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eMedication- a smartphone-based e-medication system for hospitalized patients

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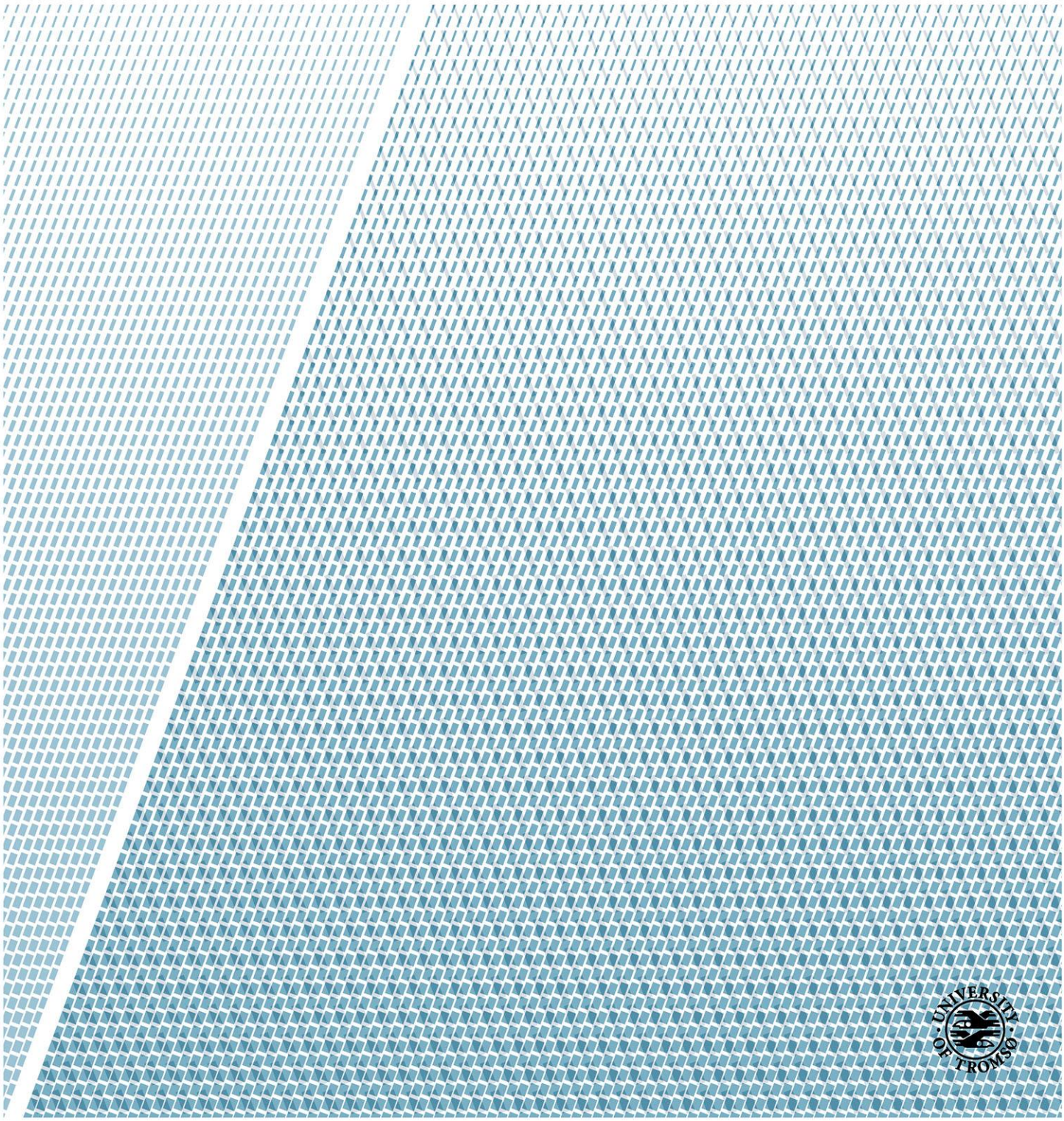
Sanjit Jung Thapa

INF-3997 Master´s Thesis in Telemedicine and E-health- October 2015



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Dedication

TO MY BELOVED PARENTS

Preface

E-medication has become very popular due to its ability to enhance safety and quality of the prescription process. E-medication has made prescribers able to electronically send patients' prescription information to pharmacy computers, which has reduced medication errors. Electronically sending and receiving prescriptions have simplified the clinical practice workflow, and patient satisfaction has improved. Moreover, connecting physician and pharmacy systems has reduced paperwork and the associated mistakes that may occur from handwritten prescriptions.

My thesis project began with understanding the scenario from Norwegian Health Director about prescription app lacking inside hospital for patients. Then, the research problem was created based on this scenario. The question was "How can a smartphone-based e-medication app help the hospitalized patients to access their own prescriptions and their details?"

The moment I started the project, I knew that this was a new concept of creating smartphone application for hospitalized patients. I had to face lot of challenges in order to deal with problems during the project. One of the biggest challenges was to get real patient medication data, which was not possible due to violation of patient´s confidentiality. Due to this, I had to manually create patient medication sample data. Other challenge was how to create something that will be used by every age group patient. So, I focused more on User Interface on how to make it look simple, easy and understandable by every age group.

Several methods were used to accomplish the project research. Review from different relevant literature, meeting with different field experts like software developer, pharmacy personnel and health informatics were used for requirement gathering on the design and implementation phases of the project. After several improvements on requirements and suggestions, a prototype was implemented using android studio and various tools for completing the prototype.

On the final phase of the project, the testing procedure was performed. User experience and satisfaction became my focus. The testing was done using 10-questionnaire survey, which were short listed questions. The prototype was personally given to 31 participants to install and provide their feedback through 10 questions. Android users installed the application and gave me feedback. For iPhone users, a demo was provided in order to give feedback. Test results were analyzed using percentage method. Due to short period of time, testing was not properly demonstrated among large number of users especially with real patients. However, prototype testing gave me some positive results. Most of the features were noticed as remarkable such as the color concept for medication, performing its intended task and friendly user interface. But, there were some improvements needed for use in the near

future. In general, the application was quite successful in achieving the goal of the project that was initially defined during the initial phase of the project.

I really appreciate the necessary support that was necessary which was provided from UIT - the Arctic University of Norway. Also, I thank Norway for giving me free education opportunity, which made my study possible. I also thank Mr. Jan Fuglesteg, who is counselor in computer science department for his moral support during hard times.

I would like to thank my supervisor, Professor Gunnar Hartvigsen who made my project possible through his essential feedbacks, suggestions and guidelines. I would also like to thank my co-supervisors Yngve Nyheim, manager at DIPS ASA, and Stian Eilertsen, IT specialist at the hospital pharmacy at UNN, for their advice and feedbacks necessary for the project. This project would never have been completed without their expertise and support. I appreciate the time allocated for advising me in their busy schedules.

Of course, a great thank to all 31 participants who were willing to participate in the testing stage of the project. Undoubtedly, without them, the research would be incomplete.

Also, I would like to thank the Department of Computer Science for providing access to the MI&T lab, which was a very friendly work environment. Also, I need to thank the Norwegian Centre for Integrated Care and Telemedicine (NST) for necessary support during the project.

Finally, I would like to thank my family and friends for their moral support and endlessly believing in me.

Tromsø, 15th October 2015
Sanjit Jung Thapa

Abstract

Purpose

The purpose of this research was to develop a smartphone based e-medication app for hospitalized patients at the University Hospital of North Norway (UNN). The app was expected to provide an overview of medication that the patient is given during hospitalization.

Motivation

E-medication has become widely popular in many countries, and has replaced the paper-based prescription. This replacement has enhanced the quality of the medication process and reduced medication error from handwritten prescription. Unfortunately, e-medication for patients has not yet been implemented in Norwegian hospitals. This we wanted to change. This e-medication app for hospitalized patient will reduce medication error as well as increase the quality of medication management.

Methods

E-medication system, a smartphone based application was developed to address the problems mentioned above. The application was implemented on an Android platform with help of Android studio using xml and the Java programming language. The application design was achieved after requirement and suggestions were collected through relevant literature review as well as different expert groups were consulted. After the design phase, the project was implemented based on the requirements. The final phase of testing was performed using questionnaire and participants gave feedbacks based on user experience as well as observing demo of the application. Finally, test results were analyzed and discussed later.

Results

Although the testing time was short which lacks proper testing of the application, but the application was quite user friendly and quite successful in achieving its intended task based on feedback from the 31 participants. The app was impressive in keeping a friendly user interface and easy to use application. As a whole, people were quite satisfied by the application and likely motivated to share it with friends and colleagues.

Conclusion

Prescription details were effortlessly embedded into the app. Due to use of color concept, simple design, friendly user interface as a main feature of the prototype helped participants to get motivated to use and give positive feedbacks. This feedback gave us promising results. For efficient implementation of project, manual data were used to show how the inside of app looks. Essential feedbacks and suggestion from the test results can be adopted in near future.

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Abbreviations

IOM	Institute of Medicine
UN	United Nations
ICT	Information and Communication Technology
GP	General Practitioner
RHF	Regional Health Authorities
IT	Information Technology
UNN	University Hospital of North Norway
App	Application
OS	Operating System
IOS	IPhone Operating System
XML	Extensible Markup Language
JSON	JavaScript Object Notation
IDE	Integrated Development Environment
UML	Unified Model Language
GUI	Graphical User Interface
SDK	Software Development Kit
API	Application Program Interface

Chapter 1: Introduction

1.1 Background and Motivation

Electronic prescription has become widely popular able to enhance safety and quality of prescribing process. Electronic prescription has been defined as the computer-based electronic generation, transmission, and filling of a prescription by replacing the paper-based prescriptions. E prescribing has made it easy for prescribers to electronically send patients' prescription information to pharmacy computers, which again has reduced medication errors. Electronically sending and receiving prescriptions has simplified the clinical practice workflow, and the patient satisfaction has improved. Moreover, connecting physician and pharmacy systems have reduced paperwork and the associated mistakes that may occur from handwritten prescriptions. This development in the approach of medication has produced time and cost savings for all patients and medical personnel involved (1).

Many providers and pharmacists have remained doubtful about completely adopting an e-prescribing system even after knowing the benefits of e-prescribing systems (1). Most patients do not remember their entire medication routine and they also occasionally forget to take their medication (2). Outpatients with chronic diseases, especially those who have to manage more than one medication or take medication more than once a day, may not take their medications properly (2). Patient adherence to medication is clinically essential in reducing mortality of serious disease and total health care costs (2).

Patient safety is a key factor in maintaining the quality of health care services and to preserve patient safety is a major concern in health care provision systems (3). Medical error has become a concern for patient´s safety. As a survey of the European Commission showed, 78% of the citizens of the European Union classify medical errors as a relevant problem (4). For the United States, the Institute of Medicine (IOM) estimated that 44,000–98,000 deaths annually are caused by medical errors and that the costs associated with preventable adverse events in the United States amount to $17–$29 billion each year (5). According to this study (3), the risk of medication errors among nurses is high and medication errors are a general problem of nursing in the emergency department. This could be minimized by use of mobile phones in hospital for the patients.

Mobile phones have particularly become one of the technologies, which is essential on delivery of health care. Mobile phones have completed replaced other means of communication and are also changing the way health professionals communicate with their

patients (6). Mobile phones offer unique prospect for personalized interaction and interaction with user anytime and anywhere in the world. According to UN, out of the world's estimated 7 billion people, 6 billion have access to mobile phones in 2013 (7). As information and communication technology (ICT) develops, a system using smartphones and smart tablets to support medication taking will become gradually necessary as a part of medication system because they are easily portable for patients to carry even in the event of an emergency or a disaster (2).

Currently, 4.3 million people uses mobile phones in Norway out of which 57.1 percent of the population accessed the Internet from their mobile phone in 2013 and expected to grow to 81.9 percent in 2017 (8). By this expected data, mobile phones could be the best solution for integrating it with health sectors.

According to Norwegian Health Directorate, "E-prescription is used by most General Practitioners (GPs) in Norway and now e-prescription made available at hospitals in Norway." The regional health authorities (RHF) are well underway with efforts to ensure that doctors in hospitals should be able to adopt e-prescription. All RHFs will be connected to Reseptformidleren (Prescription mediator). Even though e-prescriptions soon will be available at Norwegian hospitals, a lot of work remains before patient in the hospital can receive e-prescriptions.

Health related applications can help in health education including medication for health professionals and healthcare personnel as well as patients and will assist in improving patients´ quality of life. Therefore, mobile phone-based medication apps for patients can address the problems of overdose of drugs and medication error and also give knowledge about medication in an understandable and interesting way, which will improve the quality of life.

1.2 Scope and Research Problem

This project initially started addressing the above-mentioned problems and challenges in everyday lives of patients to have systematic medication management related with prescription.

The project is aimed to develop a mobile phone-based electronic prescription app for the hospitalized patients. The app is expected to provide prescription details related with drugs that are involved for the patients either past or updated drugs.

The main research problem of the project is:

" *How can a smartphone based e-medication app help hospitalize patient to access their own medication and its detail?* "

The issue for developing this application was how to design an app that will meet the requirements and expectation for the patients since this kind of app was new as well as dealing with hospitalized patients. Also, the issue was how to create an application that will be easy for use without learning any additional skills since hospitalized patients might be of different age group. Other important issue was to focus on how to enhance users´ awareness and knowledge about medication and its management. Therefore, the main research problem based on the mentioned issues is divided into sub-problems to well-define the limitations and scope of the thesis. The sub-questions are listed below:

Question 1: *What makes a smartphone-based application friendly for patients?*

Question 2: *How to create a smartphone-based application easy to master by different age group users?*

Question 3: *What can help patient to enhance medication management skills?*

Question 4*: How to make a smartphone-based application that will able to help patient improve their medication skill?*

Since, the application is targeted to the hospitalized patients that are related with prescription detail, they have prescription data flow everyday in medication process, which can lead to this question.

Question 5*: How can the user´s real data be applied into the smartphone-based application?*

1.3 Summary of Goals

The purpose of the thesis, based on above-mentioned questions can be summarized as follows:

- The thesis should study on what features of medication are esteemed in the application for patient.
- The thesis should investigate the medication process for the system design.
- The thesis should show how to use real data for the application.
- The thesis should show the process of designing and implementing a friendly and easy to adapt the application by different age groups.
- The thesis should exhibit medication app that will provide knowledge about drugs and help to enhance patient´s medication skills.

In integration to listed goals, the project should also consider the future scenarios of research in the field. Thus, one more goal of the project is:

- The thesis should definitely end up with reusable results that the future projects can be predicated on.

1.4 Assumptions and Limitation

This project mainly focuses on helping the hospitalized patients of different age groups to keep track of the medication that are prescribed for them. This medication project was chosen since it was still not applicable for hospitalized patients in Northern Norway.

In Norway, according to Norwegian Health Directorate, most general practitioners basically use e-prescription and recently e-prescription is made available at hospitals. Efforts are going on for ensuring doctors to use e-prescription system. Although, e-prescriptions soon

will be available at Norwegian hospitals, a lot of work remains before patient in the hospital can receive e-prescriptions.

Hospital pharmacies in Norway had strict policies regarding patients' confidentiality that greatly influenced in getting real patient data. This turned out to work with the manually created prescription table data with help of some general practitioners. The most limitation of the project was allocated time for the research. This led to affect the testing and result section but could be considered as certain and neutral.

Some of the assumptions that were done before starting the project were as follows:

- All application data is within the user´s internal memory and is not transferred to any external storage.
- For safety of user´s drug information, only the user who own the phone has access to the application and therefore, basic authentication is required.
- Assumption was done for patient shall not register personal information since they are already registered in hospital prescription system.
- Assumption was also made for pin codes that shall be generated by hospital management.

1.5 Methods

At the beginning, academic literatures relevant for the thesis were systematically reviewed to understand future prospects and state-of-the-art in the related field. As a result, review helped in contributing most of the significant application features, which was effective during the application design level.

Also, by the use of an engineering approach recommended by Denning and associates (9), I was able to solve identified problems in order to build application prototypes.

During the first phase of the design and implementation stage of project, a paper sketch prototype were developed several times and discussed with experts and colleagues. Frequent changes were made after discussions as well as research on the related field. Discussions with experts from health background as well as companies that are building applications for hospitals were useful for developing prototypes.

After further improvement in designing the prototypes, Android-based application was implemented.

Feedbacks, suggestions and new ideas that were generated from IT leaders of hospital pharmacy, experts from DIPS who are largest supplier of electronic health record systems to UNN was an advantage in developing this application prototype. Also consulting with supervisor who is involved in many health-related projects had great influence in implementing this app.

1.6 Significance and Contribution

The main contribution of the project is the application itself, since this app is the first attempt for developing smartphone-based medication app or hospitalized patients in Norway. The features, requirement and improvements suggestions that were identified from literature review and experts from several backgrounds were considered on the application design phase. Even though, the real data access was not possible, manually created data using tables were done with the help of general practitioner to make it look genuine medication. Despite of short testing period, the application was not able to properly demonstrate even though the application was attractive and easy to use. Therefore, research results can be helpful for other research in the field of medication for patients.

1.7 Organization

The rest of the thesis is organized into the following chapters:

Chapter 2. Theoretical Framework

This chapter gives overview about medication and its way of management through different ways. Moreover, medication in general and e-medication in precise are discussed. Furthermore, this chapter reviews literature about how android-based smartphones are able to manage electronic prescription for patient care to enhance the quality and safety of medication process.

Chapter3. Materials and Methods

This chapter explains the research methods used in this project for progress, implementation ad result evaluation phases of the project.

Chapter 4. Requirements and Specification

The chapter describes the project specification and its functional and non-functional requirements.

Chapter 5. Design

This chapter displays the design process of the project with various improvements and also the user interface design for the application.

Chapter 6. Implementation

This chapter shows the process of application development and tools involved in it. Moreover, the application structure described with different code examples and the most relevant features are described.

Chapter 7. Test and Results

This chapter shows the testing procedure as well as outputs from the project are explained.

Chapter 8. Discussion

This chapter includes discussion on the test, results as well as identified points for improvements.

Chapter 9. Conclusion and Future Work

This chapter includes suggestions for potential future work and conclusion remarks for this research.

