



SCHOOL OF PUBLIC HEALTH AND
SCHOOL OF INFORMATION SCIENCES

M.SC IN HEALTH INFORMATICS

DESIGN AN ELECTRONIC MEDICAL RECORD SYSTEM AT OUTPATIENT
DEPARTMENT OF YEKATIT 12 HOSPITAL

MEDICAL COLLEGE

BY

ALEM WASSIE

ADDIS ABABA, ETHIOPIA

JUNE, 2017

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A project submitted to the school of graduate studies of Addis Ababa University in partial fulfillment of the requirement for the Degree of Masters of Science in Health Informatics

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Name and signature of advisors and the examining board members

Advisor _____ **Signature** _____ **Date** _____

Advisor _____ **Signature** _____ **Date** _____

Examiner _____ **Signature** _____ **Date** _____

Examiner _____ **Signature** _____ **Date** _____

Dedications

I would like to dedicate this research project to my brother fantahun wassie and my families.

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First of all I would like to thank the almighty God and His mother Saint Virgin Mary. GOD gives me the chance to be here and strength to go through to successfully complete this research project and the entire study.

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Acronyms

AAU	Addis Ababa university
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AIDS	Acquired Immune Deficiency Virus
BC	Before Crist
CBIS	Computer Based Information System
CDC	Communicable Disease Control
CPR	Computerized Patient Record
CSC	Cascade Style Sheet
E-HEALT	Electronic Health
EMR	Electro Medical Record
FMOH	Federal Minister of Health
GC	Gregorian calendar
GOe	Global Observatory for e-Health
HIS	Health Information System
HIS	Health Service Integrator
HIT	Health Information Technology
HIV	Human Immune Deficiency Virus
HMIS	Health Management Information System
HO	Health Officer
ICT	Information Communication Technology

ID	Patient Identity
MIS	Medical Information System
MPI	Master Patient Index
MRN	Medical Record Number
OO	Object Oriented
OPD	Outpatient Department
PDA	Personal Digital Assistance
SDLC	system development life cycle
TB	Tuberculosis
TUTAPE	Tulane University's Technical Assistance Program for Ethiopia
UC	Use Case
UI	user interface
UML	Unified Modeling Language
US	United State
VCT	Voluntary Counseling Technique
WHO	World Health Organization

Executive summary

Introduction: Health records are the most important database of patient which consists of various data entered by health care professionals in either paper or electronic form. Reliable and timely health information is an essential foundation of public health action and health systems. Electronic-Health is the use of Information and Communication Technologies in health care. It is concerned with improving the flow of information, through electronic means to support the delivery of health services and the management of health systems. From e-health applications Electronic Medical Record which is computerized medical information system that collect, store and display patient information is one aspect. The record system provides comprehensive, reliable, relevant, accessible and timely patient information to each member of the health care.

Objective: The main objective of this project is to design and develop prototype of electronic medical record system at outpatient department of Yekatit 12 hospital medical college.

Methodology: The project was designed in an object oriented view of system analysis and design methodology with incremental and iterative designing cycle. The requirements for the system were collected through interview, observation and document review. Analysis and design of the proposed system was done using the unified modeling language by Microsoft Visio 2013.

Result: The design electronic medical record system has different functionalities to support patient record system at Yekatit 12 hospital such as patient registration, diagnosis, treatment, and laboratory result registration, search patient data and update patient visit, assign patient and generate report. Which will help to transform the paper based manual system to efficient and effective electronic system. Three tire system architecture also designed for the new system.

Summary: electronic medical record system to overcome the problems associated with manual record system was designed for users at outpatient department. The project contributes to improve the hospital business process by bringing better understanding of the use of electronic medical record system. It enables users to get timely, complete, organized, easily accessible patient data at the point of care.

Recommendation: The hospital in collaboration with the Federal Ministry of Health and regional health office has to work on the implementation and usability of the system and provide the necessary system support. The researchers/students continue the project and work on the remaining parts of the system.

CHAPTER ONE

INTRODUCTION

1.1 Background

Health records are the most important database of patient record which consists of various data entered by health care professionals in either paper or electronic form. The beginnings of health records date back to 3000 BC when the Egyptians started keeping the oldest form of health records. In ancient Greece, doctors recorded symptoms and treatments. Recently health records are kept from birth to death of a person. Consistent recording by doctors, nurses and other staff is important for monitoring of the health, planning and treatment. The main purpose of patient record is to provide a means of communication to facilitate the safe care and treatment of a patient(1).

The key to effective patient information systems is to retain the link between the individual and the data collected over time and to make those data available to multiple health care providers when it is needed. However, many health information systems do not retain data in the form of an individual patient record. There are two types of patient record systems which are used to manage patient information, namely paper-based record system and the Computer-Based Record (CPR) system(2).

CPR is a repository of electronically maintained information about an individual's lifetime health status and health care, such that it can serve the multiple legitimate users of the record. These systems have the objective of supporting patient care and improving the quality of care(3).

E-Health is the use of information communication technology (ICT) in health care. It is concerned with improving the flow of information, through electronic means to support the delivery of health services and the management of health systems. Sound and reliable information is the foundation of decision-making across all health system building blocks. Health information systems (HIS) serve multiple users and a wide array of purposes that can be summarized as the generation of information to enable decision-makers at all levels of the health system to identify problems and needs, make evidence-based decisions on health policy and allocate scarce resources optimally(4).

One of the main applications of information and communication technologies in healthcare sector is EMR which is computerized system that provides methods of collecting, storing and displaying health information(5).

EMR is an application that would aid in recording clinical data electronically, making decisions, placing and receiving orders, making requests to the pharmacy, recording X-ray and laboratory findings, and also documenting clinical activities. An EMR system requires the use of a computer system along with a network. The network would ensure the transfer and storage of the health information(6).

The perceived benefits of EMR can be summarized as reduction in human errors, improving the security of medical data, making easier access to medical information, diminishing duplication of efforts and documents, optimizing the documentation of health data , supporting decision making activities, improving the quality of care, forming data repository, and reduction of papers(7).

In developing countries, healthcare information systems have been driven mainly by the need to report aggregate statistics for government or funding agencies. Such data collection are performed with simple paper forms at the clinic level(8).

HIS is potentially very important for the development of the health sector. The practice of medical record documentation in Ethiopia is putting all the data in a folder and kept in a separate card room. But, currently the health care industry in Ethiopia expressed a great deal of interest in electronic health. Health Management information System (HMIS) was established to support informed strategic decision-making by providing quality data that help managers and health workers to plan and manage the health service system in Ethiopia. As of 2008, a comprehensive electronic HMIS has been developed in conjunction with Tulane University(9).

1.2 Statement of the Problem

HIS performance in many developing countries consistently falls short of requirements. The goal of a HIS is often narrowly defined as the production of good quality data. However, the ultimate goal to produce relevant information that health system stakeholders can use for making transparent and evidence-based decisions for health system interventions(9).

Ethiopia from sub-Saharan Africa has a poor health status in relation to other low income countries. The most serious global health problems are in third world developing countries, and good health information is vital in tackling these problems. Effective HIS offer government and health department officials a clearer understanding of the effects of their policies on the health of their people(10).

For a long period of time, the health sector used paper based recording system until computerized electronic system start to implement. The use of paper based record faces many challenges such as passive nature of the paper, requires additional personnel to handle and support paper files and to organize countless documents. A great goal of national health care system is not possible without using computer and new technology to attain accuracy in collection, classification, archiving, retrieval and processing of data. Many countries including European countries have moved toward automation hospital information system since the early 1980(11).

EMR is the commonly accepted and used application for storing and accessing patient medical information electronically. The major goal of the medical record is to serve as a repository of the clinician's observations and analysis of the patient. It is unlikely that data will be lost or misplaced. With an appropriate back-up mechanism, it serve as a permanent record of an individual's interaction with the health care system(12).

Medical practice store paper medical record in large warehouse that are filled with paper. These paper records take up space and are less environmental friendly, paper record also tend to deteriorate over time. Electronic medical record can be store in the cloud allowing the use of fewer resources. In addition everyone has different hand writing which is illegible to read and has limited space so, sometimes medical professionals don't have enough space on paper to write everything. Electronic medical records give the space to write everything we need(13).

Regardless of the documented benefits of the EMR, most clinical encounters are still recorded by hand in a paper record with the many problems. The first is that the record can only be used in one place, very disorganized and incomplete. The issue of Security and confidentiality usually ascribed as a problem of the EMR, but there are attributes of the paper record that increase its vulnerability to access by non- privileged outsiders(12).

Smart Care software development in Ethiopia happened in collaboration with the Smart Care team in Zambia and the United States. However this system has limitation, the software is closed application and it's owned by TUTAPE (Tulane University's Technical Assistance Program for Ethiopia), ministry of health doesn't have direct access to make modifications, add modules or improve the system. In addition TUTAPE and MOH inherits Zambian experience and change few things to Ethiopia context and then deploy the system(14). So, designing a system based on the country's current infrastructure and existing problem is important. This project focus on to design EMR system after analysis of the existing system and identify problems. The design system is ready for modification by authorized person.

Due to extensive changes in medical technology and increased expectations of patients, hospitals need to have hospital information system(10). That is why the proposed project is done at Yekatit 12 hospital to improve medical record system for sound, timely evidence based decision making. The current system of Yekatit 12 hospital is paper based and no any prior project is done concerning the system.

1.3. Objective

1.3.1 General objective

To design and develop electronic medical record system at outpatient department of Yekatit 12 hospital medical college, Addis Ababa Ethiopia.

1.3.2 Specific Objectives

- To assess the existing system problem.
- To assess requirements of the new system.
- To design EMR system for outpatient department at Yekatit 12 hospital.
- To develop the designed electronic medical record system prototype.
- To evaluate the developed prototype.

1.4 Scope of the project

The scope of the project is design, development and test a prototype of electronic patient record system at Yekatit 12 hospital medical college. The main focus of the project is to design a system which can maintain information about health condition of the patient who was registered at medical record unit, triage, outpatient department (OPD's) and laboratory. In addition the system sends notification message of emergency reportable disease and test the developed prototype.

1.5 Significance of the Project

Improving the use of patient data at the point of generation provide enhancement of the health of the community who get service in the hospital. Patient record system is a living document that tells the story of the patient and facilitates each encounter they have with health professionals involved in their care. It solves the problem of overwhelmingly report, the need of separate card room, additional human resource, and the loss of patient medical history. Designed EMR system can provide the different stakeholders various important tasks that simplify the provision of the major business process and saves time.

For Patients:- Indirectly benefited from the system by getting quality service which includes good documentation of their records, quicker diagnoses service, avoid repeating tests and decrease waiting time.

For health professionals:- since they are the users of the system it may have a better significance by solving the problem of illegible hand writing ,better treatment decisions having organized, complete, timely and easily accessible data. More importantly the health workers can get enough time for other accomplishments instead of collecting and aggregating manually several reports.

For the hospitals:- The EMR could have a benefit for the hospital for providing higher quality and safer care, for adequate planning and budgeting, for keeping adequate records, with diagnosis. There is no a need of separate card room and additional human resource.

