DEVELOPING FRAMEWORK FOR MEDICAL DATA ACCESSING BY HANDHELD DEVICES

YOHANIS ABATE ABESA

A Thesis Submitted to

The Department of Computing

School of Electrical Engineering and Computing

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Software Engineering

Office of Graduate Studies

Adama Science and Technology University

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APPROVAL OF BOARD OF EXAMINERS

We, the undersigned, members of the Board of Examiners of the final open defense by Yohanis Abate have read and evaluated his thesis entitled "Developing Framework for Medical Data Accessing By Handheld Devices" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Masters in Software Engineering.

Tilahun Melak (PhD)	_____	_____
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ADVISOR'S APPROVAL SHEET

To: Computing department

Subject: Thesis Submission

This is to certify that the thesis entitled "Developing Framework for Medical Data Accessing By Handheld Devices" submitted in partial fulfillment of the requirements for the degree of Master's in Software Engineering, the Graduate program of the department of Computing, and has been carried out by Yohanis Abate Id. No GSR/1509/08, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby he can submit the thesis to the department.

Tilahun Melak (PHD)	_____	_____
Advisor	Signature	Date

DECLARATION

I hereby declare that this MSc thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

Name: Yohanis Abate

Signature: _____

This MSc thesis has been submitted for examination with my approval as university advisor.

Advisor: Tilahun Melak (PHD)

Signature: _____

Submission Date. _____

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ACRONYMS

AVD	Android Virtual Device
CDSS	Clinical Decision Support System
CDC	Connected Device Configuration
CLDC	Connected Limited Device Configuration
DBMS	Database Management System
EHR	Electronic Health Record
EMR	Electronic Medical Record
HCO	Health Care Organization
HCP	Health Care Practitioners
HIE	Health Information Exchange
HIT	Health Information Technology
HTTP	Hypertext Transfer Protocol
J2ME	Java Second Micro Edition
JDBC	Java Database Connectivity
KBS	Knowledge Based System
KE	Knowledge Engineer
KM	Knowledge Management
MDACDS	Medical Data Accessing and Clinical Decision Support
MDAF	Medical Data Accessing Framework
MDR-TB	Multi Drug Resistance-Tuber Culosis
PDA	Personal Digital Assistance
POSE	Palm Operating System Emulator
SDK	Software Development Kit

ABSTRACT

The scarcity of the healthcare professionals, medical specialists and the lack of means for medical data exchanging are some of the great problems of the developing countries' healthcare organization. The healthcare organizations' main objective is providing a quality service for providing the patient safety and this quality service depends on the quality information. So patient information is the most necessary thing to provide quality service for patients. Even if, most developed countries are almost adapting the way of exchanging the medical information among concerned bodies it is still under development in developing countries. On the other hand, there should be a system that can help the medical professionals and less-experienced professionals for better medical decision support based on the accessed information in addition to the medical data exchange. So the lack of a means for medical data exchange and the absence of healthcare related knowledge based systems are the great problems of developing countries' Healthcare organizations. To curve this problem, in this research work the medical data accessing framework by handheld device is proposed and tested by the developed prototype and how to integrate some of the existing medical databases is designed by using the Electronic Medical Record, Electronic Health Record and Knowledge Base as different databases. In this research work also different methodologies and development tools are used to achieve the stated objective of the study which is medical data accessing and exchanging by handheld devices among the concerned stakeholders in addition to enabling patient diagnose disease by themselves in the Oromia Region. So as a result, the medical data accessing framework by handheld devices is developed and this framework is supported by prototype called Medical Data Accessing and Clinical Discussion Support, that run on three different handheld devices including Tablet, Smartphone and hand-watch by using the android studio as a development environment which is a java based application development operating system and thus java is used for coding purpose. The prototype also enables patients to diagnose the disease by themselves without the expert interference and displays the detail information of the medical specialists for their particular disease for further consult. To do this Tuberculosis is used as a sample disease with its common symptoms that patients insert and diagnose for and the system displays the result as a predicted disease with detail of specialist information. Finally we have recommended to develop a mobile application for knowledge based system which is based on sound recognition for those who can't read and write by any language as a future work.

Keywords: *Medical data accessing, Healthcare organization, Care providers, Medical specialist, Framework .*

CHAPTER ONE

INTRODUCTION

1.1. Background

Being health is one of the first thing that all human beings wishing to be and all human being needs to have better treatment whenever they feel any kind illness. This treatment is provided by the healthcare industry or organization which is one of the largest organization in the world. As it is large, the activities being takes place in the industry is also complex, and it plays a great role in the country development. As an example, in most developed countries like USA, the healthcare industry costs are 16 percent of the country's gross domestic product [1]. And it is still the organization that needs improvement and requires technology involvement for its quality care service. The core point of quality service is the exchange of quality information between each components of the industry. The overall activities of this industry that requires information exchange is for providing good service for the patients' safety. To do this the best and simple way is developing different application that can curve the complexity behind the healthcare industries through increasing the interoperability among the organizations by information exchanging at any required time.

On the other hand, the need for greater efficiency and patient mobility is fueling the rapid growth of wireless technologies because of the applications being deployed in the health care industry particularly in hospitals and medical centers that indicates healthcare industry has direct relation with the mobile technologies and wireless technologies are expected to significantly reduce hospital costs and medical errors, as well as improve patient safety mainly for those who are suffering from disease like cardiovascular by integrating small mobile devices that are wirelessly connected to the care providers [2].

The healthcare organizations in developing countries are currently running the patient caring activities independently without exchanging any sort of information between each other despite there is a lack of medical doctors and specialists and they only write referral letters to the nearby health sector when they unable to care their patients at their own level manually from one care

center to another. During this time of writing referral letters, still there is no means of transferring the patient information to the referral hospitals electronically.

Delivering good quality care is a complex endeavor that is highly dependent on patient information and medical knowledge. When decisions about the care of a patient are made they must as far as possible, be based on research-derived evidence rather than on clinical skills and experience alone. To enable this organizations exchange the patients' data or information among each other, there should be a simple user friendly system that enables the practitioners and workers of the organizations to exchange the required information. As stated by Kawli and et al, wireless technologies enable hospitals to streamline communications and health care practitioners to access critical care information from patient monitoring devices, as well as lab test results and radiology reports from anywhere in the hospital while smart phones connect doctors and nurses to patient information in both ambulatory and in-patient environments [2].

As discussed by Darrel and et al, health care access, affordability and quality are problems all around the world. There are well-established disparities based on income and geography, and the high costs of health care present affordability challenges for millions of different people. Large numbers of individuals do not receive the quality care that they need. Mobile technology offers ways to help with these challenges. Through mobile health applications, sensors, medical devices, and remote patient monitoring products, there are avenues through which health care delivery can be improved. These technologies can help lower costs by facilitating the delivery of care, and connecting people to their health care providers. Applications allow both patients and providers to have access to reference materials, lab tests, and medical records using mobile devices [3].

As stated by Patel and et al, mobile platforms become more user friendly, computationally powerful, and readily available, innovators have begun to develop mobile applications for increasing complexity to leverage the portability mobile platforms can offer and some of these new mobile apps are specifically targeted to assisting individuals in their own health and wellness management while other mobile apps are targeted to healthcare providers as tools to improve and facilitate the delivery of patient care. Mobile platforms are defined as commercially off the shelf computing platforms with or without wireless connectivity that are handheld in nature such as smartphones, tablet computers and other portable computers. If a mobile

application is intended for use in performing a medical device function (i.e. for diagnosis of disease or other conditions, or the cure, mitigation, treatment, or prevention of disease) it is a medical device, regardless of the platform on which it is running [4].

Also hospitals and other small practicing centers are looking for medical devices data to be interoperable, complete, standardized, detailed and accurate to improve clinical outcomes and patient safety in which this interoperability can be achieved by several different parties like: medical device manufacturer, middle ware vendors, the system integrator, healthy delivery organizations or the physician [5]

Information systems play a crucial role in the practice of evidence based medicine, by allowing healthcare practitioners to access clinical evidence and information about the patients' health as they formulate their patient-care strategies. However, current information systems solutions are far from this perspective for various reasons. One of these reasons is that the existing information systems do not support a seamless flow of patient information along the patient process. Due to the lack of interoperability issues, healthcare practitioners cannot easily exchange patient information from one information system to another and from one healthcare practitioner to another. Consequently, vital information that is stored in separate information systems and which could present a clear and complete picture of the patient cannot be easily accessed [6]

As stated by Edward T and et al, the health care industry is currently at a handicap stage in terms of meeting the growing demand of the general population [7]. In order for the healthcare industry to become efficient and effective organizations in meeting demand, it is predictable that they must adopt knowledge management principles. Through the development of information technology (IT) integrated with new technologies like mobile computing or mobile technology for the current and future medical data and information to be leveraged to develop knowledge-based solutions that facilitate collaboration amongst institutions and address the demand for healthcare by improving record management, and the development of more efficient methodologies to diagnose and treat patients in a timely manner.

So knowledge Management should be applied to the current problem of healthcare organization (HCO) in addition to change the way doctors, specialists, patients, hospitals and other healthcare industry workers can communicate with each other. Also healthcare industry is currently at

handicapped stage in terms of meeting the growing demand of the general population [7]. The use of knowledge base in delivering of quality care on cooperation of several partners can be done through exchange of knowledge on a particular area of caring procedure. So creating knowledge based in Healthcare Organizations brings together high quality concepts closely related to how knowledge management can be utilized in healthcare organizations.

Health care delivery relies heavily on knowledge and evidence based medicine besides delivery of care replies on cooperation of several partners that need to exchange their knowledge in order to provide quality of care. This is particularly true in clinical setup, but also in public health where the decision making is mainly based on data and evidence generated by knowledge [8].

Currently the computerized medical data management system uses the database management system (DBMS) for accessing, storing and managing of medical data in which the medical data can be accessible only from fixed stations [9] and there is no means of exchanging the medical information between medical specialists as well as between healthcare organizations. So developing a framework for medical data accessing by handheld devices can easily curve the problem of medical data exchange and enables the involvement of patients in their medical information as per its requirement.

So in this research work, we have proposed a framework named as a framework for medical data accessing by handheld devices to enable all healthcare organizations' environment workers to easily exchange the medical information among each other and among the healthcare organizations with some clinical guidelines as clinical decision support. In addition to exchanging the information, an android application that stores the domain knowledge of health experts and can be used by any one when there is the occurrence of lack of health care specialists/experts is also developed.

This research work is also concerned with the integration of mobile computing technology with the knowledge based system application by any handheld devices and we interested to do this because of the necessity of information for accurate decision making hence patient data must be adequate enough for making the required decision. This can be realized through accessing the stored patient data as far as possible by any handheld device which is preferable by anyone who is interesting to access that data. Hence the implementation of knowledge based systems in

healthcare organizations increases the opportunity of patient involvement in one's own health case and enables the patient to follows the doctors' and medical specialists' orders, it must be possible to carry out such activities through the use of handheld devices or any mobile device. Hence the current societies are well aware of the mobile technology this can be easily be true by using of this technology. Thus we are interested to develop a mobile framework that enables both healthcare organizations' workers and patients to access the medical information from their handheld devices at any time of their interest from anywhere.

In general this research work addresses the lack of medical data exchange and provides a decision support approaches for those practitioners who needs specialists' interaction for making decisions. Hence the accurate and current knowledge i.e. explicit knowledge can be stored as an application, the practitioners only need to access that stored knowledge by the device on their hand in addition to the overall patients' information in which the proposed framework realizes the knowledge sharing among the healthcare organization's workers through their mobile devices.

Accessing the relevant medical information leads all the healthcare organizations' workers to provide a quality service for the users mainly for patients and enables the medical doctors and specialists to serve the patient in a very effective manner if the medical data to be accessed is accurate, correct and on time. On time medical information accessing is the key for the specialists to serve the patient and avoid the exposed of losing life. In addition to accessing the medical data there should be a means to serve patients based on the accessed medical data even if there is no medical doctor and specialist at the time of access. This can be possible if there are some knowledge based system which enables less experienced or non-expert users to serve the users when the actual expert is physically not at the required place and time.

1.2. Statement of the Problem

For making good decision about the patient care, currently there are limited means of accessing the correct, accurate and on time patient information by healthcare practitioners. The current IT-based health information systems are even not implemented within the rural area of our country which is mainly focusing on the management of administrative activities than providing patient medical information and the patient related data in many hospitals are the manual based or the

paper based data processing, which easily leads the care providers to the data loss and data redundancy and expose the patient for extra problem which may loss of life.

In addition to the above problem, as stated by Sterling and et al, there is an estimation of around 4.3 million shortage of Health Care Workers around the world [10]. So in developing countries including Ethiopia the scarcity of healthcare professionals is obviously known and so the Oromia region is also being affected by the same problem. This scarcity of healthcare professionals leads us to say healthcare systems cannot perform adequately, without the sufficient numbers of professionals. Mainly specialists and medical doctors are very small in number when compared to the public they serve which leads the society being treated by these professionals to lose their life or exposed to pay more to be treated.