Chapter 2: Theoretical Framework

2.1. Basic Knowledge

2.1.1. Medication

Medication is an important part of health care and enabling the cure and prevention of many conditions using the appropriate drugs. The word medication can explain both an act and an item. But here, medication is used to describe the detail of drugs in medicine. The most frequent and cost-effective medical intervention performed by General Practitioners is prescribing drugs, which can prevent or cure many diseases and increase the quality of life. Prescribing drugs represent the vast majority of all drugs being used but drugs is also administered in hospitals. Rational use of medications can be described as General Practitioners prescribing appropriate drugs to the patients according to the patients´ clinical needs, in doses that meet individual requirement, for enough duration and convenient for patients and communities (10).

2.1.2. E-medication-Technology in Medication

There is a need for tools that can support health professionals in handling the information and making it available to the actors involved for safe and efficient medication (10). eHealth has received increasing attention in the past decade defined by European Commission as:

eHealth is the use of IT in health products, services and processes combined with organizational change in healthcare systems and new skills, in order to improve health citizens, efficiency and productivity in healthcare delivery, and the economic and social value of health. eHealth covers the interaction between patients and health-service providers, institution-to-institution transmission of data, or peer-to-peer communication between patients and/or health professionals.

E-medication is the use of IT in the medication management process for medication appropriateness (10). During the last decades, the prescribing of medications and handling of information in the medication management process have gone through a major transition from paper to electronic based (11). The adaptation of the traditional process to the electronic era offers new opportunities as well as challenges for all involved actors (10). In the e-medication process, IT is used in several steps like ordering and prescribing in health care, electronic transfer and storing of prescriptions, processing and dispensing of prescriptions at pharmacies and accessing information on a patient´s current prescriptions (10).

2.1.2. ePrescribing

ePrescribing is a broad term used to describe a variety of IT systems used in health sector to support prescribing process. The first generation of ePrescribing, executed for example in the United States, was stand-alone technology for electronic entering and reviewing of prescriptions, but where prescriptions were printed and handed to the patient. The second generation of ePrescribing includes the electronic transmission of prescriptions from the prescriber to the pharmacy, either to a specific pharmacy (push model) or to a centralized repository (pull model) (12). Norway has been using the second generation of ePrescribing in the form of software called “E-resept”.

2.1.3. Smartphones for Healthcare

Innovative mobile communications and portable computation are now combined in handheld devices called "smartphones", which are also capable of running third-party software. Smart phone users are increasing rapidly including among healthcare professionals. Many medical applications for smartphones have been developed and widely used by health professionals and patients. The use of smartphones is getting more attention in healthcare day by day. Smartphones can play a very significant role in patient education, disease self-management, and remote monitoring of patients (13).

Therefore, mobile devices have been integrated into health care practice due to the availability and quality of medical apps (14).

According to StatCounter Global Stats from July 2014 to July 2015 (15), Android based smartphones have gained more popularity in World as well as in Europe but IOS based smartphones have gained slightly more popularity in Norway.

Figures 1, 2, 3 to illustrate different graph that shows the use of Mobile Operating System from July 2014 to July 2015 by StatCounter Global Stats.

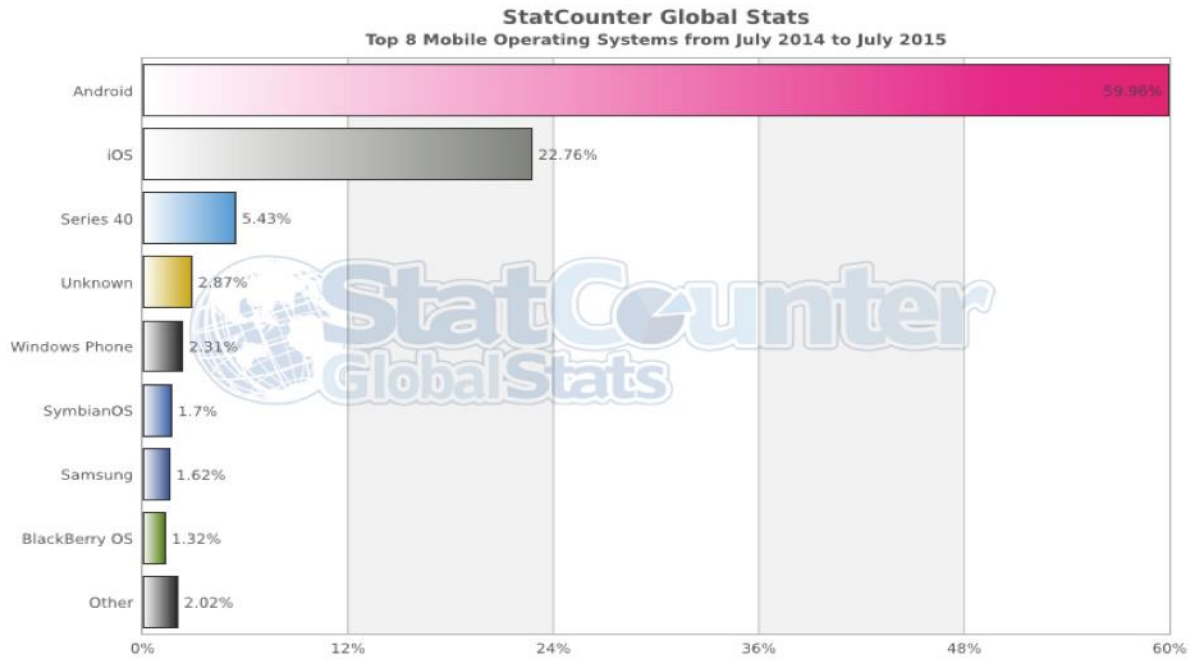


Figure 1.Use of Mobile Operating System globally

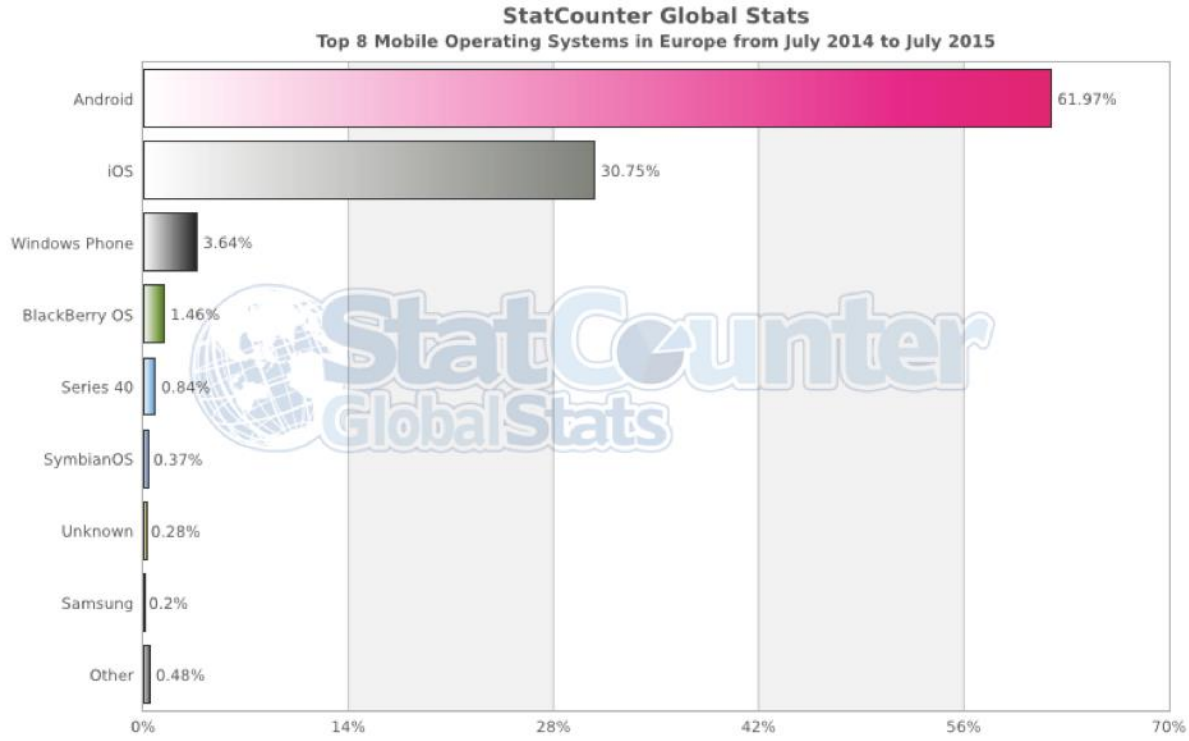


Figure 2. Use of Mobile Operating System in Europe

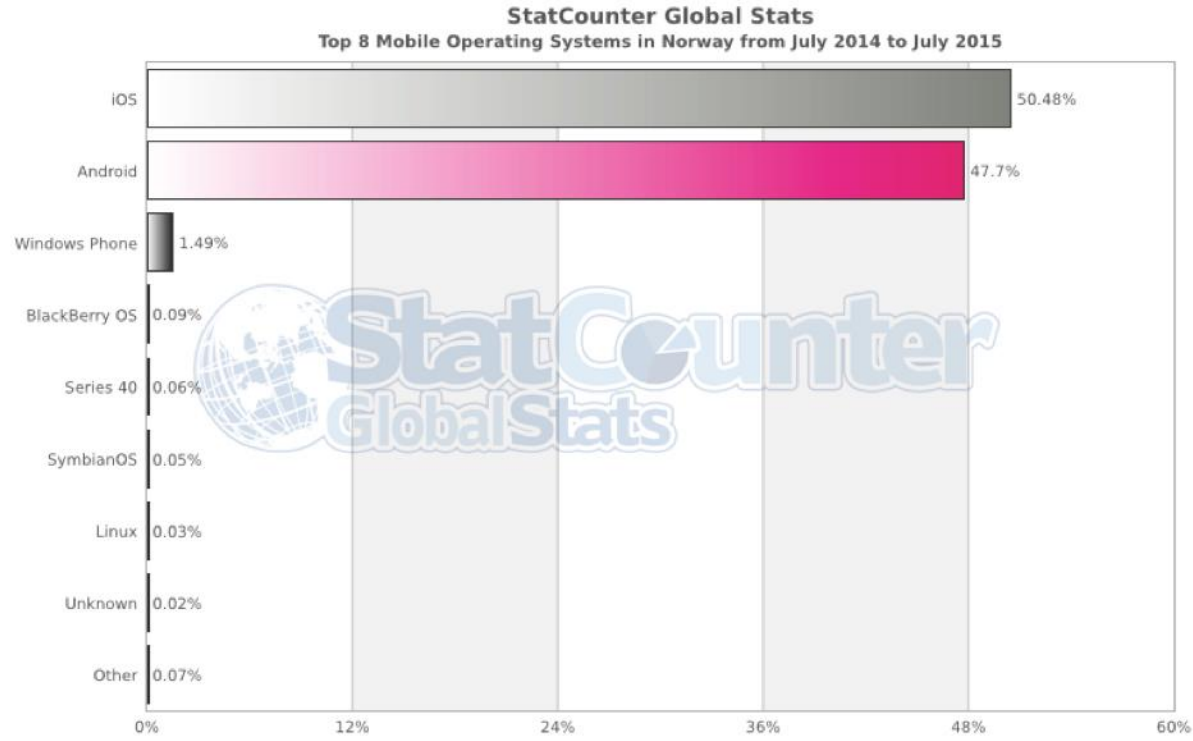


Figure 3. Use of Mobile Operating System in Norway

2.1.4. Felleskatalogen

"*Felleskatalogen AS is the publisher of the Catalogue of pharmaceutical products marketed in Norway and the Catalogue of preparations in veterinary medicine (Veterinary Catalogue*)" (16). It includes kind of drugs, use and indication and other information related to medicine. PDR, which is a catalog book free for hospitals and pharmacy, are published every year in catalogue´s official website. This PDR can be customized for smartphones for easy online navigation and search all contents through smartphones.(16)

2.1.5. E-resept

It is an existing system in Norway that is used by general practitioners to send prescription electronically to central prescription database, which is also accessed by pharmacy personnel. It also official website where every residents of Norway can access their prescription data through authentication using Norwegian Id, name and date of birth and min Id. The official site for logging online is provided by helse norge.(17)

The figure 4 shows the overall system of prescription in Norway.(18)

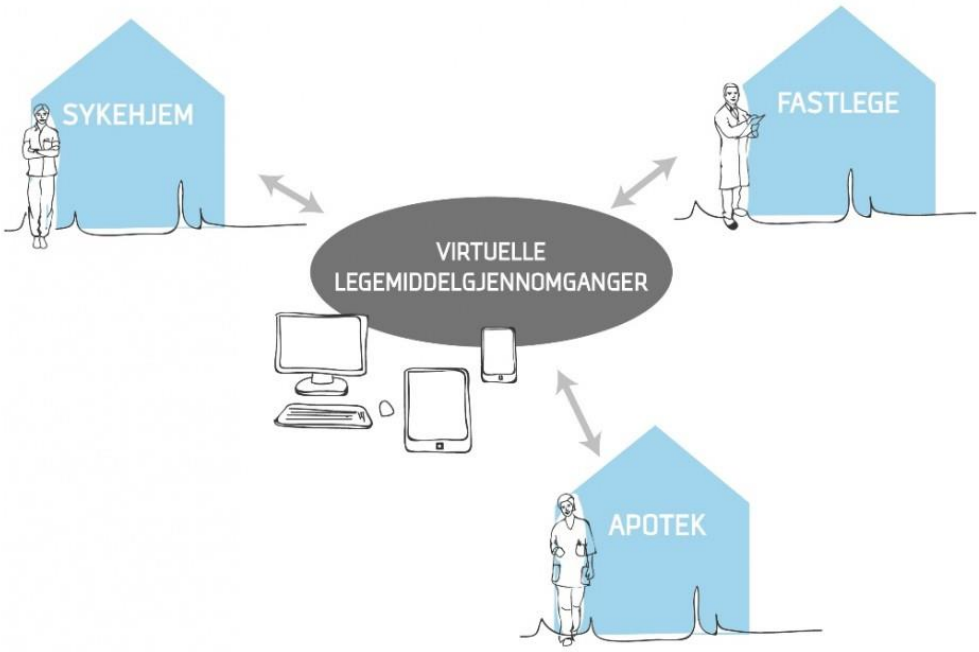


Figure 4. Virtual Prescription System overview

2.2. State-of-the-art

This part illustrates a review of academic literature about how android-based smartphones are able to manage electronic prescription in order to avoid errors, how integration of mobile devices in healthcare have changed the perception of medication and the study of different tools that are developed for patient care to enhance the quality and safety of medication process.

2.2.1. Purpose

It is one of the most challenging works for healthcare professionals for managing medication process efficiently and without any medication error. Especially, when it comes to patient care where lack of proper medication cannot risk patient´s life. So, in order to maintain the quality of patient care, it is necessary to focus on medication method, which can be done through use of mobile devices for prescription. Now, it is time to change perception of prescribing methods by introducing an Android-based e-medication app for patient. Literature describing about the use of smartphones for patient care and how these apps can

overcome medication errors and how it will enhance the quality and safety of medication process was considered as state-of-the-art for the thesis topic.

2.2.2. Data Sources and Search Criteria

I have perform literature search in the following electronic databases: PubMed (National Library of Medicine and National Institute of Health), Google Scholar, Google, BIBSYS library for accessing ebooks, journals, article and other relevant sources. Several reports related to e-medication from American Medical Association, World Health Organization, health affairs, RAND Corporation Europe, SINTEF articles, NHS Connecting for Health and Health Service Research were observed and analyzed but were not cited for this thesis.

Searches were conducted in mid September-October 2014.

Several exclusion criteria were applied with the papers that were not in English and papers without an available full text. Review papers were accepted in the literature search. The significance of each publication was examined by reading the abstract and the full text if needed.

2.2.3. Search Methods

As it was stated above, literature search was done in mid September-October 2014. While searching relevant literature, various combination of keywords related to my thesis were used. At the beginning, we were more focused on how medication process are handled in hospitals and pharmacies by different healthcare professionals and also interested in what were the impacts of technology such as mobile devices used in medication process. After the primary search, many duplicate and irrelevant papers were excluded and useful papers, which met the criteria for my thesis. Table 1 displays some basic keywords that were used in primary search.

Sources Accessed	Basic Keywords Used
Google Scholar, PubMed, Google, BIBSYS library	Medication, e-medication, electronic medication, smartphone based e-medication system, e-prescription system, electronic prescription, Use of mobile phones in health care, integration of mobile phones in healthcare, use of mobile phones in Norway, medication errors, medication errors in hospitals, electronic prescription service in Norway, Medical applications for pharmacists using mobile devices, Health and the mobile phone, patient medication management.

Table 1. Keywords Used for Primary Search

2.2.4. Findings

With the use of above-mentioned keywords, only the most relevant papers which were especially focused on medication process. Also, some that was useful for gaining ideas but not totally relevant were studied and left behind. Among not included papers were papers focused more on medication management system for healthcare and health personnel but not with medication that were focused on patients. Moreover, ways of securing proper and safer drugs management for patients without information misused and details that has to be taken in mind while creating prescription system for patients were extracted from the finally selected papers.

Apparently, the most essential parameter was the study findings that helped to identify medication features and criteria, which should be considered while developing the medication app for patient care.

2.2.5. Discussion

All the relevant literature and some Internet resources (Google, Google Play Store and iTunes Store) were searched for e-medication apps for patient.

The more focus while reviewing different apps were the platforms used create apps and for which category of people the app was developed.

While reviewing different medication apps, we found that most of the medication apps were developed for drugs guidance which were used by the general practitioners, physician, specialists, medical students, nurses and other healthcare professionals for either clinical drug information or for decision support system. The apps that focused on patient´s medication were highly focused on features like medication reminder, identifying pills and keeping the track of medication logs that were manually created by user itself.

After analyzing all the medication apps that were popular and highly rated on smartphone market, we found that there is no single mobile app that allows patients to see his/her updated and past medication list. It was also found out that apps that were developed for patients were moreover pills reminder.

Although the apps were not built for patient who could see their new and past medication list, this review helped a lot to understand the depth of different medication apps that were used.