For Policy makers and FMOH: - It facilitates planning and timely decision making process which enable to reach health needs of the community.

CHAPTER TWO

Literature Review

2.1 Overview of Literature

Starting from 1991, the development of IT has marked the new generation of networked technology which affected all areas including health care service. Nowadays, the widespread use of ICT has permeated almost all aspects of life including the healthcare sector. Health information system was introduced to fully utilize especially the Internet in providing better healthcare. Health information system are frequently refers to the interaction between people, process and technology to support operations, management in delivering essential information in order to improve the quality of healthcare services(15) .

2.1.1 A Computer-Based Information System

A computer-based information system (CBIS) is an information system that uses computer technology to perform some or all of its intended tasks. Such a system can include as little as a personal computer and software or it may include several thousand computers of various sizes with hundreds of printers, plotters, and other devices, as well as communication networks (wire-line and wireless) and databases. The basic components of information systems are Resources of people, Hardware, Software, Data and Network (16).

2.1.2 Health information and health information system

Health information is information about all resources, organizations and actors that are involved in the regulation, financing, and provision of actions whose primary intent is to protect, promote or improve health. While Health information systems refer to any system that captures, stores, manages or transmits information related to the health of individuals or the activities of organizations that work within the health sector. Overall, a well-functioning HIS is an integrated effort to collect, process, report and use health information and knowledge to influence policy and decision- making, program action, individual and public health outcomes and research (8).

The health information system provides the basics for decision-making and has four key functions: data generation, compilation, analysis and synthesis, and communication and use. The health

information system collects data from the health sector and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts data into information for health-related decision-making. Health information systems serve multiple users and a wide array of purposes that can be summarized as the generation of information to enable decision-makers at all levels of the health system to identify problems and needs, make evidence-based decisions on health policy and allocate scarce resources optimally. New technologies can contribute to improving data generation, compilation and exchange but will require the existence of clear data quality standards to be of optimal value (3).

There is a need by the health sector of developing countries to use the limited resource effectively in order to provide an efficient and equitable health service to the communities. This then requires sound management that is based on information, which is crucial at each level of the health service management. Correct and up-to-date information is critical, not only for the provision of high-quality clinical care, but also for continuing health care, maintaining health care at an optimal level, clinical and health service research, and planning and management of health system (8).

2.1.3 ICT in Health Care Industry

Health is the state of physical, mental and social well-being of an individual and not merely the absence of disease or infirmity. Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and **technology** made universally accessible to individuals and families in the community through their full participation and at a cost that the community and the country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination(17).

Information and communications technology has increased productivity in many sectors of the economy, and economic growth rests more and more on the contributions of ICT. However, even though the investments in ICT have been growing, the adoption information and communication technology has been relatively slow in health care industry. There are many reasons why the adaption of health ICT has been happening carefully. First of all, there is a lack of demonstrated cost-effectiveness. There is no comprehensive, existing evidence that investments in health ICT unquestionably improve efficiency(18).

Over the past decades, there have been great advances in ICTs for health, and the World Health Organization (WHO) has responded by establishing the Global Observatory for e-Health (GOe) to assess the adoption of e-Health as well as the benefits that ICTs can bring to health care and patients wellbeing. Electronic information systems are being increasingly adopted primarily in higher-income countries, emerging economies such as Brazil, China and India, are beginning to introduce electronic medical records (EMRs) into their health systems. Low-income countries, however, have struggled to initiate large-scale electronic medical record systems. These systems require abundant resources including skilled labor, technological, and financial means, all of which can be difficult to procure in low-income settings. Further, patient information systems designed for high-income country health systems may not be appropriate in low-income countries(2).

Among the countries that have sought to introduce national e-health and telemedicine programmers are Brazil, Colombia, Mexico and Chile. E-Health is an important instrument to improve safety, quality and access to healthcare. Eight areas in which ICT can contribute to health care are access, effectiveness, efficiency, quality, safety, knowledge generation, economic impact and integration. Each of these applies to the specific areas in which the technology is used(19).

Since 2006 Kenya has made progress putting in place an ICT policy framework and implementation strategy. In 2011 Kenya launched its national e-Health Strategy 2011-2017. Ethiopia has had a national e-Government policy since 2009. In 2011 the Health Ministry organized an e-Health workshop in order to begin developing appropriate health informatics standards and an architectural framework for interoperability and scalability of the various e-Health initiatives in the country(20).

2.1.4 Medical Record

In many countries during the 1980s, manual medical record systems were replaced by computerized medical information systems (MIS). In MIS, facts concerning the health or health care of individual patients are stored and processed in computers(21).

Medical record is a chronological written account of a patient's examination and treatment that includes the patient's medical history and complaints, the physician's physical findings, the results of diagnostic tests and procedures, and medications and therapeutic procedures. It is a medical

document that allows, a complete understanding of the patient's health situation over many years(22).

As a written collection of information about a patient's health and treatment, medical records used essentially for the present and continuing care of the patient and in the management and planning of health care facilities and services, for medical research and the production of health care statistics. Doctors, nurses and other health care professionals write up medical/health records so that previous medical information is available when the patient returns to the health care facility. If a medical record cannot be located, the patient may suffer because information, which could be vital for their continuing care, is not available. The medical record "must contain sufficient data to identify the patient, support the diagnosis or reason for attendance at the health care facility, justify the treatment and accurately document the results of that treatment" (Huffman, 1990)(21).

2.1.5 Electronic Medical Record

The idea of recording patient information electronically instead of on paper the Electronic Medical Record (EMR) has been around since the late 1960's, when Larry Weed introduced the concept of the Problem Oriented Medical Record into medical practice (3). The electronic medical record (EMR) comprises a system of recording, processing, storing, and transferring health information electronically. It is computerized medical information system that collect, store and display patient information it requires less personnel, time and less physical storage space(5).

The medical record has been used for more than a century as a tool to assist clinicians in the care of patients. Several studies have shown that paper based records cannot adequately support the task of providing patient care in an efficient manner. Moreover, the overload of general and patient specific information from many resources, seen in bulging files of patients with chronic disease, intensifies the physical and conceptual problems of maintaining paper based patient record. Electronic patient record will significantly change healthcare, rather than merely replacing the paper-based record. Computer-based patient record system: adds information management tools to provide clinical reminders and alerts, linkage with knowledge sources for health-care decision support, and analysis of aggregate data(3).

Growing use of electronic medical record (EMR) systems in Europe and the United States (US) has been driven by the belief that these systems can help to improve the quality of health care.

Decision support systems, particularly for drug order entry, are becoming important tools in reducing medical errors. Individual patient data that are collected and accessible at the point of care can support clinical management. Clinicians can easily access previous records. Physicians or nurses can check on the outcomes of individuals or groups of patients and perform research studies. Many of these functions will work well on paper or with simple spread sheets for up to 100 patients but become very time consuming and potentially unreliable with more than 1000 records, and virtually impossible with 10000 or more(8).

Through the use of the EMR, several limitations that are associated with the paper-based medical record system are clearly overcome. For example, in contrast to the paper record, the EMR can play a larger role in medical decision-making, integrating the services of various departments, customizing care to the patients, reducing medical errors, improving quality, reducing costs, etc. In addition, the EMR can effectively help to transfer patient information from one organization to another and in this way help in referrals and improving the access to healthcare (5).

2.1.6 EMR in Developing Countries

Recording of patient information in many hospitals in developing countries has been on papers. Miller et al (2005) identifies limitations of these paper-based records as including illegibility, ambiguity, incomplete data, poor availability and data fragmentation. Recording of patient information on papers impede the continuity and quality of care for patients. Electronic medical records applications can prompt for completeness; provide better ordering for searching and retrieval, and permit validity checks for data quality, research, and especially decision support(7).

Studies on the adaptation of Electronic Medical and Personal Health Records in developing countries are scarce. There are sharp differences between barriers to adaptation and implementation in developing countries to that of developed countries(23).

Developing countries usually collect district level aggregate health data to plan and manage their health systems. After they have established district level health data collection, these countries may move to more complex data systems including patient information systems, which rely on ICT infrastructure. ICTs can help developing countries make better use of limited resources to improve health by providing better use of information. The survey data analyzed by WHO region

showed that all regions have a high use of paper-based systems, particularly the African Region and South-East Asia Region(2) .

The progression of EMR in developing countries is not a simple task. Many factors contribute to the progression and diffusion of such technologies like technology accesses, Interoperability Security, Confidentiality, reliability, cost language and culture. EMR systems promisingly provide a myriad of benefits to enhance the efficiency of healthcare delivery systems in developing countries. These systems are presently being provided through user friendly and very intuitive interfaces like MS Windows applications built around MS Access, Web interface, PDAs, Voice interface system, scanner reports and e-mail. Compared with the traditional manual systems EMR provide basic benefit. Healthcare users and consumers of EMR in countries like Kenya, India, and Haiti have been reaping the benefits for quite some time. Most of the present EMR implementations in developing countries are centered on HIV/AIDS treatments (20).

2.1.7 Electronic Medical Record in Ethiopia

Ethiopia has a national e-Government policy since 2009. In 2011 the Ministry of health organized an e Health workshop in order to begin developing appropriate health informatics standards and an architectural framework for interoperability and scalability of the various e Health initiatives in the country(20). Currently an effort has been made by FMOH in collaboration with development partners to use EMR to facilitate the health care delivery process in Ethiopia. The implementation of this EMR is through software called Smart Care which is developed by Tulane International in partnership with Tulane University in US, CDC and FMOH. It includes modules for Outpatient, Inpatient, Laboratory, Pharmacy, Reports, etc. (14).

SMART CARE Ethiopia there is an electronic health record system that supports longitudinal record keeping for a clinical care, especially for HIV/AIDS treatment, TB care, VCT, and antenatal care(14).

2.2 Related Study

A study on Electronic Medical Record Adoption in New Zealand Primary Care Physician Offices shows New Zealand has one of the world's most highly automated primary care systems. All of New Zealand's 1,100 general practices use an electronic medical record (EMR) system and the

services of a health system integrator (HSI), a specialized information technology company that has expertise in integrating and supporting electronic clinical messaging, online communications, and security systems to facilitate and support communications with other parts of the health sector. Primary care doctors have comprehensive EMRs with broad functionality to manage the patient's problem list, electronically enter clinical progress notes, perform electronic prescribing, manage medication lists, order laboratory tests and x-rays, and manage diagnostic test results, automatically issue preventive reminders, and access external clinical decision support programs(24).

A project report on Design and Implementation of Hospital Management System in India (2015) the result of the project verifies and validate user input. The user is notified in case of errors detected in the course of using the system. The system captured patient's details at the receptionist which is used to create an account with the doctor and have a reference Id to use in paying bills and charges. The system generates the Patient Identity (ID) and also the Reference ID automatically and identifies inpatients and outpatients which is made possible by a checkbox. Also, it manages entering new stocks of drugs into database and how the drugs are sold which will include assigning a serial number to Reference ID given by the doctor to monitor the sales. The design also allows room for expansion. The system solved the problems associated with the existing manual system(25).