This problem of professional scarcity and lack of information exchanging mechanism can be minimized if we optimize those exist by providing easy and simple technology applications to their professional works and seeking the way they can communicate. So we proposed a framework that makes medical data exchange by handheld device for recording and accessing of patient information from anywhere at any time. And patients can diagnose the disease based on their symptoms of the patient. If the referral letter is written, the information of that patient is recorded electronically and avoids the time wasting and may lose of life during waiting for new card from the referral hospital. This all activities can be done through small devices connected to each other at least wirelessly and found in the hands of healthcare practitioners.

1.3. Objectives of the study

1.3.1. General Objective

The general objective of this study is to develop a Medical data accessing framework by handheld devices to solve the problem of medical data exchanging in healthcare organizations.

1.3.2. Specific Objectives

Specific Objectives of the study are stated as follows:

- Designing a prototype which enables medical data users to insert and access the medical information (Developing a mobile application that enables medical data users to inter and access medical data to test the stated framework i.e. the above general objective)

- Enabling hospital workers or healthcare organizations to access medical data by hand-held devices
- Enabling patients to diagnose their disease by themselves
- Integrating healthcare organizations' databases

1.4. Scope and Limitation

The main scope of this research work is to avail both patient and medical information to the concerned stakeholders through handheld devices and enabling patients diagnose disease without expert interference and guiding them to consult the concerned medical specialist. The medical doctors and specialists can access the patient information and they can give guide for other less experienced professionals those may treat patients at the lower level.

This research is also limited to the accessing of patient information for the treatment by the help of handheld devices and health information transparency among different hospitals in the Oromia region so the designed prototype is limited to access and process information by Afan Oromo.

Also this research work is not considering the actual difference between the using of handheld device medical data accessing and current procedure taking place because of the limit of time. So the parallel processing for experiment is not considered in this research.

And finally, this research is particularly limited to patients those who are literate i.e. those who can read and write to the system in case of fulfilling the patients involvement in care procedures and also to follow the doctors' and medical specialists' orders and for diagnosing of their disease.

1.5. Significance of the Study

The development of technology is obviously known in every organization as well as its necessity is high. The application of mobile technology to curve the current problem of information exchange among healthcare organization is thus important for avoiding information management complexity and patients gaining good and appropriate service from the nearest healthcare organization through the integration of mobile technology and knowledge based systems in the healthcare organization. As a general the study has the following significances:

- ✓ This study can be used as stepping stone for other interested researchers in this specific area.
- ✓ It enables the healthcare organizations to exchange patient and administrative information timely.
- ✓ Improves the satisfaction of patients
- ✓ Increases the patient safety and reduce cost and efforts
- ✓ Facilitates the patients' relevant information exchange during referral to higher hospitals.
- ✓ Easily dissemination of health education for the rural populations.
- ✓ Enabling the interoperability across care providers.

1.6. Organization of the Thesis

This research report is organized as follows for the remaining parts of this report. The following page starts from chapter two which discuses about the literature reviews and related works of the medical data exchange and knowledge based systems. And the third chapter describes the methodologies used for this study while the fourth chapter discuses about the desired framework and its databases integration and testing the framework with prototype and the final fifth chapter concludes the research work and provides the future works.

CHAPTER TWO

LITERATURE REVIEW AND RELATED WORKS

2.1. Literature Review

This chapter introduces the theoretical background of the Electronic Health Record EHR/Electronic Medical Record EMR, Health Information Exchange and its security issues, knowledge based systems as overview of knowledge management and knowledge based systems for healthcare and continues with the discussion of clinical decision support system (CDSS) and at the end concluded with related research works.

2.1.1. Electronic Medical Record (EMR) and Electronic Health Record (EHR)

The terms Electronic Medical Records and Electronic Health Record are used interchangeably by some people. But as stated by Sterling and et al, the EMR systems are those systems which replace the paper medical record or charts mentioned within the physicians records and it can ranges from scanning and digitizing of paper records and medical charts while the EHR go beyond simply providing an electronic form of all medical records such as interoperability, decision support and continuity of care as well as including any administrative data records in the healthcare industry [10].

EMR systems are systems those play a great role in healthcare improvement by increasing adherence to therapeutic guidelines and protocols, informing clinical decisions and decreasing medication errors, allow early identification of patients who miss the appointments, facilitate timely tracing and timely tracing and provide a platform for operational research [12].

The term Electronic Medical Record or EMR, as with Automated Health Records, has been used to describe automated systems based on document imaging or systems which have been developed within a medical practice or community health center. These have been used extensively by general practitioners in many developed countries and include patient identification details, medications and prescription generation, laboratory results and in some cases all healthcare information recorded by the doctor during each visit by the patient. In some countries, such as Korea, the term EMR is used to define an electronic record system within a

hospital which as well as the above includes clinical information entered by the healthcare professional at the point of care. [13]

The EHR systems start during the early 1990s in USA at the time of Computer Based Patient Record (CPR) which was mainly focusing on functions like medical alerts, medication orders, providing integrated data on a patient's registration, admission, and financial details, and recording information from nurses, laboratory, radiology, and pharmacy. Early EHR adoption has been seen in many European nations and domestically in private institutions including Kaiser Permanente and government institutions such as the hospital system, and increasingly widespread and rapid adoption in the U.S. continues as a variety of vendors distribute EHR systems to medical practices of all sizes. In all USA clinics the EHR/EMR is fully implemented by 2015 and the two terms are used for different purposes as mentioned above [11].

Even if the system was implemented but the Health information exchange was limited to the patient facility [13]. Also as stated by Waste and et al, the current definition of EHR as "The electronic health record includes all information contained in a traditional health record including a patient's health profile, behavioral and environmental information [11]. As well as the content the EHR includes the dimension of time, which allows for the inclusion of information across multiple episodes and providers, which will ultimately evolve into a lifetime record." Which implies the areas included within EHR is very larger than the area of the EMR. As stated by M. Darrell, EHR are digital records of health information which contain all the information we would find in a paper chart and a lot more, EHRs include past medical history, vital signs, progress notes, diagnoses, medications, immunization dates, allergies, lab data and imaging reports [3].

They can also contain other relevant information, such as insurance information, demographic data, and even data imported from personal wellness devices. The power of an EHR lies not only in the data it contains, but also how it's shared. EHRs make health information instantly accessible to authorized providers across practices and health organizations, helping to inform clinical decisions and coordinate care. An electronic health record can be shared with all clinicians and organizations involved in a patient's care such as labs technicians, specialists, imaging facilities, pharmacies, emergency facilities, and school and workplace clinics. It is also necessary to meet Meaningful Use requirements. Meaningful Use is a Medicare and Medicaid

program that supports the use of an EHR to improve patient care. To achieve Meaningful use and avoid penalties on Medicare and Medicaid reimbursements, eligible providers must follow a set of criteria that serve as a roadmap for effectively using an EHR.

In general, the electronic medical record is used for the following purposes [9].

- ✓ Stores patient information electronically and safely
- ✓ Stores the specialist's care findings and prior care information.
- ✓ Serve as formal and legal report of care
- ✓ Keeps the information for further public health research
- ✓ Enables interoperability of care providers
- ✓ Reduce the data redundancy risks and loss of data

2.1.2. Health Information Exchange (HIE)

For the better decision making of patient care, healthcare practitioners (HCP) should have access to correct, accurate and on time medical information of that particular patient. The accessing of the accurate, correct and on time can be possible after the implementation of the EHR/EMR have been used in most hospitals. If the medical information is recorded electronically, it is possible to exchange amongst the concerned bodies such different HCP, HCO and other third parties such as insurances. So the term medical data exchange or the HIE can be simply defined as, "the electronic sharing of clinical information across the boundaries of health care organizations." As William Hersh and et al, the HIE has been promoted as an important application of technology in medicine that can improve the efficiency, cost-effectiveness, quality and safety of health care delivery for better patient satisfaction [12]. Also the HIE realizes the ultimate benefit of the patient safety if their relevant medical information were available to various care providers whenever it is required.

2.1.2.1.Security Issues For Data Exchange

In this particular study the security issue for medical data exchange is considered by the concept of HL7 medical data exchange standards. Hence cybercrime as well as threats to national security is costing organizations billions of dollars each year, there is a critical need for organizations to share data so that analysts could analyze the data, mine the data, and make effective decisions from the data. While there is an urgent need for numerous applications

including counter-terrorism, emergency response, public health awareness, and financial analysis to share data, there is also a need to protect the information within an organization thus there should be standardized way of data sharing among each other [13]. So for this particular study it is proposed the standard data sharing mechanism to be used is the HL7 standard. As stated by Douglas Harris and et al, we need standard data sharing mechanisms for the following reasons [13]:

- ✓ Data and information integration to ensure connectivity between complex diverse data sources
- ✓ Multimedia and geospatial data management to handle different data types as well as locations
- ✓ Active and real-time data management to ensure distributed real-time information access
- ✓ Data mining and data warehousing for decision support
- ✓ Expert data management for reasoning about the events and incidents to help in decision support
- ✓ Knowledge Management for establishing strategies, processes and metrics for decision support
- ✓ Security technologies to ensure confidentiality, privacy, trust and integrity

2.1.3. Overview of knowledge management (km) and knowledge based (KB) systems

Before we start to discuss about knowledge management (KM), it is better to know some about the history and definition of knowledge. The theory of knowledge belongs to the branch of Philosophy called Epistemology. As research is essentially about producing knowledge about the world that we can claim as valid, some attention to epistemology is vital. Different epistemological traditions imply different ways of 'knowing' the world, and rather different accounts of the status of that knowledge. So the knowledge management on the other hand had always been a central in human societies. As described by, Christo El Morr and Julien Subercaze, the Philosophers of Western and Eastern have focused their attention on the question of knowledge which is already in ancient Greece scientific discussions often lead to philosophical debates and especially on the concept of knowledge [8]. The creation of

epistemology has finally formalized the question of knowledge when epistemology addresses primarily the question of "***what is knowledge***?" and discusses its creation and adoption.

So knowledge includes data, information and experience. It is the combination of facts, analysis, trainings, and lessons learned that comprise knowledge for an individual. The concept of knowledge management provides individuals and organizations with practices and methodologies that utilize a combination of intellectual capital, business processes and IT solutions to provide organizations with more efficient and effective operational means. Through the capture, organization, codification, distribution and utilization of knowledge; companies can leverage and embrace knowledge management practices that enable employees to conduct positive operations. Additionally, the repository of various types of knowledge within an organization allows future generations to learn from past mistakes and to devise innovative solutions for business needs.

On the other hand, practical knowledge management has always takes place in the society, and transmission of knowledge was much related to the technical progress. Beginning in the middle age knowledge transmission occurred under what was called "Wandergesellen" in Germany and "Compagnonnage" in France, where craftsmen and artisan take a tour of the country for 6 months or one year to learn from several masters [8]. This was one of the first structured methodologies for tacit knowledge transmission. Knowledge first spread orally, then in writing; but it was restricted to a low circle of educated people till the development of printing. If the first printing focused on religious and literature purpose, technical and specialized books began to spread after the wide adoption of the printing press [8].

Julien Subercaze and et al also stated in their work as in the 20th century, management as well as cognitive sciences and psychology led to today's Knowledge Management (KM) and the current situation of KM started in the 1980s with the wide use of information technologies in companies; the focus was on the intangible asset that knowledge represents. The word KM itself appeared in the 1980s and the academic discipline was created in 1995. Knowledge based systems developed based on the traditional set of rules were using traditional knowledge management systems and through evolution they become grew up to independent machine acts like human being called Artificial Intelligent (AI).

While developing an expert system or knowledge based System, the system can be developed in either of the following two approaches. The first approach is through the "Cognitive Science" approach while the second approach is the "Knowledge Engineering (KE)" approach. In Cognitive Science the system being developed can act just like human being and responses to the problem in same manner as human being can do. While in KE approach the system being developed can use merely the same knowledge as human to produce some solution results to the problem based on the collected and analyzed knowledge before its development.

Generally there are two broad categories of knowledge known as explicit and tacit knowledge. The former is information that is easy to capture, structure, and share with individuals and best example of explicit knowledge can be the documentations like hospital policies and procedures and clinic diagnostic methodologies. And the latter is comprised of experience and skills that an individual can acquire overtime and apply to problems. The exposure to events over time can evolve a person's thought process and it is difficult to capture, structure, and transfer to other individuals.

As cited by Ashanafi Chalchisa [14], knowledge-based systems (KBSs) are subfield of an Artificial Intelligence, concerned with the design and implementation of programs that are capable of emulating human cognitive skills, such as observing, understanding, reasoning and learning, using knowledge of a given domain which is designed to solve a problem of a particular domain. Also the KBS can help the professionals by providing precise and timely knowledge for their particular decision making. So in HCO, the application of KBS has a great role for helping fresh GP, to make good decision for the better patient care.