2.2.6. Conclusion

We identified the lack of smartphone based e-medication apps for Android and other mobile platforms that were focused on hospitalized patient to overview his/her medication list. Most medication apps were either developed for health professionals for clinical drugs

information or as a pills reminder and maintaining medication log for patients. Furthermore, an easy app that features overview of medication list either new or past with detail information are additional for patient care.

2.3.Summary

This chapter provides basic knowledge about medication and its way of management through different source. Further, concept of e-medication for hospitalized patient is introduced. Likewise, certain amount of relevant literature is reviewed in the State-of-the-art segment of the chapter.

Chapter 3: Methods and Materials

3.1. Research Paradigm and Tools

Some engineering approach is used in this thesis. This approach with four aspects was explained by Denning (9) in the task force committee report titled as "Computing as Discipline ". The method follows an iterative and incremental approach where entire development process is composed of activities such as (9):

- State requirements;
- State specification;
- Design and implement the system;
- Test the system

Since, the process is iterative, requirements can be changed or transformed in later phases of implementation.

3.2.Materials

Several tools were applied to build this application. Graphical user interface designs for this prototype were constructed with help of Microsoft PowerPoint software. Following table shows the development tools and software that were used for further implementation of the application prototype for the Android operating system.

Programming Languages	➢ Java ➢ XML (Extensible Markup Language) ➢ JSON (JavaScript Object Notation)
Integrated Development Environment (IDE)	➢ Android Studio version 1.2
Compatible with	➢ Android Version smartphones from: Gingerbread (2.3) to Lollipop (5.1.1)

Table 2. Details of tools used

3.3. Data Collection and Experimental Methods

3.3.1. Literature Review

Review of relevant literature in details in chapter 2 was used in order to collect functional and non-functional requirements for the app. Most of the concepts and features that would lead to properly developed app were identified from chapter 2. Most significant features identified can be summed up as follows:

An app should be easy to use since different age groups will use it. An app should contain fewer pages to open. An app should display detail information in simple and understandable way. An app should be easy to login and logout. An app should use colors to make it lively and attractive. Also, it is very important for an appropriately implemented app that contain attractive and simple design and easy to access.

3.3.2. Meeting with IT leader

Several meetings with an IT leader (Stian Eilertsen) from University Hospital of North Norway (UNN) of pharmacy department were conducted to gather requirements and ideas that were relevant for developing medication app. The meeting was very fruitful since it helped to understand the detail medication process in the hospital. We also came to know that this app neither for hospitalized patient nor for the hospital doctors were previously done in this hospital.

3.3.3. Discussion with Experts

Many features and concept of this app was also gained from Software Company called DIPS ASA, which is the largest supplier of electronic patient record systems to Norwegian hospitals. Several meetings were held on DIPS with application developer (Yngve Nyheim) in order to implement proper apps. Most ideas and suggestions were considered in the application development process in appropriate manner.

3.3.4. Brainstorming with supervisor

Many meetings were taken in account with supervisor (Gunnar Hartvigsen), who is currently professor at University and expert researcher in Medical informatics and telemedicine. Brainstorming with him was the most resourceful method that helped in generating new ideas based on experience. A proper user interface design process was also achieved.

3.3.5. Application Testing

As the application was related with the patient´s medication detail, testing was done after it was implemented. Testing procedure was carried out among the participants by providing the application to android users as well as demonstrating the app to iPhone users. The user experience from the participants was considered as the test results and was analyzed.

3.4. Evaluation Methods

Reviews and feedbacks are very necessary for the application that is developed. The survey questions after demonstrating the app were carried out among the participants in order to check whether the application matches the requirement and needs of the target audience and to collect user´s opinions and suggestions for improvements. These suggestions can be used for further improvements of the application and in future projects.

3.5. Critique of the Methods used

By author´s point of view, in the beginning, interactive meetings should have occurred with real patients for deeper user oriented implementation of the app and also in the end for prototype testing.

There are also other remarks such as the real patient´s medication data was not available because of hospital policies towards misuse and confidentiality of patient information, which somehow might have affected in the implementation phase of the application development.

Although the testing was held on common users but could not test on the real hospitalized patients. So, the test results should not be considered as objective and convincing. Due to the hospital policies and sensitive case for sharing patient information forced author to hesitate with hospital staffs to request for the patients to test the app.

3.6. Summary

The following methods were applied for this project:

- System design (engineering approach)

- Data collection
  - Literature review
  - Consulting and meeting with experts and colleagues

- Experimentation
  - Application Testing

- Survey questions among participants

- Evaluation (qualitative method)

This chapter clearly presents the materials used in this thesis. Introduction to Android operating system, which was selected as a target platform of the project, was also noted. Also, data collection, experimentation and evaluation are explained in this chapter. In addition, the critique of used methods is remarked at the end of the chapter.

Chapter 4: Requirements Specification

This chapter defines functional and non-functional requirements for the application. Event list and UML Use Case diagram were created to work with functional requirements systematically. In order to find out functional requirement, Volere Requirement Specification Template (19) was applied.

Certain assumptions for the app were made in addition.

- All the data is stored in hospital and is accessible only when asked for it.
- Authentication is required since we are dealing with user sensitive information on mobile phones. Hospital authorities will generate 6 digits pin codes for authentication.
- Operating system on the user's mobile phone is Android.
- Only the user (owner) has access to user´s mobile phone for the protection of user´s sensitive information.

4.1. Source of Requirements

Requirements are the obligatory needs for the app. Functional requirements are the essential subject matters of the system; they can be measured by concrete means like data values, decision-making logic and algorithms. Non-functional requirements are the behavioral properties that the system must have like performance, usability and others.

Most functional requirements were based on the previous software engineering experience of the author and some were based on advice from DIPS expert and brain storming with supervisor who is experienced in telemedicine as well as engineering field. Likewise, the suggestions and requirements were considered from pharmacist working in the University Hospital of North Norway (UNN).

4.2. Requirements

To figure out all the functional requirements for the project, some scenarios were taken in account.

4.2.1. Scenarios

According to the Norwegian Health Directorate, the e-prescription systems are only used by most GPs in Norway. The regional health authority (RHF) is underway to ensure that doctors in the hospital should be able to adopt e-prescription. Even though this takes lot of efforts but from this scenario, we could conclude that patient version of e-prescription can be implemented in the hospital.

Therefore, hospitalized patient needs application that is

- Overview of medications that is given during hospitalization
- Able to see history of medication

4.2.2. Required Behaviors

In order to get hospitalized patient motivated towards using e-medication app, certain behaviors are required.

a) Patient shall get information adapted to their specific needs about the drugs they are prescribed.
b) The app shall be interactive and user friendliness for easy use.

4.2.3. Functional Requirements

Based on scenarios above, main features for the application were defined.

1. Provide a tool, which helps patient to know about overview of the medication given during hospital time.

Use of official websites like eResept system to know about the medications for the patients was not accessible when they were hospitalized. So, this system was chosen for medication purpose.

2. Get instant access to medication overview through android phones during treatment in hospital.

To instantly access medication list from DIPS by direct use of android phone through our application is motivating for patients.

4.2.3.1. Use Case Tools

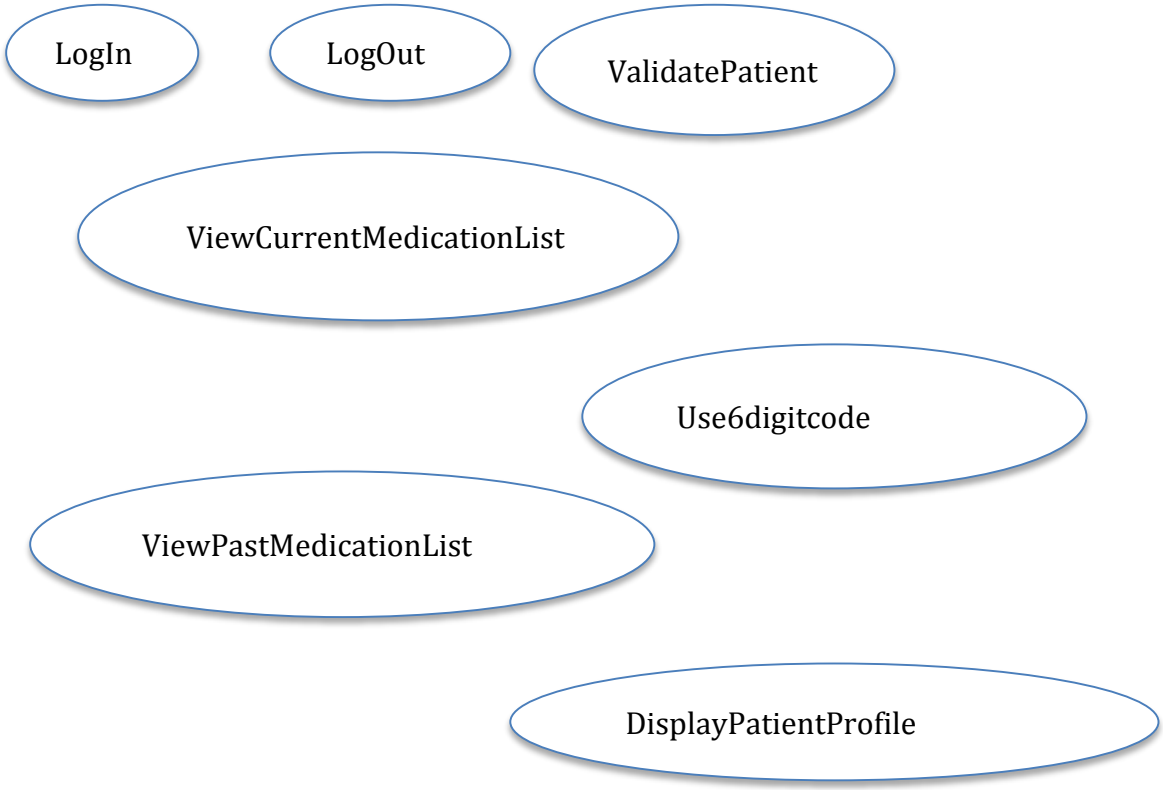
Use Case tool is used for capturing system's functional requirements. A use case is a approach used in system analysis to identify, simplify, and organize system requirements. Use case diagrams show how users will interact with the system. A use case diagram contains four components.

- *The boundary, which defines the system of interest in relation to the world around it.*
- *The actors, usually individuals involved with the system defined according to their roles.*
- *The use cases, which are the specific roles played by the actors within and around the system.*
- *The relationships between and among the actors and the use cases (20).*

For our application, actors involved:

Patient System

Possible use cases:



Use case diagram for the e-medication app as follows:

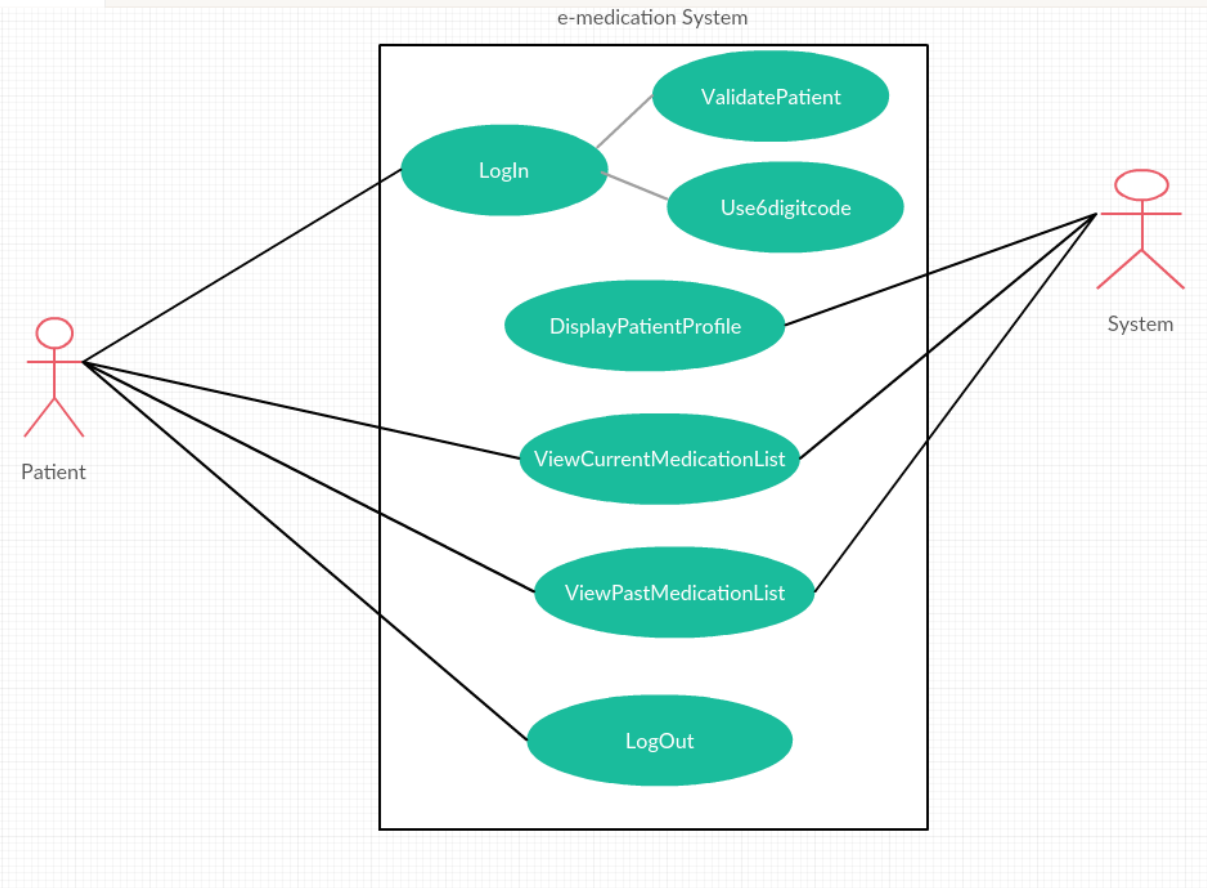


Figure 5. Use case diagram of our app

All the use cases are described in details below.

Use Case 1: **LogIn** (Actor: Patient and System)

1. *Patient opens the system*
2. *Patient is asked to login using 11-digit number*
3. *Patient gets six digit code from the system*
4. *The patient enters the code that the system provides.*
5. *The patient waits for the home page.*

Use Case 2: **DisplayPatientProfile** (Actor: System)

1. *The system displays patient's name with home page.*

Use Case 3: **ViewCurrentMedicationList** (Actor: Patient and System)

1.*Patient can view the current medication given in the hospital by the system.*

Use Case 4: **ViewPastMedicationList** (Actor: Patient and System)

1.*Patient can view the history of medication given by system.*

Use Case 5: **LogOut** (Actor: Patient)

1.*Patient closes the application by logging out.*

All the functional requirements for the System identified in the application were documented in accordance with the Volere© requirements specification template.

Hereby, the application has functional requirements as follows:

1. The system shall be able to open the application.
2. The system shall be able to authenticate users anytime.
3. The system shall be able to get 6 digits code number from Hospital.
4. The system shall be able to connect with Hospital.
5. The system shall be able to work with the data without data corruption.
6. The system shall be able to extract data from hospital database.
7. The system shall be able to display new medication list.
8. The system shall be able to access old medication files easily from hospital database.
9. The system shall be able to update the new medication list on time.
10. The system shall be understandable and no need for extra skills.
11. The system shall be easy and simple to use since users may vary in age.
12. The system shall be able to close the application.

4.2.4. Non-Functional Requirements

One of the main factors influencing all the non-functional requirements is the target users. We implement an android application for the sake of people of different age groups since it's related with hospital patients.

4.2.4.1. Security

Mostly mobile phones are to be considered as a personal and private use. Our basic assumptions state that only the owner to whom the smartphone belongs uses it. Since this is related to someone's sensitive health-related issues, it must be very confidential. But at the same time, an authentication of the user every time when application is opened can significantly reduce the tool usability.

4.2.4.2. Reliability

We need to focus on reliability of the application since patient in the hospital through smartphones uses this app. It should be developed in such a way that it can be available at any time.

4.2.4.3. Usability

We need to develop this app as user friendly and quick to learn since the patient might be of different age group.

4.2.4.4. Efficiency

Since the data needs to be accessed from hospital database for history of medication and newly updated prescription, the apps must not delay on displaying the data. Also, response time for getting 6-digit code should not lag for efficient use of the system.

4.2.4.5. Legality

Legal issues are also quite important. We should not transmit any personal data over non- secure channels without proper authorization.

4.3.Summary

This chapter describes the project specification and its functional and non-functional requirements. For the functional requirements of the application, volere requirements specification template was applied. Most requirements were also obtained from author´s previous software engineering experience as well as expert´s advice and suggestions. Scenarios were presented to explain the main features of the application. Based on required behavior identified for the application, use case diagrams were created. The chapter also includes non-functional requirement, which shall be met by the application.

Chapter 5: Design

This chapter describes brief history of the project design process and explains how application design has been used in theory.

5.1. Application Title

The application title was also considered as a part of the design process since name itself explains what application does. The application was named as “eMedication” acronym for electronic medication system for patient use. The name was inspired from “eResept” which is an Internet based electronic prescription used in Norway.

5.2. Image used for background

Background image for the design process was considered as important aspect and research for the image was done on Internet. The following image was taken for the background image since this image matches perfectly with the application title. The author chose this background since the app was related with medicines and also, the image clearly illustrated the meaning of the app itself. The image was sited from the website called information age (21).

Figure 6. Background image used for apps

5.3. Basic Features Identified for Application Design

The application design is considered as the output from the relevant literature and State-of-art from chapter 2 and also non-functional requirements identified in Chapter 4. Also, some of the concepts were used from the similar kind of apps in the market.

First, we focused a lot in user interface design. Lot of ideas to create user interface were taken from this website.

According to Paul Rand -*"To design is much more than simply to assemble, to order, or even to edit; it is to add value and meaning, to illuminate, to simplify, to clarify, to modify, to dignify, to dramatize, to persuade, and perhaps even to amuse."* (22)

Consideration was done for the appearance of the application which included user friendly and easy design. Also, we focused on how to make the app easy on skill for the users. It means even user without knowledge can quickly adapt the apps without any problem. Most of the design concept for the apps is based on with similar kind of apps that were found in android market with higher user ratings.