South Africa survey by the World Health Organization indicates that the African region and South East Asia have high use of paper and indicates minimal transformation to electronic records. The limited adoption of EMR systems in developing countries is due to limited or lack of understanding of the problems and challenges surrounding the delivery of healthcare in poor settings and addressing these special needs. As means of providing real-life examples of systems that can function in resource restricted settings, pilot EMR systems have been put in place in several developing countries to establish and provide a body of knowledge as to how EMR systems can be efficiently and effectively implemented. South Africa is no exception to the rest of the developing countries. The implementation of EMR systems in South Africa is minimal. The National Department of Health, based on the e-Health strategy of 2012, has put together future strategies towards implementation and rolling out of e-Health systems. The transformation of the

healthcare services in South Africa requires planned strategies and policies; together with a change in the traditional thinking and learning culture(13).

In Ethiopia, the implementation of EMR is through software called Smart Care. TUTAPE (Tulane University's Technical Assistance Program for Ethiopia) is developing the Smart Care software in partnership with Tulane University, CDC and the Federal Ministry of Health Ethiopia (FMOH). Smart Care was first developed, tested and deployed in Zambia by CDC for HIV/AIDS care and treatment. Besides the rich and advanced functionality and features, Smart Care has also been proven to work in limited resources environment of developing countries particularly in Africa. Thus Ethiopia adapted Smart Care as the preferred EMR application(14).

A project done in Amanuel Hospital by Getnet Alem 2014 for designing an Electronic Medical Record System with structured methodology shows that the hospital was using paper based patient records, health professionals make appointment using calendars. The focus of the project design an EMR for the hospital in the registration, outpatient, laboratory and pharmacy departments which will provide a patient registration feature, electronic order entry and clinical data entry of the registered patient, drug Information . The project concluded automating the existing paper-based patient record system of the health centers plays a great role in improving the health service delivery of the country(26).

Another academic project done on patient record system with object oriented methodology shows the paper-based record system has problems of invisibility of records, inaccessibility and difficult to deliver comprehensive and timely health information for local use. The system contain patient registration, diagnosis list, and medication and laboratory result functionalities (27). This project is designed by OOAD methodology with additional functionalities like register user and assign privileged, search patient information and send notification for emergency reportable disease. Since OPD including medical record unit is the beginning of hospital information system where patient data is start to register and used as a source for other activities the project focus on to design a system at OPD.

CHAPTER THREE

Methodology

3.1 Study Area and Period

The project was conducted at Yekatit 12 hospital which is found in Addis Ababa, the capital city of Ethiopia. The hospital was established in 1929 and became a referral hospital in 2004 E.C. currently there are 1130 employees working in the hospital. The project was conducted from January 2017 to June 2017. Currently Yekatit 12 hospital uses manual (paper based) patient record system. These records are in line with the HMIS data collection and reporting tools designed for the hospital. The daily routine service in the hospital has to be recorded manually using different paper formats and registers.

3.2 Design Science

Design science creates and evaluates IT artifacts intended to solve identified organizational problems. It involves a rigorous process to design artifacts to solve observed problems, to make research contributions, to evaluate the designs, and to communicate the results to appropriate audiences. The result of design science research project is a purposeful IT product created to address an important organizational problem(28). Hevner et al provided rules for conducting design science research project in the form of seven guidelines. From the guidelines effective design science must provide clear and verifiable contribution in the areas of design product, design foundation and design methodologies(29).

System development methodology is a standard process followed in an organization to conduct all the steps necessary from requirements analysis to design, development and testing(30). Object oriented methodology with incremental and iterative designing cycles was used as the methodology to design the system. The method is appropriate to design the system since there are different objects interacting within the system like patient, health professional, nurse, diagnosis, tests, and medications. Object-oriented program is made up of interacting objects and concerned with developing an object-oriented model of a software system to implement the identified requirements. The objects in an object-oriented design are related to the solution to the problem that is being solved. That is why the investigator uses this method to design the proposed system.

Unified modeling language (UML) artifacts was used to represent the different class, use case and sequence diagram (30).

In Incremental and iterative design the system grown via iterations and incrementally adding new features. Incremental development is a staging and scheduling strategy in which various parts of the system are developed at different times or rates and integrated as they are completed. Iterative development is a rework scheduling strategy in which time is set aside to revise and improve parts of the system(31).

Unified Modeling Language (UML) was used as visual representation .UML is a standardized general-purpose modeling language in the field of object-oriented software engineering. UML includes a set of graphic notation techniques to create visual models of object-oriented software systems(32).

3.3 Source and Study Population

All individuals working in the hospital are source population. Staffs at OPD, triage room, laboratory, medical record unit, HMIS officer and executive staff (medical director) were selected as study populations. The sample populations are those who actually participate in the study.

3.4 Sample Size Determination

A total of 18 participants were selected from each department by purposive sampling technique. The reason behind purposive sampling is that the investigator is doing a project wants to address those who have direct interaction with the system through patient registration, diagnosis and treatment, report generation. The method is important to gather the required information for designing of the system. The participants are one medical director, from 7 physicians at OPD 3, from 35 laboratory technicians 5, from 6 triage officer 3, from 20 data clerk 4, and from 5 HMIS 2 were selected purposively. The criteria for purposive sampling is work experience, educational level and those who closely interact with the system.

3.5 Inclusion and Exclusion Criteria

The inclusion criterion for the project was staffs who are currently working in the selected hospital (doctor, nurse, Data clerk, HMIS officer, medical director) and exclusion criteria those who are not available in the time of data collection due to different reason like annual leave, training and maternity leave.

3.6 Methods of Data Collection Tools

Use of qualitative data provided detail insight that enabled investigation of the depth of contents to be developed. To this effect, the investigator collected appropriate data qualitatively. System requirements for EMR system data was collected by the principal investigator using in-depth interview with semi-structured questionnaires, observation and document analysis. An interview is a data-collection technique that involves oral questioning of respondents, either individually or as a group it is an excellent way to learn in depth information from a person for primary research project (33). A face to face interview was conducted. For further analysis in the design of the system their response were taken by hand writing and recording. The interview made with each respondent takes average of 25 minute.

Observation is a technique that involves systematically selecting, watching and recording behavior and characteristics of living beings, objects or phenomena(34). Non-participant observation of the activities in the hospital (business process), and the information flow of the existing system was collected using observation checklist.

Document analysis is an investigation method that focuses on material and documents which already existed(35). Analysis of the different paper based documents, formats, registers and tally sheets were reviewed to identify problems with the current system. Data items and report generated by the current system were also reviewed.

3.7 Data Quality Assurance

Before the actual data collection, data collection instruments was prepared according to the informational need of the project. Recording the interview was done. Finally the collected data was checked for its completeness before used for the design of the project.

3.8 System analysis and design tools

The project involves analysis of the system from an object oriented view for this to have objected oriented analysis and design were used. The design is made by unified modeling language which is a graphical design notation useful for object oriented analysis and design. It is an international standard graphical notation for describing software analysis designs. When a standardized notation is used, there is little room for misinterpretation, ambiguity and provides for efficient communication (32). For the design of EMR system Visio 2007, Visio 2013, visual paradigm 10.2 and UML was used as software tools.

3.9 System development tools

The Front end user interface: HTML enable the construction of easy and intuitive user interface for accessing the database and to display in html document.

Middle ware: which is the business logic of the system through WAMP server using PHP.

Back end: My SQL it's easy to use, inexpensive database language it can run on a variety of operating system such as window, Linux, and others. It is secure and technical support is widely available on the internet but most of all it supports large databases.

3.10 System Testing

System testing is the process of analyzing a software item to detect the differences between existing and required conditions and to evaluate the features of the software item .System testing is an activity that should be done throughout the whole development process(36). System testing is used to identify the correctness, completeness, security and quality of software products against a specification(37). There are different types of system testing. Since it is prototype usability testing were done by based heuristic evaluation guidelines. Which is an informal method of usability (is a feature of interaction between the user and the system) analysis where a number of evaluators are presented with an interface design and asked to comment on it. The evaluation is done by looking at an interface and trying to come up with an opinion about what is good and bad about the interface(38). With heuristic evaluation, someone looks at the user interface by using list of rules or guidelines to identify potential problems(39).This method is appropriate because analyzing the application's usability with usability heuristics during the development phase is a low-cost and easily implementable way to improve usability(40).

3.11 Ethical Consideration

To conduct this project ethical clearance was obtained from Addis Ababa University School of public health. In addition official letter was given to Yekatit 12 hospital. Before required information was gathered, study participants were asked for their permission to be part of the project and they were told that as they have the right not respond or participate in the project.

3.12 Dissemination of Results

The final result of the project will be submitted to AAU as partial fulfillment of MSc in health informatics and communicated to Ethiopian Ministry of health and Yekatit 12 hospital. The result of the study will also be distributed through scientific conferences and publication.

CHAPTER FOUR

System Analysis and Design

4.1 Introduction

The process of requirement gathering is the key task of the first stage of software life cycle. Requirement collection and analysis is one of the basic steps in the software development life cycle. It is the step where problems are identified, possible solutions are submitted and analyzed to identify the best fit for the ultimate goal of the project. In this chapter the current system, the business process, the functional and nonfunctional requirements and different UML diagrams are presented.

4.2 Business area analysis

Investigations of the existing system in use provide the basic and necessary inputs for proper functionalities of the system to be designed. The findings of the existing system according to the respondents by the use of the semi-structured questionnaire developed for interview and observation by the investigator are identified and presented in accordance with the different information system components. Manual analysis was found to be the best method for analyzing the collected data because all the collected data is manageable in amount and all about requirement gathering. The goal is to reduce the data by producing summaries to gather requirements for the project. Since, it is difficult to write up summary from recording the information gained through in depth interview and hand writing were transcribed after transcription, organization, interpretation of data were done. Since, the aim of collecting data in this project is to gather requirements for the proposed system the investigator chose to interpret and summarize the data accordingly and present as follows.

4.2.1 Major function of the existing system

Currently Yekatit 12 hospital uses manual (paper based) patient record system. These records are in line with the HMIS data collection and reporting tools designed for the hospital. The daily routine service in the hospital has to be recorded manually using different paper formats and registers.

The major activities or business process of the existing system are:-

➤ **Patient registration**

Purpose: - The purpose of this function is to register new patient and update existing patient.

Input: - The patient personal information, address and the different registration formats.

Process: - Once the patient presents in the registration department with referral slip if the patient is new the data clerk register the patient's full information including personal information and address and gives service identification card after paying the service fee. Whereas if the patient is existing, the data clerk search the patient card by his/her service identification card and update patient visit and send to triage.

Output: - Patient is registered at medical record unit.

➤ **Assign patient**

Purpose: - It is to assign patient to each medical OPDS and other different care giving department.

In put: - Vital sine results such as temperature, blood pressure, respiratory rate, pulse rate, random blood sugar and recording formats used as an input.

