIRTH	EMAIL	PHONE	ADRESS
Olivia Wilson	♀	13/05/1980	olivia@wilson.com	+47 789 526 2222	Toronto, Canada
Oliver Barnes	♂	21/12/1975	oliver@barnes.com	+33 555 526 1111	Barcelona, Spain
Maya Cooper	♀	07/06/1985	maya@cooper.com	+47 789 526 2222	Berlin, Germany
Adam King	♂	23/02/1975	adam@king.com	+45 111 526 6789	Paris, France
Julia Henderson	♀	13/05/1980	julia@henderson.com	+47 333 526 2222	Tokyo, Japan
Sienna Butler	♀	13/05/1980	sienna@butler.com	+47 789 526 2222	New York, USA
Robert Davis	♂	13/05/1980	robert@davis.com	+35 333 526 2222	Amsterdam, Hollan
Billy Ross	♂	13/05/1980	billy@ross.com	+47 789 526 2222	Los Angeles, USA

Figure 4.11: Screenshot of Admin Interface for viewing available patients



Personal Information

FIRST NAME *

LAST NAME *

EMAIL *

PHONE *

GENDER: Choose a gender

DATE OF BIRTH: 02/03/1983

LANGUAGES

NATIONALITY: United States

COUNTRY: United States

CITY: Los Angeles

ZIP

ADRESS *

Medical Information

KNOWN DISEASES: Type 1 Diabetes

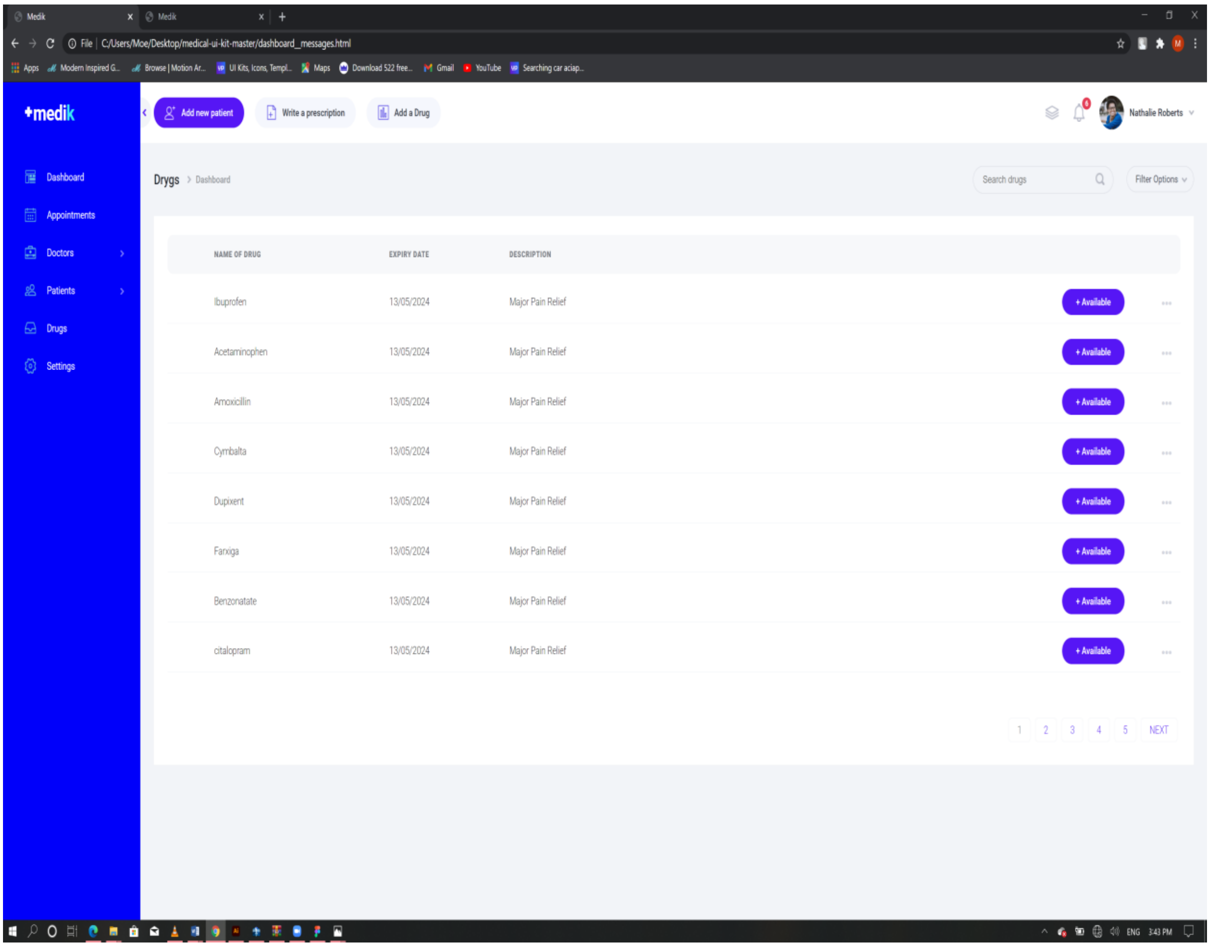
PERIOD: 11/10/2020 - 11/10/2020

FAMILY HISTORY: Mother

