MEDICINE PRESCRIPTION USING VISUAL PRESENTATION: AN ANDROID AND DESKTOP BASED APPLICATION

BSCS COMPUTER SCIENCE

Zoha Aamir	BSCS15004
Asad Manzoor	BSCS15039
Hamza Akram	BSCS15053
Zofishan Hameed	BSCS15054
Khush Bakht Naveed	BSCS15060

Session: 2015-2019

DEPARTMENT OF COMPUTER SCIENCE

INFORMATION TECHNOLOGY UNIVERSITY

LAHORE, PAKISTAN

MEDICINE PRESCRIPTION USING VISUAL PRESENTATION: AN ANDROID AND DESKTOP BASED APPLICATION

A final year project submitted in partial fulfillment of the requirements for the
Degree of Bachelor of Science in
Computer Science

Zoha Aamir	BSCS15004
Asad Manzoor	BSCS15039
Hamza Akram	BSCS15053
Zofishan Hameed	BSCS15054
Khush Bakht Naveed	BSCS15060

Session: 2015-2019

Project Supervisor: Ms. Amna Batool

Committee Members: Dr. Agha Ali Raza
                                          Dr. Saeed ul Hassan

DECLARATION

This project is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions. I also declare that this work is the result of my own investigations, except where identified by references and free from plagiarism of the work of others.

Signature: ………….

Zoha Aamir

Signature: ………….

Khush Bakht Naveed

Signature: ………….

Asad Manzoor

Signature: ………….

Zofishan Hameed

Signature: ………….

Hamza Akram

Date: ………………..

The undersigned hereby certify that they have read and recommend this project entitled "Medicine Prescription using Visual Presentation: An Android and Desktop Based Application" by Zoha Aamir, Asad Manzoor, Hamza Akram, Zofishan Hameed,   Khush Bakht Naveed for the degree of Bachelor of Science in Computer Science.

_____

Ms. Amna Batool, Final Year Project Supervisor

_____

Dr. Agha Ali Raza, Final Year Project Committee Member

_____

Dr. Saeed ul Hassan, Final Year Project Committee Member

_____

Dr. Faisal Kamran, Head of the Department

ACKNOWLEDGEMENT

ABSTRACT

The second biggest cause of fatalities, medication errors, is taking numerous amount of lives. The basic reason behind this is the misunderstanding of medicine prescription, overdoses, carelessness in taking medicines on time and communication gap between a patient and a doctor. The purpose of this research is to identify the issues related to the current prescription writing process. The research was conducted in Pakistan Kidney and Liver Institute, where the prescription has been digitized and the patient's history is stored in a central database. From research, the reasons behind these medication errors and their relationship with the current prescription writing process were explored. The major focus of the research was on illiterate patients and their guardians as they suffer the most. From research, it was found that the patients are, not only, unable to understand the digitized prescription process but also they forget to take medicines on time. These two are the most common reasons behind these errors. Based on the findings, it was concluded that 70 percent of the patients at PKLI have access to smart phones, directly and indirectly, therefore, an android application with the vertical design will be built containing graphical icons, static drawings, minimal text, hand-drawn animations and videos, each with and without voice annotation. This application will also remind patients about their medicines by an alarm.

TABLE OF CONTENTS

1 Introduction   1

2 Literature Review   3

3 Research Methodology and Initial Findings   6

4 Implementation and Testing   20

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

Thousands of articles have been published on the issue of medication adherence, also known as compliance, approaching the issue through various methods and ended with uncertain findings. The area of research on this issue includes finding the causes of non-compliance, the problem of adherence, identifying the possible solutions and exploring the factors associated with the role of patients, pharmacists, and doctors with respect to compliance.

1.1 Defining Medication Errors

According to the World Health Organization (WHO), medication errors are described as any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing, order communication, product labelling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use [1].

1.2 Problem Statement

Through research, it was found that non-compliance has more effect on the low literate and old people. Because these are the patients who found prescriptions difficult to understand. Moreover, they do not take medicines in a correct way. They take an overdose of medicines, thinking it will heal them faster. Sometimes, they forget to take medicines on time and get confused due to several types of prescribed medicines. Lack of knowledge is the main cause behind the increase in medication errors [2].

1.3 Interventions to reduce Medication Errors

To decrease the number of medication errors, several works have been done and multiple platforms are built, among which digitizing prescription is most reliable. But still, this intervention is not useful for low literate people. As these people are unable to read and write common words. Facilitating low literate community is the biggest challenge. All such previous work suggests that information should be provided in a graphical form, rather than text. Moreover, voice annotation and a good user-friendly interface are needed. It was found that audio based and visual applications are easy to understand for them. Therefore, developing a user-friendly application, to operate which, users do not need to input text will be very helpful.

1.4 Objectives

The goal is to reduce medication errors, which occurs due to the misunderstanding of prescription and taking medicines at the wrong time for which, an android application will be created. It will have graphical icons, static drawings, minimal text, hand-drawn animations and videos, each with and without voice annotation. The graphical icons will be used instead of text, and the design will be vertical instead of hierarchical, so the user only has to swap screens instead of remembering which button they should press in order to go to next screen. This application will display the prescription in graphical form, so the illiterate users will also be able to understand it, and remind the users at the time of medicines. These reminders will be automatically set as per the prescription prescribed by the doctor, which will help the patients to take proper medicines at the proper time.

Chapter 2

Literature Review

2.1 Deaths Due to Medication Errors

After heart and cancer diseases, the second biggest cause of fatalities, medication errors are taking numerous amounts of lives. In Pakistan, 500,000 people annually die due to medication errors [3]. 30-50% of patients ignore the instructions concerning medication. Moreover, 60% cannot identify medicines and 12-20% of patients take medicines without a prescription [4].

2.2 Technical Solutions

In order to improve the health care system and medication adherence, many countries have several medication reminder systems built upon different concepts and on different platforms. Computerizing the medication process system in hospital settings and pharmacological education of prescribers and nurses could help reduce medication errors. This will prove to be a huge improvement in health- care. Medication errors are mainly caused by human errors which can be corrected to a large extent by digitization of prescriptions [5] [6]. Many people have started using health-care related apps and its popularity has been growing. There are different Android-based applications which have been developed so far.

2.2.1 Seeb

Seeb is a mobile application which has been designed in compliance with Iranian health information technologists and pharmacists' requirements in 2017. It reminds the patient's guardian about the medicine. Moreover, it has the availability of user guide. Besides all these features, there was no animation for the understandability of user regarding medicine intake schedule [7].

2.2.2 Ardu Med

Ardu Med is a smart medicine reminder application for an old person which was developed in India in 2016. It supports medications synchronization with user's calendar and the quantity of pills supposed to be taken by patients. The major drawbacks of this application are manual entering of doctor's prescription by the user, internet and APIs dependencies and unavailability of the user guide for medicines [8].

2.2.3 Medication Reminder and Health-care System

Medication reminder was developed in India in 2015. It is an automatic alarm ringing system, notification is sent through email or text message. This application also provides the feature of searching doctor disease wise, his availability information and contact details. This application has two interfaces one for doctor and the other one is for patient. The doctor can register patients, schedule appointments, read health care articles, reply patients and logout. The patient can search doctors by name or by disease, can set alarm, navigate, read health care articles and logout.

2.2.4 MyMediHealth

My MediHealth is a medicine reminder system built specifically for children in the USA in 2011. It runs on smartphones and provides a user interface for managing prescription schedules and alerts for reminding patients about the type and time of the medicine according to the prescribed medicine schedule. Although it was specially built for the children, there was a lot of manual entering for the user side with the lack of animations and visual effects [9].

2.3 Limitations of Technical Solutions

The above-mentioned smartphone applications were useful in many ways. But there are some limitations which need to be solved, which include the lack of animation and illustration. Nearly all patients considered an illustrated medication schedule to be a useful and easily understood tool to assist with medication management. Moreover, there was manual entering which was troublesome for the user if he/she is illiterate. Another limitation was the absence of interface for the doctors.

2.4 Solution to Limitations

The solution will be both for patients and doctors. It will provide doctors with a brief medication history of the patient before giving them any new medicine. It will also automate the prescription writing process as well as notify the patients by giving them alarm at the time of medicine. The schedule and conditions of taking medicines will be in the pictorial form for the sake of those who are not able to read the text.

Chapter 3

Research Methodology and Initial Findings

3.1 Research Techniques

To carry out this research, the ICTD approach was used. Semi-structured interview were conducted. Random and convenient sampling was used to gather qualitative data.

3.2 Enrollment criteria

The major focus of this research was on critical patients who were suffering from kidney and liver diseases, to discover and resolve the problems related to medication errors.

3.3 Collaboration with PKLI

All research was carried out in collaboration with Pakistan Kidney and Liver Institute (PKLI), because it is in the developing phase and problems of patients i.e. medication and prescription problems, are tried to be solved by using new software systems as well as it is the only institute in Pakistan which is offering free and subsidized treatment to poor patients and researching on medication errors.

3.4 Research Questionnaire

There was total 5 stakeholders. Therefore, 5 questionnaires were made for them for the purpose of ethnographic research.

3.4.1 Patients

Table 7.2 shows a Patient's questionnaire. In order to identify a patient's occupation and background, introductory questions were asked which includes name, gender, age, occupation, education and residence city or town.

Table 3.1: Patient's Questionnaire

Theme	Question	Purpose
Mobile Phone Access	• Do you have a smartphone? • How often do you use the phone? • What type of applications are you currently using?	To identify whether he own a smartphone or not? If yes then is he/she capable of using an application?
Patients knowledge	• Who gives you medicines? • Do you take multivitamins? • Do you know when to take multivitamins? • Do you follow the prescription carefully? • Do you know not following medication direction can have serious health consequences? • Did you experience any medicine reaction? If yes then state. • Do you notice the expiry date of a medicine before taking it?	To identify whether he owns a smartphone or not? If yes then is he/she capable of using an application?

Patients views regarding currents process	• When you get doctor prescription, do they tell you that when and with to take particular medicine? • Did you find any difficulty while understanding doctor's prescription? • How do you identify the medicine you are supposed to take at a certain time?	To understand the issues which patients have with the prescription writing process and the way they take medicines.
Solution	• Do you think that technology can help you in this matter? • What changes can be made in the prescription writing process so it can be easy for you to understand? • Do you think displaying the image instead of writing its name, can be helpful for you in understanding? • Would you like to be reminded by an app? • Do you think it's a good option to share medicine usage report with loved ones?	To Identify the possible solution to this issue

3.4.2 Doctors

Table 7.2 shows a Doctor's questionnaire.