2.1.3.1.Components of Knowledge Based System

In any KBS there is the one who act as designer of the system based on the domain knowledge obtained from the domain expert is the knowledge engineer (KE). The KE uses the knowledge acquisition tools to get expert's knowledge through knowledge acquisition process and the knowledge engineer considers both human reasoning and computer techniques. So for a time being the major components of the KBS are, inference engine, explanation facility, user interface, knowledge base and there may be additional features [14]. The overall KBS components are indicated by the following figure Fig.2.1.

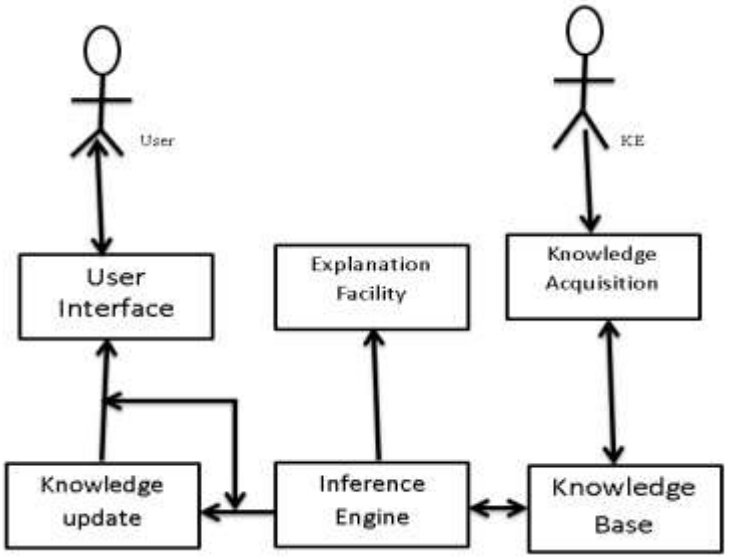


Figure 1.1 Components of KBS

Explanation facility: is a subsystem that explains the system's actions and explains how the final solutions were arrived by justifying the need for additional data. This component also provides the mechanism for querying how to get the value of variables and knowing of how a fact is established. It serves a tutor in a sharing the system's knowledge with the user component. The process associated with the query, how, searches for the rules with required facts in the THEN part and displays the rule and obtaining answers to a query what if would be very useful, if the user of the system wants to experiment with the decision making process by modifying the user input/s. This is a very short description of the Explanation Facility component of the knowledge based system's components.

User Interface: the user interface component is the means by which communication can be takes place between user and the system either through graphical or by command line interfaces in which the KBS interfaces employ a variety of user styles, including questions and answer, menu-driven, or graphical interfaces to make the dialog more user friendly and the user interface converts the rules from its internal representation to user understandable form. It simplifies communication and hides much of the complexity, such as the internal structure of the rule base. The final decision on the interface type is a compromise between user needs, the requirements of the knowledge base and inference system.

Inference engine: It is the brain of knowledge-based system. It uses the control structure and provides a reasoning methodology. It is the KBS interpreter, which analyzes and processes the rules. It is used to perform the task of matching antecedents (IF parts) from the responses given by the users and firing rules [15]. When all the antecedent clauses of a rule are available in the database, the rule is fired, resulting in new inferences. The resulting inferences are added to the database for activating subsequent firing of other rules.

The major task of inference engine is tracing through a large number of rules to arrive at a conclusion [15]. In a knowledge-based system, inference can be done in a number of ways. The two popular methods of inference are backward chaining and forward chaining

Domain Expert, KE and End Users/users are the primary people who participate in the development of the KBS in which the domain expert provides the knowledge about task performance and has special knowledge, experience, judgment and methods to give advice and solve the problem. So the domain expert is generally a person who has worked in the domain area and understands its problem solving techniques, such as shortcuts, handling imprecise data, evaluating partial solutions, and all the other skills. The domain expert is primarily responsible for making clear these skills to the knowledge engineer [15].

There are different methods used to develop the inference engine of the KBS. Many scholars categorizes the methods into two broad categories the backward chaining and forward chaining. The backward chaining method involves the goal-driven process. In order of their appearance in the knowledge base, then the goals are established by the backward chaining of the inference engine and based on the goals then reasoning starts to verify whether the goal is true or false. And the forward chaining on the other hand is the data-driven mechanism i.e. it starts from the available information as it become available and attempts to draw conclusion. The user of the system has to give all the available data before the start of the inference. The inference mechanism tries to establish the facts as they appear in the knowledge base until the goal is established [16].

Knowledge Base: this component is the heart part of the KBS which contains the necessary knowledge for problem solving i.e. the overall knowledge of the expert is stored within this component. So it is the warehouse of domain specific knowledge captured from the expert

through knowledge acquisition process of knowledge engineering. To represent the knowledge production rules, frames, logic, semantic net and others can be used [15].

The knowledge engineer should have the knowledge of KBS technology and should know the development environments. In addition, the knowledge engineer desires to know the general knowledge of the domain and familiar with the key terms used in it. Because, it helps to understand the domain knowledge easily and reduces the communication gap between the knowledge engineer and the expert [16]

Knowledge engineer creates the knowledge base, conducting a series of interviews with the experts and organizes the knowledge in a form suitable to the system. The knowledge engineer should have the knowledge of KBS technology and should know the development environments. In addition, the knowledge engineer desires to know the general knowledge of the domain and familiar with the key terms used in it hence it helps to understand the domain knowledge easily and reduces the communication gap between the knowledge engineer and the expert [16]

So the knowledge base in the KBS is generally the storage area of the expert's knowledge and it is designed by the knowledge engineer who has deep knowledge about the KBS. The KE can get the knowledge from the expert and determines the architecture and usability requirement of the system from the end users and by considering the user needs KE develop the possible knowledge based system for specific problem domain which is solved by the domain expert knowledge.

2.1.4. Clinical Decision Support System (CDSS)

Ever since the birth of the medical industry, health scientists have recognized the importance of informed clinical decision making and the CDSS is one type of knowledge based system. Unfortunately, for a long time, efficient methods for researching and evaluating such methods were quite rare. Clinicians often relied on extensive research and handwritten records to establish the necessary knowledge for a well-informed decision. Naturally, this proved to be both error prone and very time consuming. Fortunately, the evolution of business related computing in the 1970s and 1980s gave clinicians an easy Mechanism for analyzing patient data and recommending potential courses of treatment and thus CDSS were born.

Decision support systems are computer based systems which are used for the process of decision making. As its name indicates CDSS is a computer system designed for clinicians for helping them while they make a decision for better patient treatment. The clinical decision support systems are mainly used for improving diagnosis accuracy and for achieving precision medicine. To achieve improved outcomes through the use of EHR the best methodology is by developing an evidence based decision making system based huge data obtained from the EHR. The development of EHR puts the first step towards clinical decision support system. The CDSS are being used as tools that incorporate established clinical knowledge and updated patient information to enhance patient care by providing the patient follow up, warning systems for deadlines for data submission and diagnostic suggestions. [17]. So CDSS are designed to assist the physician-patient encounter at multiple points from initial consultation to diagnosis to follow up.

The following figure illustrates the overall literatures that was searched from different databases and from different search engines. This is the literature as a methodology that we have used for this research work. Based on our key words and title, we have searched the related titles as per our key words and the title. Totally we have searched more than 200 scientific papers and some research reports after they are searched we sorted them depending on their titles. From the sorted papers and reports we again selected them by mainly reading their abstracts and looked at the papers key words again. And finally the more key papers are selected as a theoretical literature review materials and the other papers found as not relevant are discarded.

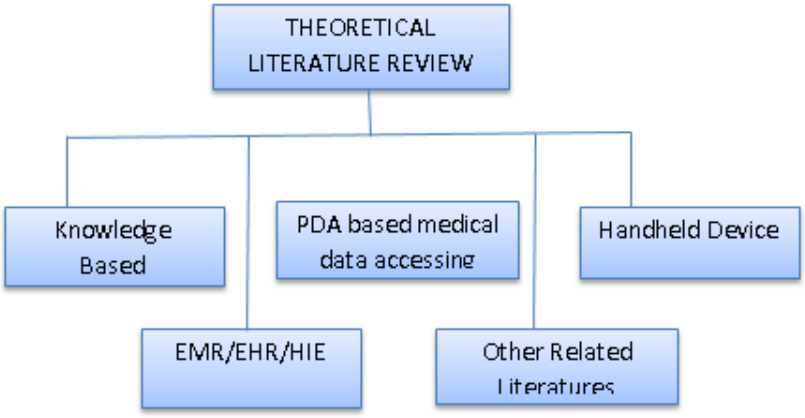


Figure 2.2 Theoretical Literature Review

2.2.Related Works

Beyond its payment reaches 16 percent of the USA Gross Domestic Product (GDP), the health care faces different challenges when it comes to delivering quality cares in USA only. But the health care industry is making a global push to increase the quality and efficiency of care through healthcare IT (HIT) in addition to the government funding to the medical data exchange for improving the medical data access. For this purpose in 2009/2010 the United States has allocated $36 billion in stimulus funds to install electronic health records for interoperability solutions to meet the demands for access to care of patients. As indicated in this study, the main concern is the lack of quality care delivering and the scholars propose the electronic data exchange which takes place only through the networked computers by the use of cisco hard wares [1]

As D. Hunde, the medical data accessing based on the PDA based client which means accessing of the medical data through the use of a PDA device for entering and accessing of the medical data has been proposed under this study by considering the Buta Jira hospital of southern nation nationality people regional state of Ethiopia [9]. The scholar stated that the possibility of accessing medical data from remote site by using the personal digital assistant device. As indicated within the study, the scholar proposes accessing the medical data by PDA and experiment was done by using the palm operating system emulator (POSE) machine and the research result hadn't implemented under real situation. So the study considered only about the medical data accessing by using a single device which means that research result can be implemented through platform dependent. The study was also considering about the lack of specialists and medical doctors only i.e. there is nothing stated about the consequences of the error occurred. Hence the lack of specialists is obvious, there should be a mechanism to represent the knowledge of that specialist or expert without need of that expert physically at the time of cure decision making.

Accessing up-to-date lab results and clinical information in remote locations is a persistent and difficult problem for clinicians in the developing world [18]. As stated under this work, the scholars were targeting on the Multi-Drug Resistant Tuberculosis (MDR-TB) and the access to the medical record of such chronic disease from remote clinics was so challenging by using computers even if it was possible for archiving and retrieving of information by using the internet connection and computers. Thus the scholars proposed the accessing of medical records

from remote by using the Personal Digital Assistant (PDA) based client. During their work, the scholars used the commercially available Avant-Go software as a web platform they have linked with the PDA-EMR with their existing web based EMR which allowed them to develop the user interfaces in standard HTML. As a general, the summary of the scholars includes patient demographics, current and past drug regimes, physical exams, diagnoses, lab results, drug sensitivity tests and information on X-rays accessible through the use of only PDA devices.

Improving Health Care through Mobile Medical Devices and Sensors [3]was done by scholars of center for technology innovation at Brookings and Applications such as the I Wander app for Android devices are being used for patients suffering from Alzheimer's disease or dementia. It makes use of the GPS function of smart phones to track patient locations. If the individual travels away from their home or other known locations, it triggers a signal to the person's family or caretaker to check on their status. Through geo-location coordinates, the person can easily be found and returned to the care setting. Mobile technologies offer the ability to connect patients with their doctors, care-givers and loved ones and enable timely health monitoring which suggests improved patient engagement and better health outcomes. Darrell also stated that mobile technology can aid in providing access to information, helping to lower costs, facilitating remote care and increasing efficiencies by connecting patients to their providers virtually anywhere [3]. Mobile health applications and services are becoming an essential tool in extending health care resources around the world. This all about the innovation of mobile devices based health information management and look after patients through mobile devices.

All of the above findings are mainly focused on a single device except the last one which has some concept of mobile devices. But the proposed system is mainly concerning all mobile devices including laptop computers, tablets, smart phones, and wears like hand watch and even some automobiles like Ambulance. Far apart from the above mentioned findings we have reviewed as a related work, there should be a means of exchanging medical information on hospital ambulances during emergency cases or in any means patients are on the way towards care organizations by using Automobiles in addition to the whole mobile devices.

So as a research gap, what we fill is accessing the medical data and/or patient information is not enough to give quality service for patients even if the accessed data is correct, accurate and on time. There should be a guide for better decision making based on other experts' knowledge. So

the system we proposed helps the accessing of medical data by different mobile devices such as Tablets, smart phones, wears like hand watch and automobiles those support android operating system products rather than by a single device and gives a guide for decision making based on the accessed medical data at the absence of medical doctors and specialists and enables the patients themselves follow the orders given by specialists at their own home than daily visiting the healthcare providers. Also patient should diagnose their disease by using the proposed system without the expert interference.

CHAPTER THREE

METHODOLOGY

The way we have followed to solve the stated problem started from data collection and continued to develop the framework and also developing the prototype for testing the framework and designing the integrated database. To accomplish these, we have used different methods which are described as follows:

3.1.Data Collection

The purposive data collection method is used for this research by directly contacting the Healthcare Organization workers and interviewing them. Based on some semi-structured questions we have prepared which is attached under the appendix section and we interviewed the Medical director of five different hospitals and also we interviewed the director of Oromia Region Health Bureau to compare the available medical doctors and specialists within the region with the total population of the region. So interview is used as a particular data collection method used for getting the required information regarding the healthcare's lack of specialists and medical doctors and also we obtained the information regarding the interest of the healthcare organizations workers' towards health information exchange. But we haven't interviewed the total healthcare environment actors except that we have mentioned above. This primary data collection method is selected and used as/for purposive data collection method as it is based on the scholar interest to get the information as a hint for conducting the study and some other information is used for the prototype development.