DISEASES: Type 1 Diabetes

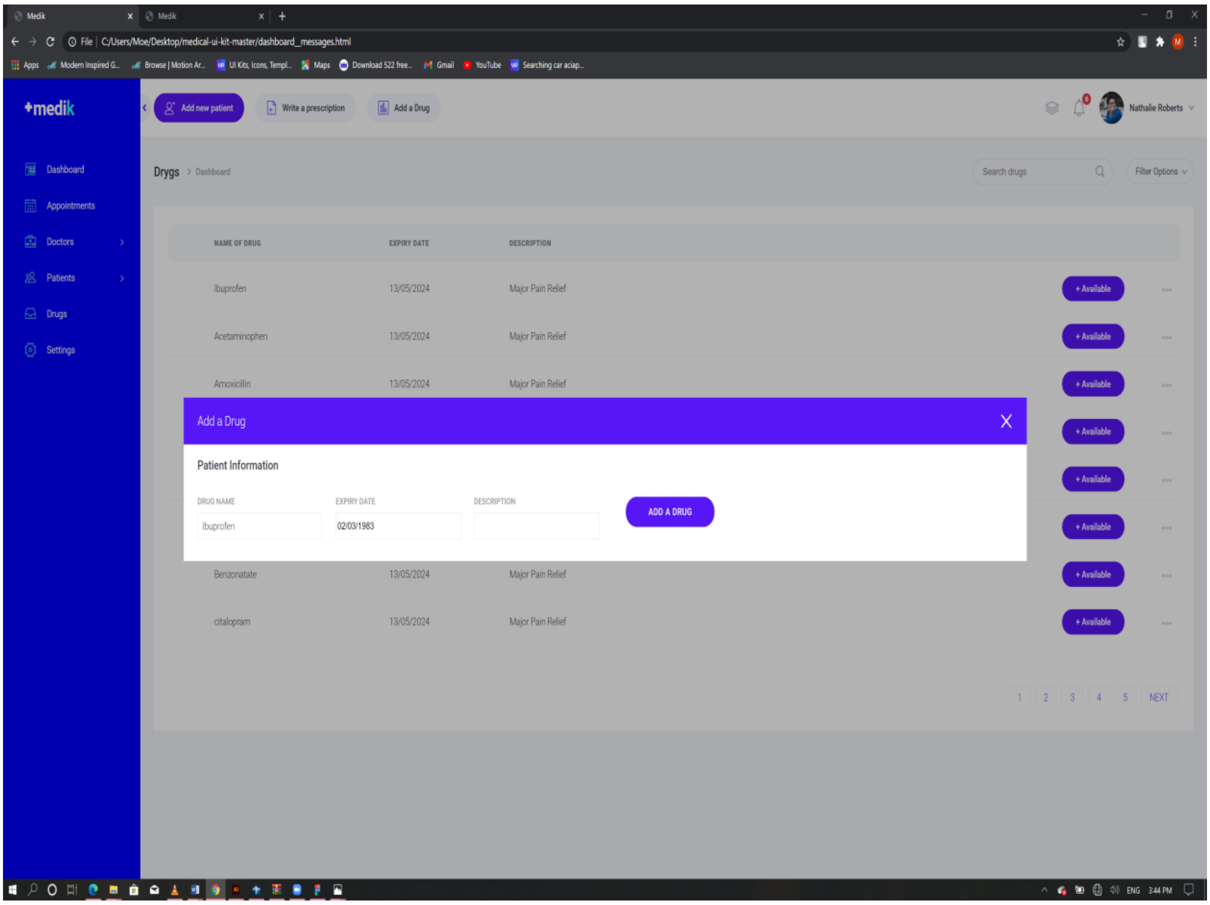
NOTES *

Figure 4.12: Screenshot of Admin Interface for adding a new patient.



NAME OF DRUG	EXPIRY DATE	DESCRIPTION	
Ibuprofen	13/05/2024	Major Pain Relief	+ Available
Acetaminophen	13/05/2024	Major Pain Relief	+ Available
Amoxicillin	13/05/2024	Major Pain Relief	+ Available
Cymbalta	13/05/2024	Major Pain Relief	+ Available
Dupixent	13/05/2024	Major Pain Relief	+ Available
Farxiga	13/05/2024	Major Pain Relief	+ Available
Benzonatate	13/05/2024	Major Pain Relief	+ Available
citalopram	13/05/2024	Major Pain Relief	+ Available

Figure 4.13: Screenshot of Admin Interface for viewing available drugs



NAME OF DRUG	EXPIRY DATE	DESCRIPTION		
Ibuprofen	13/05/2024	Major Pain Relief	+ Available	•••
Acetaminophen	13/05/2024	Major Pain Relief	+ Available	•••
Amoxicillin	13/05/2024	Major Pain Relief	+ Available	•••
			+ Available	•••
			+ Available	•••
			+ Available	•••
Benzonatate	13/05/2024	Major Pain Relief	+ Available	•••
citalopram	13/05/2024	Major Pain Relief	+ Available	•••