Table 3.2: Doctor's Questionnaire

Theme	Questions	Purpose
Information regarding medical errors	- According to you, what are medication errors? - What do you think about medication errors in Pakistan? - What are the main reasons behind medication errors? - What are the most common medication errors cases, you have dealt with? Please elaborate - Do you think current prescription writing process can be a reason behind medical errors?	To know what medical errors are and why they happen.
The general behavior of the patients towards medication	- What is the common way of prescribing medicine to patients? - Does patient take non-prescription medicine before consulting any doctor? - Does patient ask about medicines and its timing in prescription? - Do patients follow prescription and advice of doctors? - Are there any rules of taking medicine with some fluid or something and some pre and post conditions?	To understand the behavior of patients, which doctors observe.

	• Do patients take medicines at the right time?	
Consequences of medical errors	• What if critical patients do not take medicines on time? • What is the complication to the patients when he/she didn't take medicine on time? • What happens if the medicine does not suit a patient and cause a reaction? • What happens when a patient takes an expired medicine?	To understand the consequences, a patient has to face in the result of medical errors.
Solution	• How to address the culture of over diagnosis and over-treatment practiced to avoid the medical error? • What do you think about involving technology in solving the medication errors? • According to you, what is the best technology solution to reduce the medication errors? • Do you think that the current prescription writing process can be changed? • Do you think that introducing the pictures and animations in the prescription writing process will be helpful?	To find a working possible solution to the medication errors problem

3.4.3 Nurses

Table 7.2 shows a Nurse's questionnaire.

Table 3.3: Nurse's Questionnaire

Theme	Questions	Purpose
Information regarding medical errors	- According to you, what are medication errors? - What are the main reasons behind medication errors? - What are the most common medication errors cases, you have dealt with? Please elaborate. - Do you think current prescription writing process can be a reason behind medical errors? - Are you aware of the various categories of medication errors? - Are you aware of the various interventions to prevent medication errors? - Are you aware how to proceed if medication errors occur? - If you noticed a medication error, whom you will inform first? - Do you think current prescription writing process can be a reason behind medical errors?	To know what medical errors are and why they happen.

The general behavior of the patients towards medication	• Which kind of patients do you attend? • What are your responsibilities regarding these patients? • Do you attend patient medication on time? • What kind of difficulties do you face while attending your patients? • Do they take medicine properly according to the prescription?	To understand the behavior of patients, which nurses observe.
Consequences of medical errors	• What are the complication you have seen when didn't take medicine on time?	To understand the consequences, a patient has to face in the result of medical errors.
Solution	• Do you recommend an integrated approach toward training and education about the medication error in the medical institutions and the general public? • What do you think about involving technology in solving the medication errors? • According to you, what is the best technology solution to reduce medication errors? • Do you think that the current prescription writing process can be changed?	To find a working possible solution to the medication errors problem

3.4.4 Pharmacists

Table 7.2 shows a Pharmacist's questionnaire.

Table 3.4: Pharmacist's Questionnaire

Theme	Questions	Purpose
Information regarding prescription errors	• According to you what are prescription errors? • What are the main reasons behind prescription errors? • What are the most common prescription errors, you have dealt with? Please elaborate.	To know what are prescription errors.
Knowledge of patients about prescriptions Medicine laws in Pakistan	• Do patients ask about medicines and its timings? • Do patients ask about how to take a medicine i.e. before the meal, after the meal, with milk or water? • Are patients able to read and understand the prescription? • Do Patients come to you for buying medicines without prescriptions? • Do you give medicines to patients without prescription?	Patients perception regarding a prescription To understand how many people follow medicine laws in Pakistan

Solution	- What do you think about involving technology in solving the prescription errors? - According to you, what is the best technology solution to errors? - Do you think that the current prescription writing process can be changed? - Do you think that introducing the pictures and animations in the prescription writing process will be helpful?	To find a working possible solution to the medication errors problem

3.4.5 IT Expert

Table 7.2 shows an IT Expert's questionnaire.

Table 3.5: IT Expert's Questionnaire.

Theme	Questions	Purpose
IT related	- In your opinion what would doctor prefer handwritten prescription or digital prescription? - Do doctor have enough time to select medicines from given options? - Is it a good option to have an assistant for feeding doctor's prescription in the system? - What type of database are you using? - How to access the database? - Will the doctors feel comfortable using a computer? - Do doctors have Smartphones? - Do doctor have access to the internet? - What is the average time a doctor spends with a patient? - Are there any problems that a doctor encounters during patient examinations?	To understand the current method

Solution	- Do you recommend an integrated approach toward training and education about the medication error in the medical institute and the general public? - What do you think about involving technology in solving medication errors? - According to you, what is the best technology solution to reduce medication errors? - Do you think that the current prescription writing process should be changed?	To find a working possible solution to the medication errors problem

3.5 Findings from the Initial Research

Total 24 detailed interviews from PKLI were conducted to support this research, including 18 patients (10 males and 8 females, aged 18-75 years), 6 experts (2 doctors, 2 nurses and a medical IT officer) and 1 pharmacist. The interviews were conducted in both Urdu and English language and responses were collected on paper. Later these responses were presented in the tabular form.

3.5.1 Patients and Guardians Perspective

13 out of 18 patients, which were interviewed at PKLI had access to Android phones and the Inter- net. They all find it difficult to take medicines at the time, and due to a large number of prescribed medicines, identifying each medicine uniquely is tricky for them. After analyzing the previously collected data, illustrated prototype of the prescription was designed in order to resolve the problems regarding the prescription format.

3.5.1.1 Issues with PKLI Current System

In PKLI the prescription is digitized but still, 14 out of 18 patients who were illiterate, were having difficulty to understand it. As these patients are not able to read and write. However, in PKLI the doctors communicate well with the patients and do cross questioning with them in order to make sure that they take correct medicine on time. Because of this, the patients said that PKLI is more reliable than government hospitals.

3.5.1.2 Issues with the Prescription

From patient's interviews, it was found that patients face difficulty while understanding the prescription written by the doctors, as the writing is illegible to understand.

3.5.2 Doctors Perspective

Doctors found uneducated patients most difficult to handle. To deal with such patients, they do cross- questioning and discuss the medication process in detail. The language barrier was also a major issue, due to which communicating with the patients is difficult.

3.5.3 Nurses Perspective

Nurses found low literate patients difficult to deal, as these patients visit doctors and Hakeem in parallel. Moreover, such patients often misbehave with the nurses. To make sure that patients don't do self-medication these nurses do psychological therapy of the patients.

3.5.4 Pharmacists Perspective

The pharmacists do cross questioning with the patients and make sure that patients are able to identify each medicine uniquely. Also for the pharmacist, the language barrier is a major issue. The pharmacist also suggested useful animations, which can be added in the visual prescription.

3.5.5 IT Experts Perspective

The current system in PKLI is totally digitized. Patients are identified by unique Identity Number which is assigned by PKLI through some unique random number generator, and patient's medication history is stored in the central database of the organization. Doctors are using laptops to prescribe medicines. Using the system, they can select the medicine by entering its name, set its quantity, timing and it automatically generates complete prescription using that information. In the end, for the ease of patients, the digitized prescription carrying the name of medicine, it's timing, and its quantity is printed and given to them. The same system is used by nurses and pharmacists. Nurses are using the system on tablets to enter the details after checking the patient's vitals. Moreover, pharmacists are using the system on laptops to maintain the medicines records.

In order to train the doctors, nurses and pharmacists, it was very costly as to train them, they hired a bunch of trainers. They filtered out many functionalities of the system because of complexities. Still, they are having issues with the current user interfaces, as it is complex and doctors find it difficult to use.

3.6 Data Analysis

When the patients described the problem, it was deduced that these issues can be solved by a mobile-based application. Moreover, it was found that almost every patient had a smart-phone, which means that he/she can use the application easily. As, many patients said that sometimes they forgot to take medicine on a specific time, as a result, they have to repeat the whole process again, which is very costly, and sometimes the result is even worse.

3.7 System Design

To cater all these issues, it was decided to link the prescription with the central database, to maintain patient medication history for future use. At the doctor's end, the name of the medicines will be present in a table, where they can search and choose a specific medicine and can modify the table also. For the quantity and timing, the user only had to mark the

listed options, for example, one tablet for the morning, one for noon and one for the night. After this process, the picture of the respective medicine will be attached to the name and it's salt so that there is no misunderstanding about the similar looking medicines, animations will be used for timing. For the timing sun and moon animations will be used. For the quantity of medicine, numeric characters will be used e.g., for two medicines, 2 were displayed below the animation of timing. For user interaction, voice annotations and alarm will be used to notify patients on a specific time at which he/she is supposed to take medicine. This application will be developed for Android users in Android Studio (Language: JAVA) by using SQLite Database.

Chapter 4

Implementation and its Testing

From the survey, different factors associated with low literate patients and medications were explored. These factors are not taken into consideration by medical personnel, as they have converted the handwritten prescription into digitized one but illiterate patients cannot read this also. From research, it was found that 70 percentage of the patients have access to the smart-phone, directly and indirectly, from which it was concluded that a smart-phone based application is useful to display animated prescription and to remind patients at the time of medicines by an alarm. It will be a smart and organized application. The application will have two modes, one for the doctor and other for the patient. The medication history of the patient will be stored in the central database.

The application will be user-friendly, easy to use with a simple interface, so anyone after 10-15 min training will be able to use it correctly.

4.1 Phase 1

At first phase, 2 prototypes were made, and overall 5 participants outside General Hospital Lahore were recruited for testing. For each prototype all the participants were asked to perform three main task.

4.1.1 Prototype 1 and its Testing

In the first prototype as shown in the **Figure 4.1**, conventional way of keeping the medicine was followed to keep consistency as from the interviews it was found that medicines are kept in separate packets according to the timings, so the data was presented timing wise i.e. day, noon and night. To symbolize the timing, icons of rising and drowning sun was used to symbolize day and noon, for the night, moon icon was used.

| Task	Task Status	Overall Status
Telling what the screen is about	Yes	All five participants answered correctly.
To tell what the icons are about	Yes	4 participants were confused about sun and moon icons.
To check the button after taking medicine.	Yes	5 participants performed this task easily.

Figure 4.1: Phase 1-Prototype 1

4.1.2 Prototype 2 and its Testing

While conducting interviews a pharmacist gave a suggestion of adding clock, so in 2nd prototype only one sun icon was used and to distinguish between day and noon clocks were

used. The result of the testing are given below. In this prototype they had to click on the capsule after taking medicine.