3.2.Prototype Development Environment and Tools

3.2.1. Android Studio

Android is a LUNIX based OS and an open source for mobile devices' application development. It was developed by the Open Handset Alliance which led by the Google and other companies. The prerequisite for android studio is the java development kit (JDK) [19] and then the Android Software Development Kit (SDK) which is suite of software tools required to develop android applications. This tool is selected because of its features empower all the mobile devices and the

research also deals with enabling medical data accessing by the mobile devices and developing application that supports the clinical decision support by using any handheld device.

The most features that makes Android studio is selected for this particular study as one of the development environment tools is that android will continue to consolidate its dominant global market position for several reasons. Android's modular architecture allows for a wide variety of configurations and customizations. And almost all the core application that ship standard with Android devices are interchangeable with any number of third-party applications, and that includes applications like the phone dialer, the e-mail client, the browser, and even the OS navigator. Android devices are available in an amazing variety of shapes and functions. There are Android augmented reality glasses, Android game consoles, Android watches, Android tablets of every conceivable size and of course Android smartphones and android automobiles [19].

In this study we have used the android software development kit (SDK) integrated with the JDK because of the additional features of the Android Operating System such as beautiful user interface, good connectivity, high storage capacity by using SQLite, different media support, any web browser through the use of open source Web kit layout engine and etc. Under the android studio we also used the Android Virtual Device (AVD) as a simulation device. The proposed system prototype is run by using the virtual machine provided by the AVD.

Android has also its own ecosystem called android ecosystem of tools supporting the android. The most important tools in the android studio ecosystem are Git (which is a distributed source control tool) and it is integrated with an impressive GUI interface. Gradle is another android supporting tool which is a build tool similar to Ant and Maven that allows us to manage library and library projects. Android Studio does a good job of managing libraries all on its own, but Gradle makes this task easy and portable. As with Git, Gradle is fully integrated into Android Studio, which ships with an impressive array of views that allow the user to inspect Gradle files graphically and examine the output of a Gradle build process

3.2.2. Java

Java is related to other programming languages like C, C++.and C# and it also has a contribution to internet through special kind of java program called Java Applet which is designed to

transmitted over internet and automatically executed by a java compatible web browser and downloaded on demand without further interaction with users.

For this particular study, java is used as a programming language with the Android Studio as a programming environment because of android studio's applications are java based applications in addition to the following advantages that java can provide than other programming languages:

- ✓ It is platform independent Write Once Run Anywhere slogan.
- ✓ Java embodies the modern object-oriented programming philosophy.
- ✓ Security issue is very well established by java designers; java provides a secure means of creating internet application. Also java doesn't support the pointer feature of C++ to avoid the problem of accessing the resources outside the program through the pointers.
- ✓ It is simple and easy also no time wasting of compilation and java is multithreaded.
- ✓ Its portability property
- ✓ Easily connectivity with internet
- ✓ Java is robust (provides error free programming by being strictly typed and run time checks)
- ✓ Its functionality extend both at server side through Servlet and at client/browser side through applets.
- ✓ Java has a high performance because the byte code is highly optimized for speed of execution.
- ✓ Java is also memory managed i.e. programmer does not need to be concerned with de-allocating memory off the heap, nor with worrying about memory leaks.

Here all the above listed are the advantages and main features that enforce us for using java programming as java is also the prerequisite of the android studio; mainly the JDK must integrate with android studio to enable the SDK to write the entire code of the proposed system prototype for testing the overall system framework. Mainly the Java 2 Micro Edition (J2ME) is used because of its plenty advantages and it is the newest portion of Sun's java product and it is designed for handheld devices' applications development because of its configurability and interface ease. J2ME is the newest and smallest addition to the Java family. Sun has extended the scope of Java technology with the introduction of Java 2 Platform, Micro Edition (J2ME TM) in 1999 [20]. And it also has over the technologies targeting at the small wireless device such as

Wireless Application protocol (WAP) or i-mode. It is a standard subset of the Java (J2SE) class libraries, which enable Java applications to run on small computing devices. Just like the other Java technology, J2ME platform maintains the following qualities:

- ✓ J2ME provides built-in consistency across products
- ✓ It is a high level object oriented programming language with larger developer base
- ✓ It is a safe network delivery
- ✓ Codes of J2ME is portable and its upward scalability with J2SE and J2EE.

J2ME is designed as two building blocks of configuration and profile. Configuration defines a set of class libraries representing common functions available for a broad range of devices. In J2ME there are two configurations named as Connected Device Configuration (CDC) and Connected Limited Device Configuration (CLDC) and shortly described as follows: [9]

3.2.3. Genymotion

Genymotion is the cloud based virtual machine provider. To test the prototype developed for this research work, there should be a machine that used for emulation. This simulation virtual machine can be integrated with the android studio from the Genymotion by running the AVD. And the selected virtual machine from the Genymotion is automatically integrated to the android studio's AVD and it is simple to test the prototype with that machine without needing the actual machine by plugging USB machines.

3.2.4. SQLite

In addition to the Tomcat which a freely available reference implementation of the Java Servlet and Java Server Pages (JSP) specifications the SQLite is an in process library that implements a self-contained, server less, zero configuration and transactional SQL database engine for client side activities and serve as data sore. Tomcat is available to any company or developers to be used in web servers, development tools, and to create dynamic, interactive Web sites.

Also SQLite does not need to configure as other DB engines with the system. This tool is used as a backend for this particular study and the main features that initiate the scholars to use this tool are the followings [21]:

- ✓ SQLite does not require a separate server process or system to operate (server less)
- ✓ SQLite comes with zero-configuration, which means no setup or administration needed.
- ✓ A complete SQLite database is stored in a single cross-platform disk file.
- ✓ SQLite is very small and light weight, less than 400KB fully configured or less than 250KB with optional features omitted
- ✓ SQLite is self-contained, which means no external dependencies.
- ✓ SQLite supports most of the query language features found in SQL92 (SQL2) standard
- ✓ SQLite is written in ANSI-C and provides simple and easy-to-use API.
- ✓ SQLite is available on UNIX (Linux, Mac OS-X, Android, iOS) and Windows (Win32, WinCE).

The best feature that more makes the acceptance of the SQLite as data storage for this study is that, the SQLite enables the read-only property that enables the security of the data being shared amongst different sources. So the data owner does not need of worrying about the security concern. The users are forced to use the data in only read-only mode which enables us to share the data publically because the users can't alter their information suddenly, which may leads them to expose themselves to other problems specially with drug interactions [21]. Because of these advantages we are interested in using the SQLite for this particular study as database server.

3.2.5. Edraw

Edraw is used for drawing some architecture included within this research work and it is used as UML diagramming software. It's all-in-one graphics software that makes it simple to create professional looking flowcharts, network diagrams, organizational charts, business presentations, building plans, mind maps, fashion designs, UML diagrams, workflows, program structures, web design diagrams, electrical engineering diagrams, directional maps, database diagrams [22]. In this study we designed different architectures such as system architecture, data exchange flow diagram, event driven activity diagram, knowledge based system architecture and literature reviews as a methodology diagram. For drawing all of the above diagrams we have used the edraw as diagram designing tool. We have selected this tool because of odd features it has than other diagramming software which includes the followings:

- Supports to upload drawings to Cloud
- Easy to collaborate on files through team cloud which supports real time uploading and document sharing.
- Fully vector-based graphic software, which facilitates rapid creation of flowcharts, organizational charts, network diagrams and more.
- Just drag the build-in shapes from the library pane and drop them on your page. Drawing couldn't be easier if it was not by using the edraw.

In general, the above methods and methodologies are used in this particular study. The data collection method is used for gaining the hint for designing the proposed framework and testing prototype and also it is a purposive data collection as a development environment the android studio used because of its features that support handheld devices' application development and its easily configuration with other tools used in this study such as java. Java is selected because of android studio itself is a java based programming environment. And the edraw used for its simplicity of architecting any diagram needed by programmer and concerned engineer. It also consists of all designing component needed to include in any engineering diagrams. The SQLite is selected for the data storage purpose of the prototype developed for this study. It is free and server less data storage tool which enables the handheld device to store the data on themselves as far it is required by the user. SQLite has also a read only property at the time access which enables security concern of the data being exchanged [22].

CHAPTER FOUR

PROPOSED FRAMEWORK

4.1. Developing Medical Data Accessing Framework (MDAF)

Medical Data Accessing Framework (MDAF) describes the entire work flows of the overall healthcare organization's activities and it is supported by architecture to show the core components within the framework and the system architecture have a two tier architecture i.e. client server architecture. From the architecture, one can understand how the data assessors can access the required data from the database. Medical data access and exchange is necessary for reducing harmful errors by connecting different agents together for providing the patient safety. This can be done whenever doctors are connected with pharmacists, hospitals are connected with each other to transfer medical records, laboratories connected to patient's electronic health record and doctors also need to connect with patients for personal health record and also doctors need to connect with each other during care transfer.

The patient's medical data assessors (MDA) include the specialists, medical doctors, nurses, pharmacists, patient themselves and other concerned healthcare industry bodies like health insurance. The medical data can be accessed and stored either through the EMR or EHR. Health care providers can use either of the two terms even if they are not identical as discussed under chapter two. Within both EMR and EHR, the main data to be recorded is patients' information. The patient information or the patient medical record should have to contain the detail information of that particular patient including the previous care taken for that patient and other necessary information. Including the previous care is used for protecting the patient from different drug interaction that may cause the allergic to the patient in addition to gaining the prior medication given for that patient. As stated by Cascorbi, there are different types of drug interactions and the Drug-drug interaction is the main drug interaction caused due to the interaction of one drug with another drug and can cause up to 7% hospitalization mainly for a person in the range of elderly age [23]. Thus this proposed system provides alert for the patient if the pharmacist suddenly gives a drug that may cause interaction with the drug that the patient was using. This alert is not only for the patient but also for the pharmacist. If the pharmacist do what is mentioned above, the system provides alert and inform that pharmacist the patient has

allergic to that drug, please check his/her previous medication history. During the experiment one drug-drug interaction have shown and the system clearly notifies both patient and pharmacist as the patient may exposed to problem by taking of that particular drug which is Acetylsalicylic acid interact with Ibuprofen hence the two drugs can eliminate each other and the best solution to such drug interaction is the electronic prescribing through the use of systemized healthcare process [23].

The system also provides the orders the patient should have to follow during they are at home apart from the care providers and there are certain medications take place at their own home as per the orders given by specific specialist. This is mainly for patients suffer from common disease like TB, HIV/AIDs, Diabetes and other cardiovascular diseases. Currently the world's population is being affected by these diseases in particular. So those who are suffering from such disease are not always waiting for doctors' order at the hospitals because they can follow the order by their own mobile device at their home once the system is provided for them.

Main work of the system is the accessing of medical data of patients by handheld and mobile devices. The application developed or the prototype developed to test this framework is run on different mobile devices like smartphones, hand watch and tablets. The medical data is required to be accessed by these devices because of their simplicity and almost found on the hands of all people because "Smartphone and tablets are currently known as the doctors black pocket at their work environment" [24]

Accessing the patient medical data by using the handheld devices is useful mainly for implementing the research. Because if it is possible to access the medical data by handhelds, the medical data assessors don't bored to use the system hence they are always with these devices. The data being accessed is stored either at central data warehouse or at the local DB. Then the data accessors can easily get the required medical information of the patient. The patient themselves can also access their particular information from the central DB. The information stored at the local DB should have accessed only at the desired organization. The overall medical database integration is separately discussed in detail under the next section of this report.

The study also considers the information of the specialists mainly by stating at which care provider center they are found whenever the patients know their disease and need to directly

communicate with the specialist for further consultation. Currently the way patients are getting the specialist of their particular disease is just by moving through different care providers and they get their disease's specialist or care provider even through referral letters to that care provider or specialist. But the proposed framework enables the patients to access the required specialist once they can diagnose the disease at their home and directly meet their specialist based on their interest.

Far from the all discussed above, the MDAF also contains separate DB that contains the experts' knowledge that can aid the non-experts to treat the patient based on the accessed medical information. Once the system can diagnose the disease and provides the medication procedures for that particular disease, there is no need of expecting the specialist at the care center physically. Doing so is reducing the time wasting of treating patient and the writing of referral letters to other care providers. Those patient who are literate can easily follow their orders given by the doctor or specialist which is stored also at the KB data base of the MDAF. The framework also provides the lists of drug interaction and produce alert for them if they made error. This type of medication includes all medication procedures up to even small surgical care even full surgery medication is not considered in this medication. Doing this is so important mainly to save the life of person who suffer the Appendix disease. It is simple but it can expose to death.