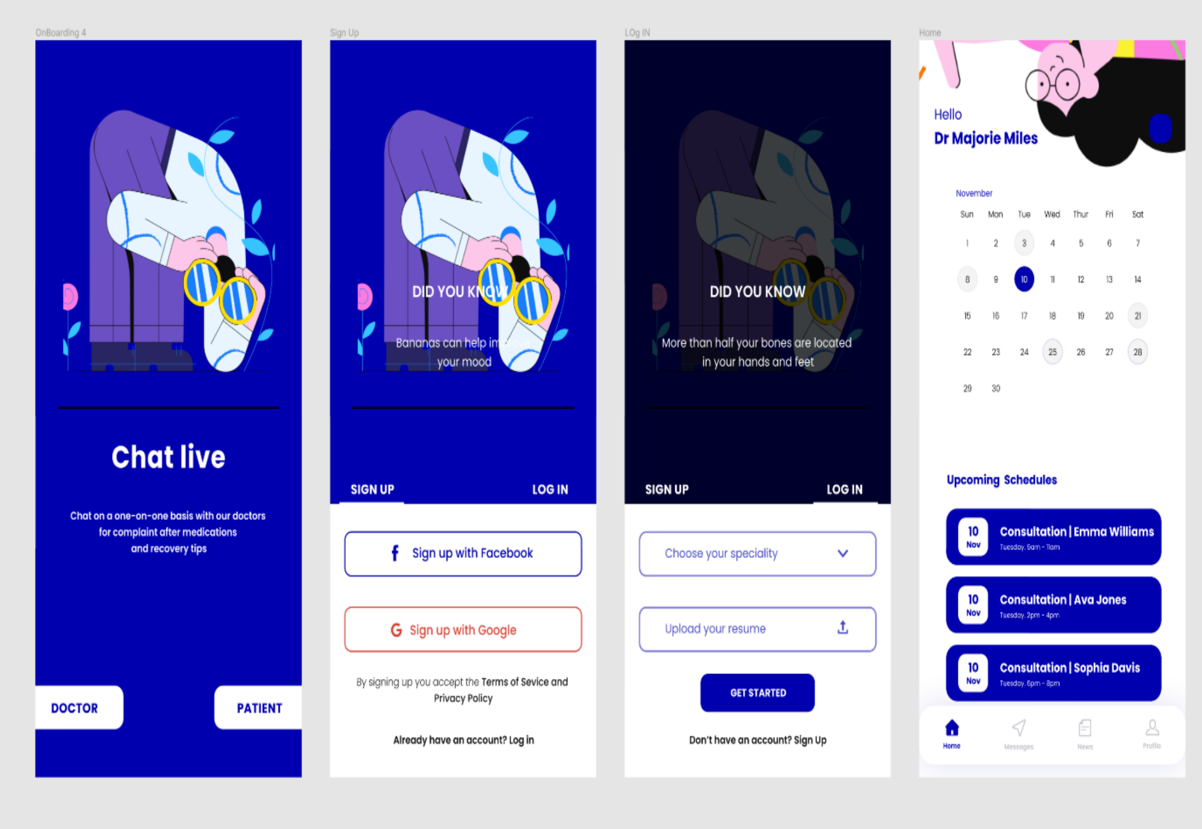
Add a Drug

Patient Information

DRUG NAME: Ibuprofen
EXPIRY DATE: 02/03/1983
DESCRIPTION:

ADD A DRUG

Figure 4.14: Screenshot of Admin Interface for adding new drugs.



Chat live

Chat on a one-on-one basis with our doctors for complaint after medications and recovery tips

DID YOU KNOW

Bananas can help improve your mood

By signing up you accept the Terms of Sevice and Privacy Policy

Already have an account? Log in

DID YOU KNOW

More than half your bones are located in your hands and feet

Don't have an account? Sign Up

Hello
Dr Majorie Miles

November

Sun	Mon	Tue	Wed	Thur	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Upcoming Schedules