5.4. Design Tools

The design process was developed using Microsoft PowerPoint with the help of user interface design kit from android UI design kit (23) as a design layout.

Figure 7. Sample Android UI design used for app

5.5. Application Scenario and Contents

5.5.1. Login Page

In the beginning, the patient has to log in using their social security number and use the one time 6-digit code received on the phone to authenticate the user. The idea of using this kind of layout came on mind from the Norway´s online tax system portal called altinn which uses personal id and one time code generated using message on mobile device registered in the system. The login page looks like this:

Figure 8. Design Layout for Login Page

5.5.2. Main Menu

When user logs in successfully, the home page appears as a main page, which includes the overall medication list for the patient. From this page, patient can see the current, ongoing and past medication list, which are mentioned with different colors to make user easy to see only the page they want. The idea behind how the concept of color system was designed might sound different since the concept was applied from the traffic light signal that are used all over the world. Also, index is designed for identifying different color symbols. This design layout can be seen in following figures.

Figure 9. Main Menu/Home Page Design Layout

5.5.3. Ongoing/New Medication Detail Page

This page comes after clicking either new or ongoing color links from the Home page. This page design shows the detail of the medication that was given to user using the table format. Figure clearly illustrates how the design process was done for this.

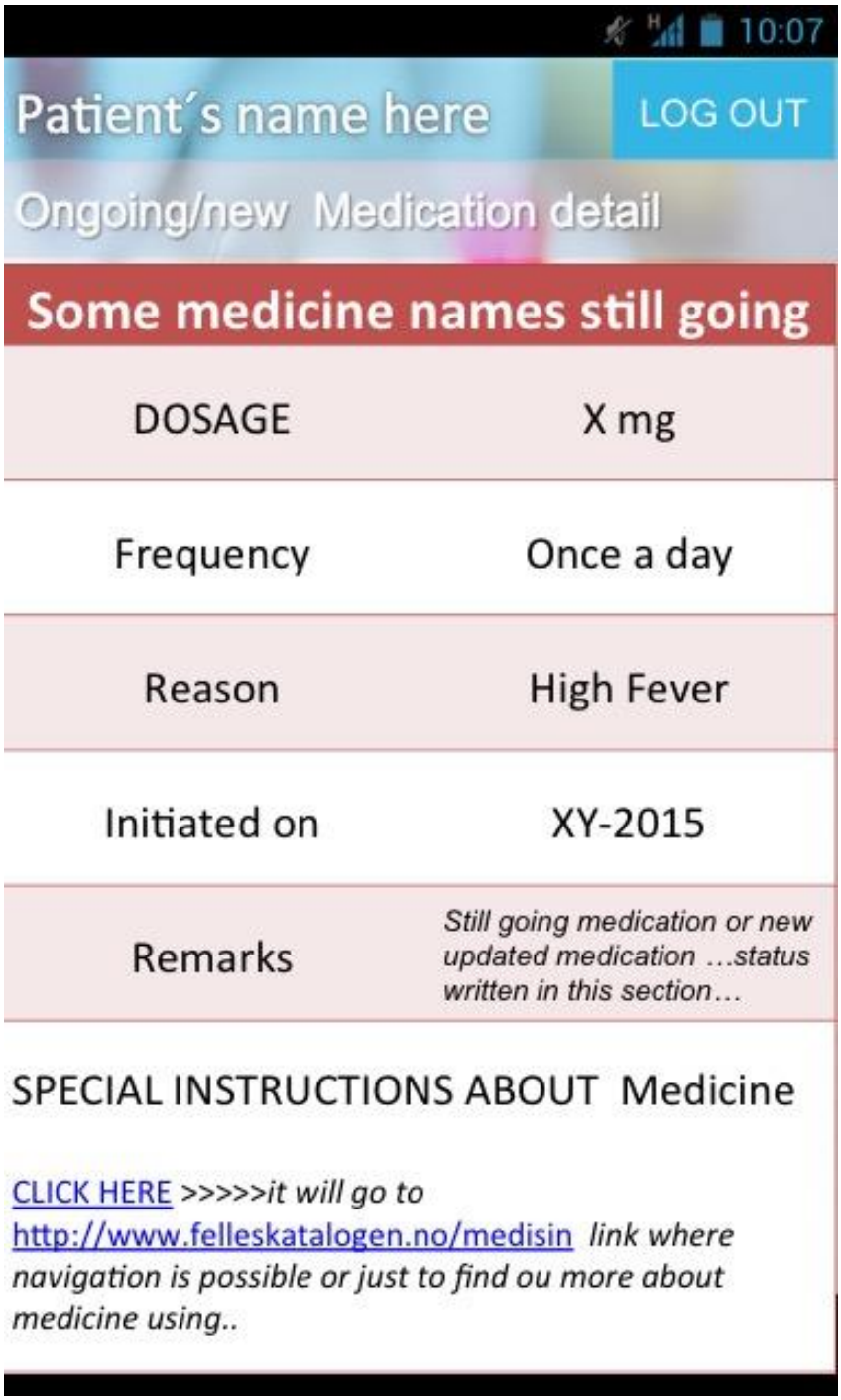


Figure 10. Ongoing/New Medication Page

5.5.4. Past Medication Detail Page

This page occurs after the past medication color link is clicked. This page design uses the table to display detail of medication used in past. Following figure shows the layout design.

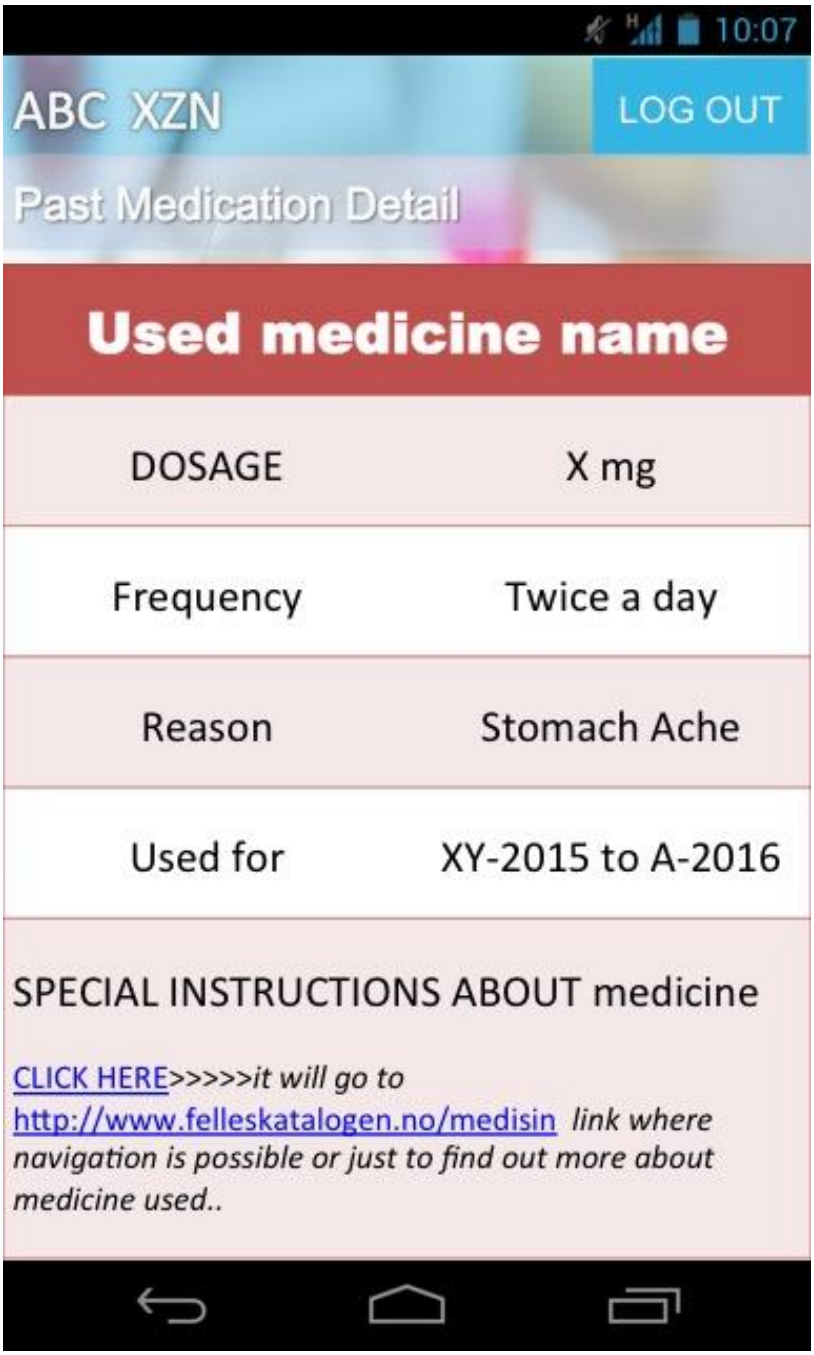


Figure 11. Past Medication Detail Page

5.5.5. Log out Page

This page is displayed after logout button is clicked which is in every design page except Login Page. Figure shows how to assure that we have logged out.

Figure 12. Log out Design Layout

5.6. Summary

The description of the application title and the research on image background for the apps was mentioned in the starting of this chapter. Then, the basic features that were identified in previous chapters were considered for design process. After this, the tools and layouts that were used in design process were described in details. Furthermore, the user interface that described whole application scenario with contents of each page of design was explained with images that were used for design process.

Chapter 6: Implementation

This chapter describes about the implementation process of the application that were designed in chapter 5. This chapter includes brief description of target platform used for implementation of the application. Then, an introduction to the tools that were used in developing application is mentioned in this chapter. Ultimately, the application structure is explained with most significant features and application code examples.

6.1. Android as a Development Platform

Mobile phones have gained lot of popularity in last decade because of its availability and portability. This is the reason for choosing mobile platform for developing prototype of the application.

Android platform was chosen among other platforms for several reasons. The first reason was that I was used to the android devices. Also, according to the StatCounter Global Stats mentioned in chapter 2, android has gained lot of popularity in the world as well as in Europe (see Figure 1 and 2). Due to the following statistics and personal ease, android was one of the possibilities to choose to build a prototype.

6.2. Android System Architecture

Android is a package of software that includes an operating system, middleware and core applications. The Android SDK provides powerful tools and APIs essential to develop applications on the Android platform using the Java programming language (24). (See figure)

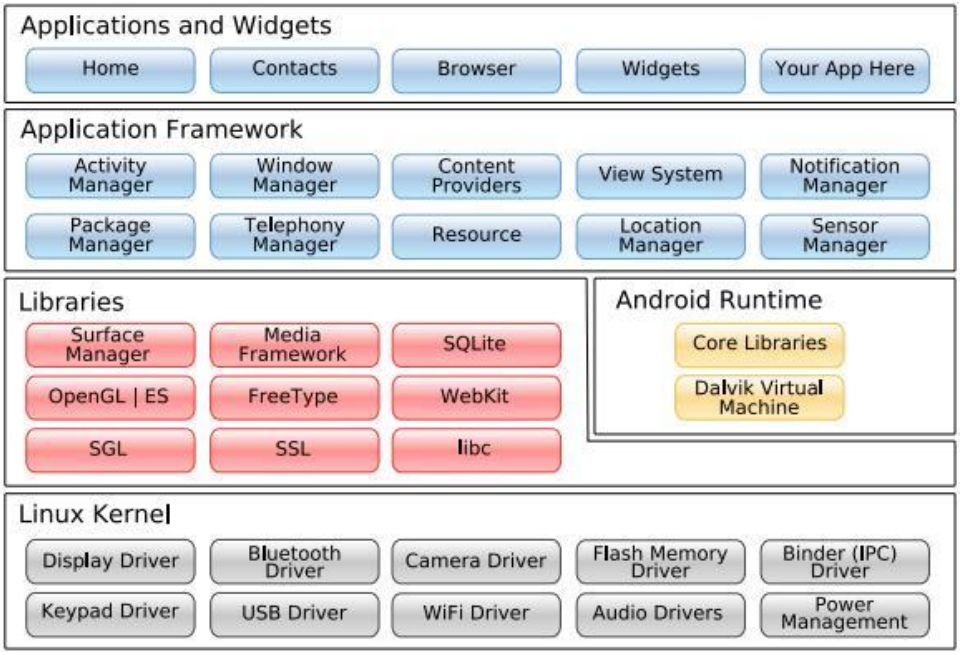


Figure 13.Android System Architecture

Android is built on Linux Kernel (version 2.6) and uses Linux for memory management, process management, network stack, security and driver model.(25) The core can be viewed as an abstraction layer between applications and hardware. For launching every application, the Linux kernel runs a separate instance of the Dalvik Virtual Machine (Java Virtual Machine). This implies that each application runs in its own process. Furthermore, the kernel supports threads and lowest-level memory management (25).

In Android, most functionality in the core libraries is on Java programming language. All the framework Application Programming interfaces used by core application are available for all developers. The users can replace each of the components and this reusability of components makes it comparatively simple (24).

For application development for the Android OS, Java is used as programming language. Android studio, an integrated development environment (IDE) was chosen as a development environment for implementation part of the application.

6.3. Android Studio

Android Studio is the official integrated development environment (IDE) for developing android application, which is based on IntelliJ IDEA. This tool was used for implementing our e-medication app.

The screenshot shows the interface of Android studio version 1.2 which was used for implementation of this project.

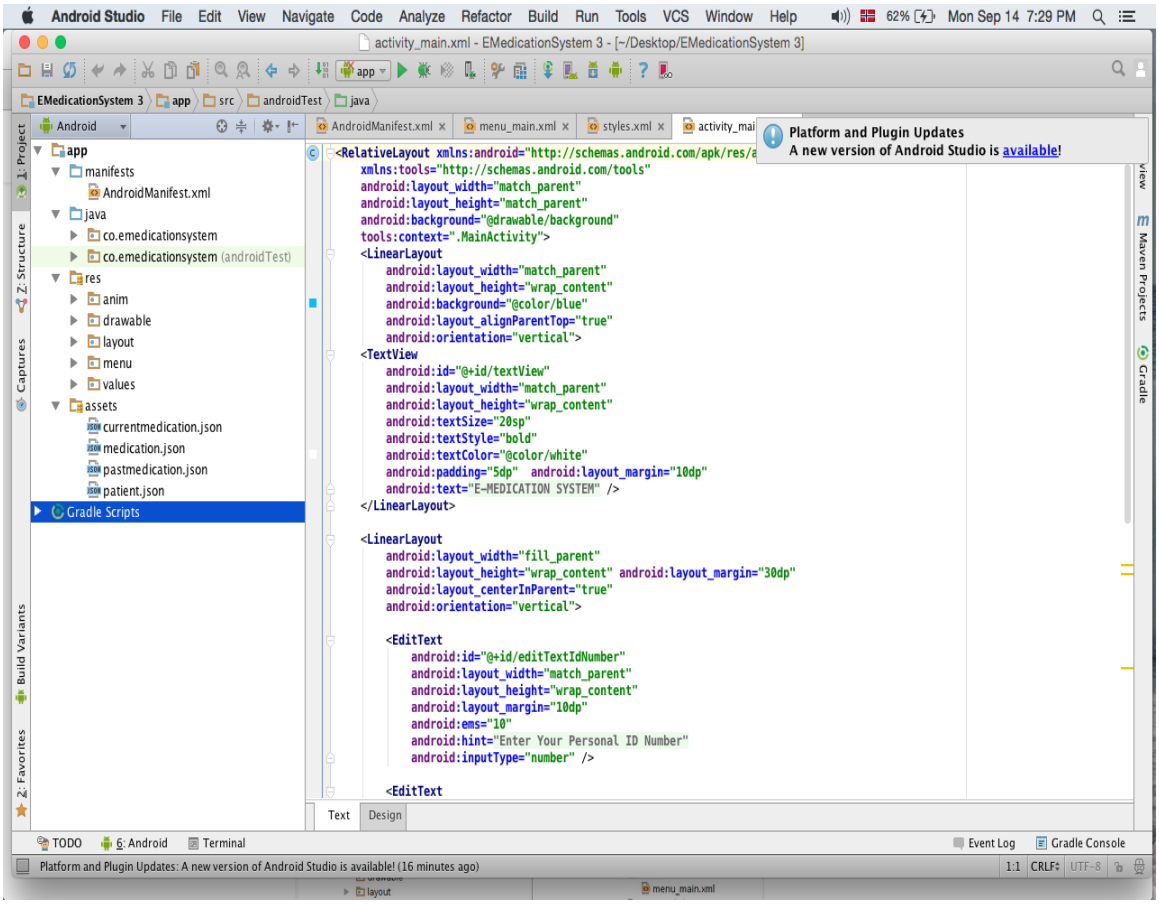


Figure 14. Screenshot of android studio

6.4. Project Description

The following screenshot shows overall android project view which includes all elements that were used in implementing our app.