Hence the patient information is accessed through the central database called as data warehouse, this system introduces one card system for all integrated care providers. Once the patient information is stored it is accessible in any part of the country as far as the internet is accessed. This is done through recording each patient's information electronically through the use of the EMR or EHR system.

On the other hand, this system helps the doctors and specialists at their own work organization during they are on the round. During round those doctors who are allowed to round are moving on each patient's bed and they check the medications being given for each individual patient. Hence doing this activity is so boring, the system provides how they can check each individual activities at the bed side from anywhere they are than moving from ward to ward hence everything is recorded electronically. In this MDAF, the medical images like CT-Scan, X-ray, ultrasound and the likes can be easily accessible with their full description which can be used at time of care and care transfer.

In general the MDAF shows how it is possible to access patient medical information from mobile devices and from remote care centers to provide guides for those who needs help in medication. It stores knowledge of expert to help non-expert and some less-experienced like fresh medical doctors on how to treat patient of particular disease without the intervention of the actual expert. Experts need to use the system whenever they need to access the prior medication history of their patients. This framework supports two working languages as in this study. Those who ca not understand other language than their native language Afan Oromo, the system is designed by this language. For those who are strange for the area and can't understand the language they can use the English language to perform their work by using the system.

Currently many of the healthcare organization workers in the Oromia Regional State are using only Afan Oromo to communicate with patients as well as to do their activities. Mainly nurses are rarely understand another language than Afan Oromo. Thus this system helps them to do their work in their native languages. Not only nurses patient themselves also can't understand any other languages than Afan Oromo. So they simply can use this system by using the language they preferred to use.

The framework consists of a rule based inference engine that controls the flow of message between end user through interface and the KBS. Based on the logical statement developed by java program in the code the inference guides the patient to access the result of disease diagnose from the KB database. So the inference engine act as a mediator between the user and the system. If the logic is fulfilled, then the inference allows the user to proceed to the next logic. Then the engine controls the user until the end of the task and if all the set rule is satisfied then the user can get what he/she wants to get otherwise the inference engine returns the missed point to that user.

4.2.**Database Integration**

Healthcare organization as any other organizations have a large variety of database to conduct their everyday activity. Most of the time large organizations have their database on separated platforms and databases are usually designed from scratch due to application specifications for that particular database. Sometimes the same real world object can be occur in different semantic in different DB [25]. Database of the healthcare organization are geographically distributed, they

are in different environment, may have different models and with different semantics. So the integration of such DB is must for users to easily acquire their interested data.

We can design distributed DB just by Bottom-up approach by starting from the scratch but such DBs can be in different model as well as geographically, structurally, logically and functionally different. But in this study, such type of DBs can be integrated to use the available data together which is done through the process called Database Integration. During the DB integration process we have used the Schema and Data Integration Technique and we have integrated the available three DBs for designing purpose. Theses DBs are the database for Electronic Medical Record, Health Information Record and that of Knowledge Based Systems' DB. By a single query users enable to access information from any of the three databases. The main activity in Schema and Data Integration Technique is the standardization of data which enables the DB users do not aware about the underlying system rather it initiates the system as of a single database. This is tested by created Federated DB of the EHR, EMR and KB in this particular study by using this schema and data integration technique [26]. The most important advantage of a data integration system is that it enables users to focus on specifying what they want than thinking about how to obtain the answers. As a result, it frees the users from the tedious tasks of finding the relevant data sources, interacting with each source in isolation using a particular interface, and combining data from multiple sources. [26]

For health information exchange, specifically, establishing both trust and interoperability among two or more organizations that want to share data represents a significant barrier. So a trust framework ensures the data privacy and security, its integrity (encompassing quality and accuracy), confidentiality (in light of the privacy laws safeguarding, and availability including completeness of the record [24]

Data integration for healthcare organization itself requires its own research work. But in this study we high lightly described the required data integration from different databases as data source mainly for good decision making or verifying the clinical decision support. So under this sub tittle we have shown the architecture of data integration to create the healthcare organization big data container as data warehouse. The main database to be included in the healthcare organization/health care industry are the HIS database, Knowledge base (mainly for clinical Decision support and evidence based medicine), EMR/EHR, Patient Medical record and other

administrative DB. To simplify the accessibility of the medical data the users do not need to directly connect to the separate DB of patient medical records unless they are using the independent DB at their own care center.

The best way of good clinical decision making is based on the accessing of quality patient information and rules followed as CDS [17]. The patient information can be accessed from EHR of initially care provider of that patient and the procedures to be followed for curing the patient is stored at the CDS of KB. The two different databases should have to integrate to provide the stated quality care service. So when the patients need to diagnose their patient, they should access the CDSS part of the Framework. During this time the designed inference engine guides the patient as a mediator between the KB data storage and the patients. If they satisfy the required set of rules in their query or request to the system, then the inference fetches the result from KB. The retrieved result by the inference is displayed to the user and prepare them for the next step processing if required. The overall components of the KB those discussed under section 2.1.4 of this report are hidden behind the part shown as KB information of the following figure 4.1. So during the information accessing from the KB mainly the CDSS integrated to the system architecture below is controlled by the inference engine part of the KB system. Thus whenever the user browse the desired page of patient, that inference engine follows as the patient is following the desired rule or not. If the patient is on the right way i.e. if the patient meets the pre stated rules, then the final result for that request is fetched from the KB and predicts the disease based on the entered symptoms of that patient and the system also displays the specialist or doctors or any care providers' details in addition to the predicted disease. How data can be accessed by the proposed framework is designed as it is indicated on the following figure.

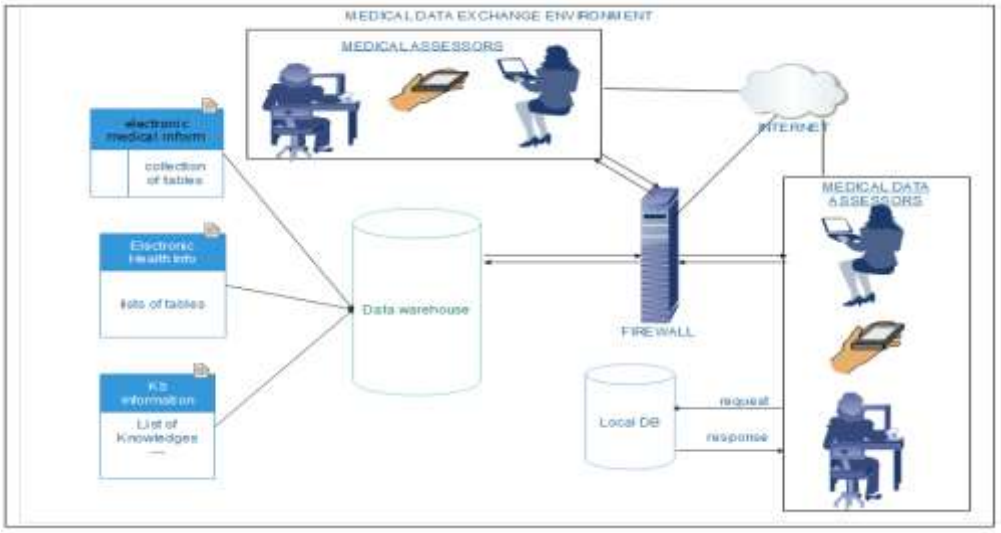


Figure 4.1 Medical Database integration and architecture

On the diagram the left side three components, electronic medical information, electronic health information and KB information are the already developed medical systems but should have to integrate with our system to provide commonly used sub systems. The three components together form the medical big data environment called the medical data warehouse. Each interested medical data assessor does not need to directly connect with each of these three components rather connected to the warehouse. This simplifies and integrates the three components together for the assessors. For the data security purpose the organization firewall is used as physical hardware. Each data assessor has their own local DB which is used for storing their own organizations' secret data if any. Also they are not required to store everything at the central data warehouse thus they are enabled to store their individual care activities at their local DB. This is better for the data backups and avoiding the overload of the central data warehouse. Medical data assessors can be anyone who is using the desired electronic device and incase of this particular study, the electronic devices are those we have mention in the final paragraph of the related work part or under section 2.2 of this report. The MDA can access and store the patient medical data to and from the central data warehouse. What is stored by one MDA can be later used or accessed by another MDA from the same care provider or another care provider as per its requirement and those MDA are all those mentioned under section 3.2.6 of this document.

in general, the Framework and its required data storages together forms the overall MDAF, the medical data assessors can access, store and share the required information both online and offline. How the offline and online accessing and storing the relevant information is described under the fourth chapter i.e. under result and discussion section of this report. So above diagram illustrates the integration of required databases to create the Medical data Warehouse and how the framework enables the accessing the relevant information by professionals at any care provider without consideration of the location. Once the system is implanted and connected to the internet it is possible to access the patients' relevant information and treat them asper their prior medication history.

4.3.Testing the Framework with Prototype

The above mentioned tools and methods under the third chapter are used to design the prototype for testing the MDAF. The prototype is developed based on the architecture stated in the previous sections and it is named as Medical Data Accessing and Clinical Decision Support (MDACDS). The prototype was designed as a multi lingual website but during designing of the prototype by considering the rural population of the Oromia Region we designed our prototype by Afan Oromo.

In this prototype design there are two main parts that we were thinking about, which are the user side activities and the server side activities. In android studio projects, once the activity is created, system divides that activity into two, one is the client side activity directly declared and created by using the scripting language XML for the user interface while its' event click or action is declared and created as a java class. All the user side activities are done through this client side i.e. through the user interfaces while all the server side activities are done by the java classes created as servlet class which are designed by programmer from scratch. The code which shows how the two activities performed is attached under appendix section of this paper.

4.3.1. Client and Server Side Prototype

The MIDlet Application interface enables the mobile client to look up with the servlet on the Apache Tomcat web server using HTTP connection which is fully integrated to the site of 00web host. Servlet is used as a middleware to get access with the medical data warehouse that contains the three different databases (EMR, EHR and KB) databases on the server. And the servlet is

directly connected with the medical data warehouse by using JDBC connection to connect the SQLite database and with the client user interfaces. In the following figure there is a list of MIDlets which represents the list of interface to the Handheld Devices' client. The MIDlets applications interface enables handheld client to store records entered by the user for some time in the SQLite as shown in the figure.

As it is discussed under next sections, each MIDlet has its own functionality and some of them stores the medical and patient information to the SQLite database while some of them are used for retrieving the stored information from the database. For this particular study the developed prototype was also tested online by uploading the experiment as a project to 00webhosting site. The site then provides its own testing server which is the Apache Tomcat web server as a data storage. So the provided data storage was used to test the network connectivity of the prototype and the stored information is able to retrieve online through the use of http connectivity as indicated on the figure below.

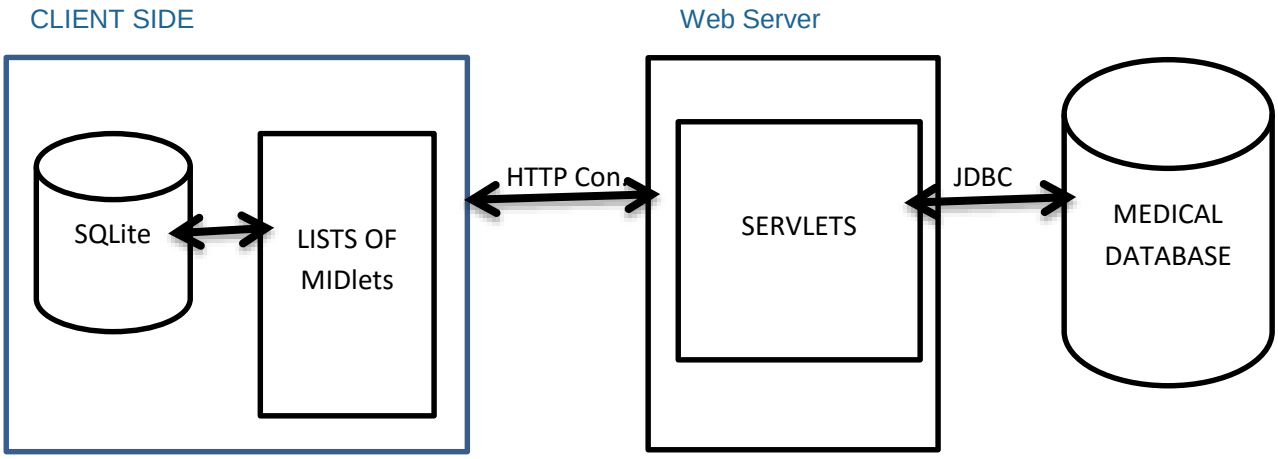


Figure 4.2 Accessing Medical Data by Client from the server

So the client side connectivity with the servlet through the http connection works correctly when the project is kept online by the concerned bodies like Oromia Regions' Health Bureau. So designed framework absolutely works both offline and online to meet the desired objectives of this research which is the exchange of medical data between patients and health professionals. Here how the prototype works offline is shown under the next section 4.2 of this paper. The

message flows between care providers and patients and the system itself both online and offline. The offline activities mainly take place when the users are used the system as CDSS for disease diagnoses. The data fetched from the server through the use of the servlet is accessible on the client by using the SQLite temporary data storage. Then the SQLite displays the stored data whenever the user request for it.