10 Nov Consultation | Emma Williams
Tuesday. 9am - 11am

10 Nov Consultation | Ava Jones
Tuesday. 2pm - 4pm

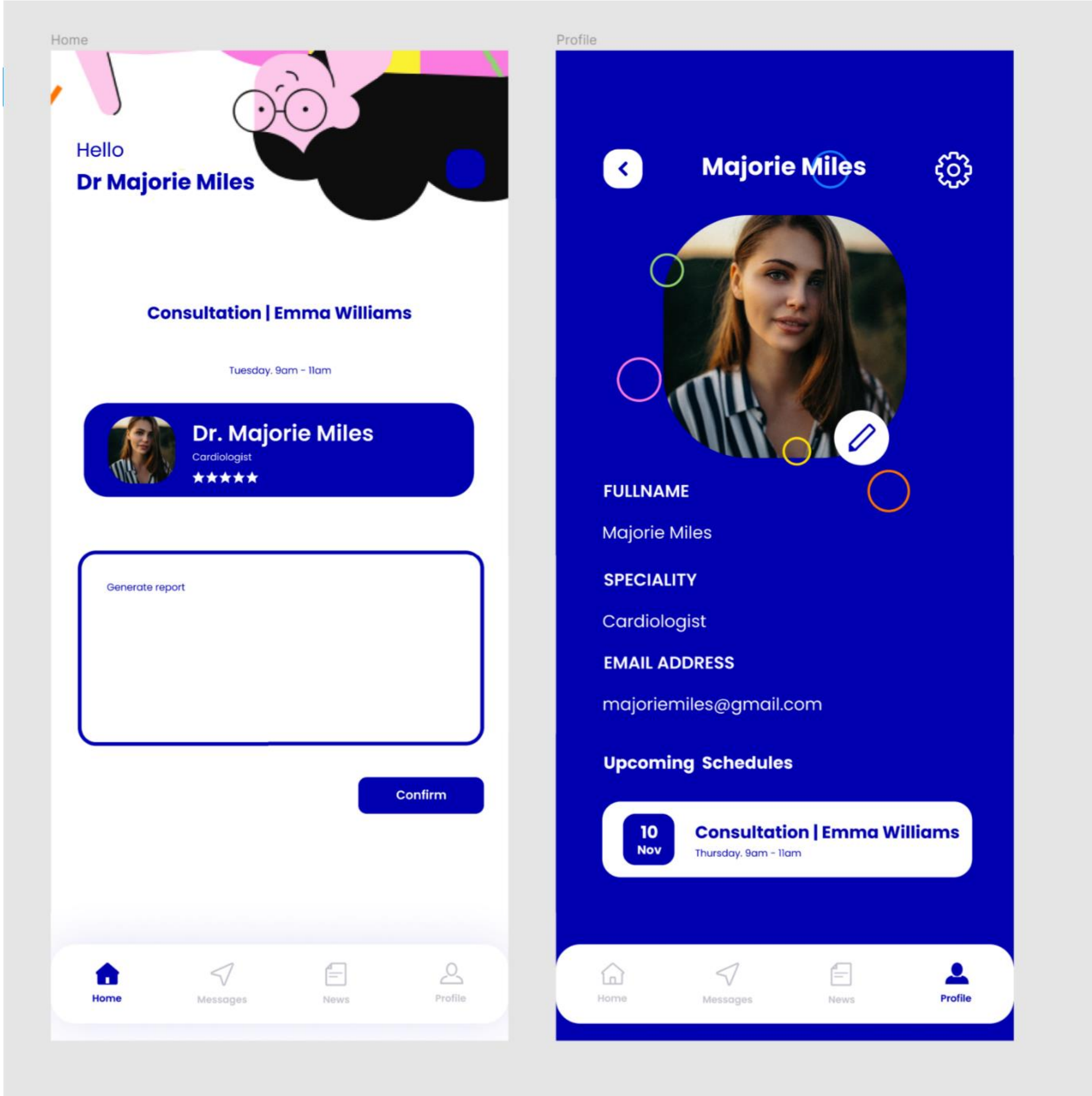
10 Nov Consultation | Sophia Davis
Tuesday. 6pm - 8pm

Figure 4.15: Screenshot of doctor interface (signup and homepage)

the doctor after all verification is complete. It shows the calendar for the day and the doctors upcoming schedules with the patients name written there and time.

Figure 4.16 shows the result of the second set interface for a doctor on the mobile application. The first user interface screen shows the a report form for a patient after consultation which would include the prescribe medication to be taken by said patient. The second screen shows the profile of the user (doctor) alongside; full name, specialty, email address and a view at the upcoming schedules. Figure 4.17 shows the result of the interface for a patient on the mobile application. The first user interface screen shows the difference between a patient and a doctor. When a patient comes on the app, he moves to the next screen which would be the Signup screen for first time users. This screen uses verification from Google or the users' Facebook account. The third screen is for returning users as they can login with their email address and password or choose the third party verification. The fourth screen consists of the basic functionalities of the application from diagnostics to consultation and then to reporting an emergency.

Figure 4.18 shows the result of the interface for a patient on the mobile application when he or she clicks on the diagnosis button. This screen consists of a list of possible symptoms which when filled accordingly sends a report over to the doctor to give a better understanding of the ailment before appointments. Figure 4.19 shows the result of the interface for a patient on the mobile application when he or she chooses to book a consultation. On this screen, there comes a list of doctors according to their specialties. The user picks from this list and moves to the next screen where he or she sees the available time slots for the chosen doctor and chooses one thereafter writing a brief complaint to aid the process of the diagnosis before and while seeing the doctor.