Process: - After registration, the patient came to triage room. The triage officer screen the patient by measuring there vital sine (pulse rate, respiratory rate, blood pressure, temperature) depending on the history given by the patient they also do random blood sugar test. Finally they assign the patient according to their result to the corresponding outpatient department.

Output: - Patient is assigned accordingly to get service.

➤ **Patient diagnosis and treatment**

Purpose: - The purpose this activity is to take patient history, do physical examination, diagnose and treat patient.

In put: - Patient history, physical examination result, laboratory result and the different HMIS registers.

Process: - The business process of the outpatient department is once the patient arrives in the outpatient department with patient card, the nurse registers patient name, medical record number, age, sex and date of visit. The doctor takes the identification information which includes the socio demographic information, the vital singe measured by the triage officer. Take detailed history of the patient, perform physical examination and order laboratory investigation if needed. According to the laboratory result and medical history of the patient, the physicians prescribe medication and appoint the patient to the next visit if it is needed. Finally patient card is collected and returned to medical record unit. Depending on the type case there may be consultation, referral and admission cases.

Output: - patient is diagnosed and treated.

➤ **Laboratory service**

Purpose: - The purpose is to investigate the patient to support the diagnosis process.

In put: - laboratory request forms and the type of test needed.

Process: - The patient comes in the laboratory department with laboratory request. The laboratory technician register the test order in the logbook which includes the department which ordered the test, name of the patient, sample id ,date and the type of test and estimate the cost that the patient has to pay for the service. One of laboratory technician takes sample and tell to the patient to go back to outpatient department and wait there. The result is recorded in the result logbook and distributed accordingly by porters.

Output: - laboratory test result.

➤ **Generate Report**

Purpose: - To compile report from different care giving unites from different registration books and tally sheets.

Input: - Registration logbooks and tally sheets.

Process: - HMIS officer Collect report of each department and generate as aggregated report.

Output: The outputs are either weekly, monthly, quarterly biannually nine month or annual report.

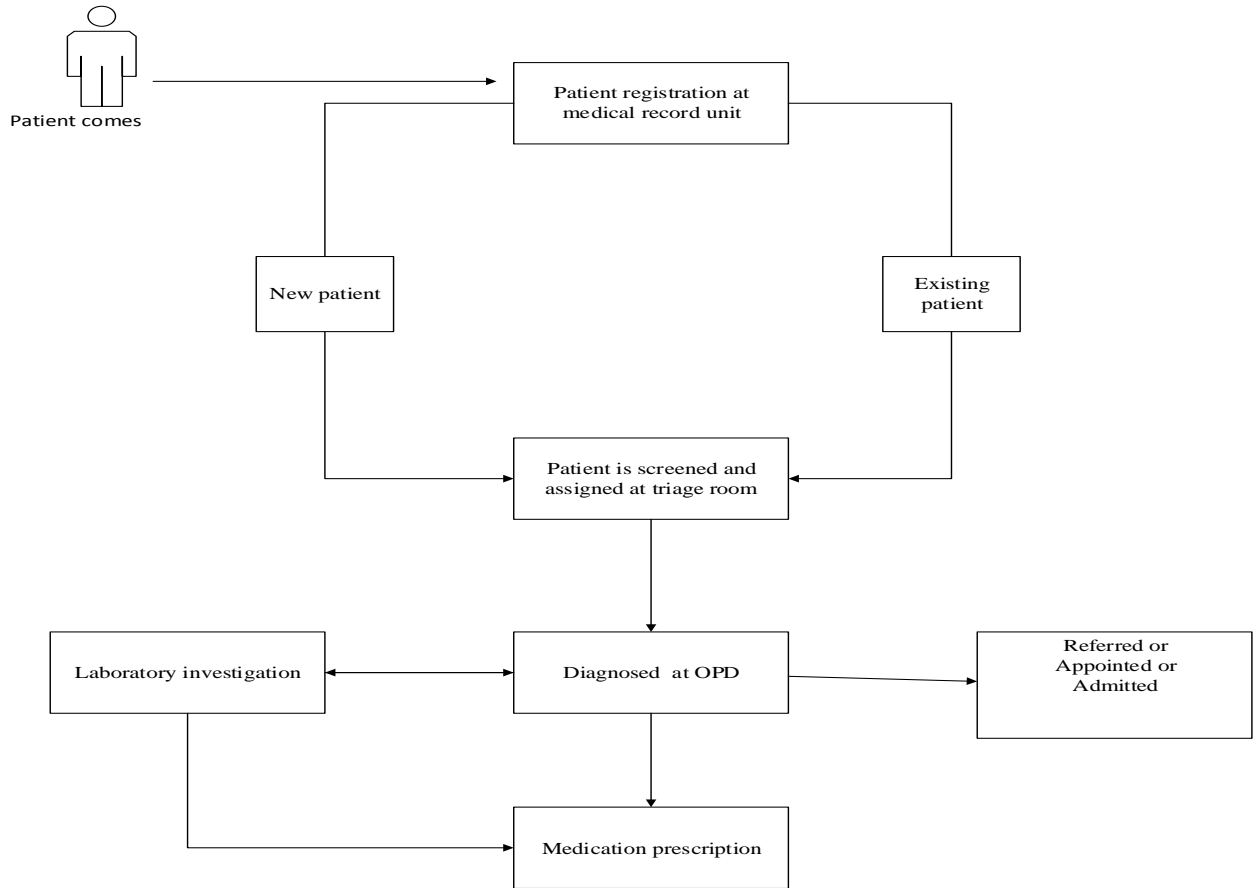


Figure 1: Business process flow chart of the current system.

4.2.2 Formats and registers used in the existing system

There are different HMIS formats, registration books and tally sheets in the current system.

✓ Registration Form

Purpose: - This form is used to record patient personal information and address.

Content: - Integrated card, service identification card, and master patient index.

User: - Data clerk.

✓ **.Diagnosis form**

Purpose: - This form is used to record patient medical history, physical examination, diagnosis and treatment.

Content: - Personal identifications information, chief complaint, medical history of patient physical examination finding laboratory result and diagnosis.

User: - The user of this form is a Physician (doctors).

✓ **Laboratory Request Form**

Purpose: - To request different types of laboratory investigation to support the diagnosis processes.

Contents: - The content includes the different laboratory request forms such as hematology, chemistry, serology, bacteriology, urine analysis and stool.

Users: physicians (doctors, HO, nurse) and lab technicians.

✓ **Prescription Form**

Purpose: - To prescribe medication for the patient.

Content: - It contains patient personal identification information, diagnosis, drug name, dose, frequency, duration, name of prescriber's and signature

User: - Used by physician (doctor, HO, nurse)

✓ **Appointment Form**

Purpose: - Used to appoint patient for follow up.

Contents: - Personal identification information, diagnosis, reason for appointment and date of appointment.

User: - /Doctor /Nurse

✓ **Referral Form**

Purpose: - Used to refer patient to other facility for further diagnosis and management.

Content: - personal information, diagnosis, treatment given, investigation done ,reason for referral, name of receiving hospital or department name of receiving hospital or department.

User: It is used by physician (doctor).

✓ **Admission form**

Purpose: - Used to admit patient to in patient department.

Content: - personal information, diagnosis, treatment given, investigation done, reason for admission.

User: It is used by physician (doctor).

✓ **Consultation form**

Purpose: - Used to consult other physician or department about patient diagnosis.

Content: - personal information, diagnosis, treatment given, investigation result, clinical finding and reason for consult

User: It is used by physician (doctor).

4.2.3 Report Communication in the existing system

Routine data generated from the hospital are aggregated and reported to Addis Ababa health biro every month, quarterly, biannually, nine month and annually. Depending on the type of report and stakeholders, there are also daily and weekly reports. HMIS registers and tally sheets are used as input tools in which data from each department is registered and collected manually into different reporting format to be compiled by HMIS officer and generate as report as an output .

4.2.4 Players of the existing system

Those who have a major role in the existing system of outpatient department are:

Table 1: Players of the existing system

Actor name	Description
Data clerk	Data clerk refers to a person who gives service in the registration department (medical record unit), register the patient personal information and address.
Triage officer	Triage officer refers to a professional who screens and assign patients to each case teams
Physician	Physician doctor/HO/nurses refers to professionals who diagnose and treated patients and record the diagnosis and treatment.
Laboratory technician	Laboratory technician refers to professional who performs the diagnostic services or laboratory request, and record the result.
HIMS officer	Compile HIMS report

4.2.5 Software and hard ware in the current system

The coordinator in card room says that they used to use smart care data base donated by Tulane University with demographic information (name, address, and medical record number (MRN)) that helps in tracing patient medical record by their name or phone number in case if they lost their service card. But currently it suddenly stop working and they are waiting maintenance for the last 3 month. They also use manual patient tracing system using MPI to find uniquely identifying MRN of a patient who lost his/her service card by linking client's name with his/her MRN. MPI are kept in medical record unit in alphabetical order. The medical director of the hospital Saied that they are planning to purchase on network installation to use the EMR system in the long run. In the outpatient department of the hospital (medical record unit, triage room, outpatient department and HMIS office) there is a total of 12 desktop computers. There is no any computer in the OPD. The available computers are used mainly for patient registration in the card room and report generation. Some activities of the existing system has to continue as it is like medication prescription.

4.2.6 Problems of the existing system

Routine patient data is recorded in paper-based HMIS data recording and reporting tools. However, these tools were not free of any problem. The problems of the current system by The PIECES Problem-Solving Framework and Checklist. Where P- Performance, I- information, E-economy, C-control/security, E-efficiency and S-service.

A) Performance

Performance Problems means the amount of work performed over some period of time, and the average delay between a request and a response to that request.

- ❖ The routine activities in the hospital starting from patient registration to diagnosis and treatment is time taking.
- ❖ Retrieval of patient history card from the shelf's, searching previous patient information and aggregating report from paper files takes a lot of time.

B) Information

Information problems means problems related to in input, output and stored.

- ✓ Input related problems
 - ❖ Data is not properly recorded
 - ❖ Data is difficult to read
 - ❖ Same data captured more than once
 - ❖ Missed up of laboratory result
- ✓ Output related problems
 - ❖ There is Loss of necessary patient information
 - ❖ There is unreadable too much information
 - ❖ Information is not timely to users

- ❖ Invisibility of records during the interview made, it was found that the registers and tally sheets have created problems because the hand write of some health providers was difficult to read and understand by other users of the data that result in data redundancy, overwhelming and duplication.
- ✓ Stored data related problems
 - ❖ Data is stored redundantly in multiple files not complete and well organized
 - ❖ Data is not secure to accident
 - ❖ Data is not flexible to use and it is not easily accessible

C) Economy

- ❖ There is a need of huge separate card room with many shelf's and tables to keep patient history folders result in resource wastage.
- ❖ Hiring additional human resource for arranging folders on the shelf. And porters to distribute patient card to each department.
- ❖ High use of stationary materials.

D) Control/security

Patient information should be secured from the initial creation of the data until the final disposal of the information in order to attain the applicable objectives of preserving the integrity, availability, and confidentiality of information resources. And there should be backup system in case the original data get damaged by different factors that are lack of disaster recovery. The participants clear out that information recorded in the registers can be accessed by unauthorized individuals because there is no means of securing the class room especially at working hours and there is also no backup system.