The lists of MIDlet in the diagram is the java applet program developed during experiment. This Applets are run on the client side and connected with both SQLite and Medical Data Warehouse. Hence the applets cannot directly communicate with Medical Data Warehouse, unless they do pass through the Servlets. During codifying the prototype the applet classes and the servlets classes are developed by java program. The applets are directly visible to the client side users who are the medical data assessors. While the servlets run on the server side. The three servlets are developed to connect the applets with the basic databases chosen during database integration. The applet and servlet communication takes place through the HTTP connectivity. Then the servlet connected to the medical data warehouse the JDBC connectivity and send the client request to the database and fetch the response from the database. HTTP connectivity is the bridge between client side and Server side programs and the http request is translated by the servlets and forwarded to the database and the database processes the request asper its necessity.

The data accessors mention in previous sections are now able to access the required data from the integrated databases and patients can create dialog with the system to diagnose their disease and once they diagnose it, they can access the detail information of the specialist/s for that particular disease as stated in the framework.

MDAF is tested for specific disease called Tuberculosis (TB) to assist the rural population of Oromia Regional State. In this prototype, users once registered with their Id and full name; and then they enable to diagnoses the disease by entering at least four different symptoms. Once they have inserted their symptoms the MDACDS displays the possible disease that their disease can be based on that symptoms. As the scholar discussed with one of the experts i.e. the medical doctor from Adama Hospital who is an internist, the main symptoms of the TB are “chronic cough, weight loose, fever, night sweating, chest pain, hemoptysis and the like. So when patients insert these types of symptoms the MDACDS diagnoses” the disease and finally as stated under

the framework designing part, the system displays the possible disease with the available specialists for serving them.

Even if the users does not insert their Id number i.e. if they didn't know their id number, the system by itself generate the id number for the patient. This seems to be very import to track the patient as per their time of registration. Then there is no need of manual patient tracking. The first registered patient is treated first if the number of patient being treated under the same medical profession at that time is more than two. This is one of the great result obtained during this research work. The professional doesn't require to know who comes first and the patients also do not need to wait for card. At any care provider their relevant information is available and can be treated at any care provider of their interest.

Once the disease is diagnosed there is no need of consulting other care providers to get extra information for treatment procedures. The system itself directs the patient to specific specialist for the predicted disease. The system displays full information of the doctors who can serve patients based on their inputs and result obtained. And they can directly contact with the specified care provider for further treatment processes. When the patient visit the specified doctor or specialist he/she doesn't need to tell the symptoms to that doctor again but the system does.

As the title of this paper tries to describe, each and every process could be done through handheld devices like Tablet, Smart phones, hand-watch and other mobile devices. Thus this prototype is tested on three different handheld devices which are smart phone, tablet and hand-watch. The Android studio's AVD provides these testing/simulation tools and the program run on this three devices. Once the system keeps all the patient information inserted by the patient him/herself, the doctor can browse it by using either device of his/her interest i.e. the device he/she had. Also the designed prototype considers the symptoms of one disease and the result of that disease. The selected disease is the TB disease because of its one of the disease that commonly affecting the developing country next to HIV/AIDS. Thus patients who are not knowing their disease before, can just get hint based on their symptoms and they can also get the information of internist to treat them.

4.4.Detail of the Prototype

As an example let us have a look at the following screen shoots that describes when the MDACDS is opened and on each device of the medical data assessor. Once the system is connected to the internet more or less wirelessly or also offline, the medical data assessor whoever it is from those who were mentioned under the previous sections, can accessed their interest data from their handheld devices. So from the screen shot, there are four options written in Afan Oromo. The first one is "DHIBAMAA" meaning the patient, the second is "DOKTORA" which means Doctor, the third option is "GARGAARAA/TUU" which stands for Nurse and the final option is "FAARMAASII" equivalent with pharmacist.

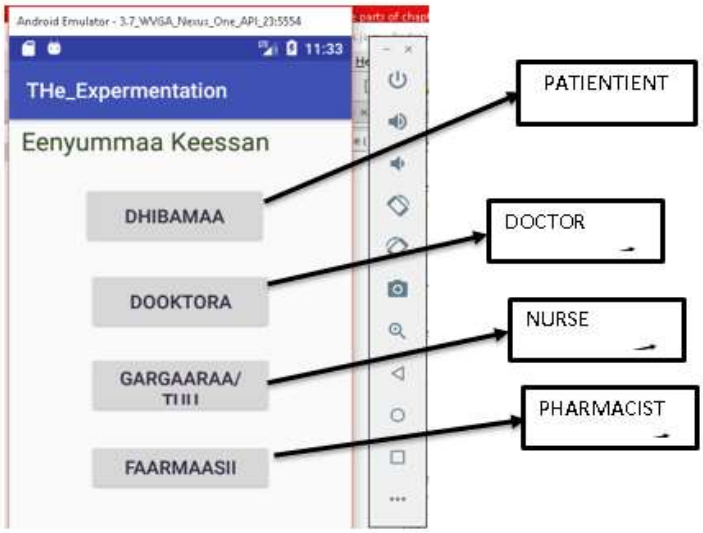


Figure 4.3 Medical Data Assessors page of the MDACDSS

Each of the medical data assessors are directed to their respective page and all of them except the patient are authenticated by inserting their username and password. The patients are not required to have password and username hence they are not always required to stay with the system and they also not require the system for other purpose except sending their symptoms and use the system for diagnose their disease. So all of them have their respective page as they have their specific action in the system. This system also helps the experts during they want to access the patients' relevant information including the patients' prior medication history. So all of the medical practitioners including Nurse and pharmacist wants to access the patients' relevant information this is why they are considered as a part of medical data accessors.

Once the medical data assessors authenticate themselves, the MDACDS directs them to their respective pages. From the figure we have considered when the data assessor is the first one who is the patient and want to know or diagnose his/her disease based on the symptom he/she showing at that time. Then MDACDSS directs the patient to the following page as shown it is shown on the figure.

Figure 4.4 Patient pages of MDACDS

Here once the patent sends the first information then MDACDS directs the patient to the next page which asks three different questions based on the symptom inserted from this page. These three questions are the set of rules determined during the inference engine design. The inference engine compares the inserted symptoms by the patient with this previously set rules. If the user input matches with the rule, then inference engine checks the second input and compare it with the rule and do same for the next inputs.

4.4.1. Inference Engine Pseudocode

During the design of the system or prototype as well as during designing the inference engine, the scholar itself was considered as the KE. By asking the actual expert from hospital, the scholar designed a logical java statement that controls the patients' user interface for proceeding to the

next interface. This logical statement consists of block statement that rotates the user between the interfaces until they get their destination interface which is the result of predicted disease plus the professions' information used for contact for further process. The pseudocode is implemented based on the forward chaining method of inference engine designing which is discussed under section 2.1.2.1.of this report. A pseudocode for the inference engine is that implemented by the java logical statement during the prototype designing is shown here as follows:

1. Start/Activate MDACDS
2. Choose your respective use
3. If DHIBAMAA button pressed display Patient Page
4. Prompt to insert one of the symptoms the patient is feeling or showing
5. If the first symptom is Chronic cough, then ask the patient whether he/she is feeling night sweating;
6. If the answer is YES, then again ask whether the patient has saw hemoptysis during cough and saw loss of weight and tiredness else go to 5
7. If the answer is Yes, then again ask if the patient is feeling chest pain and loss of appetite then check from lab result and go to 4
8. Save all the result to the backend as "Qufaa", "Qaama Gubaa", "Hir'ina Ulfaatinaa", "Hir'ina Fedhii nyaataa" in the corresponding tuple.
9. Retrieve all the saved symptoms and display again to the patient and prompt for verification.
10. If verified i.e. the patient accepts the displayed symptoms are correct, then read data record from EHR back end and access the internist tuple
11. Display the accessed from internist for that patient and display as the predicted result is TB in Afan Oromo.

This is the sample rule based inference engine designed in java as logical statement and it controls the patient when they insert their symptom for disease diagnose. This is the required result odd from other researchers in medical data accessing and exchanging. By using this the patients are both diagnosing their disease as well as they sending their information to the concerned body simultaneously.

When the above pseudo code is implemented the expected result as database integration, mobile computing and KB integration is succeeded. So we have tested it by implementing as we have designed and the system performs as expected to do. KB is accessed by the patient during diagnose other databases are accessed whenever the professionals access the patient information, like when doctor need to see the symptoms saved by visiting patient.

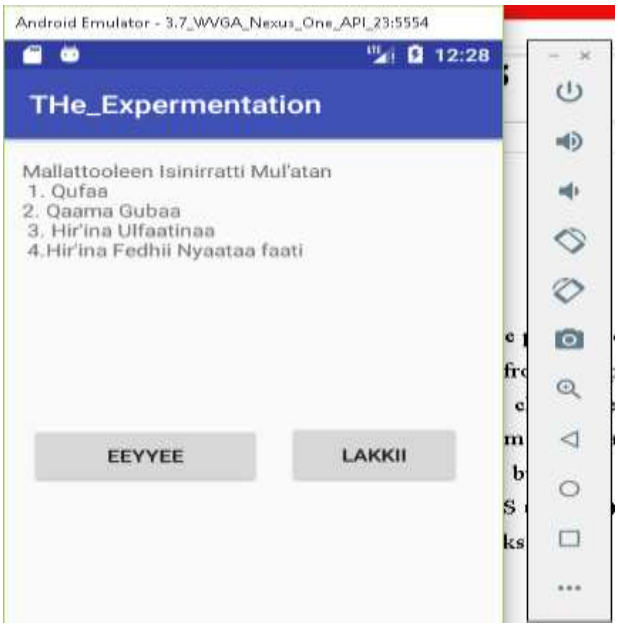


Figure 4.5 MDACDS's page return the symptoms inserted by patient

Then after the patient verifies that the inserted symptoms are correct then the overall patient's information with his/her symptom is inserted to the MDACDSS database and the result of the predicted disease is returned to the patient with full information of the doctor who can treat that patient as it is presented on the following figure. Then the patient can decide itself for what to do next. He/she can contact the desired practitioner by using the displayed addresses or if he/she is nearest to the care provider can also consult another practitioner at that care center. Thus during visit to the desired professional the patient is lucky he/she doesn't required to tell the doctor what is happening to him/her for the next process because the patient is nearly to know the his/her disease at this time. What is expected to tell the doctor is only either his/her name or id if knows, then the doctor able to retrieve the patient's previously inserted data. At this time the doctor tells the patient all the information including the patient's id for later use. Then the patient expected get laboratory test and based the laboratory result the prescription is written for the patient and

the written prescription is forwarded to the nurse for serving the patient. The following figure is final result of the patient inputs once the overall rules set in the inference engine is satisfied.