Home

Hello
Dr Majorie Miles

Consultation | Emma Williams

Tuesday. 9am - 11am

Dr. Majorie Miles
Cardiologist
★★★★★

Generate report

Profile

Majorie Miles

FULLNAME
Majorie Miles

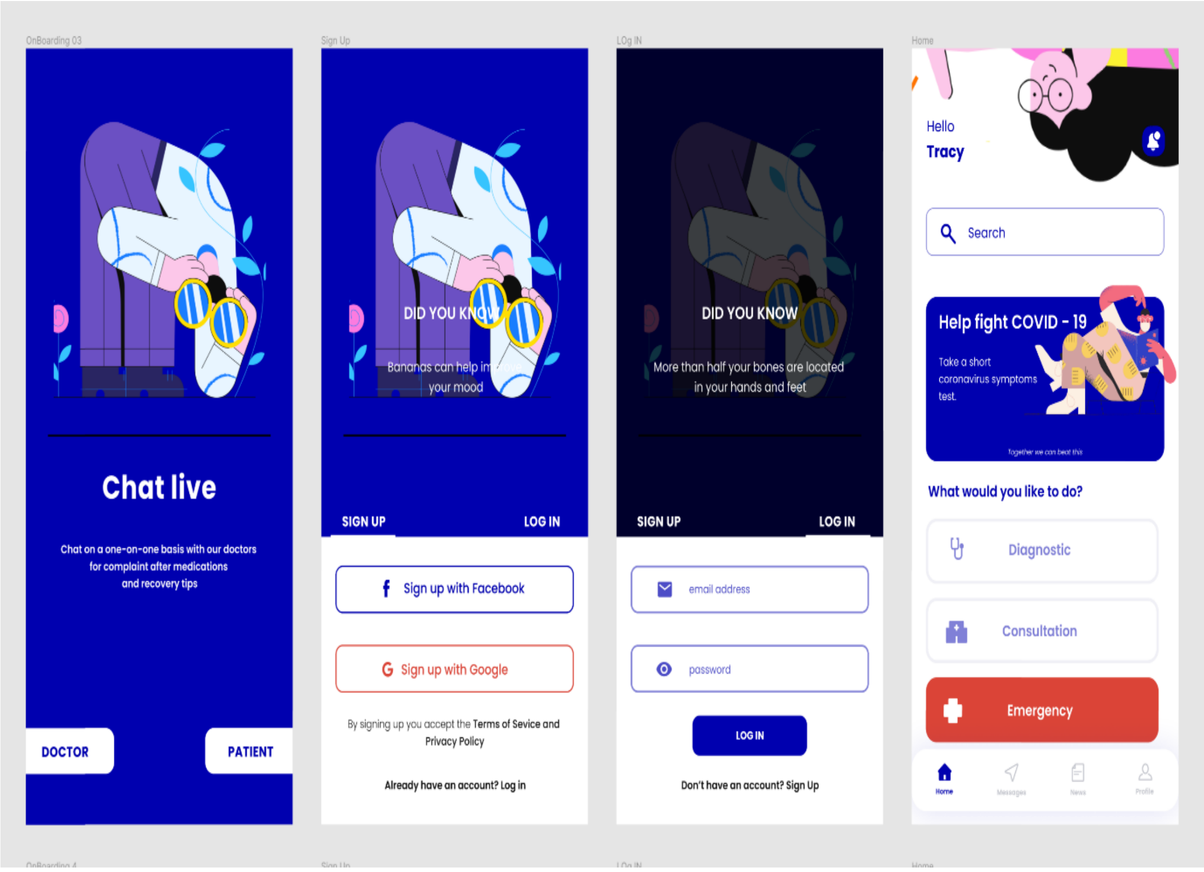
SPECIALITY
Cardiologist

EMAIL ADDRESS
majoriemiles@gmail.com

Upcoming Schedules

10 Nov
Consultation | Emma Williams
Thursday. 9am - 11am

Figure 4.16: Screenshot of doctor interface (report and profile pages)



Chat on a one-on-one basis with our doctors for complaint after medications and recovery tips

DID YOU KNOW

Bananas can help improve your mood

By signing up you accept the Terms of Sevice and Privacy Policy

Already have an account? Log in

More than half your bones are located in your hands and feet

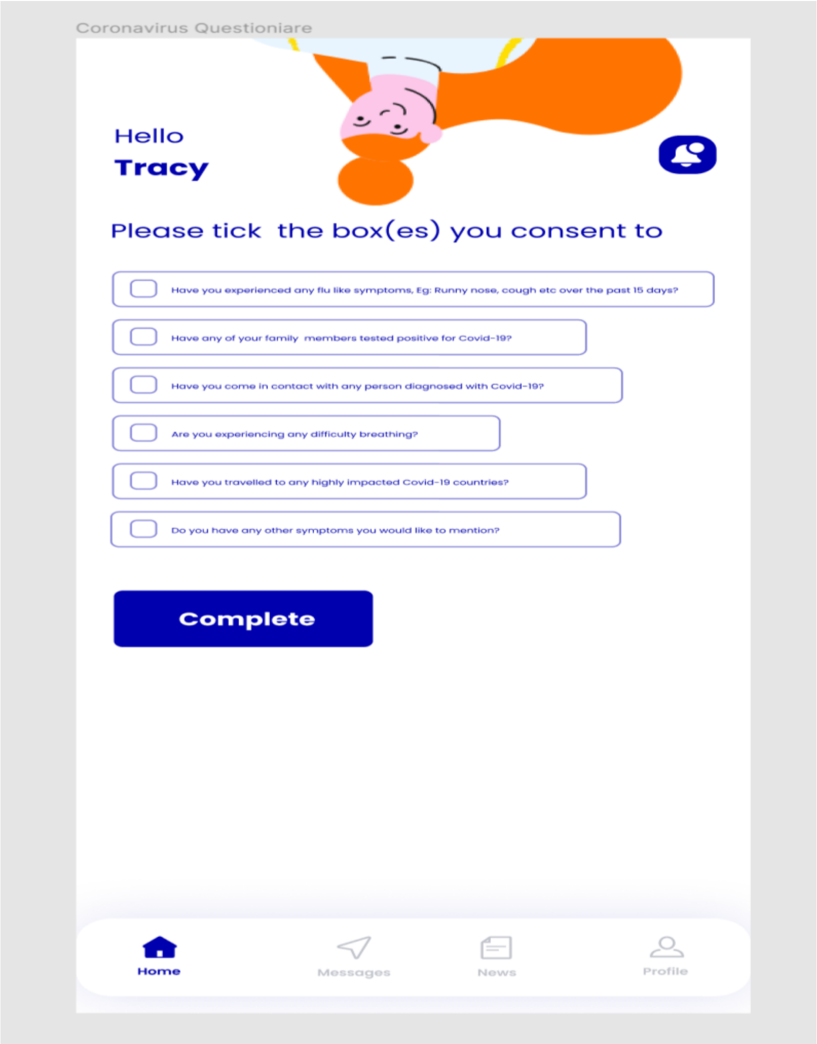
Don't have an account? Sign Up

Take a short coronavirus symptoms test.