E) Efficiency

- ❖ The routine process wastes time
- ❖ Searching patient information , and organizing patient documents is not an easy task for health professions
- ❖ The generation report from different registration books and tally sheets is time taking.
- ❖ Sometimes the whole patient card is lost, this all result in decrease efficient use of resources.

F) Service

- ❖ The manual system is not easy to accomplish tasks timely
- ❖ Patients has to wait for some time result in decrease patient satisfaction
- ❖ Delay in planning , budgeting and decision making

4.2.7 Practices that need to be preserved from the existing system

There is a need to continue some activates in the existing system such as the finance process, medication prescription and laboratory request depending on patient need.

4.2.8 The proposed system

The proposed system for Yekatit 12 hospital works on computers via local area network. There is a database to store the patients' health record as well as to integrate the department's registration, triage, laboratory, and outpatient departments. The users use computers to record and review the patient information. The system will help to facilitate information exchange, to have complete, organized timely available data that improve the quality of health care. In addition it will reduce the errors that are prevalent in the manual paper based recording system. The generation of timely report from the system will also enable a sound decision making by the stakeholders.

4.3 Requirement analysis

Requirement analysis is the process of studying and analyzing the customer and the user needs to arrive at a definition of the problem domain and system requirements. The quality of the final product is highly dependent on the effectiveness of the requirements identification process(41).

4.3.1 System function

Functionality of a system is defined by the set of actions or services that it provides to the users. Requirements gathering are necessary for the development of systems that satisfy user expectations, support clear design, development, and test procedures of system development. System requirement is an aspect of what the proposed system must do and a constraint on the system's development. In either case it must contribute in some way towards adequately solving the customer's problem. It can be either functional or nonfunctional(42).

I. Functional requirement

Functional requirements describe the behaviors (functions or services) of the system that support user goals, tasks or activities. A functional requirement relates directly to a process the system has to perform or information it needs to contain explain what has to be done by identifying the necessary task, action or activity that must be accomplished(43). Accordingly the functional requirements of designing electronic medical record system are:-

1. The system registers users of the system.
2. The system should authenticate the user and assign privileges according to the assigned rights
3. The system should be able to register the necessary patient information.
4. The system searches patient information.
5. The system updates the patient information
6. The system updates user account
7. The system records patient diagnosis and treatment data.

8. The system registers the appointment date of the patient.
9. The system registers the patient laboratory order and result.
10. The system records medication order
11. The system alert emergency reportable disease
12. The system should be able to generate reports of outpatient department.

II. Non-functional Requirements

Non-functional requirements include constraints and qualities. Qualities are properties or characteristics of the system that its stakeholders care about and hence will affect their degree of satisfaction with the system. Constraints are not subject to negotiation and unlike qualities are theoretically at any rate off-limits during design trade-offs. They are requirements that specify criteria that can be used to judge the operation of a system(43). Nonfunctional requirements regarding the system are:-

➤ Security

Security is keeping unauthorized entities from doing things or Prevent Unauthorized or Inappropriate access. File permissions are based on user identity, which is based on authentication pass word (44). The system is about to handle patient information which is confidential and personal. There are many users that interact with the system so the issue of security is mandatory. The proposed system should have access to authorized user with unique user names and passwords and shall authenticate and validate each user with a unique identification number. The information exchange between triage officers, laboratory technician and outpatient department should not allow any other person.

➤ Availability

Availability is the time when the system must be available for use. To keep information available when and where it is needed, plan for backing up information contained in the system and recover the system in the event of an incident, such as fire, or natural disaster(45). Since the hospital give service for 24 hour the system must be available to users Monday through Sunday all the time 24

hours of a day and 7 days of a week . There has to be 24 hour electricity and back up source generator to work the system without interruption.

➤ **Maintainability**

Maintainability is the activity of modifying a software product after initial delivery. Maintainability is the ease with which a software product can be modified(46). The system shall be easily maintained by the developer as well as other authorized trained person and will also be modifiable at any time to enhance features based on the hospital needs.

➤ **Reliability**

Reliability is identification and solution to potential problems. The ability of system and integrity of information maintained and supplied to the system(45). The information stored in the system is very important for future patient management and decision making so a daily base backup data must be stored on external hard disk and saved. The saved data should be stored in a space where they shall be protected from fire or water damage.

➤ **Performance**

Describes performance constraint involving time/space bonds such as work load, response time, and availability storage space(45). Health professional need organized, complete, timely available patient information for care provision. For this to have the system should have a very simple and user friendly interfaces for everyone to understand the functionalities easily. The System should display stored patient information with speed at the time of need and able to generate required report.

➤ **Usability**

Interface requirements describe interaction of the system with users, hardware, software, and communications(47). Since there are different users of the system with different knowledge on technology user interface should be able to address this usability needs. The system interface should present an easy and user friendly interface to the user.

4.3.2 Essential use case diagram

Are abstract technology free dialogues of user intention and system responsibility that effectively capture the requirements for user interface design, Once the design is completed essential use cases would be translated into more conventional form. Essential use cases can drive object oriented design directly since they are requirement gathering tool. Provide practical operational guidance on how to move to an object oriented design from the requirements(48). Essential use cases are semiformal models which we automatically extract from natural language requirements(49).

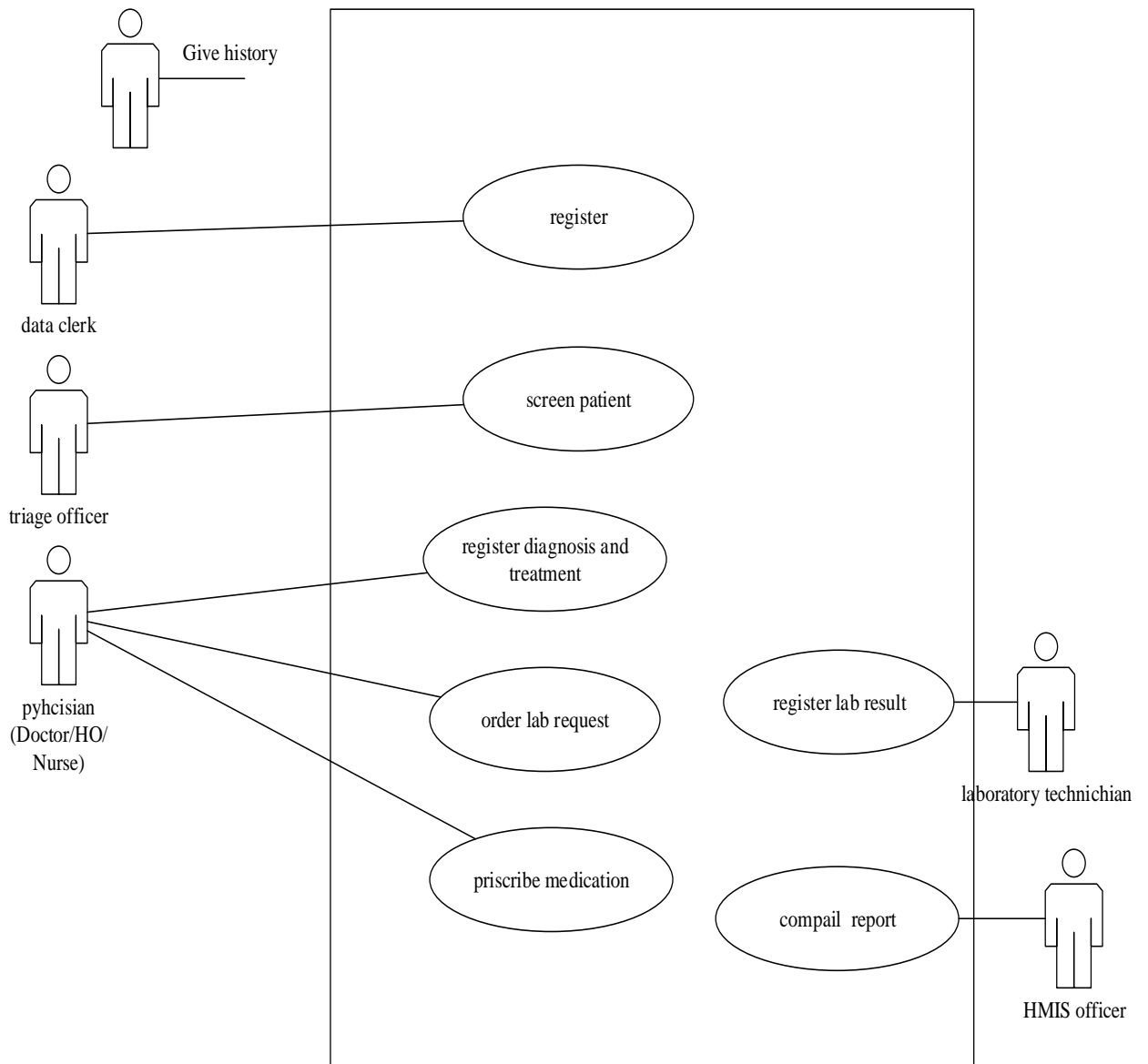


Figure 2: Essential use case.

Essential use cases selected for requirement analysis are patient registration, screen patient, register diagnosis, treatment and laboratory test result.

Table 2: Registration essential use case scenario.

Use case ID	UC-1
Use case name	Patient registration
Primary actor	Data clerk
Description	This Use Case describes the process of how the data clerk register new patient/update repeat patient.
Pre-condition	Patient has to come with referral paper
Post-condition	1.The patient has to register 2.The patient will have unique specific ID(medical record number)
Main Scenario	<ol style="list-style-type: none"> 1. The Use Case starts when a data clerk ask for referral paper 2. The patient give the referral paper. 3. The data clerk write the required information on the card 4. The data clerk transfer Patient card to triage 5. Use case ends
Alternative flow	<p>3a. if patent existing.</p> <p>3a1. The data clerk take patient service identification card and search patient card by medical record number</p> <p>3a2.update patient visit</p> <p>4. Use case ends.</p>

Table 3: Screen Patient essential use case scenario.

Use case ID	UC-2
Use case name	Screen Patient
Primary actor	Triage officer
Description:	This Use Case describes the process of how triage officer screen and assign patients to the specific case team.
Pre-condition	1.The patient should be registered at card room and have patient card
Post- condition	1.Patient is screened and assigned to the corresponding OPD
Main Scenario	<ol style="list-style-type: none"> 1. The Use Case starts when a patient comes at triage department 2. The triage officer ask the symptoms of the patient 3. The triage officer measure vital sine 4. Based on the findings The triage officer transfer patient to OPD 5. Use case ends

Table 4: Register diagnosis and treatment essential use case scenario.