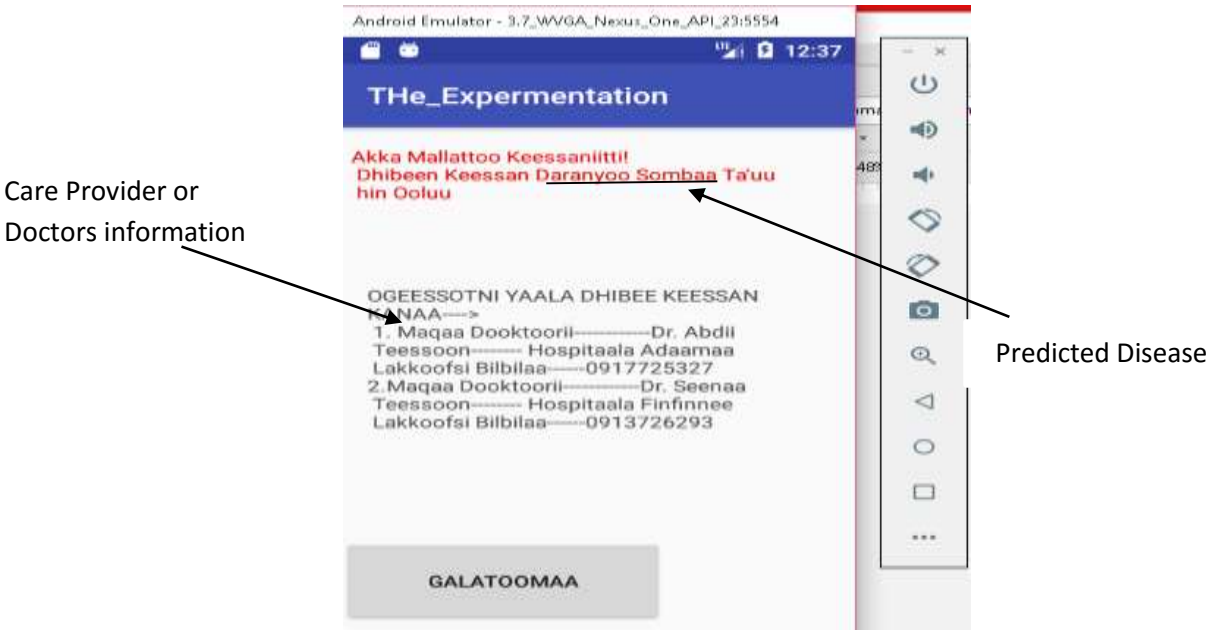
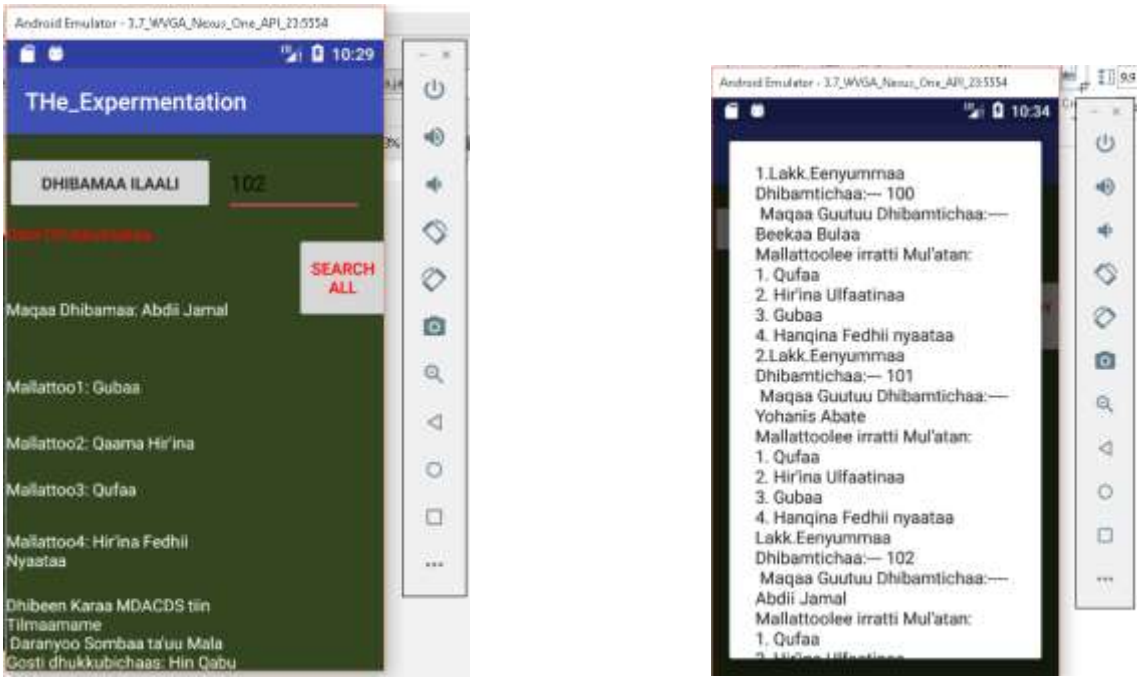


Figure 4.6 MDACDS displays the diagnosed disease

Then after patient finished and obtained the diagnose result the doctor can also access the patient who are waiting for care from distant or from anywhere saved on the system. Then the doctor can either search patients one by one whenever knows the patient id or the patient name if the patient itself knows its Id, then the particular patient can tell that id to the doctor and then the doctor can access the patient's relevant information individually. Also the doctor can access all registered patients by searching all of them at the same time and the system performs the patient arranging based on their id which by default keeps the time of their registration hence the id is automatically incremented. This is important for patient tracking when many patients are asking for the same care provider at the same time. Here on the following figure 4.8 a) and figure 4.8 b) indicates when the MDAF medical data assessor is the doctor and wants to see the information of the patient one by one and all at the same time respectively. Patient id or patient name is filled on the space provided for the doctor. When the doctor fills the id or name of the patient the result that matches the input is retrieved from the database and if the id or name is not found in the database, then the system return there is no such patient registered by that id message for the

doctor. All the results are processed in Afan Oromo. The present patient's information by id number 102 is displayed on figure 4.8 a) and that of all by search all is displayed on figure 4.8 b)



(a) (b)

Figure 4.7 a) MDACDS Displays Individual Patient. b) Doctor retrieves all patients

So the above shown figures or screen shoots show the conversation takes place among the patient, MDACDS and Doctor. Based on the experiment done the exchange of medical data is completed between the patient and the doctor it takes place between medical data assessors.

The other medical data assessors mentioned under the MDAF designing section are not indicated in this report but they are used during experimentation. For example, the one who performs the doctors' prescriptions are the Nurses. Thus the information in-coded by the doctor is visible for the nurse whenever the nurse interest to access the prescription and always when he/she needs to treat patient. Also in most rural care providers or care centers, most of the time there is no medical doctors while those perform all the medical process are nurses and some university graduated health professionals like Health Officers, Clinicians, pharmacists and etc. rather than doctors. So when these professionals who are less-experienced as well as less profession than medical doctors try to treat patients, we have hypothesized there should be a means of processing

the accessed medical information. Here the developed framework does the same thing when the actual professional is absent from the care provider. This curves the patients' loose of life for the lack of medical professional when the developed framework obtains some characteristics of expert properties or acts and performs partially the same thing that an expert can do.

The developed framework and the proposed designed prototype plays as an expert system. When the patients diagnose their disease the system predicts the disease than telling the as the result of diagnose is particular disease. This is because of there are diseases which have nearly same symptoms. So the system prefers to predict than make decision and the system's prediction has a great role in less experienced professions' decision making. Also it encourages the experts decision making ability because of evidence based decision making more preferable than experience based decision making. This is discussed under the literature review how evidence medication is important than experience based decision making. Here after now on, the framework supports the non-experienced and experienced professionals' decision making in medication procedures.

The system also curves the problem of medication error which exposes patient to lose of life. The most serious medication error as discussed under the designing framework section is drug interaction. This system avoids the drug interaction error caused mainly by the pharmacist hence it produces alert for the pharmacist as he/she has not to allow the patient to take that drug based on the patients' prior medication history. Hence the patients' relevant information is available at any care provider, the medical data assessors browse the patient prior history and can prepare decision for the current medication process without any medication error by following the system's medication procedure for each disease but this activity requires more time and the medication procedure is proposed but not implemented for testing the framework.

So in this research by considering the lack of health professionals and the absence of a means for exchanging the medical information which enables the developing countries to use effectively the available health professionals, how to exchange the medical data between or among health care providers as well as how patients by themselves can diagnose their disease at home by using any mobile device is succeeded. Medical professionals can exchange medical data among other care providers which increases the care providers' interoperability. Thus the early mentioned

problems are curved as above result shown us. Hence the developed prototype is by Afan Oromo, the lack of HCP in the region is solved by developing such applications.

Mobile devices are used as simulation tools and the prototype is developed and tested by using these mobile devices like Tablet, Mobile Phone and hand-watch. The developed prototype is completely run and work on actual tablet and mobile phone and tested by hand-watch simulator of android studio's virtual device. This is the result of the hint the scholars obtained during discussion with the expert on which device is more appropriate for medical professionals. Thus handheld devices are preferable to other electronic devices for the health professionals.

Two technologies the mobile computing technology and Knowledge based system are integrated to produce the final result of this study. The availability of mobile device in hands of this generation is used to solve the problem of lacking quality care service. Quality service is based on quality information which must obtained correctly at a required time. But the obtained information is not enough if there is no means of using that information. So in this research work, the correct, accurate and timely information can be accessed at anywhere by any authorized person and the accessed information is used by less experienced professionals and non-experts to solve ones problem at any time by the integrated these two technologies.

The main goal of this research report is the development of secured Medical Data Accessing Framework which can be implemented by using mobile devices or handheld devices. The framework has an integrated database as a data warehouse composed of three different databases (the EMR, EHR and KB). It also has a rule based inference engine which connects the KB with user interfaces through which patients interact with it and diagnose their disease. The inference engine is used as the default patient guide. The patient can omit the rule or can't pass over the rule to diagnose disease because that inference engine controls that patient's inputs.

In general the developed framework enables both professionals and nonprofessionals to provide quality service and avoid the patients' losing of their life mainly for those who are at rural. The prototype used for testing the framework is developed by Afan Oromo and the population of the rural area of Oromia region can easily use the system. Professionals require the system when they want to access the medical record of the patient. Less experienced professionals need the system when they need give a real evidence based medication. And patients are able to diagnose

their disease by themselves as nonprofessionals. The flow of message between the users and the system is controlled by the integrated inference engine developed by java logical statement.

The developed framework also curves the boring activities takes place by the doctors during the round working. As mentioned the round work is to check each patient for the bedside caring each morning by rounding through all the wards. This activity is the manual medication error controlling but the developed framework enables the medical doctors to check the electronic round activity and electronic medication error controlling. In general we can summarize this research work by saying the stated objective which exchanging the patient and medical information among the concerned stakeholders by using handheld devices is achieved when we follow the activities under this chapter. The other specific objectives are also realize the general objective hence the developed prototype enables the MDA to access and exchange the medical data as stated in the framework.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1.Conclusion

In addition to the scarcity of medical doctors and specialists in developing countries which is the great problem of our population the absence of means for medical data exchanging is the other great problem of developing countries. Mainly rural populations are currently suffering tremendously to the extent of losing life because of this problem. So to assist both the medical professionals and patients to easily access and exchange the medical data between each other for better patients' treatment, there should be a means by which they can do so. Also for less-experienced professionals accessing the medical information is not enough to provide quality service for the patients. In addition to the accessed medical information there should be a system that provides a way of medication in the form of accumulated knowledge. Then those less experienced professionals can serve the patients without the need of actual professional at the time of treatment. To solve the problem the availability of mobile technology is helpful hence it is currently available at the hand of almost all people even at rural population. Thus a system is developed to curve the problem by using any mobile device such as Tablet, mobile phone and hand-watch.

The developed system has a two tired architecture which is client server architecture. The client sides are developed and consists of a collection of MIDlet applications as activity. Each activity represent one MIDlet and these MIDlets are developed by using scripting language XML which is a default Scripting language of Android studio and an android studio is a java based mobile application development tool.

As android studio is a java based application development tool, the server side activities are developed by using the java servlet program. And the developed prototype completely enables the medical data assessors to access and exchange data between each other in addition to the system itself diagnose the disease based on the symptoms inserted by the patients in Afan Oromo. Doing this is essential to solve the problem of rural population of the Oromia Regional.

The client side activities are run and connected to the SQLite database which is freely integrated to the android studio and it is self-contained, server less, zero configuration and transactional SQL database engine to serve as data sore for the server side.

The developed Framework is tested by developed prototype and as a result the conversation is made among the system, patient and medical doctors. The patient enabled to diagnose his/her patient by inserting their symptoms and system displays the possible disease it can be based on the inserted symptoms. And medical doctor can access the patient information which was inserted by the patients.

Generally it is possible to make the dissemination of healthcare service to the rural population by using the mobile devices like mobile phone, tablet, hand watch and the likes. The proposed system is so important in case of facilitating patient information transferring during referral letter to the referral hospitals and different databases are integrated to create the overall healthcare data warehouse to enable all medical data assessors exchange the required information among each other. This increases the care providers' interoperability to easily transfer knowledge and information among each other. Reducing the medication error caused by less experienced professionals that leads patients to lose of life is also decreased by avoiding the drug interactions. So the early stated objectives are achieved once this research is fully implemented by the healthcare organizations as it stated within this research report.

5.2.Recommendations

Fact finding based on the real mobile application using of the population in the rural area requires another research work in the future. Developing fully knowledge based system mobile applications which enables other Ethiopian populations to use by their own language is recommended for the future and for those who can't read and write, developing a system which is based on sound recognition in this area is also more recommended for future works.