Together we can beat this

What would you like to do?

Figure 4.17: Screenshot of patient interface (signup and homepage)



Coronavirus Questioniare

Hello

Tracy

Please tick the box(es) you consent to

□ Have you experienced any flu like symptoms, Eg: Runny nose, cough etc over the past 15 days?

□ Have any of your family members tested positive for Covid-19?

□ Have you come in contact with any person diagnosed with Covid-19?

□ Are you experiencing any difficulty breathing?

□ Have you travelled to any highly impacted Covid-19 countries?

□ Do you have any other symptoms you would like to mention?

Figure 4.18: Screenshot of patient interface (diagnosis page)

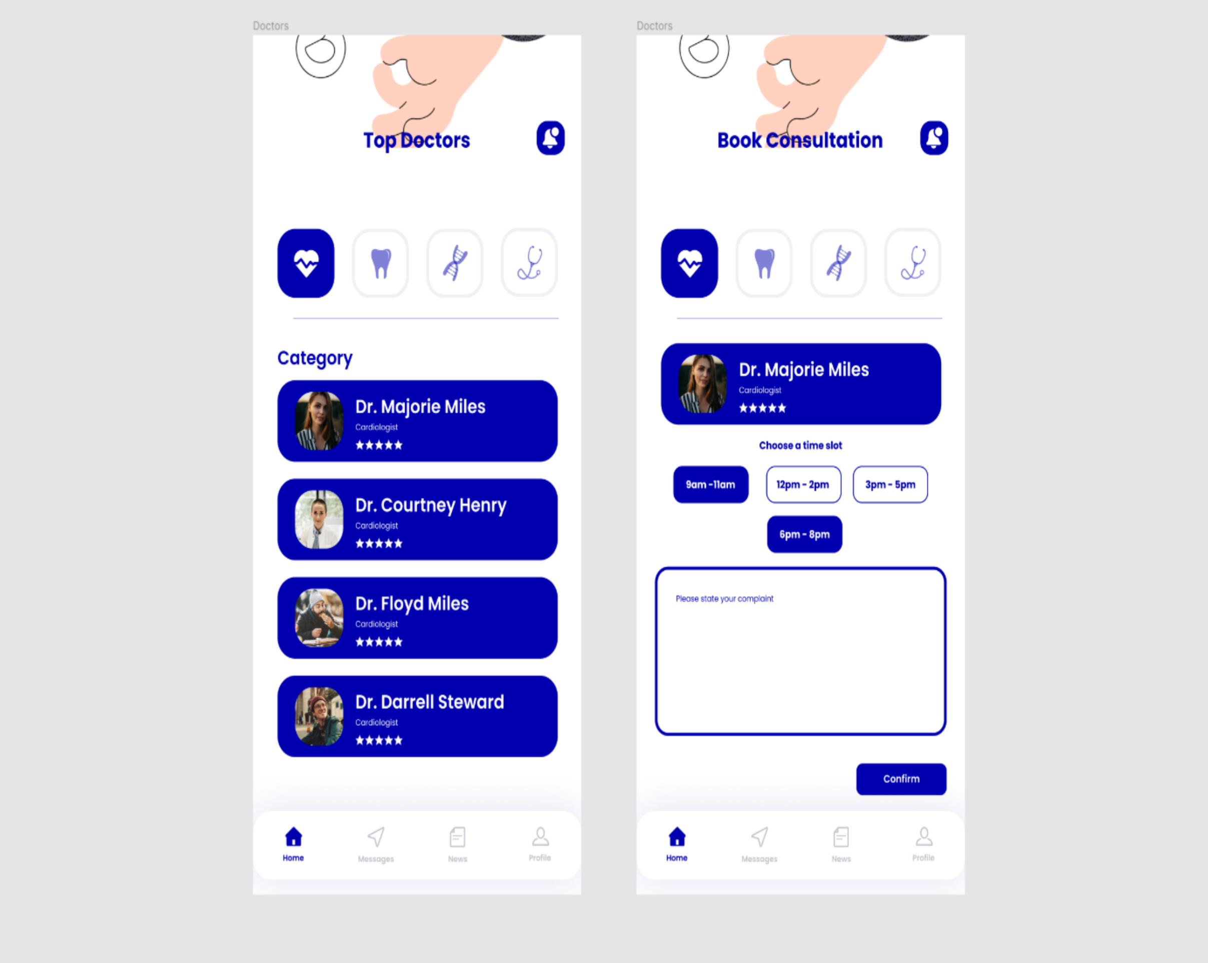


Figure 4.19: Screenshot of patient interface (consultation)

Figure 4.20 shows the result of the interface for a patient on the mobile application when he or she wants to report an emergency. The user chooses from the available list of emergencies or simply writes what they choose to report urgently. Figure 4.21 shows the result of the interface for a patient on the mobile application as regards medications. The first screen consists of a user's upcoming medications and their specified time. Thus when the time for the medication reaches, an alarm as shown in the second screen would pop up in-app and an option to confirm is display which then confirms the reminder and usage of the specified drug.