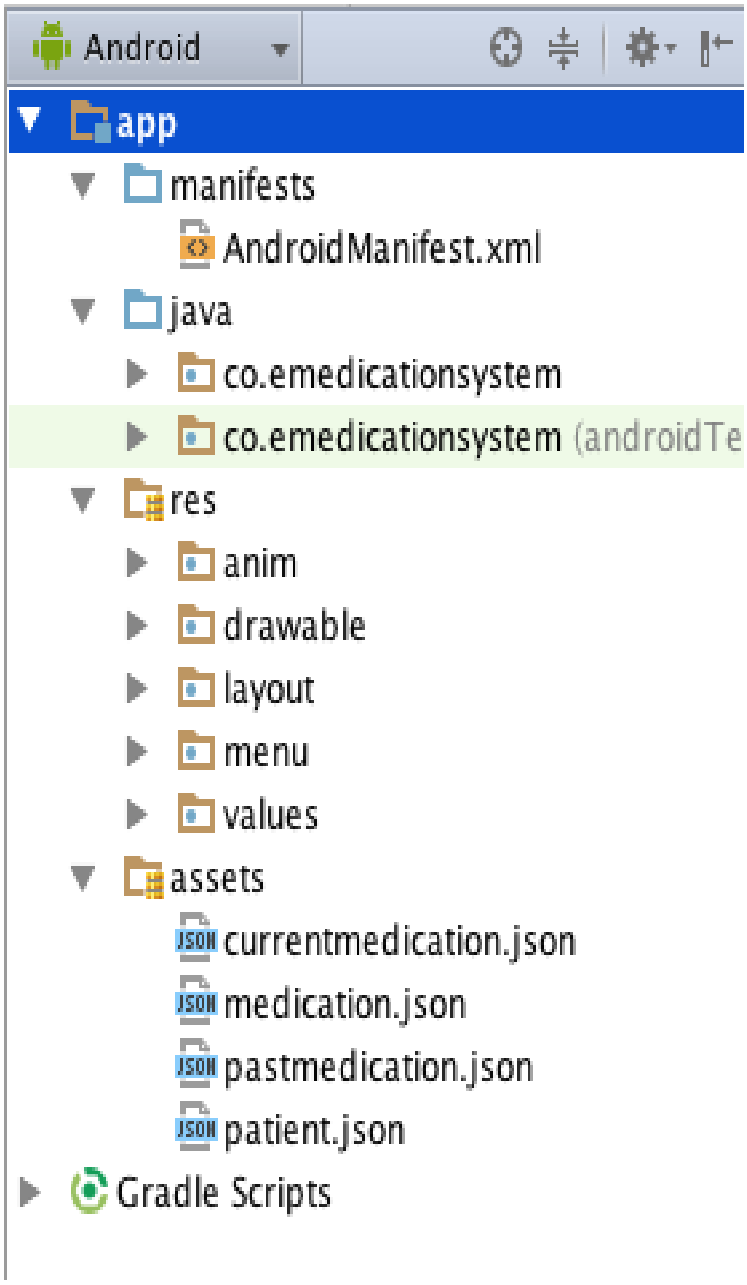


Figure 15. Android Project Overview

It contains four main elements. They are as follows:

6.4.1. Manifests

Every application must have Android manifest.xml file. It contains essential information about our app as well as declared components of the application.

The following screenshot shows our general structure of manifest file that was created for our app.

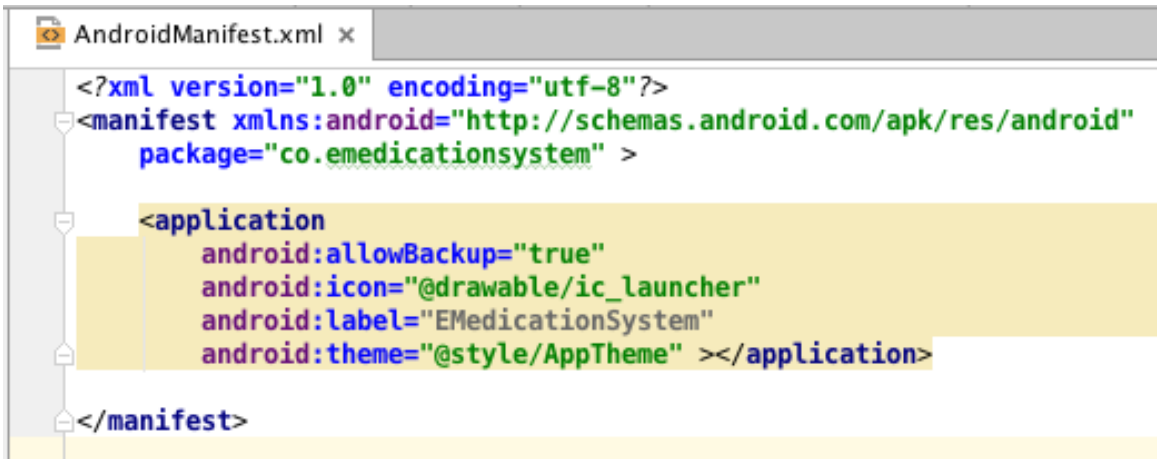


Figure 16. Android manifest structure

6.4.2. Java

It contains various source files that were used in our app. It contains different class files that were implemented for this project.

Screenshot to display the list of class files used for implementing this app.

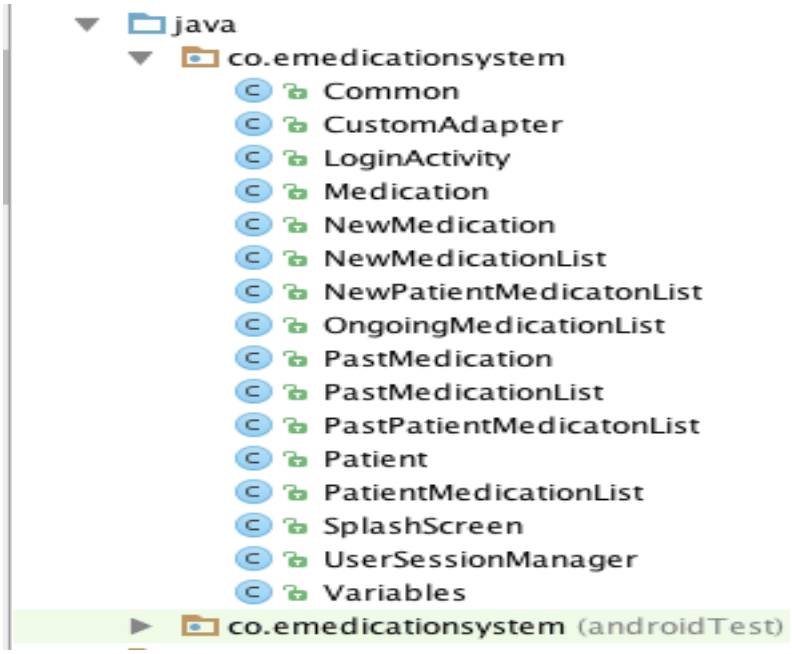


Figure 17. List of class files used in our app

6.4.3. Assets

Assets basically help to store any kind of data. Author implemented manual prescription data for our application using json files. JSON normally is very light weighted, easy, structured and much human readable. JSON is the best option to xml when our android apps need to interchange data.

The following screenshot shows json files on assets directory.

Figure 18. Screenshot of assets directory

The following code shows how author implemented manual patient information, which was used for the app. The following code is “patient.json” file from assets directory.

Figure 19. Patient.json file from asset directory

6.5. Summary

This chapter describes the implementation phase of the project. The targeted platform was described in the beginning, which was android studio. After that, all the files and folder structures used for implementing the app was explained. Some of the texts from source code were presented in this chapter, but they are available in the project source code.

Chapter 7: Test and Results

This chapter includes testing procedure and results from the testing that was performed with the application prototype. At first, the author using the sample authentication data made for the application login did the application testing. Each and every pages of the application were checked before any further procedure. Then, a clear demonstration of the application was done with detailed explanation of how the application works. At the end, some survey questions were distributed to the participants to get some results.

7.1. Testing Procedure

The final version of the application was tested using author´s android smartphones. While testing, manually created patient data was used which also included authenticating users. There were three patients' data created manually and the author tested all of them.

Secondly, several questions were created at the beginning for running the application survey. Among them, only some of the specific questions that were relevant for the results of the application were short-listed.

At last, the application was demonstrated to participants of different education background and different age groups. Subsequently, the selected survey questions were given to them for the application review.

The 10 specific questions and its significance with results are illustrated with figures in result section.

Finally, the participants were sincerely thanked for their willing effort to participate in the test and research. Therefore, the participants´ responses were considered as testing results and analyzed.

7.2.Test Results

7.2.1. Results from Questionnaires

An end user´s survey was conducted to evaluate overall success story of the app that we developed. During the questionnaires, 31 participants were involved to answer 10 questions that briefly describe the application. Among 31 participants, 24 male and 7 female participated. The age group of participants was from 18 to 40 years. Interdisciplinary subjects were selected from different field of study such as telemedicine and ehealth system, computer science, pharmacy, medical doctor, nursing, public health, business studies, art and humanities and so on.

The following are the list of questions that were asked in the survey with results.

- **Question 1**: included the information regarding the participants that were age, gender and field of study.

Question2: *Do you own a smartphone?*

Most people use smartphones of different operating systems such as android, windows, ios and others for communication and other purposes. This application was developed for android-based smartphone users only. So, the purpose of this question was to identify whether the users were smartphone friendly or not. We could get more precise results if the users were smartphone friendly. Following diagram shows the survey results from 31 participants in overall percentage.

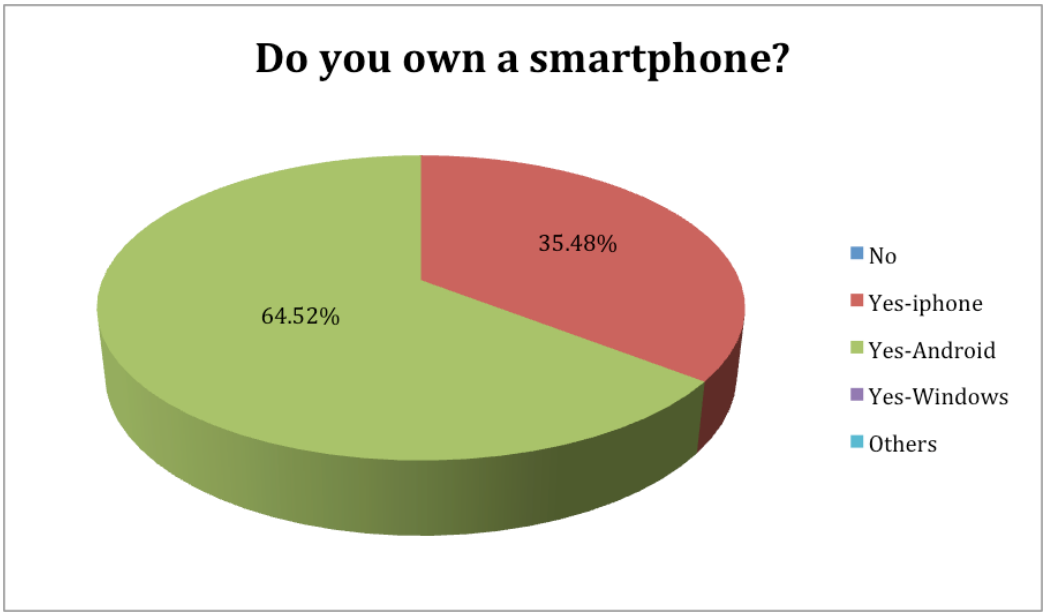


Figure 20. Survey from question 2

The above diagram shows that out of 31 participants, 35.48% of users were using ios operating system and 64.52% of users were using android operating system in their smartphones. The majority of the respondents were using android system, which might give us precise results.

Question3: *How easy was it to install our e-medication apps?*

Owning smartphone does not make one capable of using different apps. User needs to install the application and use it. So, this question signifies that whether the users were able to install e-medication application on their smartphones or not. Following diagram shows the survey results from 31 participants in overall percentage.

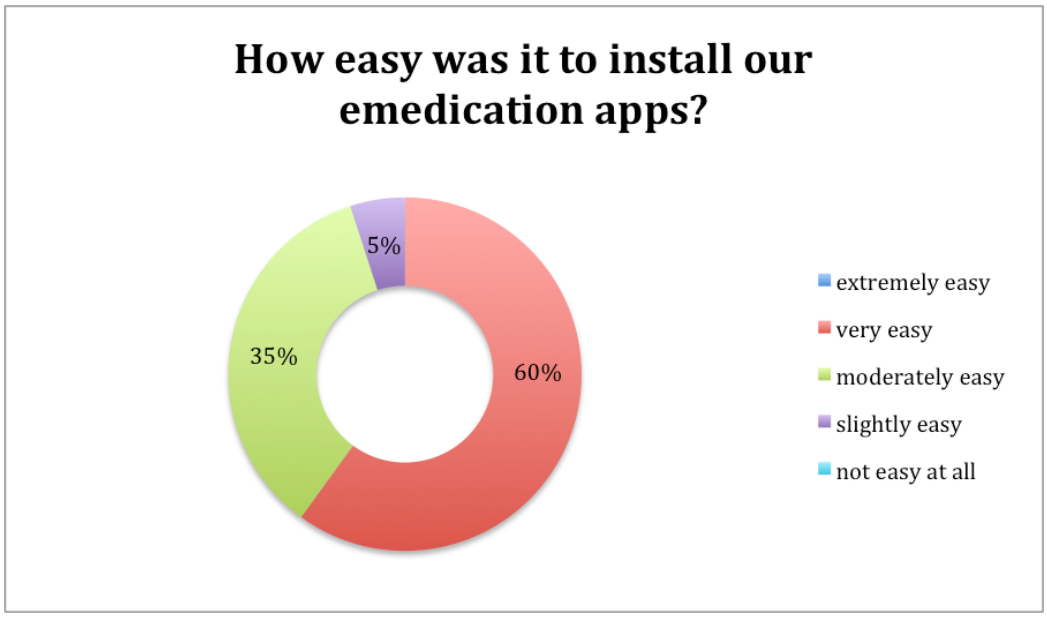


Figure 21. Survey result from question 3

The above diagram shows that 20 participants have installed the e-medication application on their android smartphones. Out of them, 60% of them found it very easy to install, 35% of them found it moderately easy and 5% of them found it slightly easy to install. The majority of the participants found it easy to install the application on their android smartphones.

Question4: *How user-friendly is our e-medication system´s interface?*

This survey question signifies that whether the system's user interface was handy for its users or not. This question was created to ensure the design requirement that were focused on clarity, easy to use, learn and understand the app while using. It was our interest to know whether the users found the e-medication system's interface friendly or not. Following diagram shows the survey results from 31 participants in overall percentage.

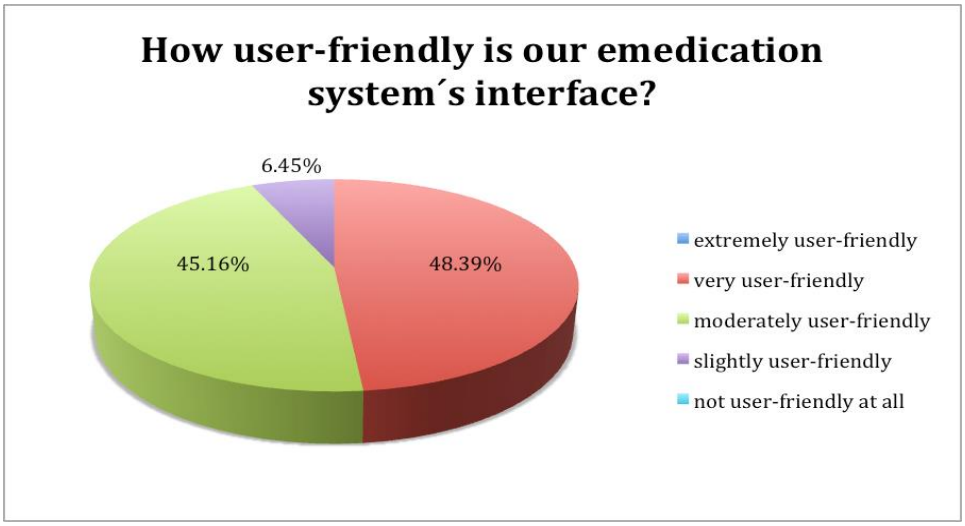


Figure 22. Survey result from question 4

The above diagram shows that out of 31 participants, 48.39% of user found the user interface very user-friendly, 45.16% of user found it moderately user-friendly and 6.45% user found it slightly user-friendly. Out of 31 participants, 29 of the users found the e-medication system's interface very and moderately user-friendly, which shows the competence of the app for its users.

Question5: *How often does our e-medication apps freeze or crash while using?*

After installation and using the application in the smartphones, sometimes the application get crash and freeze while using. It was necessary to identify the efficiency of the application. Following diagram shows the survey results from 31 participants in overall percentage.

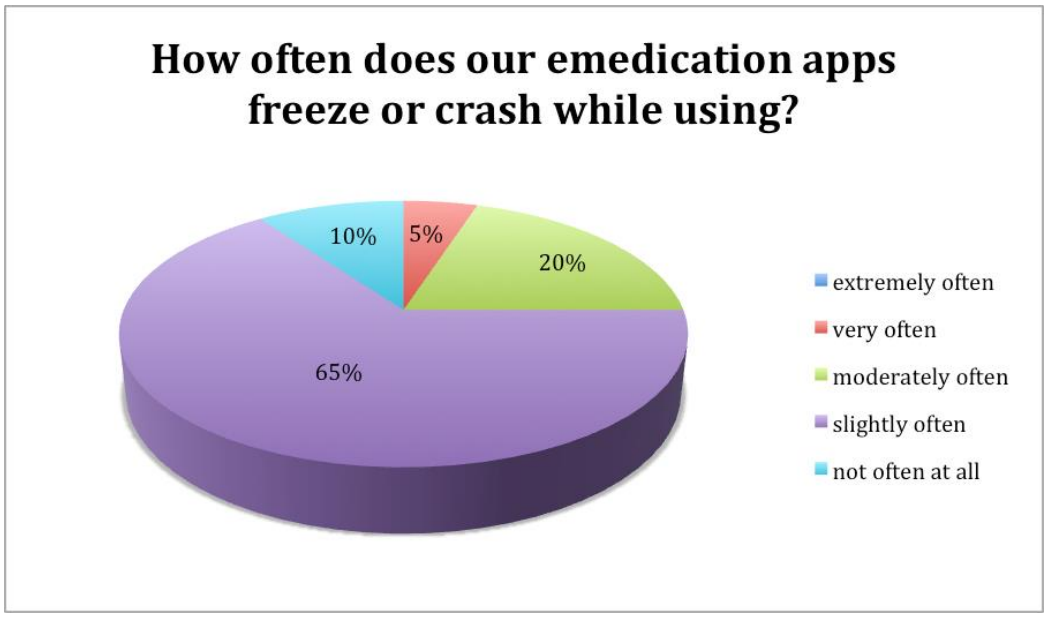


Figure 23. Survey result from question 5

The above diagram shows the efficiency of the application after its use. Out of 20 participants, 5% of the users found the application get crash very often. 20% and 65% of users found it crash and freeze moderately often and slightly often respectively. But 10% of the users found no freeze and crash while using. 90% of the users found the app freeze or crash at least once; such bugs on the application will be fixed in near future.