Table 4.2: Phase 1-Prototype 2-Testing Results

Task	Task Status	Overall Status
Telling what the screen is about	Yes	All 5 participants answered correctly
To tell what the icons are about	Yes	All 5 participants understood the icons.
To check the button after taking medicine.	Yes	All 5 participants failed to perform this task.
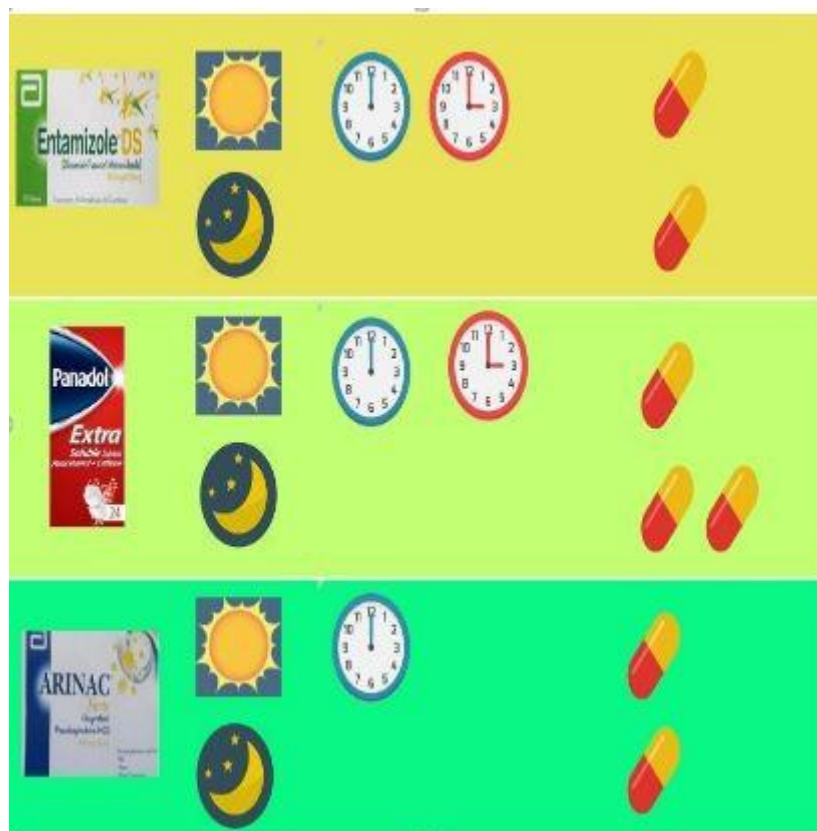
Figure 4.2: Phase 1-Prototype 2

4.2 Phase 2

In this phase the issues identified by the participants during the evaluation of first two prototypes were incorporated, and one final prototype was made. For the testing, five random people outside General Hospital, Lahore were recruited as participants and think Aloud method was used.

After the testing of prototypes in phase 1, it was found that participants found clocks easier to understand the timing, and the tick icon was easier to understand because of the feedback it gives instantly. In the first prototype, it was observed that if the amount of medicine is large, and the patient is required to take all the medicines for more than one time then list will be long and the patient has to scroll it down. So, it was decided to merge both the design, from 1st prototype its background, tablet and spoon icons, and tick button was selected. From the 2nd prototype clock icon was selected. Below is the result of the testing.

Figure 4.3: Phase 2-Prototype 3

Table 4.3: Phase 2 Prototype 3 Testing Results

Task	Task Status	Overall Status
Telling what the screen is about	Yes	All five participants answered correctly
To tell what the icons are about	Yes	All participants understood the icons.
To check the button after taking medicine.	Yes	All five participants performed this task easily.

Chapter 5

Use Cases

The project has use cases which help to capture the visible functionality of the system and details that are needed to identify the user experience and interaction with application, which play an important role in proper elicitation of requirements and its implementation.

5.1 Desktop Application

Pharmacist and Doctors are the main stakeholders of the application. Both will be able to perform tasks of adding medicines to database, add and search prescription, and add and search patients.

Figure 5.1 Show the Desktop Application use case.
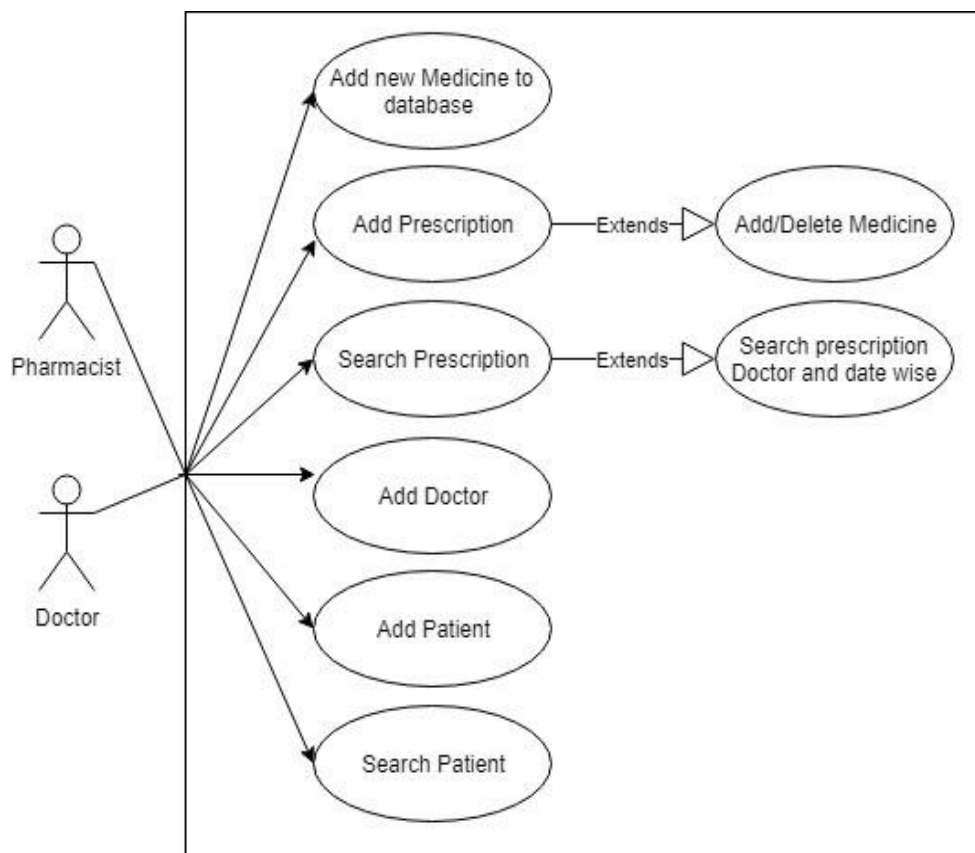
Figure 5.1: Use case 1-Desktop Application

5.2 Android Application

Following will be the tasks, which user can perform:

1. Login

2. Set alarm

3. View state

4. View prescription

5. View doctor information

Figure 5.2 show the Android Application use case.
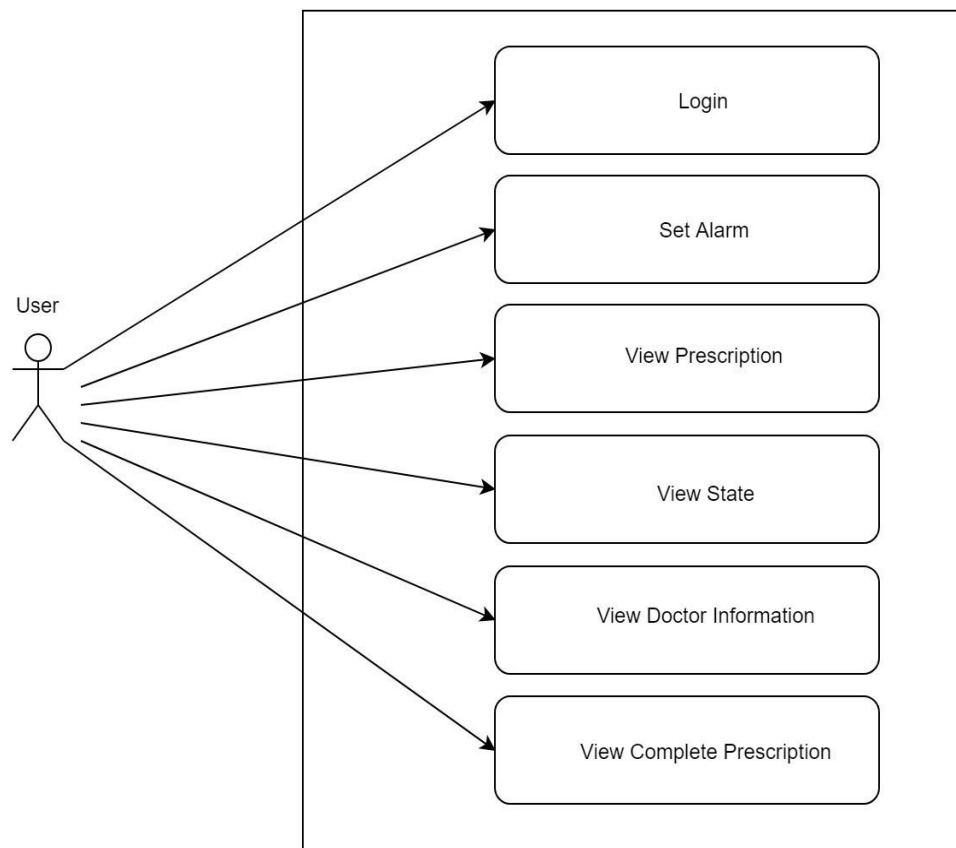
Figure 5.2: Use case 2-Android Application

5.2.1 Login

Following are the steps for login:

1. Open the application

2. Enter the phone number and CNIC number

3. Get himself register by clicking the Login button in order to get updates

5.2.2 View Prescription

To view the pictorial prescription only by clicking on the prescription book icon from the menu screen and after login prescription will also be shown as main screen.

5.2.3 Set Alarm

Set alarm by clicking on the clock icon from the menu screen. This will be in the future work.

5.2.4 View Stats

To view state of the patient, it give the count of taken and missed medicines only by clicking on the state icon from the menu screen.

5.2.5 View Doctor Information

To view the details of the doctor, Details may include doctor name, contact information etc. By clicking on the doctor icon from the menu screen. This will be in the future work.