4.4 Discussion of Results

The result of the study has been presented which showed the different expectations of this study based on the objectives that were stated in the earlier chapters of this study. The results of the identification of the user and system requirements allowed for the identification of the different users of the proposed system such as super user and the primary users of the system. The results showed that the super user was responsible for creating and managing doctors, patients and appointments on the system. The results also showed the segmentation of roles across the doctors and patients.

The results of the specification of the design showed that the user requirements of the proposed system were clearly identified following the use case diagram which was used to design the different interactions of the system users with the system alongside their respective feedback. The results of the system interface using HTML, Javascript and CSS, showed that the system was able to provide interfaces that were compliant with the system and user requirements that were identified in this study. The system implementation allowed for patients to get alerts on their prescription using the system thus, removing the error of forgetting when and which drug exactly to take at a particular time.

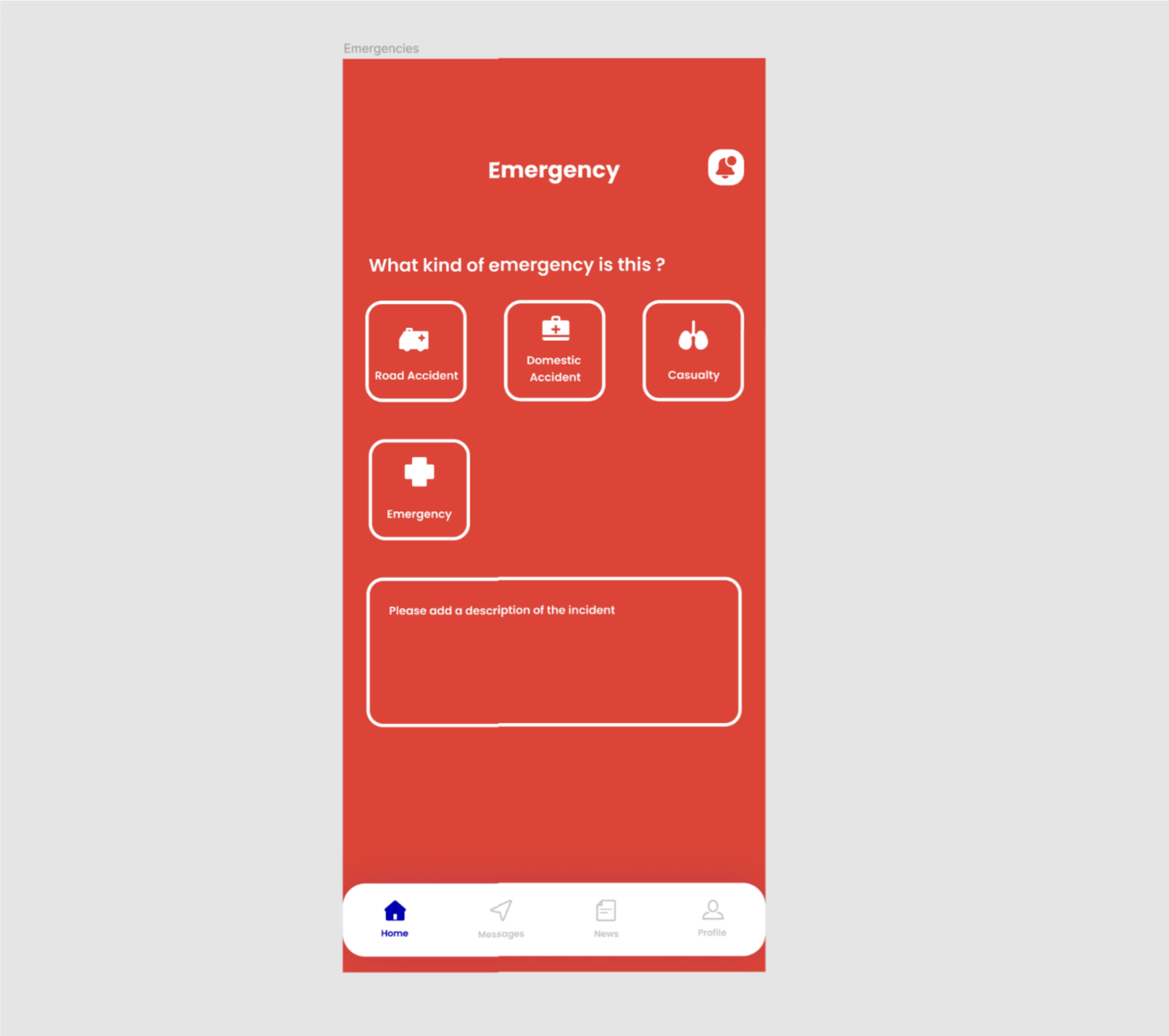
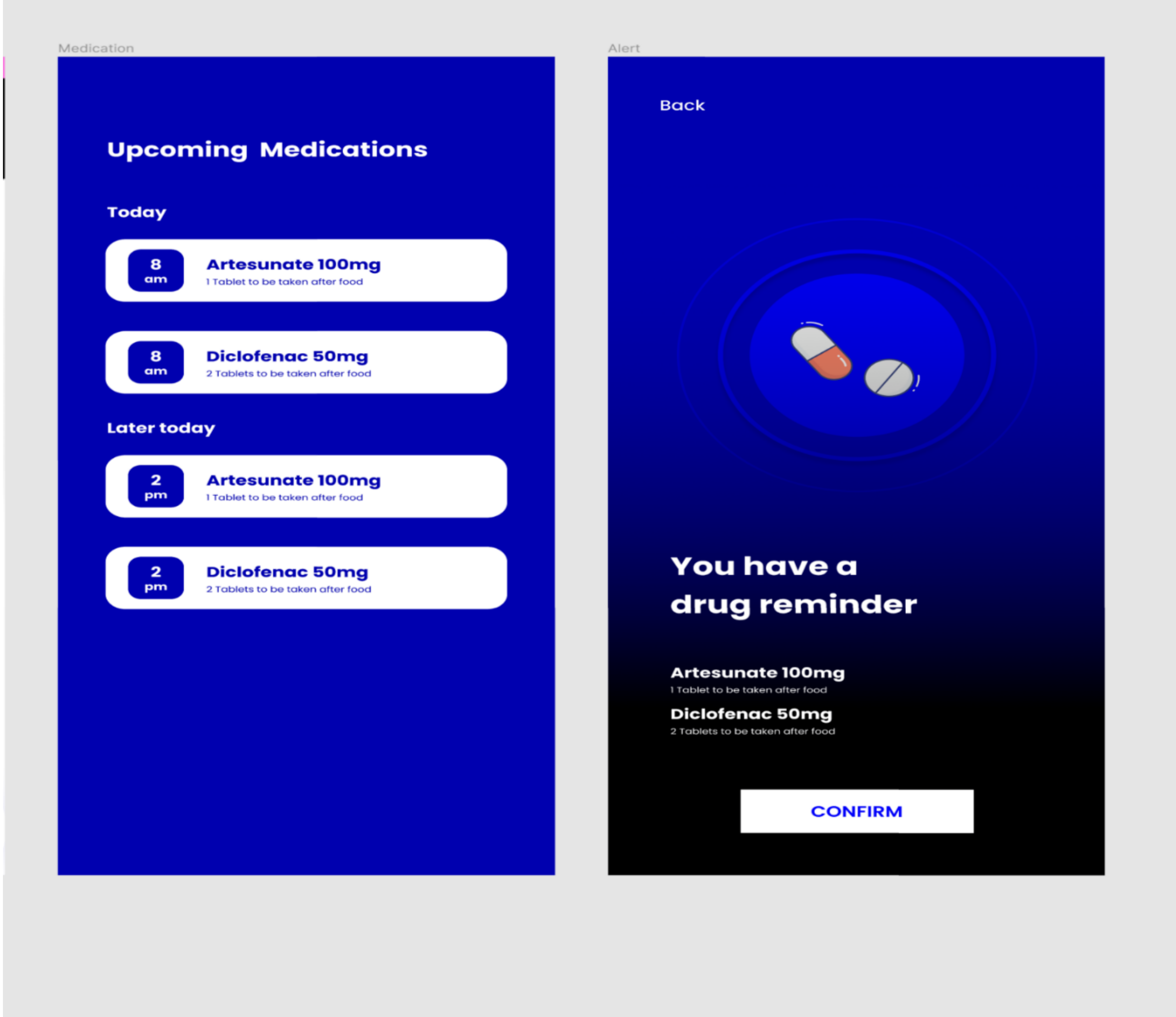