Use Case ID	UC_3
Use case Name	Register diagnosis and treatment
Primary actor	OPD physician
description	This use case describes the process used to diagnose and treat patient at outpatient department.
Pre-condition	1.Patient registered and assigned
Post-condition	The patients full clinical detailed history, diagnosis and treatment is registered.
Main Scenario	<ol style="list-style-type: none"> 1. The Use Case starts when a patient come 2. The physician registers the patient history in to the form 3. physician write laboratory request 4. The result comes by porter 5. The physician view test result 6. The physician prescribe medication and give to patient 7. Use case ends
Alternative flow	<p>3a. If No need of lab test</p> <p>3a1.The physician record diagnosis and treat asymptotically</p> <p>6a.If no need of treatment</p> <p>6a1.The physician may counsel and appoint the patient</p> <p>6a.The physician may refer or admit patient</p> <ol style="list-style-type: none"> 8. Use case ends

Table 5: Register laboratory result essential use case scenario.

Use case ID	UC-4
Use case name	Register Laboratory result
Primary actor	Laboratory technician
Description	The use case describes the process used to record laboratory result
Pre-condition	There has to be laboratory order
Post-condition	1.Laboratory test has to be done 2. Laboratory result is registered
Main Scenario	<ol style="list-style-type: none"> 1. The use case starts when the laboratory order is come 2. Laboratory technician perform the request 3. The laboratory technician fills lab results on the lab order entry form and distribute to OPD by porters 4. Use case ends

4.3.3 Essential User Interface

A user interface is the system by which people (users) interact with the computer. It can contain both hardware and software components(47). Requirements need to be validated at an early stage of analysis to address inconsistency and incompleteness issues. Essential Use Cases are tools for capturing requirements that will be translated to essential User Interface. User Interface is an interface between the user and the computer. Essential user interface provides the general idea behind the UI but not its exact details. It focuses on the requirements and not the design(49).A user interface is well designed when the program behaves exactly how the user thought it would(50).

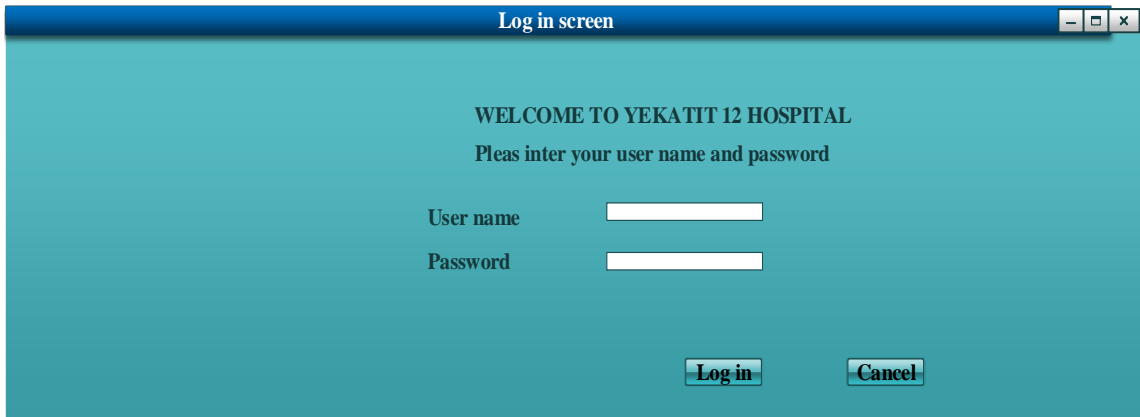


Figure 3: Essential login window.

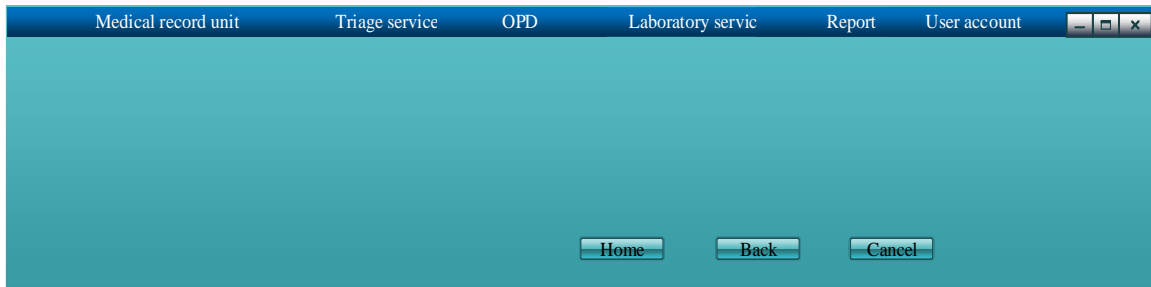


Figure 4: Essential main window.



Figure 5: Essential window for medical record unit.

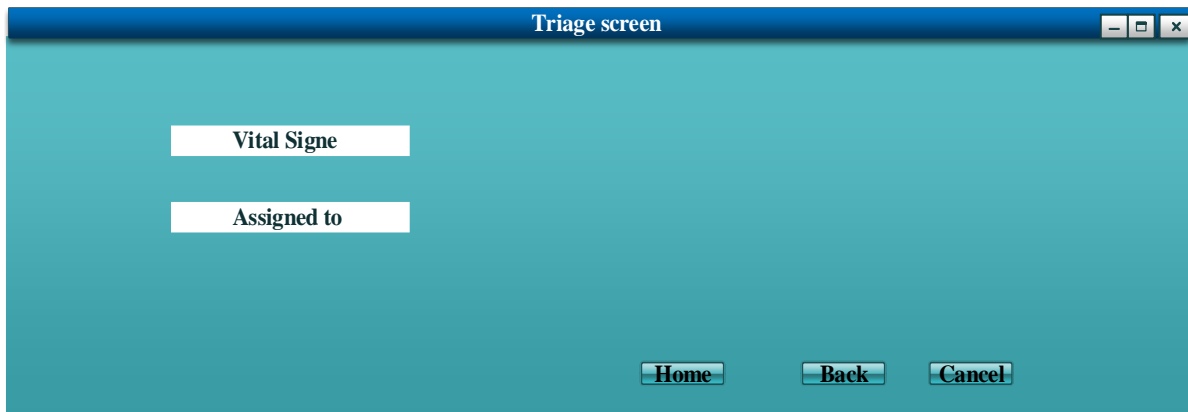


Figure 6: Essential window for triage screen.

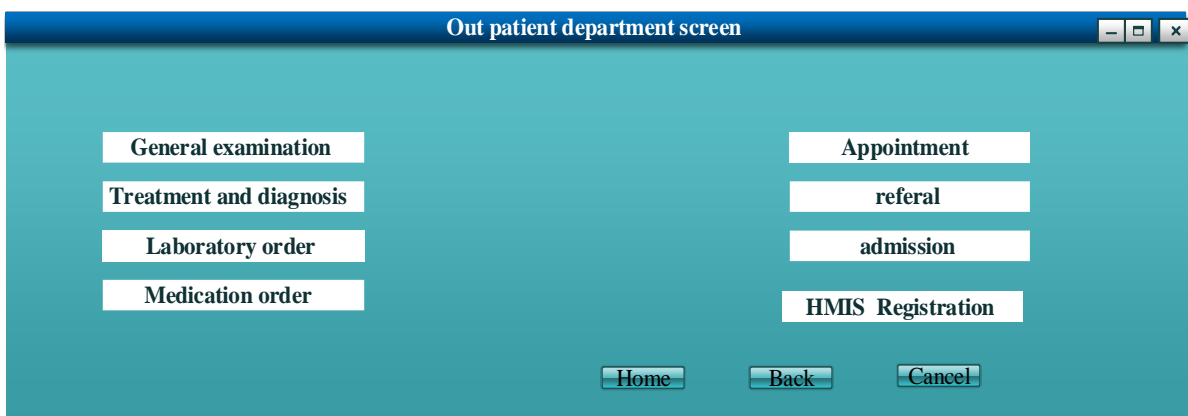


Figure 7: Essential window.

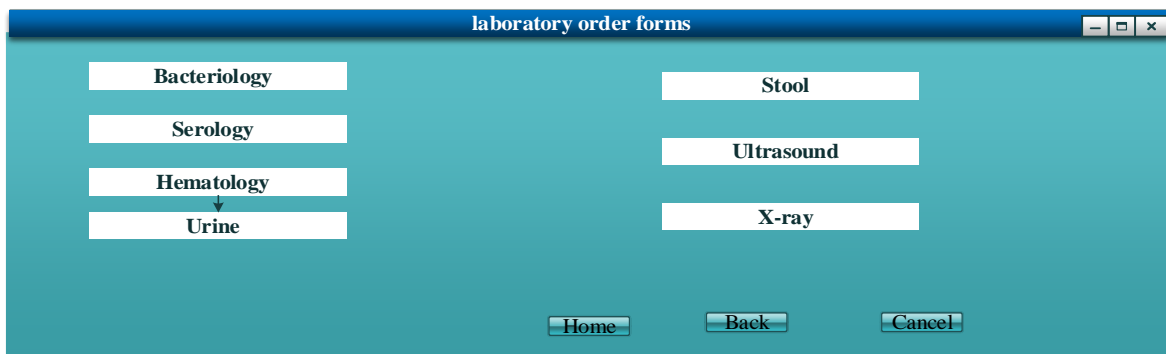


Figure 8: Essential laboratory order window.

4.4 System Analysis

The analysis step focus on defining the problem by collecting the requirements that indicate the specific problems to be solved (51). Studies the organization's current procedures and the information systems used to perform tasks. Analysis has several sub phases. The first sub phase involves determining the requirements of the system to determine what the users want from a proposed system. This sub phase involves a careful study of any current systems, manual and computerized, that might be replaced or enhanced next study requirements and structure according to their interrelationships to generate alternative initial designs to match the requirements. The output of the analysis phase is a description of the alternative solution(52).