Chapter 6

Development

After testing and analyzing all 3 Prototypes and requirements, a need for a proper system was felt, containing two ends one for the doctor and the other for the patient, from the doctors interviews at Pakistan Kidney and Liver Institute (PKLI), it was found that using desktop is more easier for them to enter the prescription as it has big screen and better resolution. So, a desktop application and an android application was built for the automation of medicine prescription and its reminder. After entering prescription on the desktop application, a prescription will be retrieved on the android application in the form of visual presentation of medicines, dose timings.

6.1 Desktop Application

Desktop Application was built and named as "E-Medication". It was for the clinical and the doctor's end. The users will be able to add a prescription, search a prescription, enter patient's information, search patient, and view a patient's history etc. In order to use the system, initially there are four options for the user. Four Option are shown in the main screen **Figure 6.1**.
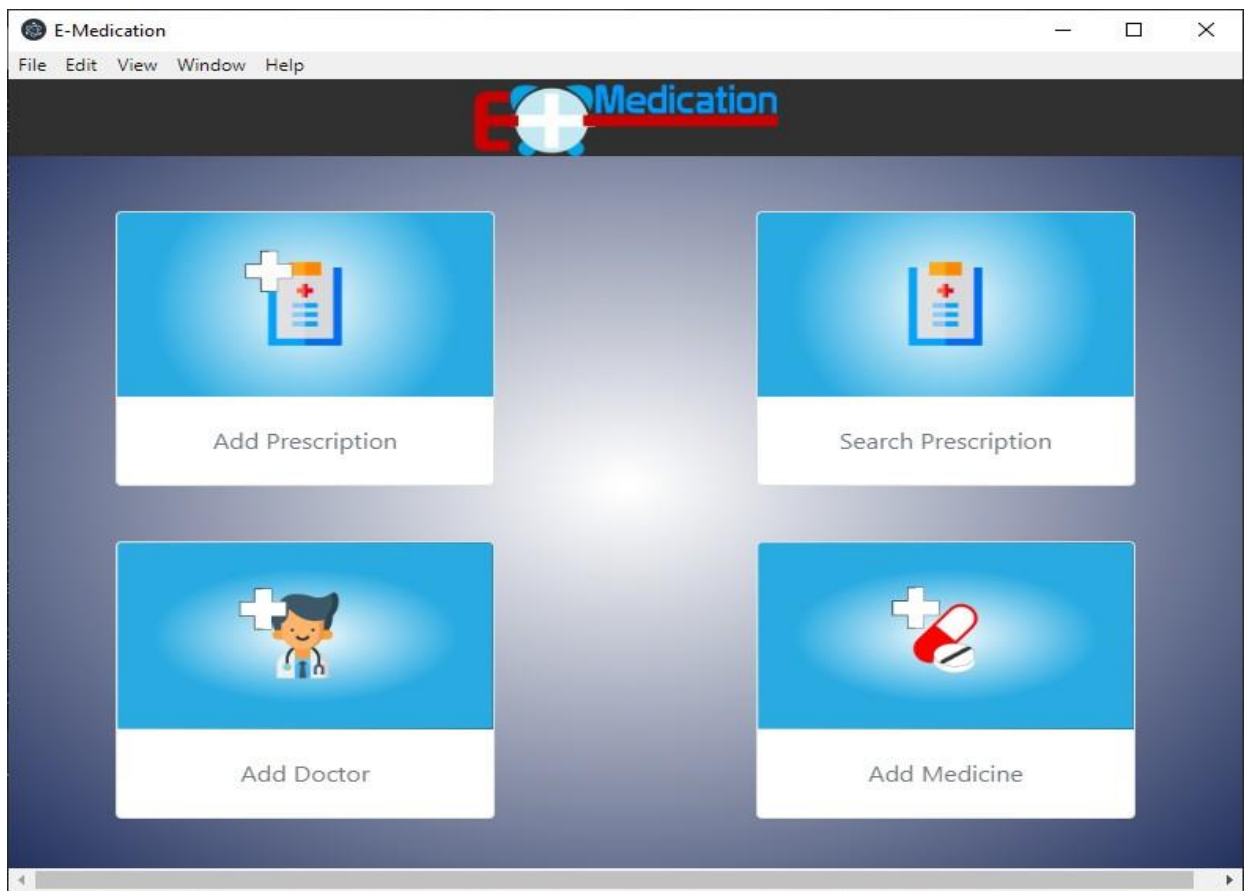
Figure 6.1: Screen 01-Main Screen for Option

6.1.1 Add Doctor Button

If the user click on the "ADD DOCTOR". Then a new dialog box will open containing the following input text fields as shown in the **Figure 6.2**.

1. Enter Doctor Name
2. Enter Doctor Number

After entering name and number of a doctor, information will be saved in the database.
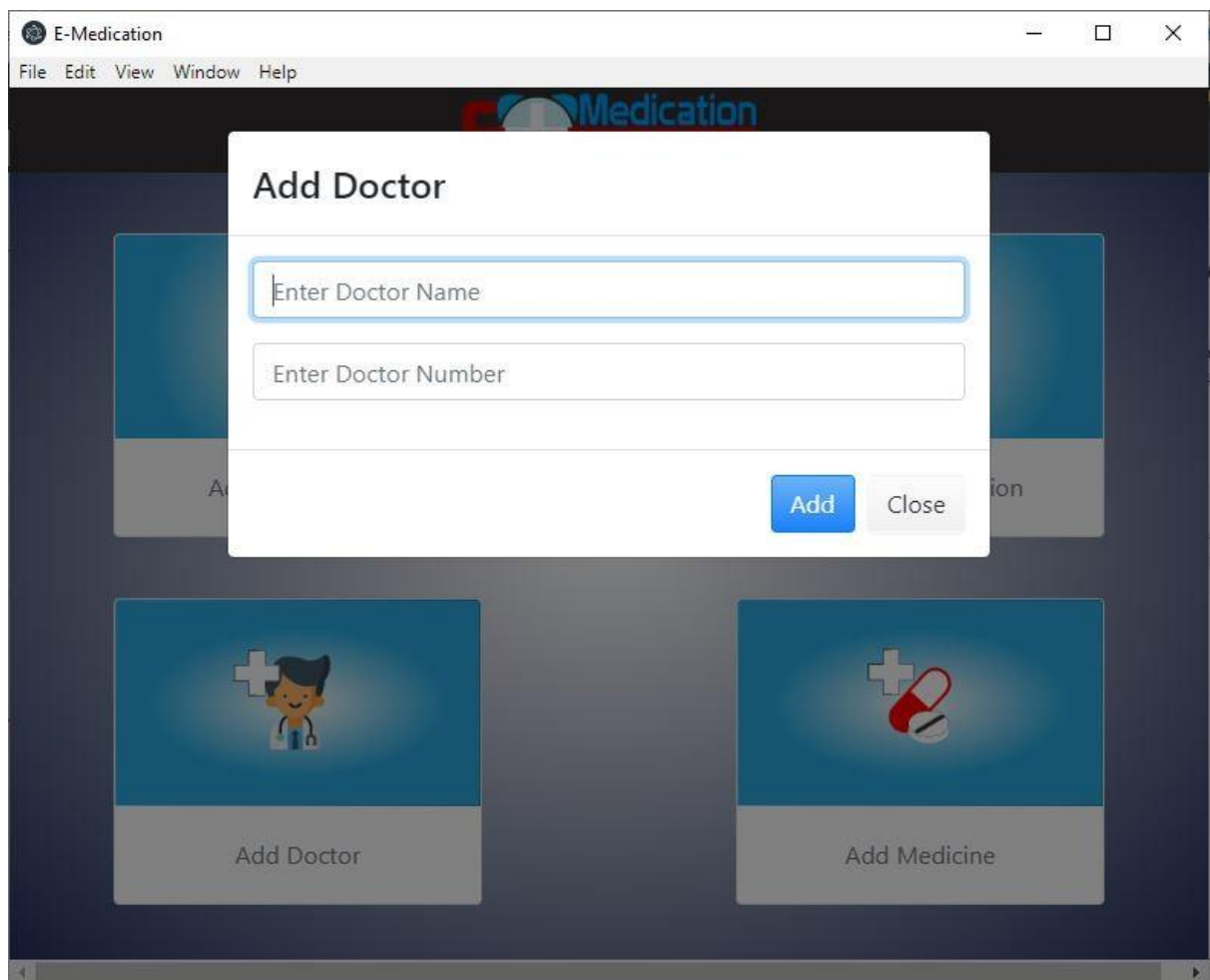
Figure 6.2: Screen 02-Add Doctor

6.1.2 Add Medicine Button

If the user click on the "ADD MEDICINE", a new dialog box will open containing the following input text fields as shown in the **Figure 6.3**