Figure 4.20: Screenshot of patient interface (emergency)



Upcoming Medications

Today

8 am Artesunate 100mg
1 Tablet to be taken after food

8 am Diclofenac 50mg
2 Tablets to be taken after food

Later today

2 pm Artesunate 100mg
1 Tablet to be taken after food

2 pm Diclofenac 50mg
2 Tablets to be taken after food

You have a drug reminder

Artesunate 100mg
1 Tablet to be taken after food

Diclofenac 50mg
2 Tablets to be taken after food

Figure 4.21: Screenshot of patient interface (medication page).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

This study established a mobile platform that alerts a patient on the specific drug(s) to take and at what times. The study defined the user and system specifications that had to be met by the system. In addition to the hardware and software requirements of the system, the user and system requirements were defined. System specifications were also defined using unified modeling languages, user specification use-case diagrams for user requirements, data modeling specification class diagrams, system interaction display activity diagrams, system activity timing diagrams, and overall system background diagrams. The system was implemented using Web 2.0 technologies such as HTML, Javscript, MongoDb and CSS for web layout and data movements in and out of web interface types from and to system databases. Kotlin for the mobile application interfaces.

5.2 Conclusion

In conclusion, this study was able to design and incorporate a functional monitoring framework for the alerting of patients through a controlled system on whatever drug to take. The study was also able to define the respective users and system specifications of the system and suitable designs were used to determine these requirements provided by the users using use-case, sequence, activity, class and context diagrams. In addition, the system database was placed in place to suit the processes and inner workings of the new system, and also provided a way for easy consultations across the mobile application.

5.3 Recommendation

From this study the following is recommended the following about the system as follows:

a. The entire health system should embrace the use of technology more in the day to day running of the hospitals.

b. The system upgrade should be available free of charge to the general public for easy access and use.

c. During future study on the design and development of a medication-based system, this can be used as a reference point.

d. The system should be developed further to house many more functionalities in the future.

e. In the event of a hardware or software malfunction, backups should be formed often to prevent data loss

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