4.4.1 Process modeling

A Process Model is a formalized view of a business process represented as a coordinate set of parallel and/or sequential set of process activities that are connected to achieve a common goal. A Business Process is a collection of related structured activities that produce a specific service or product for a particular customer(29). Business process diagram shows the processes that take place within the system that is being developed. The most important thing is that the diagram displays the processes in the correct order to achieve the goal(53)

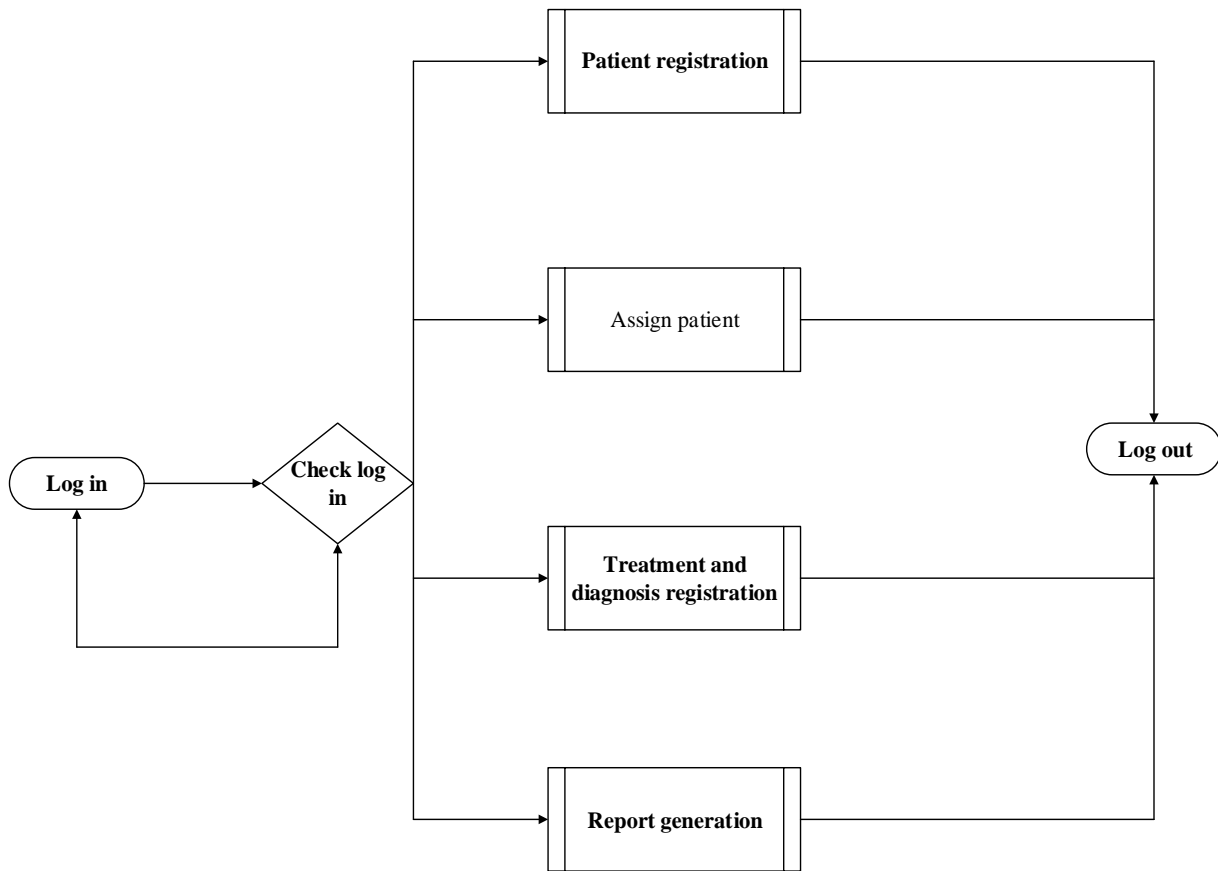


Figure 9: Business process modeling of the proposed system.

4.4.2 Contextual diagram modeling

It is mainly a high level modeling technique that is used to position the boundaries of the system, so that we know exactly where to cut it off, if we have a doubt or ambiguity in the requirements we should be model. Essentially illustrate the operational context of the system. So, that we are trying to differentiate what the boundary of the system and scope out the system(54).

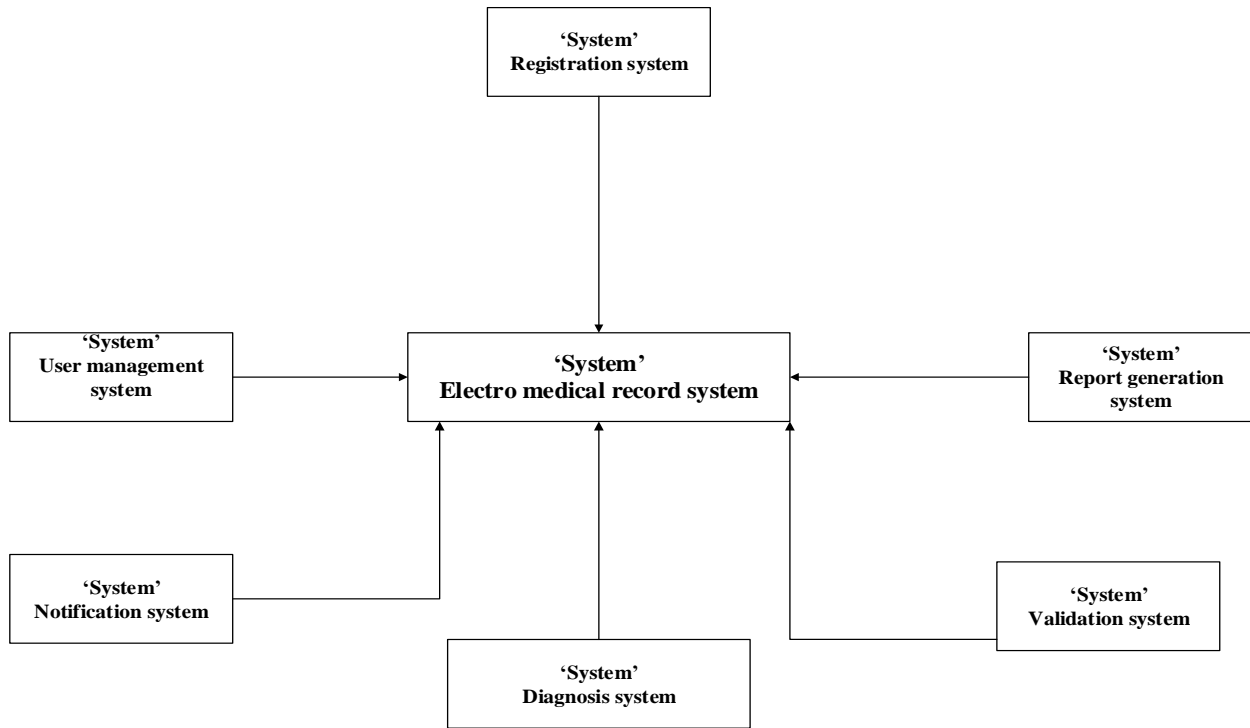


Figure 10: Contextual diagram of the proposed system.

4.4.3 System Modeling

System modeling is the process of developing abstract models of a system, with each model presenting a different view or perspective of that system. System modeling has now come to mean representing a system using some kind of graphical notation, which is now almost always based on notations in the Unified Modeling Language (UML). System modelling helps the analyst to understand the functionality of the system and models are used to communicate with customers(55).

4.4.4 Object oriented modeling

Object oriented systems development is a way to develop software by building self-contained modules or objects that can be easily replaced, modified and reused. An object orientation produces systems that are easier to change, more flexible and reusable. UML can be used throughout the software development life-cycle and across different implementation technologies. Used model both structural and behavioral aspects of these systems, Structure-related notations class and use case diagram ,behavior-related notations sequence diagram(56).

4.4.5 Use case modeling

Use case modeling is a different and complementary way of eliciting and documenting requirements. There are four components of use case modeling actors (roles played by people or things that use the system), use cases (things that the actors can do with the system); relationships (meaningful relationships between actors and use cases) and system boundary (a box drawn around the use cases to denote the edge or boundary of the system being modeled) (57). Use cases drawn as ellipses with a name in or below each ellipse describes a sequence of action that the system perform to achieve an observable result to an actor the name is usually an active verb and a noun phrase(58). Each Use case describes a typical scenario in which the user uses the system. Use case diagrams are produced during the analysis stage of soft were development life cycle to model the interaction between system clients(51). Scenario is a brief user story explaining who is using the system and what they are trying to accomplish. A Scenario is made up of a number of simple discrete steps that are designated as being performed by either the system or a user(59).

The electronic medical record system has six major actors in which each of them have their respective identified tasks.

Table 6: System actors and description for electronic medical record system.

Actor name	Description
Data clerk	Data clerk refers to a person who gives service in the registration department (medical record unit), enters the patient personal information and address to the system and send to triage officer.
Triage officer	Triage officer refers to a professional who screens and assign patients to each case teams
Physician/HO/nurses	Physician/HO/nurses refers to professionals who diagnose and treated patients and enters the diagnosis and treatment data's to the system
Laboratory technician	Laboratory technician refers to professional who performs the diagnostic services or laboratory request ,record laboratory information to the system and send to the OPD
Administrator	Administrator refers to the person who administers or manages user account the system.
HIMS officer	Compile the whole report from each department to Generate aggregated HIMS report

The electronic medical record system has a total of 10 (ten) use cases these are log in, register patient , assign patient, add diagnosis and treatment data, send alert, register test result, search and update patient ,manage user account and generate report .

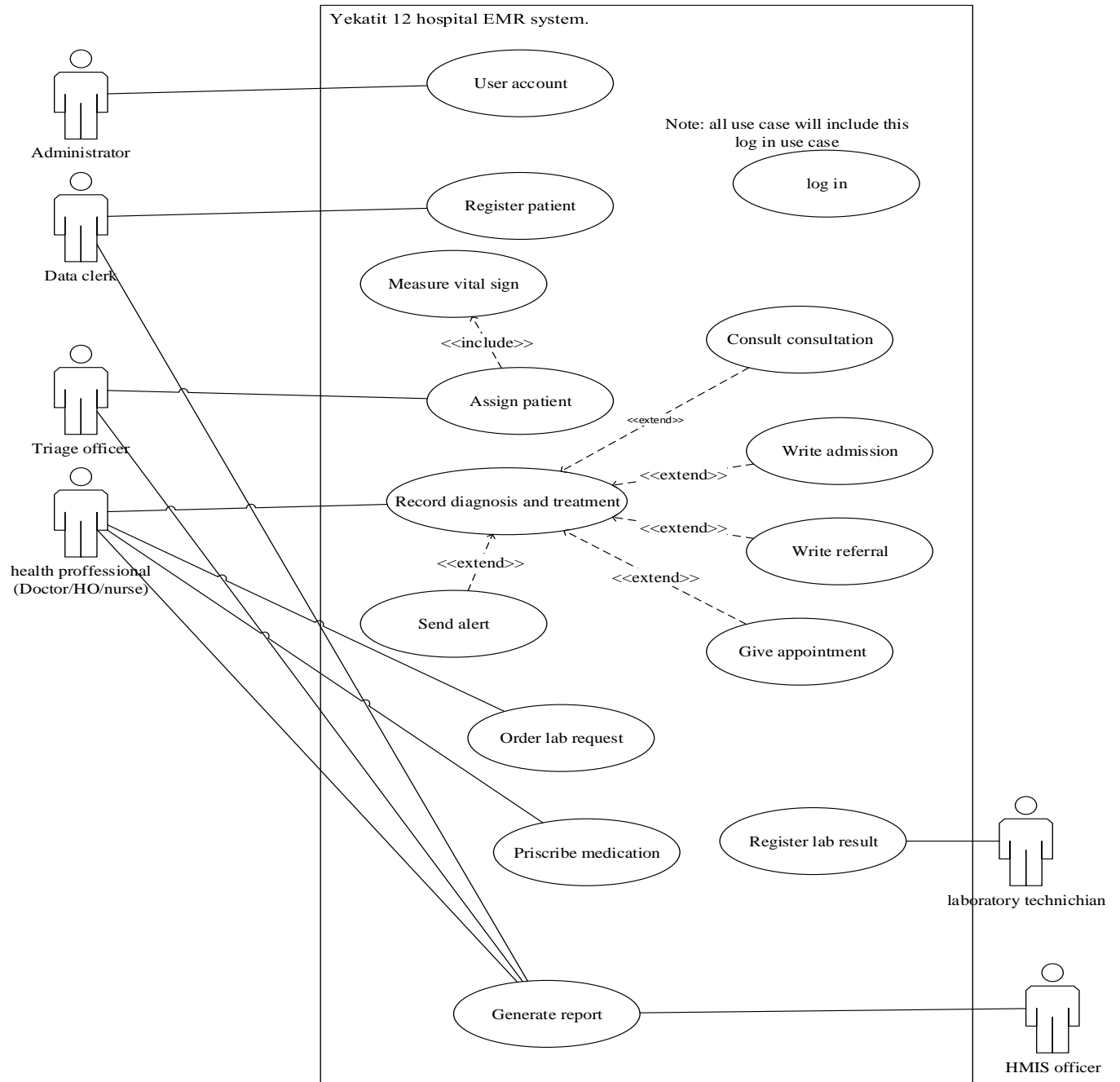


Figure 11: Use case diagram for the proposed system.