1. Enter Medicine Name
2. Enter Medicine Picture URL
3. Click on add button.
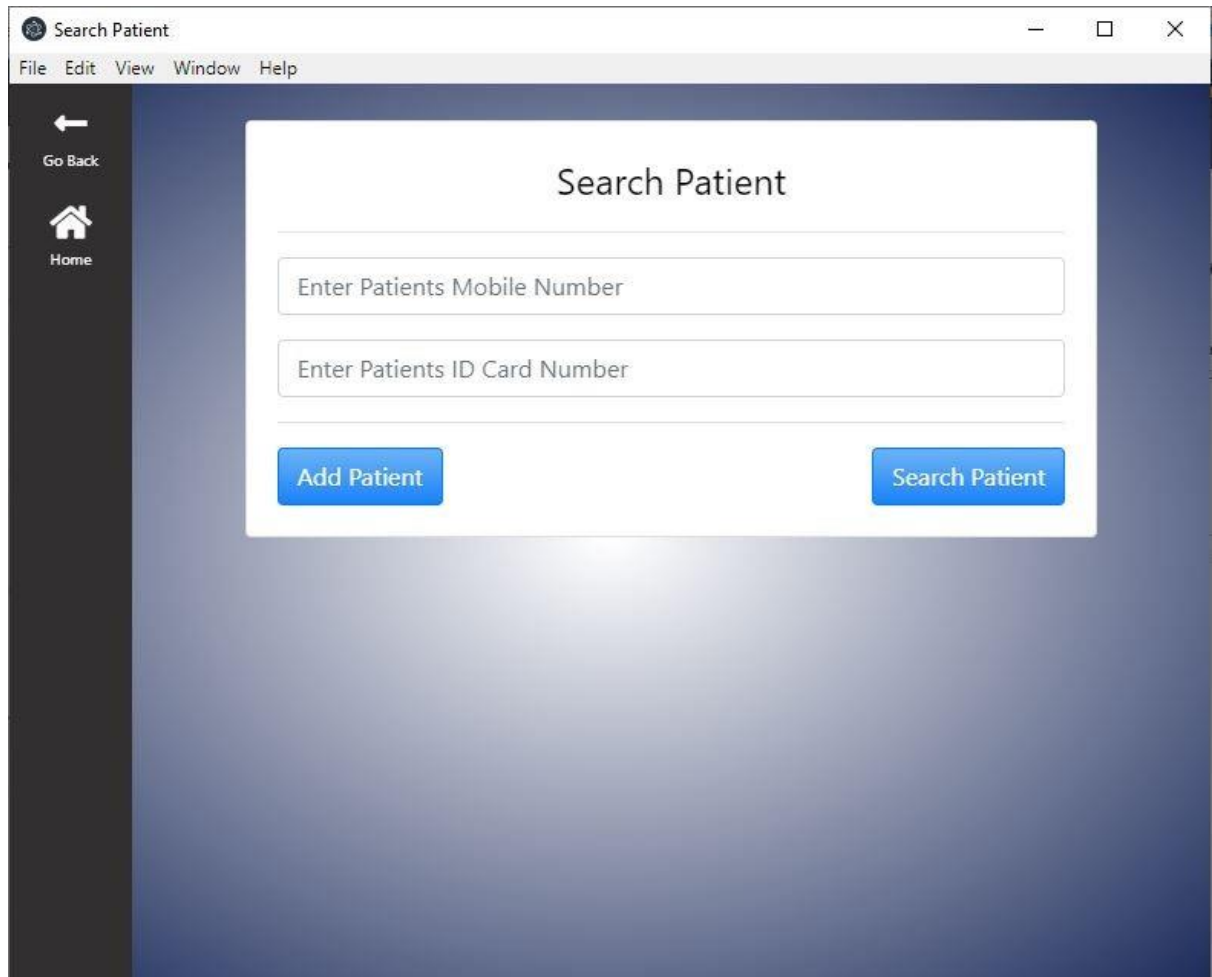
After entering the name and URL of the medicine the user will click at OK button, required image from the URL will be retrieved and the information will be stored in the database.
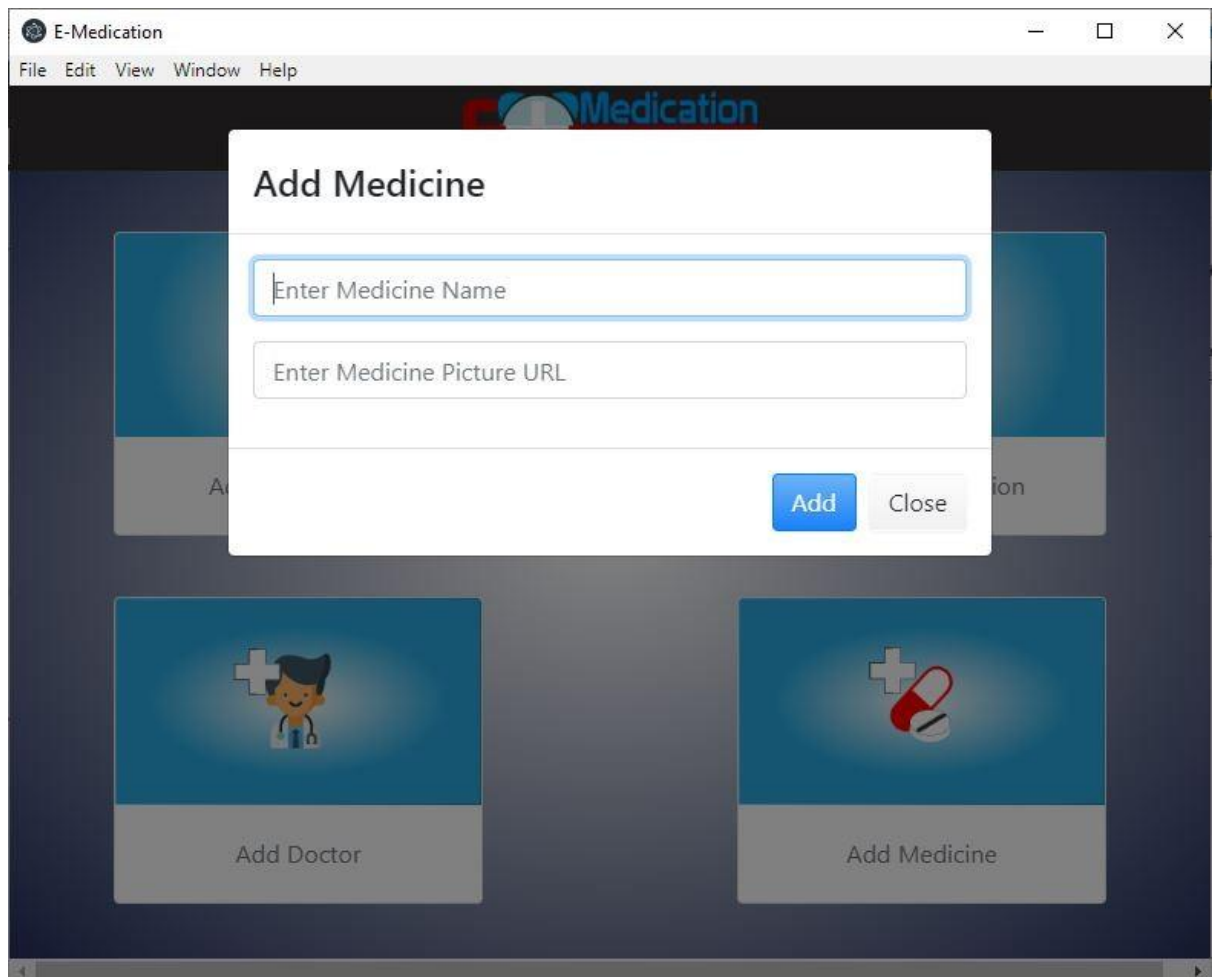
Figure 6.3: Screen 03-Add Medicine

6.1.3 Add Prescription Button

If the user click on the ADD PRESCRIPTION, a new screen will open as shown in the **figure 6.4**. In order to add prescription, initially, a patient should be added by clicking Add Patient Button. After adding patient, patient will be searched for creating prescription.
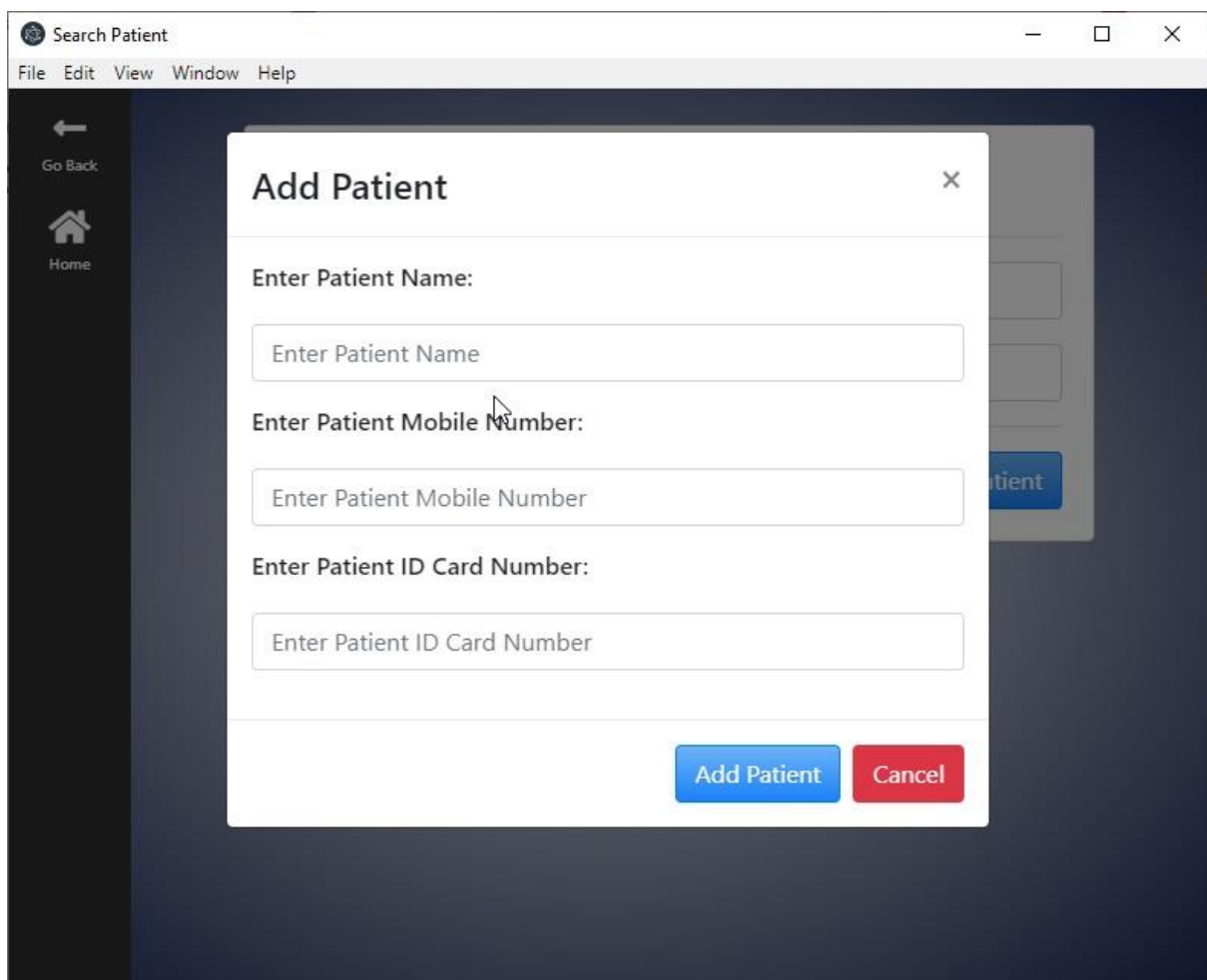
Figure 6.4: Screen 04-Add Prescription

6.1.3.1 Add Patient

If the user click on the "ADD PATIENT", a new dialog box will be open containing the following input text fields as shown in the **Figure 6.5**.