Question6: *How successful is our e-medication system in performing its intended task?*

It was necessary to identify whether the smartphone based e-medication system was implemented the way it was designed to meet the research problem. For this, another survey

question was prepared, whether the e-medication system perform its intended task successfully or not. Following diagram shows the survey results from 31 participants in overall percentage.

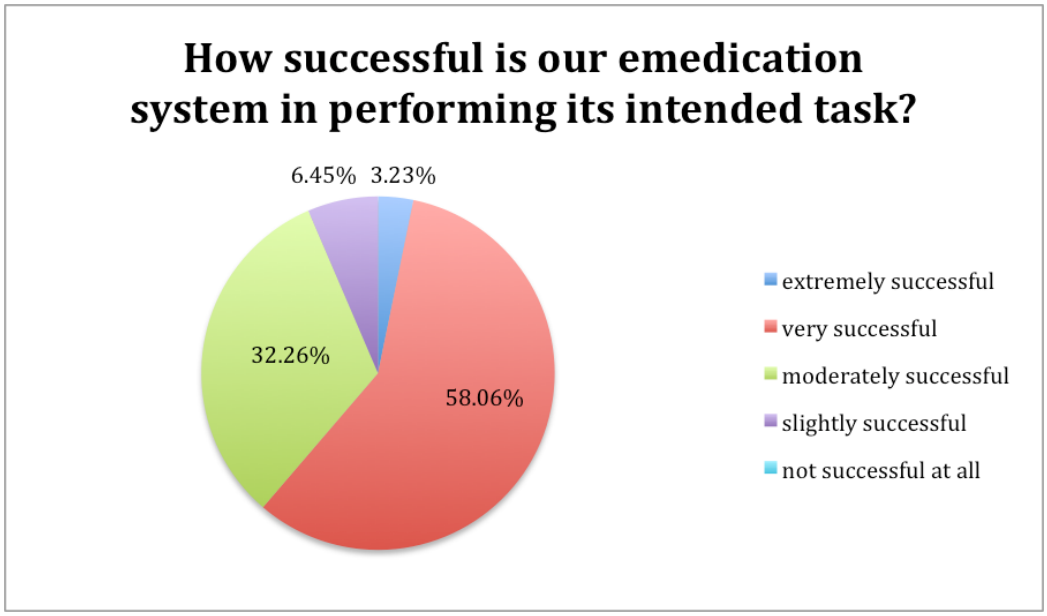


Figure 24. Survey result from question 6

The above diagram shows that the majority of the users were highly satisfied with the successful use of e-medication system while performing its intended task. Out of 31 participants, 58.06% of the users found the intended task of the system very successful. 32.26% of the users found it moderately successful and 6.45% found it slightly successful. However, the majority of the users were satisfied while performing its intended task.

Question7: *Do you think this application has all the necessary information for prescription follow up?*

Most users were satisfied with the intended task of the emedication system. It was also important to understand whether the system had enough prescription detail from user's perspective. This question determines whether the app was fulfilling its requirement on the basis of user´s experience. Following diagram shows the survey results from 31 participants in overall percentage.

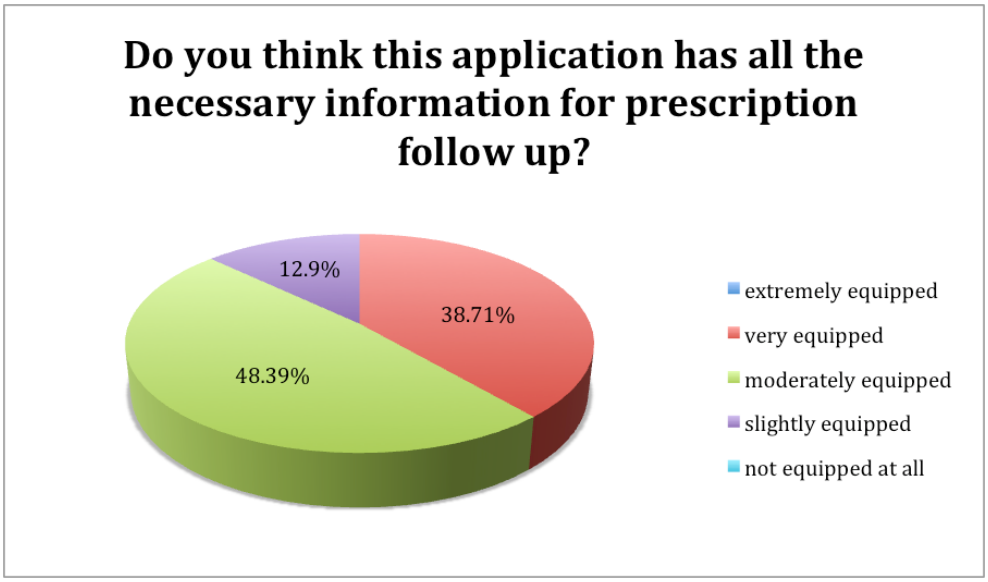


Figure 25. Survey result from question 7

The above diagram shows that the application has all the necessary information for prescription follow up that the users required. Out of 31 participants, 38.71% users found the app with very equipped prescription detail and 48.39% users found it moderately equipped prescription detail. In total, 27 participants out of all found this app sufficiently equipped for prescriptions follow up information that user require for proper medication. This app shows the promising result after user experience.

Question8: *Do you think this e-medication software will resolve the current medication system for patients?*

This question signifies whether this e-medication app was able to solve the current research problem to some extent or not. Following diagram shows the survey results from 31 participants in overall percentage.

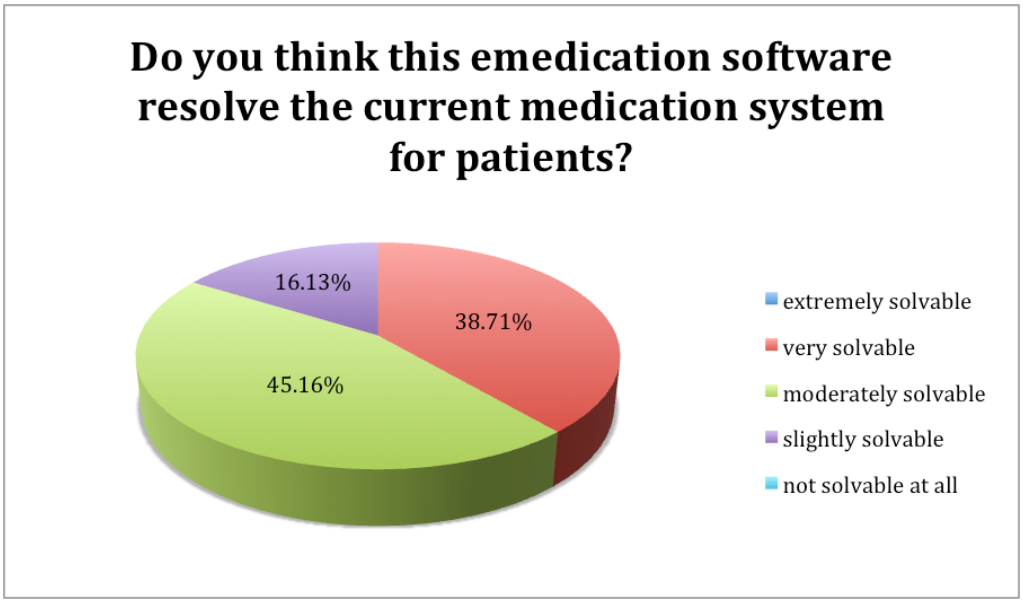


Figure 26. Survey result from question 8

The above diagram shows that out of 31 participants, 38.71% of the users found it very solvable, 45.16% of the users found it moderately solvable and 16.13% of the users found it slightly solvable. The users gave various opinions but on the whole, majority of the participants found the e-medication software could resolve the current medication system for patients to some extent.

Question9: *Overall, are you satisfied with our e-medication service, dissatisfied with it, or, neither satisfied nor dissatisfied with it?*

This survey question gives an overview of the user satisfaction towards the app that was implemented. This is an overview of user satisfaction, dissatisfaction, neither satisfied nor dissatisfied with e-medication system. Following diagram shows the survey results from 31 participants in overall percentage.

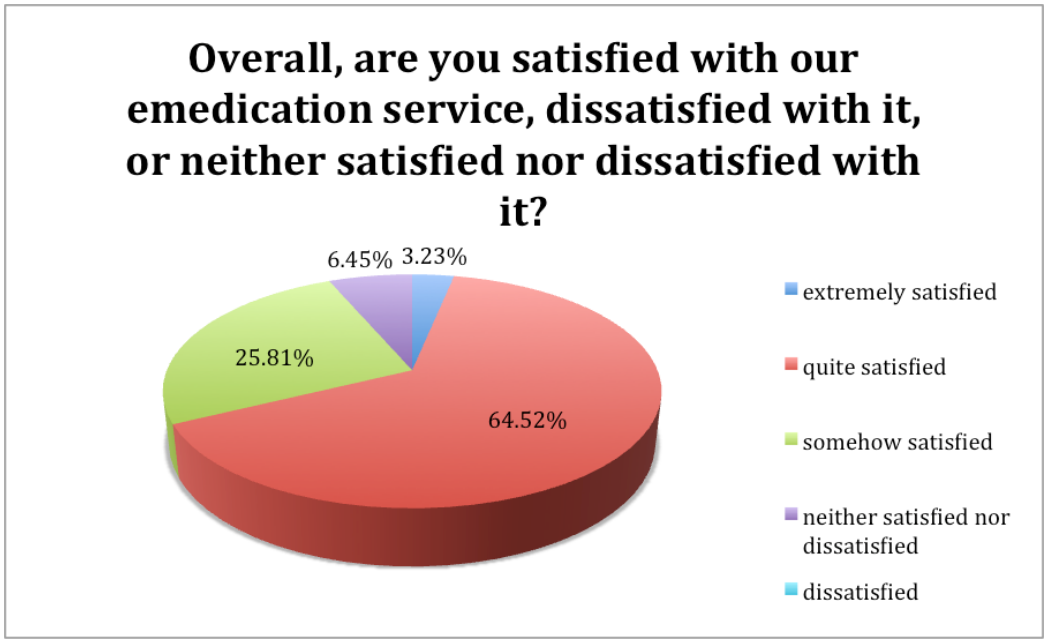


Figure 27. Survey result from question 9

The above diagram shows that out of 31 users, 3.23% of the users found it extremely satisfied, 64.52% of the users found it quite satisfied, 25.81% of the users found it somehow satisfied and 6.45% of the users found it neither satisfied nor dissatisfied. The overall review of the users show that majority of the users were satisfied with service provided by the e-medication software. It shows the positive results that this application could be the next possible solution.

Question10: *How likely is it that you would recommend our e-medication app to a friend or colleague?*

The final survey question answers whether the users of e-medication application users will recommend the application to its friend or colleague. Following diagram shows the survey results from 31 participants in overall percentage.

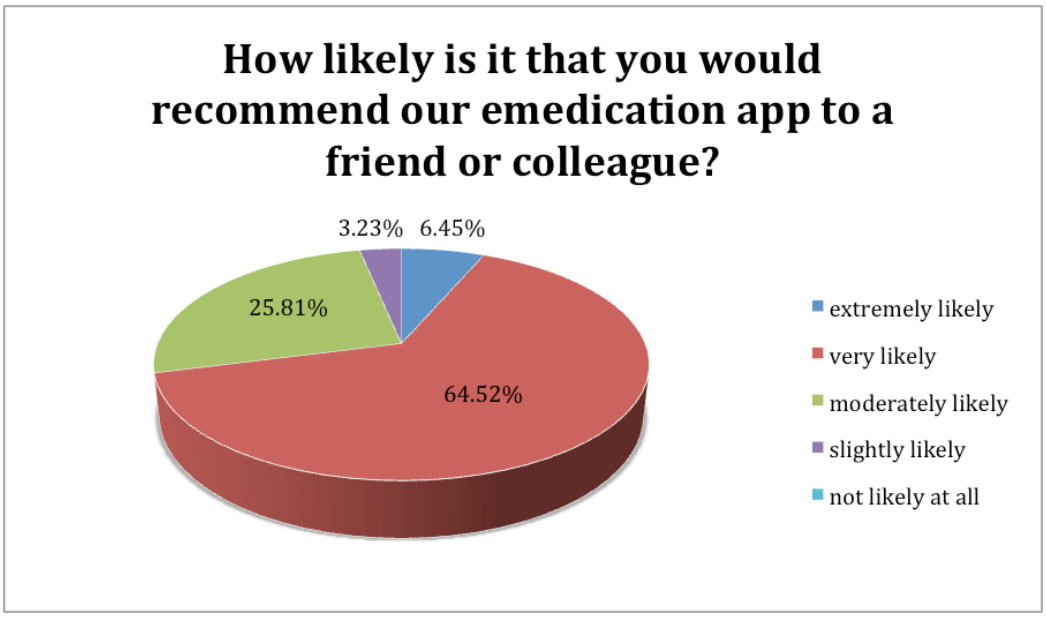


Figure 28. Survey result from question 10

The above diagram shows that the different categories where the users of emedication application falls. Out of 31 participants, 6.45%, 64.52% and 25.81% of the users found it extremely likely, very likely and moderately likely respectively. Only 3.23% of the users found it slightly likely. In overall, 30 participants are likely to recommend the application to its friends and colleagues, which shows the potential of the app and its promising results in near future.

7.3. Summary

The chapter illustrates about how the application was tested and the results were analyzed based on the user experience. First of all, author examined the application on the smartphone before testing procedure was further carried out. Then, the participants involved in the survey observed as well as installed the application. Lastly, this chapter presents the results from tests.

Chapter 8: Discussion

This chapter includes the interpretation of the test findings that were done on previous chapter. (Chapter 7) Based on feedbacks from the survey, findings will be presented in this chapter. Then, project ethical issues are discussed. Lastly, the identified points to improve the projects are described.

8.1. Findings from Testing

While doing the testing procedure, we had used questionnaire method to find precise results from our participants. We had 31 independent participants from different profession, education and background. It is necessary to get results from diversified participants so we can get fair results free from biases. In this questionnaire survey, we had 10 different questions related to our prototype, which gave us final results. Later, these results were closely examined.

In the beginning, it was necessary to mention that we had difficulty in getting significant result due to time limitation. The entire result is based on 31 participants and their experiences towards the app. We were unable to bring the prototype to real patients whose opinion and experience might have result into different consequences. So, this limits our results from limited participants, which cannot be considered as objective and convincing.

Secondly, we had discussed the findings we got from the participants based on the questions. In this procedure, user interface of the app is highly satisfactory and commendable. Majority of the participants found the app user friendly and comfortable to use. This app had succeeded to fulfill its intended task where it meets the requirements of the participants. However, this app was developed for android users and the participants were ios users too. So, we personally demonstrated the app to ios users in android devices. Although this app was fully focused on android platform but due to participation of ios users which might lead us to develop the app that is compatible with all kind of platforms.

This app might need some improvements and adjustment to make it fully equipped.

Few participants have raised an issue that whether this app was appropriate to use when the patient have large number of medication list. Few participants experience the crash and freeze of the application while using on their devices so, it was challenge to convince them the app would be bug free in coming future. There has been contradiction whether the app was able to resolve current research problem, as people were resistance to change which result as a barrier to accept new e-medication app to them. So, some participants were in favor

of using the app and some were hesitated to install and use the app. Later, most of the participant found it easy and reliable app to use in daily purposes. This survey was unable to cover the experience from old people and children that might have slightly different result. On the whole, the majority of the participants were satisfied with the app and interested to share their experience with their friends and family.

8.2.Ethical Issues

In the requirement chapter it was mentioned that no personal data would be transmitted over unsecure channels without the consent of authoritative personnel and all the data would be confidential.

As it was assumed in chapter 4, all the data is stored in hospital and will be accessible only after authenticating user with pin code generated by hospital management. It was also assumed that only the owner of the mobile phone where the application was installed could use the app. As a result, this prevents the major ethical issues related with information flow.

During the survey, we had only taken the information's like age, gender and background of the participants. No personal information was mentioned and ever discussed in the entire project. Since the manually created data was used during the survey for all the user´s, which might have prevented ethical issue, related with medication data. Somehow, this data might have helped participants to feel secured and protected while using the app.

8.3.Essential Improvements

On the basis of test results the following factors were identified as the further improvements of the project.

8.3.1 Time Duration

Time duration plays a vital role in gathering important information. More time spent result into larger information and less time spent result into limited amount of information. Because of the limited time, few numbers of participants were participated in the survey. We lacked survey from old people and children due to time limit and the result were sum up from middle-aged group participants.

8.3.2 Use of Timeline for medication overview

Most of the participants were curious to know how this app will help them if they were using large number of prescriptions. According to this book(26), timeline overview

could be the proper solution to provide a chronological overview of the patient's medication list. Based on this app, we design this simple framework that might be implemented in near future to solve this issue.