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APPENDIXES

Appendix 1: XML file for user interface craetion

```
<?xml version="1.0" encoding="utf-8"?>
<android.support.constraint.ConstraintLayout
xmlns:android="http://schemas.android.com/apk/res/android"

xmlns:app="http://schemas.android.com/apk/res-auto"

xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"

android:layout_height="match_parent"
    android:background="#344620"

tools:context="com.thesis.the_experment
ation.com.thesis.MedicalDataAccessingan
dClinicalDecisionSupport.Dooktora"

tools:layout_editor_absoluteY="81dp"

tools:layout_editor_absoluteX="0dp">

    <Button

android:id="@+id/dhibamailaaluu"
        android:layout_width="176dp"
        android:layout_height="50dp"
        android:text="Dhibamaa Ilaali"

app:layout_constraintTop_toTopOf="paren
t"
        android:layout_marginLeft="-
7dp"
        android:layout_marginTop="16dp"

app:layout_constraintLeft_toLeftOf="par
ent"

tools:layout_editor_absoluteY="20dp" />

    <TextView
        android:id="@+id/txtvmaqaa"
        android:layout_width="233dp"
        android:layout_height="58dp"
        android:layout_marginLeft="0dp"
        android:textColor="#FFFFFF"

app:layout_constraintLeft_toLeftOf="par
ent"
        android:layout_marginTop="0dp"

app:layout_constraintTop_toBottomOf="@+
id/textvwmataduree" />

    <TextView
        android:id="@+id/txxvmal1"
        android:layout_width="179dp"
        android:layout_height="47dp"
        android:layout_marginTop="7dp"
        android:textColor="#FFFFFF"

app:layout_constraintLeft_toLeftOf="par
ent"

app:layout_constraintTop_toBottomOf="@+
id/txtvmaqaa"
        android:layout_marginLeft="0dp"
/>

    <TextView
        android:id="@+id/txtvmal2"
        android:layout_width="165dp"
        android:layout_height="39dp"
        android:layout_marginLeft="0dp"
        android:layout_marginTop="0dp"
        android:textColor="#FFFFFF"

app:layout_constraintLeft_toLeftOf="par
ent"

app:layout_constraintTop_toBottomOf="@+
id/txxvmal1" />

    <TextView
        android:id="@+id/txtv3"
        android:layout_width="167dp"
        android:layout_height="44dp"
        android:layout_marginLeft="-
18dp"
        android:layout_marginTop="0dp"
        android:textColor="#FFFFFF"

app:layout_constraintLeft_toLeftOf="par
ent"

app:layout_constraintTop_toBottomOf="@+
id/txtvmal2" />

    <TextView
        android:id="@+id/txtv4"
        android:layout_width="160dp"
        android:layout_height="46dp"
        android:layout_marginTop="0dp"
        android:textColor="#FFFFFF"

app:layout_constraintLeft_toLeftOf="par
ent"

app:layout_constraintTop_toBottomOf="@+
id/txtv3"
        android:layout_marginLeft="0dp"
/>

    <EditText
```

```
        android:id="@+id/plain1"
        android:layout_width="116dp"
        android:layout_height="51dp"
        android:layout_marginLeft="8dp"

android:layout_marginRight="16dp"

        android:layout_marginTop="16dp"
        android:ems="10"

android:inputType="textPersonName"

app:layout_constraintLeft_toRightOf="@+
id/dhibamailaaluu"

app:layout_constraintRight_toRightOf="p
arent"

app:layout_constraintTop_toTopOf="paren
t" />

    <Button
        android:id="@+id/btnsearch"
        android:layout_width="80dp"
        android:layout_height="73dp"
        android:text="Hundaa Ilaali"
        android:textColor="#FF0000"
        android:layout_marginTop="17dp"

app:layout_constraintTop_toBottomOf="@+
id/plain1"

app:layout_constraintLeft_toRightOf="@+
id/textvwmataduree"

android:layout_marginLeft="18dp" />

    <TextView

android:id="@+id/textvwmataduree"
        android:layout_width="227dp"
        android:layout_height="64dp"
        android:textColor="#FF0000"

tools:layout_editor_absoluteX="-12dp"
        android:layout_marginTop="8dp"

app:layout_constraintTop_toBottomOf="@+
id/dhibamailaaluu" />

    <TextView

android:id="@+id/txtvwdhibeetilmaame"
        android:layout_width="255dp"
        android:layout_height="86dp"
        android:layout_marginLeft="0dp"
        android:layout_marginTop="8dp"
        android:textColor="#FFFFFF"

app:layout_constraintLeft_toLeftOf="par
ent"

app:layout_constraintTop_toBottomOf="@+
id/txtv4" />

</android.support.constraint.Constraint
Layout>
```

Appendix 2: Code for SQLite Database creation and connecting:

```
package
com.thesis.MedicalDataAccessingandClini
calDecisionSupport;

import android.content.ContentValues;
import android.content.Context;
import android.database.Cursor;
import
android.database.sqlite.SQLiteDatabase;
import
android.database.sqlite.SQLiteOpenHelpe
r;
import android.util.Log;
import static
com.thesis.MedicalDataAccessingandClini
calDecisionSupport.conectionclass.*;
import static
com.thesis.MedicalDataAccessingandClini
calDecisionSupport.conectionclass.Table
InfoKuusaa.*;


public class dhibeekuusuudb extends
SQLiteOpenHelper {
    public static final int db_version
= 1;
    public String CREATE_QUERY =
"CREATE TABLE
"+Name1+"("+conectionclass.TableInfoKuu
saa.Eenyummaa+"
TEXT,"+conectionclass.TableInfoKuusaa.M
aqaa+" TEXT);";

//+conectionclass.TableInfoKuusaa.Malla
ttood+"
TEXT,"+conectionclass.TableInfoKuusaa.M
allattool+"
TEXT,"+conectionclass.TableInfoKuusaa.M
allattoos+"
TEXT,"+conectionclass.TableInfoKuusaa.M
allattooa+" TEXT);";

    public dhibeekuusuudb(Context
context) {
        super(context,
TableInfoKuusaa.DB_name, null,
```

```
db_version);
        Log.d("Databaes dhibee
kuusuuf","Databasen Uumame");
    }

    @Override
    public void onCreate(SQLiteDatabase
sdb) {

        sdb.execSQL(CREATE_QUERY);
        Log.d("Databaes dhibee
kuusuuf","Gabateen Uumame");

    }

    @Override
    public void
onUpgrade(SQLiteDatabase db, int
oldVersion, int newVersion) {
        db.execSQL("drop table if
exist"+Name1);
        onCreate(db);

    }

    public void
putInformation(dhibeekuusuudb dhk,
String eenyuu, String maqaa String
mall1, String mall2, String mall3,
String mall4){
        SQLiteDatabase SQdhk;
        SQdhk =
dhk.getWritableDatabase();
        ContentValues cvdh;
        cvdh = new ContentValues();

cvdh.put(TableInfoKuusaa.Eenyummaa,
eenyuu);
        cvdh.put(TableInfoKuusaa.Maqaa,
maqaa);

cvdh.put(TableInfoKuusaa.Mallattood,mal
l1);

cvdh.put(TableInfoKuusaa.Mallattool,
mall2);

cvdh.put(TableInfoKuusaa.Mallattoos,
mall3);

cvdh.put(TableInfoKuusaa.Mallattooa,
mall4);
        long k =
SQdhk.insert(TableInfoKuusaa.Name1,
null, cvdh);
        Log.d("Databaes dhibee
kuusuuf","gabateetti record galeera");
    }

    public Cursor
getInformation(dhibeekuusuudb Dop)
    {
        SQLiteDatabase SQ1 =
this.getReadableDatabase();
        String[] Columns =
{conectionclass.TableInfoKuusaa.Eenyumm
aa,
conectionclass.TableInfoKuusaa.Maqaa};
conectionclass.TableInfoKuusaa.Mallatto
od,
conectionclass.TableInfoKuusaa.Mallatto
ol,
conectionclass.TableInfoKuusaa.Mallatto
os,
conectionclass.TableInfoKuusaa.Mallatto
oa};
        Cursor crc =
SQ1.query(TableInfoKuusaa.Name1,Columns
, null, null, null, null, null);
        return crc;
    }
    public Cursor getAllData(){
        SQLiteDatabase db1 =
this.getWritableDatabase();
        Cursor crs =
db1.rawQuery("select *
from"+Name1,null);
        return crs;

    }

}
```

Appendix 3: SQLite DB Browser's queries for Database Operations

PRAGMA foreign_keys = "0";

PRAGMA encoding

SELECT type,name,sql,tbl_name FROM sqlite_master UNION SELECT type,name,sql,tbl_name FROM sqlite_temp_master;

SELECT type,name,sql,tbl_name FROM sqlite_master UNION SELECT type,name,sql,tbl_name FROM sqlite_temp_master;

SELECT type,name,sql,tbl_name FROM sqlite_master UNION SELECT

```
type,name,sql,tbl_name FROM
sqlite_temp_master;

SELECT COUNT(*) FROM (SELECT `_rowid_`,*
FROM `employee` ORDER BY `_rowid_` ASC);

SELECT `_rowid_`,* FROM `employee` ORDER
BY `_rowid_` ASC LIMIT 0, 50000;

INSERT INTO
`employee`(`emp_id`,`emp_firstName`,`emp_la
stname`,`emp_position`,`emp_Speciality`,`emp_
salary`) VALUES
(NULL,NULL,NULL,NULL,NULL,NULL);

//for updating

UPDATE `employee` SET `emp_firstName`=?
WHERE `_rowid_`='1002';

UPDATE `employee` SET `emp_firstName`=?
WHERE `_rowid_`='1002';

UPDATE `employee` SET `emp_lastname`=?
WHERE `_rowid_`='1002';

UPDATE `employee` SET `emp_position`=?
WHERE `_rowid_`='1002';

UPDATE `employee` SET `emp_Speciality`=?
WHERE `_rowid_`='1002';

UPDATE `employee` SET `emp_Speciality`=?
WHERE `_rowid_`='1002';

UPDATE `employee` SET `emp_salary`=? WHERE
`_rowid_`='1002';

//For Selecting Desired Row from desired Table

SELECT type,name,sql,tbl_name FROM
sqlite_master UNION SELECT
type,name,sql,tbl_name FROM
sqlite_temp_master;

SELECT COUNT(*) FROM (SELECT `_rowid_`,*
FROM `employee` ORDER BY `_rowid_` ASC);

SELECT `_rowid_`,* FROM `employee` ORDER
BY `_rowid_` ASC LIMIT 0, 50000;

SELECT COUNT(*) FROM (SELECT `_rowid_`,*
FROM `employee` ORDER BY `_rowid_` DESC);

SELECT `_rowid_`,* FROM `employee` ORDER
BY `_rowid_` DESC LIMIT 0, 50000;

SELECT type,name,sql,tbl_name FROM
sqlite_master UNION SELECT
type,name,sql,tbl_name FROM
sqlite_temp_master;

CREATE TABLE `Patient_Record` (

        `patient_id`       INTEGER NOT NULL
PRIMARY KEY AUTOINCREMENT,

        `PatientFirst Name`       TEXT NOT
NULL,

        `PatientLastNAme`       TEXT NOT
NULL,

        `MedicationHistory`       TEXT

);

SELECT type,name,sql,tbl_name FROM
sqlite_master UNION SELECT
type,name,sql,tbl_name FROM
sqlite_temp_master;

SELECT COUNT(*) FROM (SELECT `_rowid_`,*
FROM `Patient_Record` ORDER BY `_rowid_`
ASC);

SELECT `_rowid_`,* FROM `Patient_Record`
ORDER BY `_rowid_` ASC LIMIT 0, 50000;

CREATE TABLE `Disease` (

        `DiseaseId`       BLOB NOT NULL
PRIMARY KEY AUTOINCREMENT,

        `diseasename`   TEXT NOT NULL,
```

```
	`Disease type`	TEXT,
	`Symptom1`	TEXT,
	`symptom2`	TEXT,
	`sysmtom3`	TEXT,
	`sympotm4`	TEXT
);
//For Creating Table that Stores Disease Information that used in Clinical Decision support
CREATE TABLE `Disease` (
	`DiseaseId`	INTEGER NOT NULL PRIMARY KEY AUTOINCREMENT,
	`diseasename`	TEXT NOT NULL,
	`Disease type`	TEXT,
	`Symptom1`	TEXT,
	`symptom2`	TEXT,
	`sysmtom3`	TEXT,
	`sympotm4`	TEXT
);
INSERT INTO `Disease`(`DiseaseId`,`diseasename`,`Disease type`,`Symptom1`,`symptom2`,`sysmtom3`,`sympotm4`) VALUES (2,'',NULL,NULL,NULL,NULL,NULL);
UPDATE `Disease` SET `diseasename`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `Disease type`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `Symptom1`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `symptom2`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `symptom2`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `symptom2`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `sysmtom3`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `sysmtom3`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `sympotm4`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `sympotm4`=? WHERE `_rowid_`='2';
UPDATE `Disease` SET `sympotm4`=? WHERE `_rowid_`='1';
INSERT INTO `Disease`(`DiseaseId`,`diseasename`,`Disease type`,`Symptom1`,`symptom2`,`sysmtom3`,`sympotm4`) VALUES (5,'',NULL,NULL,NULL,NULL,NULL);
UPDATE `Disease` SET `symptom2`=? WHERE `_rowid_`='4';
```

INTERVIEW QUESTION

Interviewer detail information

- Name: _____
- Date of interviewing: _____

Open questions:

1. What is the ratio of doctors/specialists to the population of Ethiopia? ------
2. Is there a means to exchange medical information or medical data from specialists to specialist, hospitals to hospitals or among any health care organizations' workers?
3. What is the extent of your experience towards information technology?
4. Have you information communication in your hospital? If yes for what purpose this system is helping you?
5. Are there enough specialists found in your hospital? If No how you are serving the patients?
6. What do you know about the accumulation of the medical specialists' knowledge to serve patients even when he/she is not physically there?
7. Are you interested in a system that can serve as an expert without the physically appearance of that expert at specified location? If no why?
8. Currently what system you are using for information exchange and management purpose?
9. Do you and also patients are satisfied whit your current system? If yes how? If no what you are expecting with related to the technology?
10. Do you interest in technology interference with the healthcare organizations? If no why? If yes for what kinds of activities?
11. What is use of Information technology strategies with health organizations