1. Enter Patient Name

2. Enter Patients Contact Number

2. Enter Patients ID card Number

3. Click on Add Patient button.

After entering the patient name, Contact no and unique ID, the user will click at Add Patient button, as the ID no of each person is unique so this number will be used to identify each patient uniquely as well as to store his medical history. Once the user will enter the patients required data in these fields, the information regarding the patient associated with the ID number will be stored to the database.

Figure 6.5: Screen 05-Add Patient

6.1.3.2 Search Patient

After entering patient as described in the **Section 6.1.3.1**, in order to add prescription, the patient will be searched first. Following fields should be filled as shown in the **Figure 6.6**.

1. Enter Patients Mobile Number
2. Enter patients ID card Number
3. Click on Search Patient button.

Figure 6.6: Screen 06-Search Patient

6.1.3.3 Choose Doctor

After searching the patient, result Table will be shown as in the **Figure 6.6**. There will be an option "Select" in front of the record of a patient. After clicking on the "Select", the new screen will open as shown in the **Figure 6.7**. This New screen will contain a list of doctors who will prescribe the medicines.
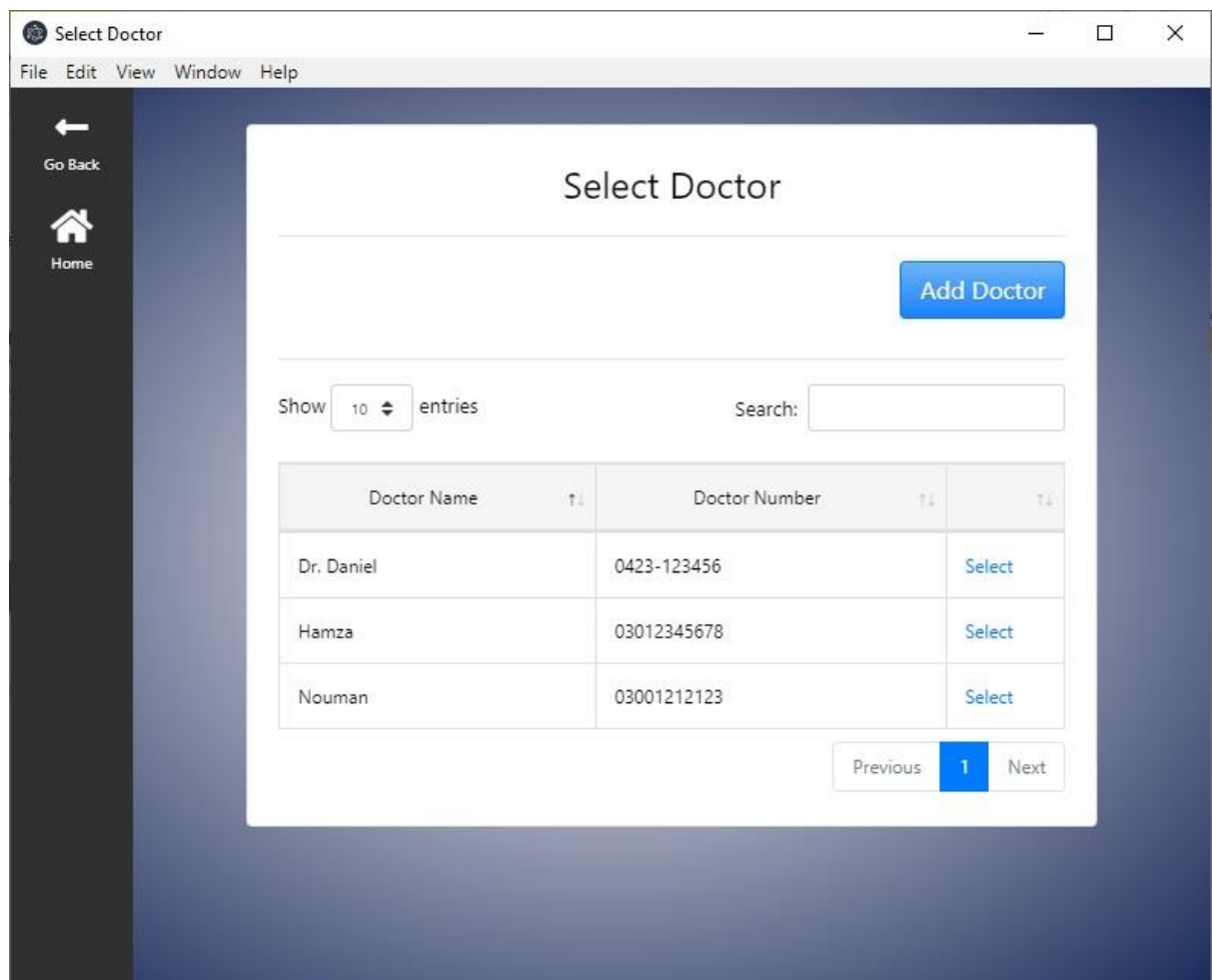
Figure 6.7: Screen 07-Choose Doctor

6.1.3.4 Add Medicine Create Prescription

After selecting the doctor, new screen will open as shown in the **Figure 6.8**.

Figure 6.8: Screen 08-Add Prescription

If the user clicks on "Add Medicine" Button, a new dialog box will open for adding medicine. The following input text fields will show in the dialog box as shown in **Figure 6.9**.

1. Enter Medicine Name
2. Enter Morning Dose
3. Enter Evening Dose
4. Enter Night Dose
5. Enter Medicine Duration Days
6. Click on add button

Figure 6.9: Screen 09-Add Medicine

After entering the above required fields the user will press OK button, in result of which the screen will show containing the medicines as shown in the **Figure 6.10.** After Adding Medicines, user have the option to delete medicine before creating prescription.

Figure 6.10: Screen 10-Medicines Added

After clicking on the "Create Prescription" button as shown in the **Figure 6.10**, the prescription will be created associated with the information data of the patient and a conformation message will be shown in the form of a dialog box as shown in the **Figure 6.11**.
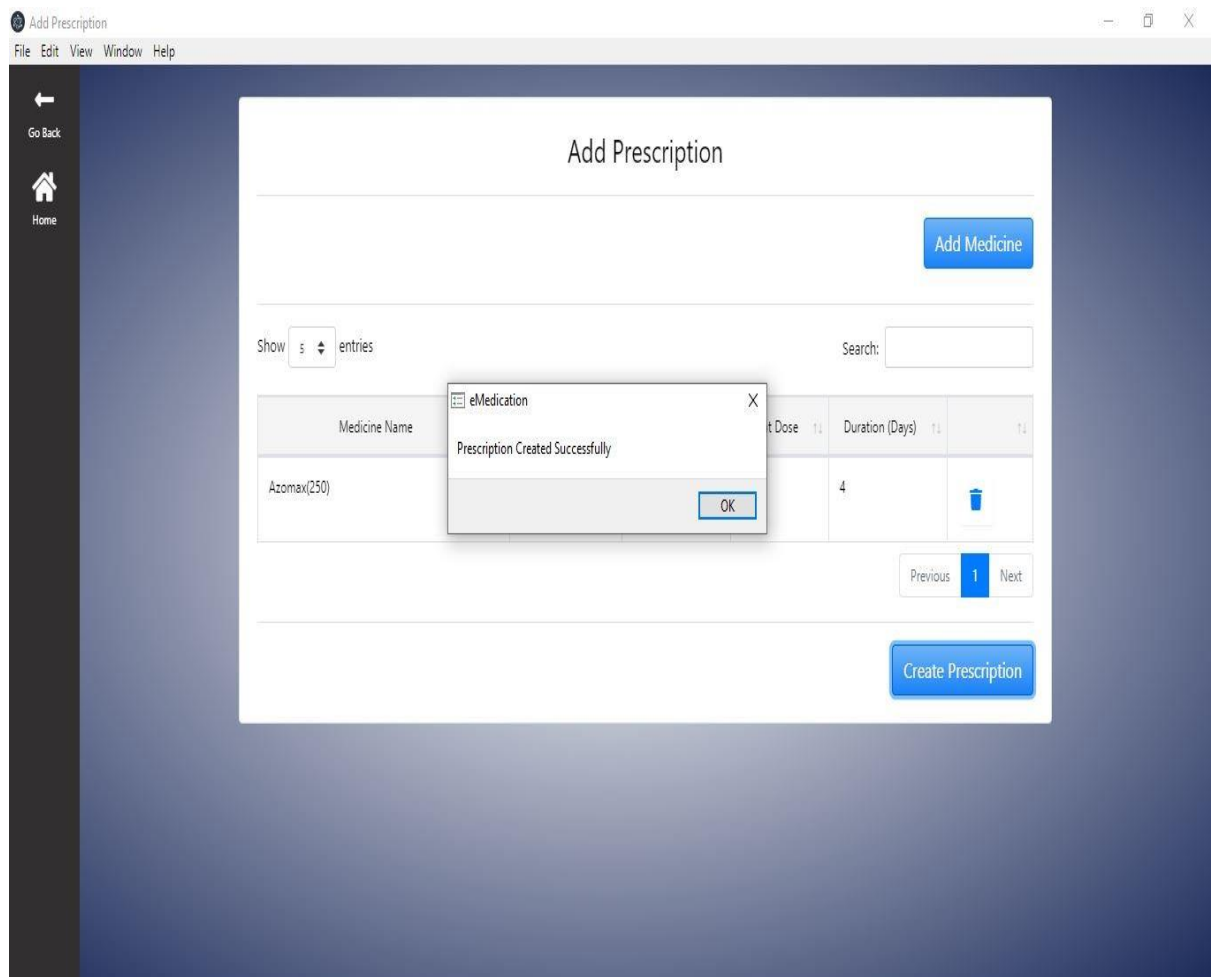
Figure 6.11: Screen 11-Prescription Created

6.1.4 Search Prescription

This screen contains two fields for the entry of patients contact no and ID card no, an option to search patient and another option to add patient, in order to search patient the user will click "Search Prescription" as shown in the **Figure 6.1**.

6.1.4.1 Search Patient and View Results

By providing CNIC number Mobile Number of a patient, result Table will be shown containing the option to view Prescription as shown in the **Figure 6.12**.