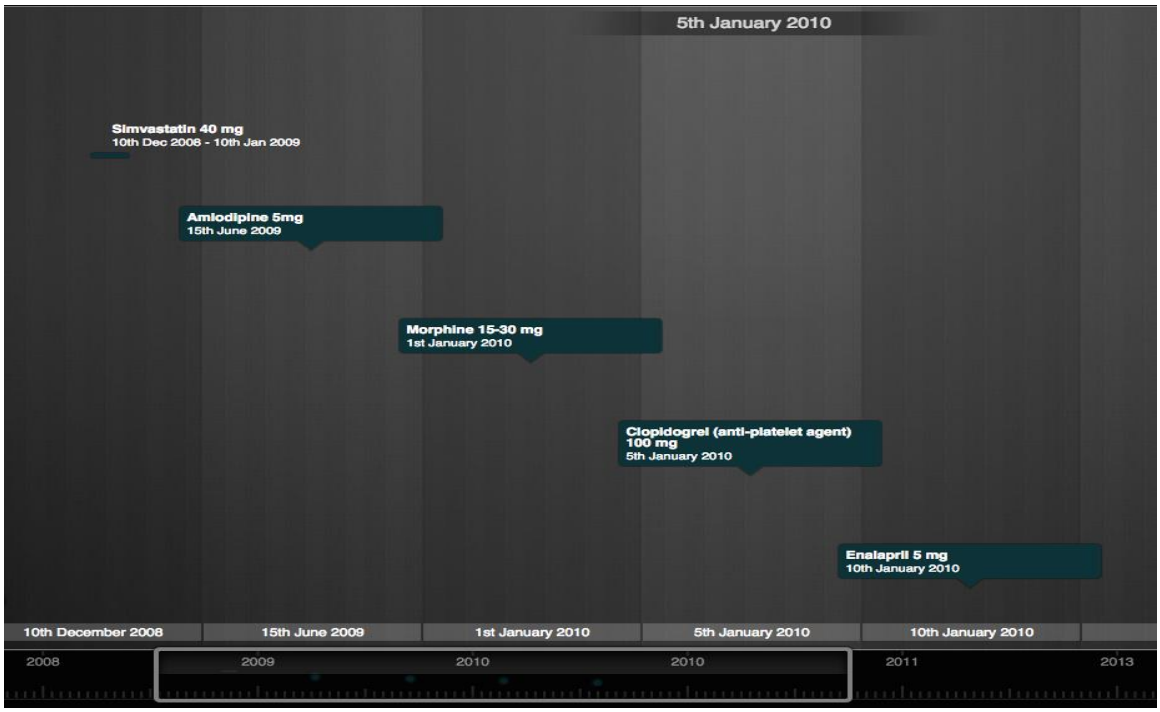


Figure 20. Sample timeline layout of our app

8.3.3 Selection of Testers

Since this project was focus on hospital patients, result would have been more precise if hospital personnel conducted the testing. In this project, we could not test the app with real patients because of the hospital policy towards its patient. Hospitals do not want to violate the patient's' personal confidentiality. More concise and precise result might have obtained if the test was conducted with hospital personnel and hospitalized patients.

8.4. Summary

This chapter discusses the overall outputs of the research and testing. At beginning, the results from the survey questionnaire that was related to user experience from the app are discussed. Also, the ethical issues of the project are discussed. Lastly, the essential improvements that are important in near future are discussed in the chapter.

Chapter 9: Concluding Remarks and Future Works

9.1. Conclusion

The main research problem articulated in the beginning of the project was to develop a prototype app that will help the hospitalized patients to keep the track of the medication, which they are prescribed with. This will improve the quality of medication management related with patients. The major goal of this project was to develop e-medication app that will help patient to access their medication details. Therefore, an android-based e-medication system was developed to address the current medication problem related with hospital patient.

The application was designed based on the study carried out in the initial phase of the project as well as based on expert advice. Implementation of the prototype was done based on the design model.

The app was tested in the final stage of the project although the time duration for testing was very short. Time limit might have affected to show significant results but the feedback from the involved participants was quite impressive. According to participants, app was very successful in performing its intended task. Also, User interface was very friendly according to most of the participants. Most participants were quite satisfied with overall app.

9.2. Thesis Contribution

First smartphone based application for hospitalized patients in Norway

The project was the first effort to develop an application for hospital admitted patients for android platform in Norway. The app design with features was identified based on different literature review and state-of-art. Also, different age groups were considered while developing user interface design. After implementing the project based on expertise, end-users were used to get feedback. End-users were residing in Norway and gave some promising output results.

Use of manual data as an additional motivational factor

Since the real patient data was confidential and hard to get easily, we created manual prescription data, which might be fake but was created with the help of colleague who is general practitioner in profession. The user gave feedback when they saw real looking medicine list while using the app, which might have contributed in getting positive feedbacks.

Self-Awareness and Management

This thesis might have given contribution to the hospital admitted patients who can keep track of medication themselves and also helped to get self-awareness about the medication they are using for during hospital time.

Positive test results

The feedback from 31 end-users was very precise and successful in what it was intended. This positive test results might contribute in near future when there is no time limits.

Reusable project results

The research including the detailed design process including user interface, test results and source code can become a basis for other research in the field of medication. This app is totally new for hospital, which might be partly used, in future time when such kind of app will be initiated.

9.3. Future work

Integration with DIPS

DIPS have been succeeded in handling electronic health record in Norway. The future work might include integration of app with DIPS Company for betterment of the app. So, DIPS could be the ultimate solution for our app´s overall management. The feedbacks and suggestions from the test result can be taken in granted if DIPS will be involved in managing the app.

Since this is the beginning of the project related with hospital patient and in future, there might be more challenges that needs to face. But, the features as well as feedbacks from test results can be used for future work when the project will be initiated in the future. Although, the result should not be considered as convincing, it might provide some contribution in the near future. In future, real patient data could be used for more precise result.

Appendices

Appendix 1: Table of List of similar medication apps available in the market

S.No	App Name	Purpose/ Features	Compatible	User Rating (Out of 5)	Link to app
1.	Drugs.com	App for information on drugs, identify pills, check interactions and also helps to create manual Personal medication records	Both on android and IOS as well as on website	4.2	http://www.drugs.com/apps/
2.	WebMD	decision-support tools including WebMD's Symptom Checker, Drugs & Treatments, First Aid Information and Local Health Listings and also gives access to first aid information without	Both on android and IOS as well as on website	4.1	https://play.google.com/store/apps/details?id=com.webmd.android&hl=en
3.	Medisafe Meds & Pill Reminder	Helps to keep track of medication using reminder system	Both on android and IOS	4.5	https://play.google.com/store/apps/details?id=com.medisafe.android.client&hl=en
4.	Dose cast - Medication Reminder	Reminds us to take medications, vitamins, or birth control pills on time, and tracks own medication	Both on android and IOS	4.3	https://play.google.com/store/apps/details?id=com.montunosoftware.dosecast&hl

		adherence			=en
5.	PocketPharmacist	Drug Information, Interaction Checker, and Medication Organizer	IOS only	4.5	https://itunes.apple.com/en/app/pocketpharmacist-drug-information/id387365379?mt=8
6.	My Medications	Patients can store, carry and share their critical medical information (i.e. medications, allergies, emergency contacts, etc.) in one secure place	IOS	Not mentioned	http://www.ama-assn.org/ama/pub/about-ama/apps/my-medications.page
7.	GoodRx	Helps patients afford the drugs they need by comparing prices	Both on Android and IOS	4.6	https://play.google.com/store/apps/details?id=com.goodrx&hl=en
8.	MedHelper App	helps individuals and caretakers to manage the challenges of staying on time up to date and on schedule with very simple to very complex regimes	Both on Android and IOS	Not mentioned	http://medhelperapp.com/
9.	Pill Organizer	Contains alarm functions and allows to control when and how many tablets we took	Android	4.3	https://play.google.com/store/apps/details?id=com.necessary.pillorganizer&hl=en

Appendix 2: Table1: Manually created sample patient data information

Name	Age	Sex	Personal ID(11-digits)	One time code sample (6 digits)
Ram Prasad	21	Male	11111111111	123456, 654321
Sita Devi	35	Female	22222222222	222333, 333222
Hari Bahadur	52	Male	33333333333	666999, 999666

Appendix 3: Table2: Manually created sample current medication list for above patients

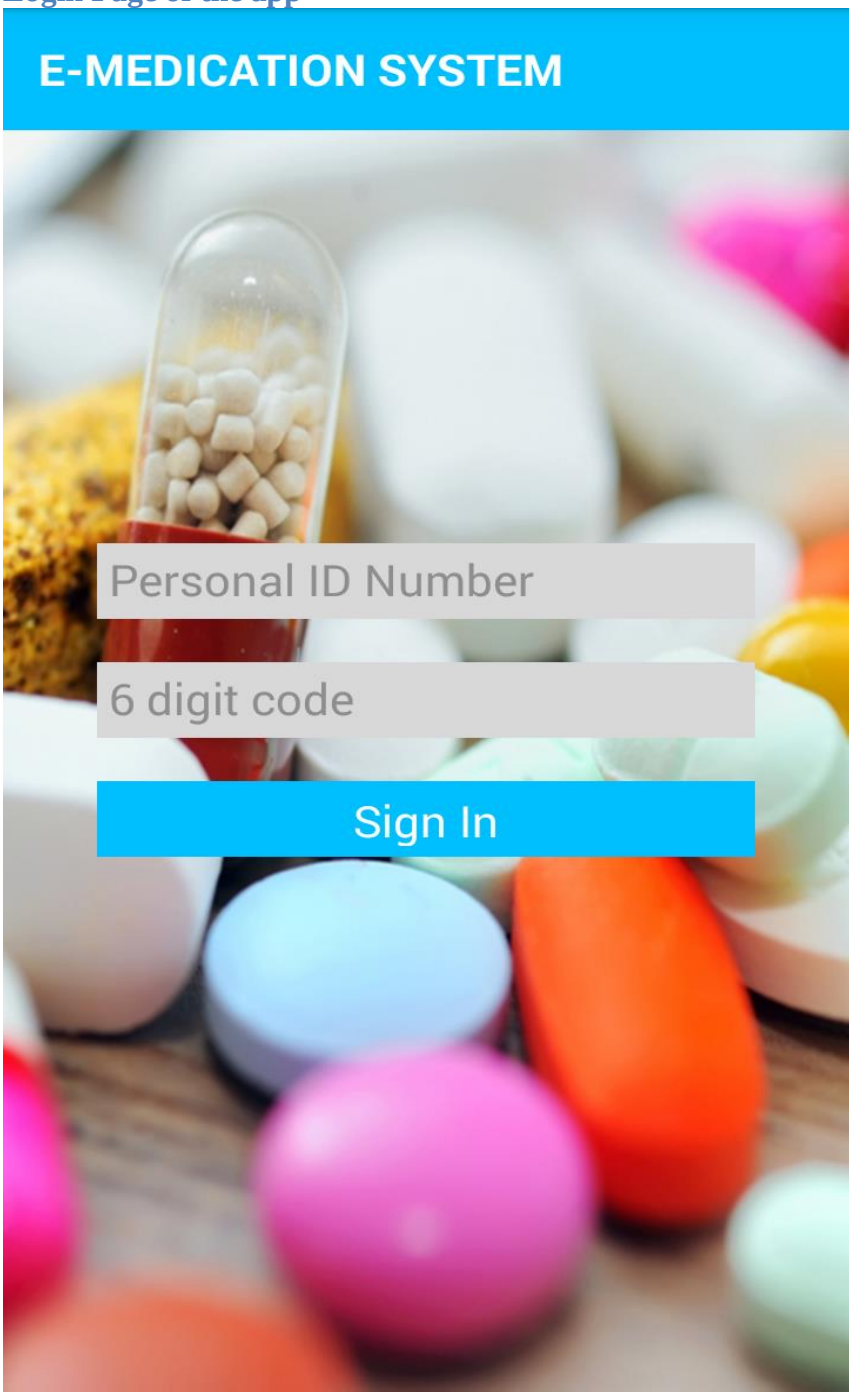
Name	Current Medication List	Dosage (mg)	Frequency/ Time	Diagnosis	Initiated on	Status	Remarks
Ram Prasad	Salbutamol	180	5 times per day	Asthma	01/01/2010	ongoing	
	Oral prednisone	40	once a day	Asthma	01/01/2010	ongoing	
Sita Devi	Amoxicillin	500	twice a day	Pneumonia (with diabetes mellitus type 2)	05/12/2010	ongoing	
	Ceftriaxone Img	10	once a day	Pneumonia	10/12/2010	ongoing	
	Metformin	1000	three times a day	Diabetes	14/12/2010	new	
Hari Bahadur	Morphine	15-30	three times a day	Ischemic heart disease	01/01/2010	ongoing	
	Enalapril	5	once a day	Ischemic heart disease	10/12/2010	new	
	Clopidogrel (anti--platelet agent)	100	once a day	Ischemic heart disease	05/12/2010	ongoing	

Appendix 4: Table 3: Manually created sample patient medication list for above patients

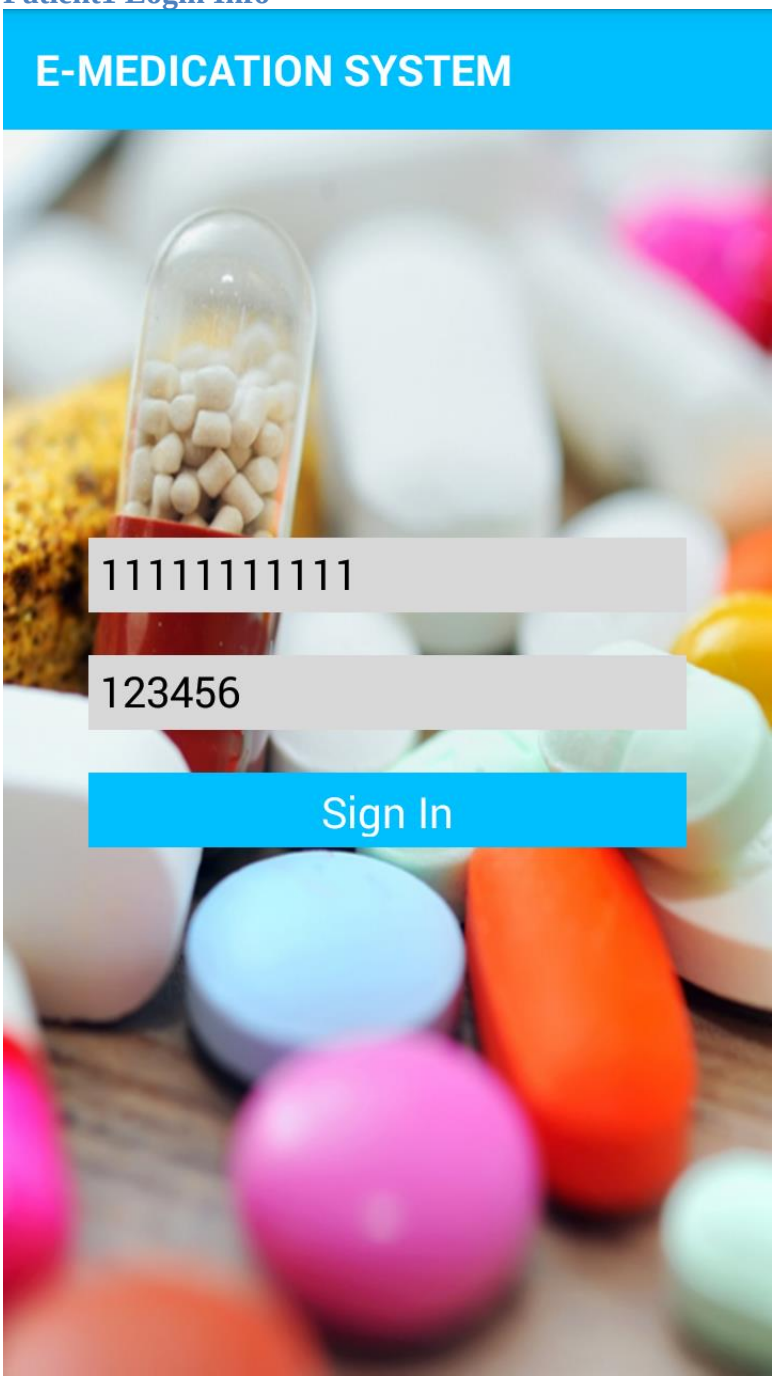
Name	Past Medication List	Dosage (mg)	Frequency/ Time	Reason	usage time
Ram Prasad	Penicillin V	250	twice a day	tonsillitis	09/12/2008 to 16/12/2008
Sita Devi	Clavulanate	500	two times a day	pneumonia	10/10/2009 to 20/10/2009
Hari Bahadur	Simvastatin	40	once a day	Ischemic heart disease	10/12/2008 to 10/01/2009