Figure 6.12: Screen 12-Search Patient and View Results

6.1.4.2 Doctor's Prescription List

Select the "View Prescription" in order to view it. By clicking, a new screen will open containing list of doctors who prescribed the medicine already as shown in the **Figure 6.13**.
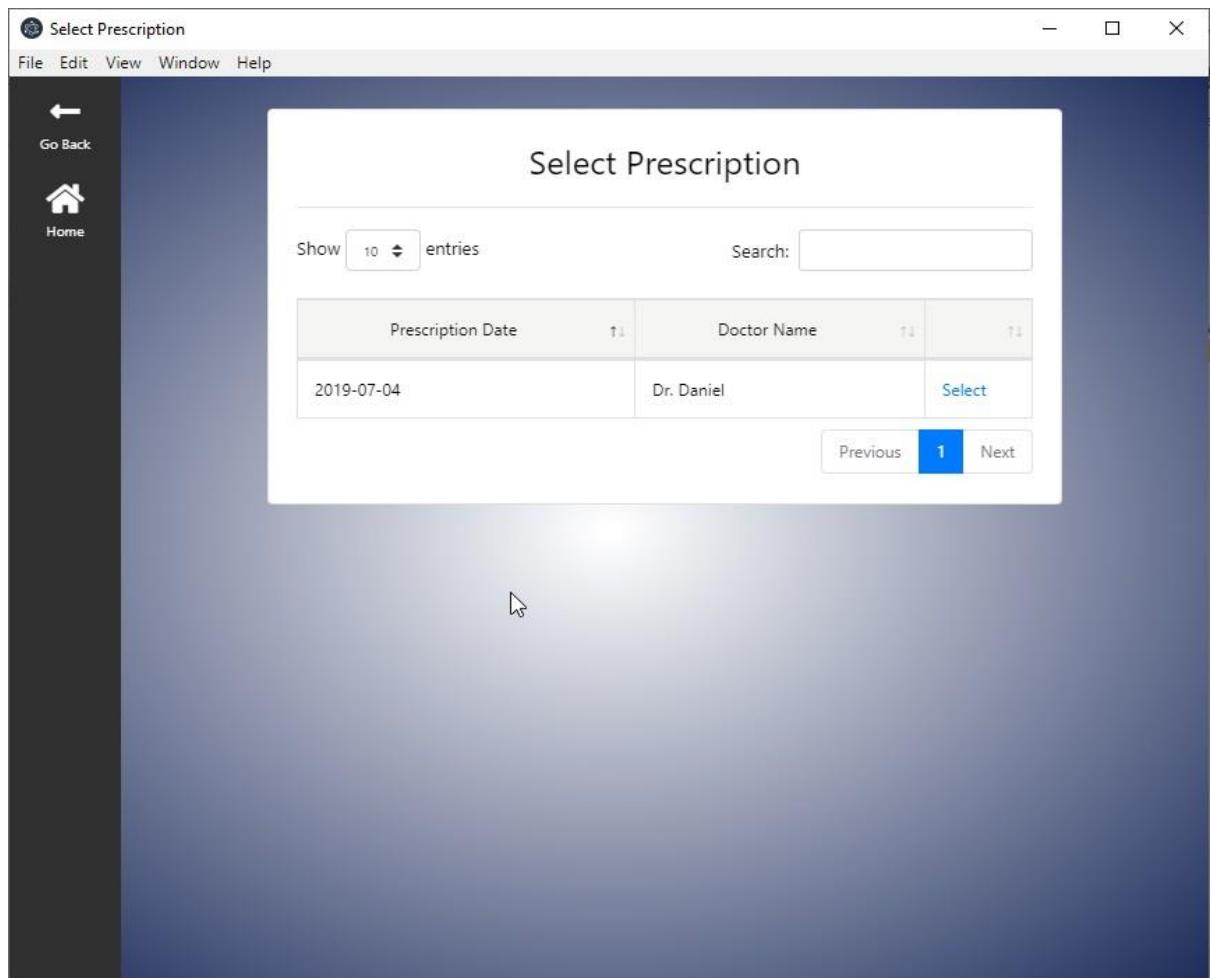
Figure 6.13: Screen 13-Doctor's Prescription List

6.1.4.3 View Prescription

In order to view a prescription by a specific doctor, click on the "Select" as shown in the **Figure 6.13**. After clicking it, a new screen will open containing the patient's Prescription as shown in the **Figure 6.14**.
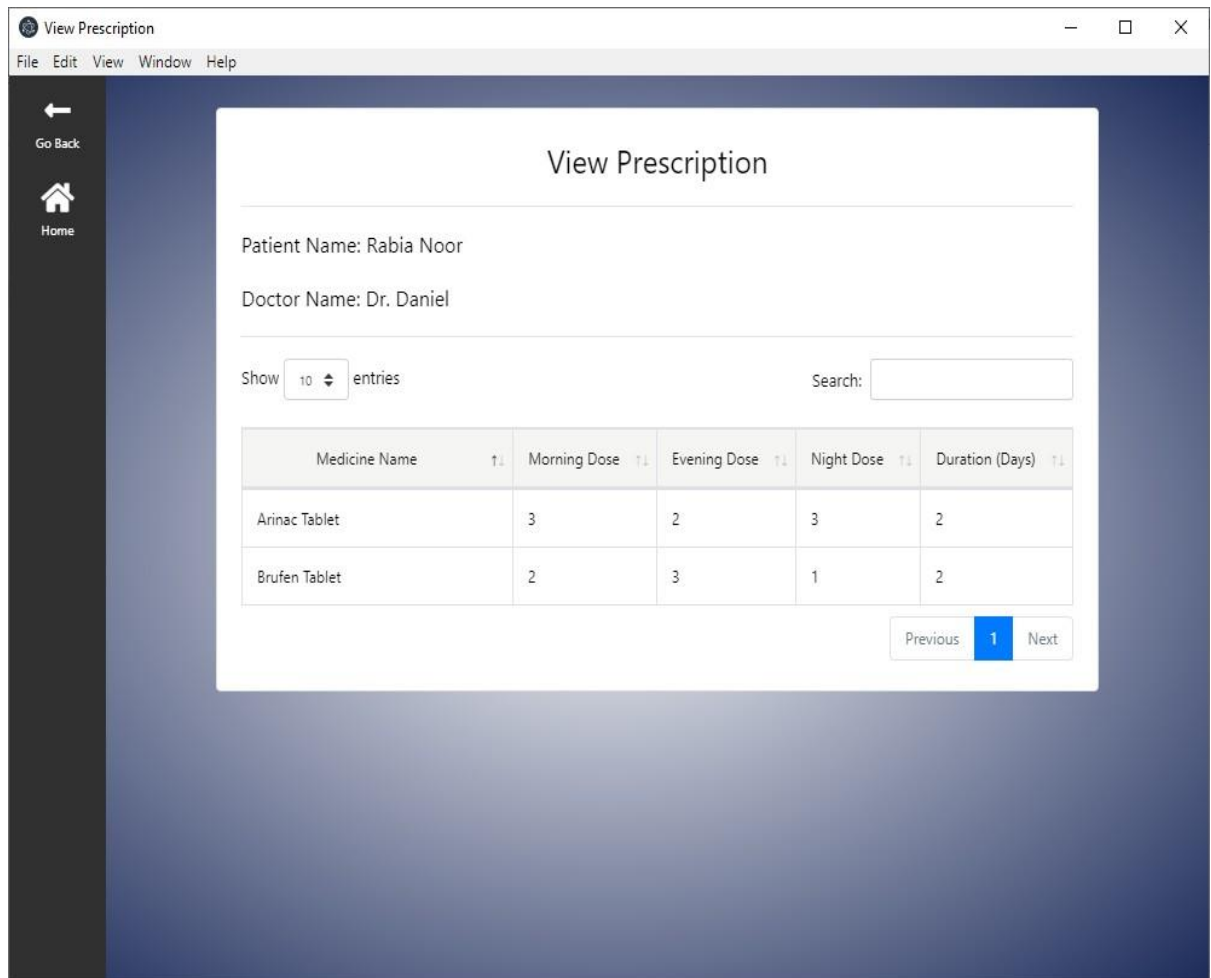
Figure 6.14: Screen 14-View Prescription

6.2   Android Application

An android application was developed for the users to view automated prescription, as well as they are able to maintain medical history in digital form.

6.2.1   Login Screen

Phone number and CNIC number was used in order to identify every user or patient uniquely. So, this is the initial step user should login first and then it keep him login until he logged out. Following information is require to login new users as shown in **Figure 6.15**

1. Phone number

2. CNIC number

After login this information will be saved in the database, user will move the main screen.
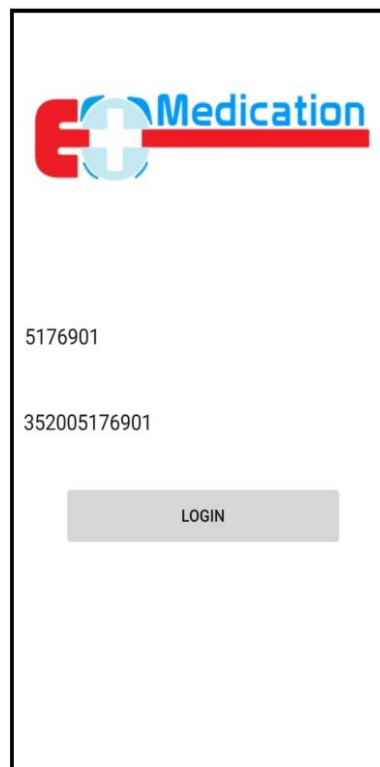
Figure 6.15: Screen 01-Login Screen

6.2.2 Prescription Screen

Prescription screen, this screen contain user's current prescription. When pharmacist enter his prescription into the Desktop application, then it will automate the prescription into pictorial form and then visualize it on the users E-Medication app as a main screen. This screen was designed after ethnography to make sure that user will understand the Interface. This screen was divided into 4 columns, 1 for the medicine picture and other 3 were used for morning, noon and evening. In order to make it clear, clocks with different times were used. As shown in **Figure 6.16**, for morning 8:00 am, for noon 2:00 pm and for evening 7:00 pm used. Different icons were used to properly describe quantity to be taken according to the type of the medicine. Icons that were used are tablets, capsule and spoon for syrup.
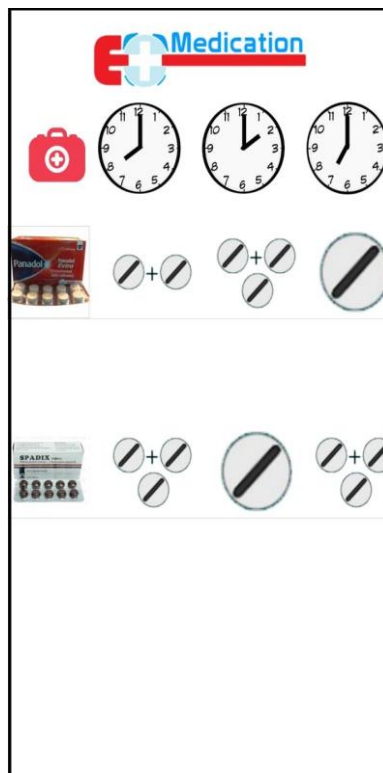
Figure 6.16: Screen 02-Prescription Screen

6.2.3 Menu Screen

In menu screen, users have access to the information regarding doctors, medical states, alarm and prescribed medicines. For this purpose following are 4 icons were used as shown in **Figure 6.17**.

1. Clock (to represent alarm)
2. Graph (to represent state)
3. Doctor (to view information about the doctor)
4. Prescription book (to show complete prescription)

Back button was used in order to move to the main screen.

Figure 6.17: Screen 03-Menu Screen

6.3 Tools and Technologies Used

6.3.1 For Desktop Application

Following were the tools and technologies used for making Desktop Application:

1. Android Studio
2. Java Language
3. SQL Database

6.3.2 For Android Application

Following were the tools and technologies used for making Desktop Application:

1. Node JS
2. HTML
3. CSS
4. JQuery
5. NGNIX server
6. Electron Framework

Chapter 7

Testing Results

For Testing Purposes, it was done in Ganga Ram Hospital in Lahore. There was total 23 participants who participated in testing. In phase 1, there were 13 participants and in phase 2, there were 10 participants.

In phase 1, 8 out of 13 participants were patients and 6 out of 8 patients were smartphone holders. From testing, it was found that most of the patients and visitors found the android application more reliable and understandable than handwritten prescription. At first, few of them were not able to understand what the screen is about, but after a tutorial they found it easy to understand. At the end of testing a question was asked from each of them regarding the issues, they think this prescription has, from the answers it was found that the tablet icon is a bit confusing for them. Two doctors from ENT ward were asked to give us the reviews regarding the desktop app. The senior doctor was quiet happy with the idea of automating this prescription writing process and asked us to deploy this system in his clinic, however junior doctor said, she don't have this much time while checking the patients in which she can use this system to enter prescription, and asked us why she should use it? How this system will be helpful for her and the patients. However she agreed that using this system, the issue of misplacing the paper prescription can be solved as a patient's medical history will be stored in the database along with the patient's ID card no. **Table 7.1** shows the results of the testing phase 1.

Table 7.1: Testing Results of Phase 1

No.	Participant	Gender	Assign Task	Status	Understand-ability
1	Patient	Female	Android App	Confused	After 1 try, she understood the UI
2	Patient	Female	Android App	Confused and Shy	Took time to understand the UI
3	Patient	Female	Android App	Confident	Easily understood the UI
4	Patient	Male	Android App	Confident	Easily understood the UI after taking 1 look
5	Patient	Female	Android App	Confident	Easily understood the UI after one try
6	Patient	Female	Android App	Confident	Easily understood the UI
7	Patient	Female	Android App	Confused	Took time to understand the UI
8	Patient	Female	Android App	Shy	Took time to understand the UI
9	Medical Rep	Male	Android App	Confident	Easily understood the UI
10	Medical Rep	Male	Android App	Confident	Easily understood the UI
11	Medical Rep	Female	Android App	Confident	Easily understood the UI
12	Doctor	Female	Desktop App	Confident	Easily understood the UI
13	Doctor	Male	Desktop App	Surprised	completed the task

In phase 2, 10 patients were tested and all were smartphone holders. In phase 2, all the issues were rectified that was found in testing first phase, like capsules icons were used instead of tablets to make the interface more interactive to the users, from testing, it was found that it actually increase the understand-ability of the user. Even a 10 year old kid was able to understand the application after a tutorial. Patients found digital prescription better then hand written prescription. They also said that by marking a medicine after taking, it becomes easy for them to remember that they have taken the medicine or not. **Table 7.2** shows the results of the testing of phase 2.

Table 7.2: Testing Results of Phase 2

No.	Participant	Gender	Assign Task	Status	Understandability
1	Female	Female	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Confident	After 1 try, she understood the UI
2	Kid	Female	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigate between days	Shy but confident	Took time to understand the UI
3	Female	Female	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between	Confident	Took time to understand the UI

					days
4	Patient	Male	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Nervous	Took time to understand the UI
5	Patient	Male	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Confident	After 1 try he understood the UI
6	Patient	Male	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Confident	After 1 try she understood the UI
7	Patient	Male	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Confident	After 1 try she under stood the UI

| 8	Patient	Male	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Shy	After 1 try he under stood the UI
9	Patient	Male	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Confident	After 1 try she under stood the UI
10	Patient	Male	• Understand UI • Identify medicines • Mark tick for taken medicines • Navigatebe between days	Confident	Easily understood the UI

Chapter 8

Upgrading and New Changing in Development

8.1 Tablet Icon

After testing in Ganga Ram Hospital, some patients was confused about the tablet icon, therefore, a new icon was replaced with the old one in the android application as shown in the **Figure 8.1**.

8.2 Tick Tablet

For the convenience of the patients, a new update was added in the android application, when a user click on the tablet which he had taken, the tablet will change into a tick mark, which mean, he had taken the medicine. Moreover, he can track his medicine which are taken or not taken as shown in the **Figure 8.1**.
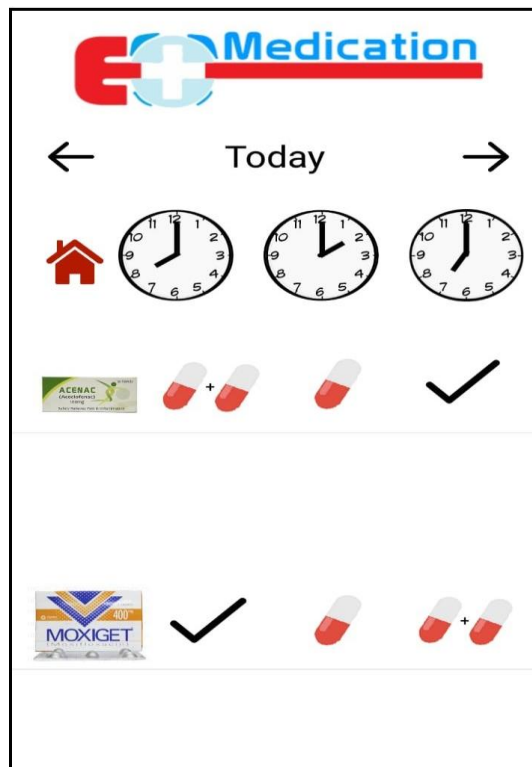
Figure 8.1: Upgrade Prescription Screen

8.3 Today's prescription Screen

For the convenience of the patients "Today" is shown on the present day prescription as shown in the **Figure 8.1**. By showing this, patients will not get confused with the other days of medicines.

8.4 Yesterday prescription Screen

For the convenience of the patients, right and left arrows are added as shown in the **Figure 8.1**. The purpose of the left arrow is to show the yesterday medicines which patients took already. When a patient will click on that left arrow, a screen will open showing the yesterday date instead of "Today", which will show his entire medicines either he ticked marked or not marked yesterday for his record. The good thing is that the next day, he cannot tick mark those medicines he never took yesterday.

8.5 Tomorrow prescription Screen

For the convenience of the patients, right and left arrows are added as shown in the **Figure 8.1**. The purpose of the right arrow is to show the tomorrow's medicines which patient will take next day. When a patient will click on the right arrow, a new screen will open showing the next coming day with the date which will contain the prescription of medicines which he will be going to take.

Chapter 9

Conclusion and Recommendations

Overall, it was observed that patients found this visual prescription easier to understand than hand- written prescription. But they were having issues with few icons which will be incorporated in future. Patients were satisfy that they can view prescriptions anytime and anywhere in the phone. Doctors appreciated the Desktop application, but they were not satisfy for entering the patient's data every time because they have patients to attend and entering prescription for them is time taking. Issues pointed out by the participants can be resolved by making few changing in the working of the application, which will be made in future.

References

[1] Aziz Sheikh, Liam Donaldson, Neelam Dhingra-Kumar, David Bates, Edward Kelley, Itziar Lar- izgoitia, Sukhmeet Panesar, Chris Singh, Debra Silva, Stewart Mercer, John Furler, Keith Mof- fat, Denis Fischbacher-Smith, Lena Sanci, Ahmed Al-Mandhari, Tejal Gandhi, Katherine Hayes, Arnoldas Jurgutis, Chow Mun Hong, and Ruth Wilson. Multimorbidity: Technical series on safer primary care. geneva: World health organization; 2016. licence: Cc by-nc-sa 3.0 igo. 12 2016.

[2] John K. Zao, Mei Ying Wang, Pei-Hsuan Tsai, and Jane W.S. Liu. Smart phone based medicine in-take scheduler, reminder and monitor. In *12th IEEE International Conference on e-Health Net- working, Application and Services, Healthcom 2010*, 12th IEEE International Conference on e- Health Networking, Application and Services, Healthcom 2010, 10 2010. ISBN 9781424463749. doi: 10.1109/HEALTH.2010.5556577.

[3] The Newspaper's Staff Reporter. Medication errors cause half a million deaths in pakistan, say pharmacists. *DAWN*. URL `https://www.dawn.com/news/1362951`.

[4] Ivander Liestyo and T.M. Santella. Medication compliance research: Still so far to go. *Journal of Applied Research*, 3:254–261, 06 2003.

[5] Ebru Kilicarslan and Glzade Uysal. Causes, reporting, and prevention of medication errors from a pediatric nurse perspective. *Australian Journal of Advanced Nursing*, 29:28–35, 06 2012.

[6] Mira Desai. A study of medication errors in a tertiary care hospital. *Perspectives in Clinical Research*, 7, 10 2016. doi: 10.4103/2229-3485.192039.

[7] Sakineh Saghaeiannejad, Asghar Ehteshami, Ebtesam Savari, and Ali Samimi. Developing the medication reminder mobile application seeb. *Acta Informatica Medica*, 25:108, 06 2017. doi: 10.5455/aim.2017.25.108-111.

[8] Himanshu Singh Nalini N Mayuresh Waykole, Vatsalya Prakash. Ardumed - smart medicine reminder for old people. *International Journal of Scientific Engineering Research*, 7, 05 2016.

[9] Kevin B Johnson. My medihealth: A paradigm for children-centered medication management. *Agency for Healthcare Research and Quality*, 25, 07 2013.