Appendix 5: List of Screenshots of all patient from the app

Login Page of the app

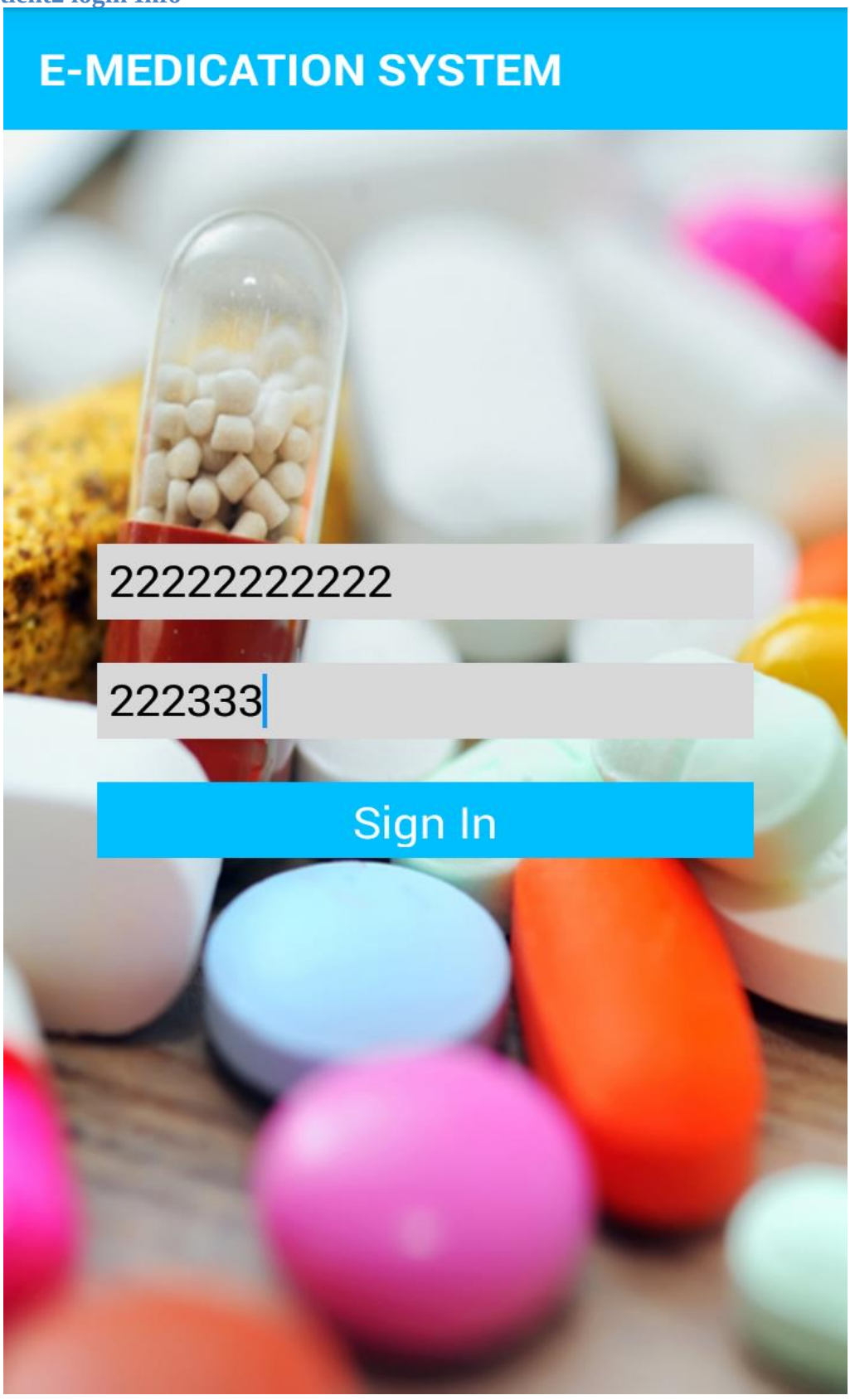


Patient1 Login Info



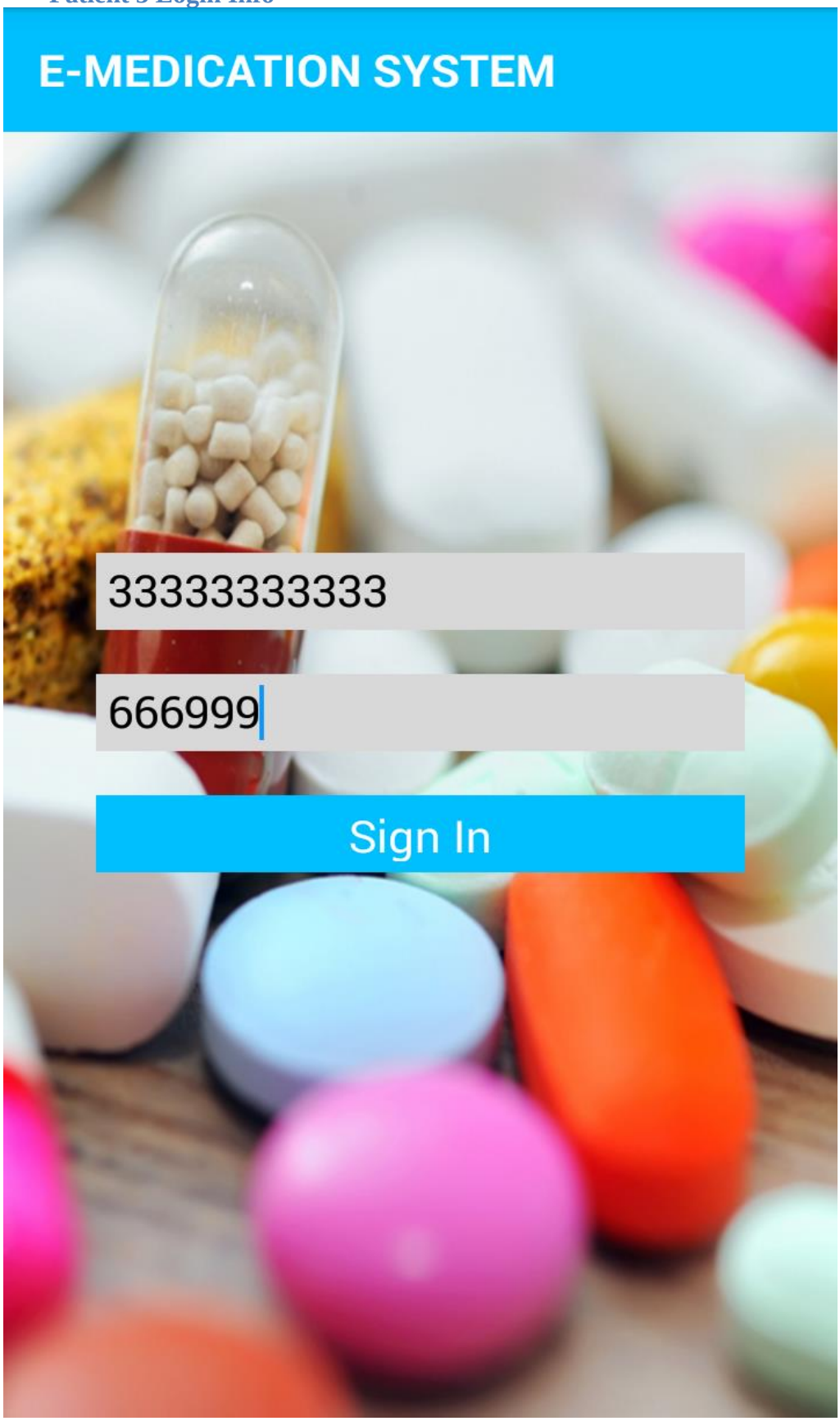
Patient1 Home Page or Overview Medication Page

Patient2 login Info



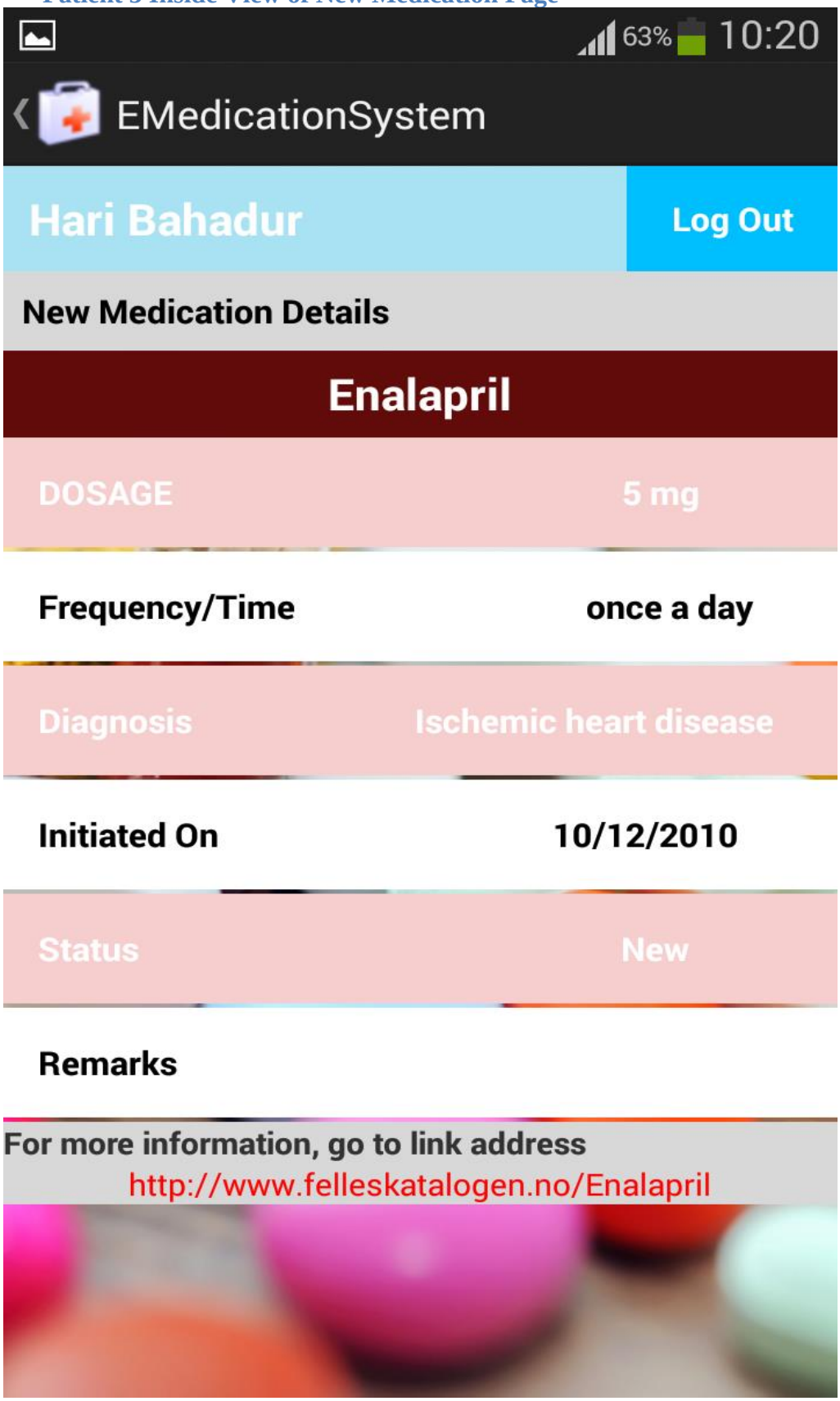
Patient 2 Overview Medication Page

Patient 3 Login Info

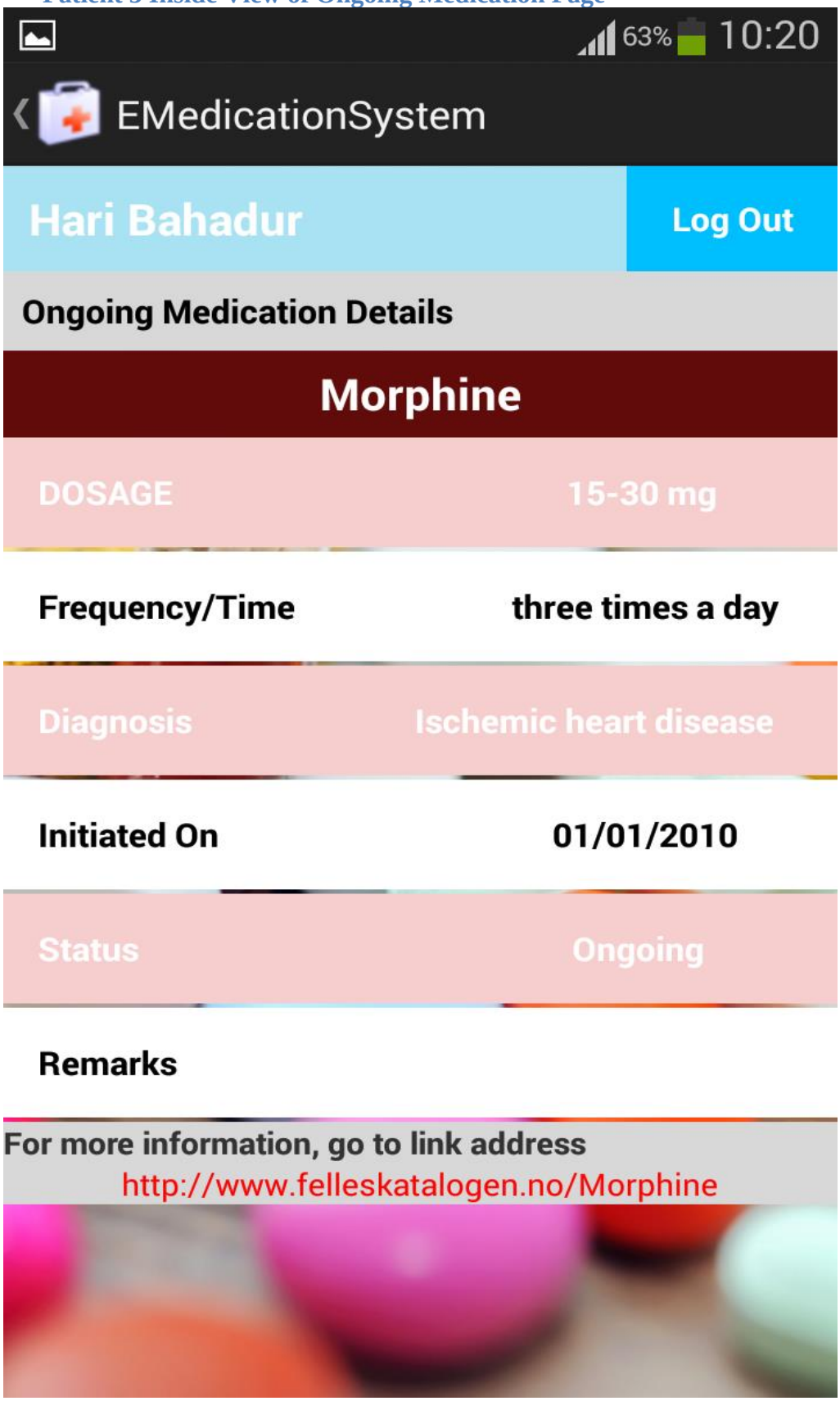


Patient 3 Overview Medication Page

Patient 3 Inside View of New Medication Page

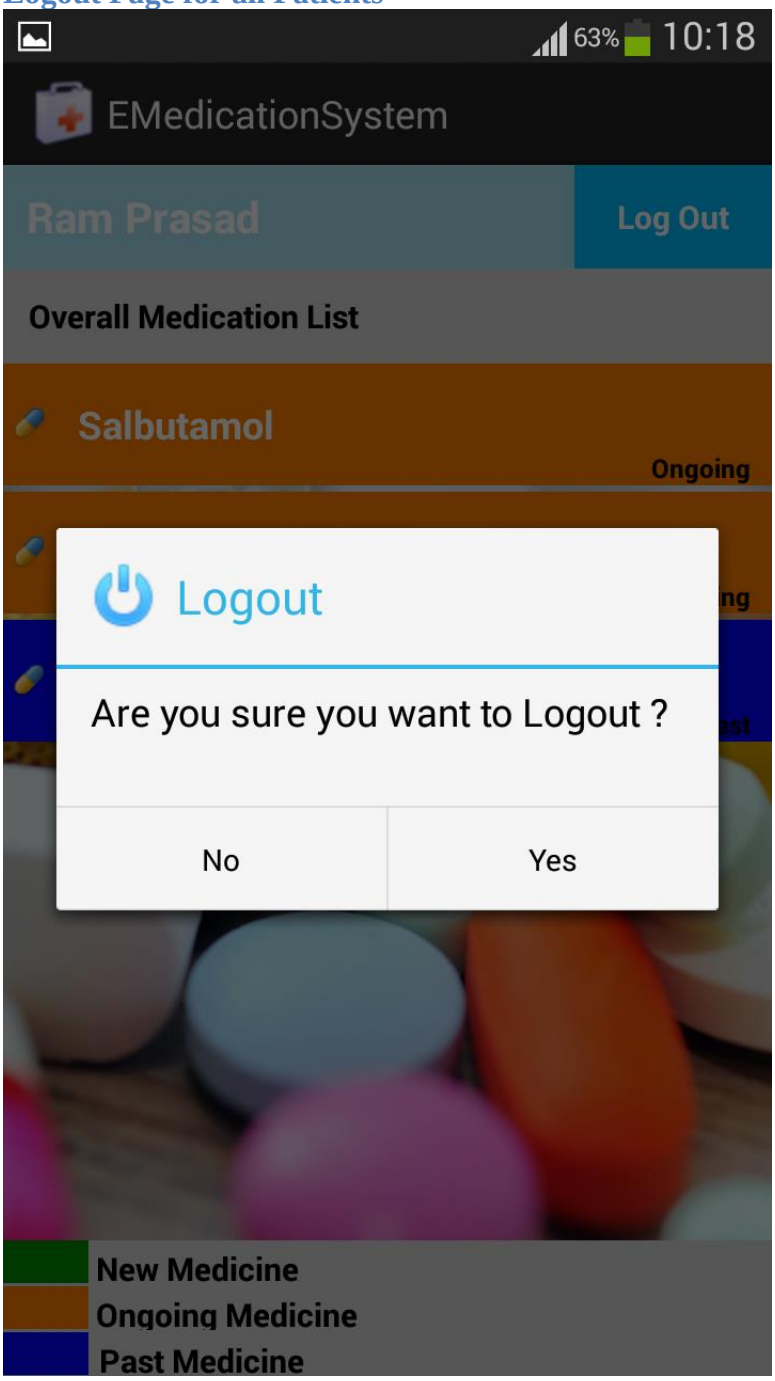


Patient 3 Inside View of Ongoing Medication Page



Patient 3 Inside View of Past Medication Page

Logout Page for all Patients



Appendix 6: List of questions asked to Participants with options

Q1. Please state your age, gender and field of study

Age *Gender* *Field of Study*

Q2. Do you own a smartphone?

No *Yes-iphone* *Yes-Android*
Yes-Window *others*

Q3: How easy was it to install our emedication apps?

Extremely easy *very easy* *moderately easy*
Slightly easy *not easy at all*

Q4: How user-friendly is our emedication system's interface?

Extremely user-friendly *very user-friendly* *moderately user-friendly*
Slightly user-friendly *not user-friendly*

Q5: How often does our emedication apps freeze or crash while using?

Extremely often *very often* *moderately often* *slightly often*
Not often at all

Q6: How successful is our emedication system in performing its intended task?

Extremely successful *very successful* *moderately successful*
Slightly successful *not successful at all*

Q7: Do you think this application has all the necessary information for prescription follow up?

Extremely equipped *very equipped* *moderately equipped*
Slightly equipped *not equipped at all*

Q8: Do you think this e-medication software will resolve the current medication system for patients?

Extremely solvable *very solvable* *moderately solvable*
Slightly solvable *not solvable at all*

Q9: Overall, are you satisfied with our emedication service, dissatisfied with it, or neither satisfied nor dissatisfied with it?

Extremely satisfied *quite satisfied* *somehow satisfied*
Neither satisfied or dissatisfied *dissatisfied*

Q10: How likely is it that you would recommend our emedication app to a friend or colleague?

Extremely likely *very likely* *moderately likely*
Slightly likely *not likely at all*

Appendix 7: SWOT Analysis

Internal	
Strengths	**Weaknesses**
↓ Android apps, easy access ↓ New apps for hospital patients	↓ Not launched in real world ↓ Only for Android system ↓ Limited experience in Android development
External	
Opportunities	**Threats**
↓ Can be customized with felleskatalogen ↓ Can be helpful if inbuilt in Electronic health record system ↓ Motivate for developing similar apps for hospital doctors ↓ More secured if hospital management handles the data flow ↓ Integration of app with DIPS for app management	↓ Huge challenge for hospital to share patient data in mobile phones

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