Table 7: Login use case for the EMR system.

Use case ID	UC-1
Use case name	Log in
Primary actor	All user
Trigger	The user wants to open the system
Description	This describes how the user logs into the system.
Pre-condition	The user must have user name and password
Post-condition	The user logs into the system
Main Scenario	<p>The use case starts when:</p> <ol style="list-style-type: none"> 1. A user opens the system 2. The system displays the log in window 3. The user enters the username and password 4. The user clicks on the log in button 5. The system validate the user name and password 6. The system display success message 7. Use case ends
Alternative flow	<p>3a1.if the user name or password is incorrect the system displays an error message</p> <p>3a2. The user clicks an ok button and reenters user name and password</p> <p>3a3. If the user does not use the correct password the system will lock down after five trial</p> <p>3a5.use case ends</p>

Table 8: Patient Registration use case for the EMR system.

Use case ID	UC-2
Use case name	Patient registration
Primary actor	Data clerk
Description	This Use Case describes the process of how the data clerk register new patent/update repeat patient on the system.
Trigger	Patient wants to register
Pre-condition	The data clerk is authenticated Patient need to have referral paper
Post-condition	1.The patient is registered on the system and transfer to triage case team 2. The patient will have unique specific medical record number.
Main Scenario	<ol style="list-style-type: none"> 1. The Use Case starts when a data clerk opens main window. 2. The system displays the main window. 3. The data clerk selects the registration window 4. The system display the registration forms 5. The data clerk register patient information 6. The system validates the input data. 7. The system display success message 8. The data clerk send the registered patient data to triage room 9. The system stored/save the record 10. Use case ends
Alternative flow	<p>5a. patient is already registered or repeat.</p> <p>5a1. The data clerk enters the patient name or MRN and search the patient record</p> <p>5a2. The system displays the patient data.</p> <p>5a3. The data clerk clicks update button</p>

	<p>5a3. The system updates patient visit.</p> <p>6. Use case ends.</p> <p>5b. Data clerk makes miss necessary information while enters the data, the system displays error message.</p> <p>5b1. The data clerk clicks an ok button.</p> <p>5b2. The Data Clerk re-enter patient information</p> <p>6. Use case ends.</p>
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Table 9: Assign patient use case for the EMR system.

Use case ID	UC-3
Use case name	Assign Patient
Primary actor	Triage officer
Description:	This Use Case describes the process of how triage officer screen and assign patients to the specific case team.
Trigger	patient is linked from medical record unit
Pre-condition	<ol style="list-style-type: none"> 1.The triage officer is authenticated 2.The patient should be registered to system
Post- condition	<ol style="list-style-type: none"> 1.Patient is screened and assigned
Main Scenario	<ol style="list-style-type: none"> 1. The Use Case starts when triage officer open the main window 2. The system display the main window 3. The triage officer selects the triage window 4. The system displays the assign patient form 5. The triage officer take highlight clinical history and measure vital singe. 6. The triage office assign the patient to the corresponding OPD 7. The system stored/save the record 6. Use case ends

Table 10: Register diagnosis and treatment use case for the EMR system.

Use Case ID	UC_4
Use case name	Register diagnosis and treatment
Primary actor	OPD physician(HO/Nurse/Doctor)
description	This use case describes the process used to diagnose and treat patient at outpatient department.
Trigger	Patient assigned to OPD physician
Pre-condition	1.Patient registered 2. Patient is assigned 3.The physician is authenticated
Post-condition	The patients full clinical detailed history, diagnosis and treatment is registered.
Main Scenario	<ol style="list-style-type: none"> 1. The Use Case starts when a physician opens outpatient department screen. 2. The system provides the general examination patient form 3.The physician registers the patient history in to the form 4. The physician select the laboratory menu 5.The system display's list of laboratory order forms 5.The physician selects on lab test he/she wants to order and send to laboratory 6. The physician received message of lab result 7. The physician clicks on test result information 8. The system displays the test result form 9. The physician view test result information and click save button 10. The physician open medication menu 11. The system display's prescription paper 12. The physician prescribe medication , print it and give to the patient 13. The system saves the data on the system 14. Use case ends
Alternative flow	<ol style="list-style-type: none"> 3a. No lab request 3a1.The physician record diagnosis and treat asymptotically

	<p>10a.No need of treatment</p> <p>10a1 The physician may give appointment, referral, admission or consult consultation</p> <p>10a1.1 If Patient needs appointment the physician clicks on the appointment form</p> <p>10a1.1.2 The system displays the appointment menu</p> <p>10a1.1.3 The physician fills the appointment card and appoints the patient.</p> <p>10b.If Patient needs admission the physician clicks on the admission form</p> <p>10b1.The system displays the admission form</p> <p>10b2. The physician fill the admission form</p> <p>10c. If patient needs further investigation the physician clicks on the referral form</p> <p>6c1.The system displays the referral form</p> <p>6c2. The physician fills the referral information and print out.</p> <p>10d. If patient needs consultation the physician clicks on consultation form</p> <p>10d1. The system display consultation form</p> <p>10d2. The physician fills the form and request the department</p> <p>7. Use case ends</p>
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Table 11: Register laboratory result use case for the EMR system.

Use case ID	UC-5
Use case name	Register Laboratory result
Primary actor	Laboratory technician
Description	The use case describes the process used to record laboratory result
Trigger	Laboratory test is requested
Pre-condition	The laboratory technician is authenticated
Post-condition	Laboratory result is registered
Main Scenario	<ol style="list-style-type: none"> 1. The use case starts when the laboratory technician open the main window. 2. The system display the main window. 3. The laboratory technician open laboratory menu 5. The laboratory technician select laboratory order 6. The system displays the selected test request. 7. The laboratory technician perform the request 8. The laboratory technician fills lab results on the lab order entry form and click submit button 9. The system sends lab result to respective outpatient department. 10. The system saves the data on the system 11. Use case ends
Alternative flow	<p>8a. if the laboratory technician makes error while enters the data, the system displays error message.</p> <p>8a1. The laboratory technician clicks an ok button.</p> <p>8a2. The system informs the laboratory technician to reenter the data.</p> <p>8a3. The physician re-enter the data</p> <p>9. use case ends</p>

Table 12: Search use case for the EMR system.

Use Case ID	UC_ 8
Use case Name	Search patient
Primary actor	User
Description	Describes how the user searches information from the system to view or modify the information.
Trigger	The physician wants patient information
Pre-condition	The user is authenticated. The user should enter patient name or patient ID.
Post-condition	The user gets the information what he/she needs.
Main scenario	<ol style="list-style-type: none"> 1. The Use Case starts when the user enters the patient name or MRN. 2. The user clicks the search button. 3. The system checks data input register. 4. The system validates the entered data. 5. The system displays list of search result by type (name or ID) 1. Use case ends
Alternative flow	<p>3a. If the user makes error while enters the input, the system displays error message.</p> <p>3a1. The user clicks ok button.</p> <p>3a2. The system inform the user to re-enter the information</p> <p>6. Use case ends.</p>

Table 13: Generate report use case for the EMR system.

Use Case ID	UC_ 9
Use case Name	Generate report
Primary actor	User (Doctor HO/Nurse, Data clerk HIMS officer)
Description	The use case describes the process used to generate report.
Trigger	The user wants to generate report
Pre-condition	The user has authentication to generate report
Post-condition	The user generates report from the system.
Main scenario	<ol style="list-style-type: none"> 1. The Use Case starts when the user clicks on the report button. 2. The system displays a report window that contains different report options (daily, weekly, monthly quarterly, annually). 3. The user select type of reports needed. 4. The system processes and generates the selected report. 5. The system Save the report 6. Use case ends

Table 14: Mange user account use case for the EMR system.

Use Case ID	UC_ 10
Use case Name	Manage user account
Primary actor	System administrator
description	The use case describes how the system administrator activates, inactivates and provides privilege to the users of the system
Trigger	For the users to access the different services based on their provided privilege
Pre-condition	The administrator should register as an authorized administrator
Post-condition	Different user account information are created and manage
Main scenario	<ol style="list-style-type: none"> 1. The use Case starts when the system administrator log in to the system 2. The System administrator selects system administration menu 3. The System presents the different users of the system. 4. The system displays a new account creation form 5. The System administrator checks staffs have a user account from the list of Identification numbers 6. The System administrator fills the required forms 7. Click submit button to save the data 8. The system creates account that provides privilege to use the system 9. The system validates and confirms the inserted data 10. The use case ends
Alternative flow	<ol style="list-style-type: none"> 6 a. If the system administrator wants to update user account b. selects the identification number of the user c. The system administrator changes the information of the user d. the system administrator updates the needed data e. the system administrator clicks update f. the data will be saved onto the database 8. A) if the system administrator wants to deactivate the user

	<p>B) click on the identification number of that user</p> <p>C) The system displays the information of the user</p> <p>D) the system administrator clicks on the user inactivate button</p> <p>E) the system will inactivate the user from the database</p> <p>F) the data will be saved onto the database</p> <p>8. if the primary password mismatches with the confirmation password</p> <p>A) the system notifies the passwords mismatch</p> <p>B) the system lets the user to reinsert password</p> <p>9. If the system administrator skip the necessary information</p> <p>A.1 the system prompts an error message on the blank space</p> <p>A.1.1) if the information is updated the system display “Updated” message</p> <p>A.1.2) if the information is not updated the system display “Not Updated” message</p>
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4.4.6 Analysis Level Class Diagram Modeling

In object-oriented programming and even more so in modeling, classes have numerous tasks. Primarily, they serve to group and encapsulate attributes and associated methods to create a conceptual unity. In analysis, class diagrams are used in order to structure real-world concepts. In contrast in design and implementation class diagrams are especially used to depict a structural view of the software system. The classes presented in the implementation view can actually be found in implemented systems too. But classes from analysis are often significantly modified, supplemented by technical aspects, or fully omitted when they only belong to the system context(60). The noun phrase approach were used to identify the class in this system. Nouns in the textual description are considered to be classes and verbs to be methods of the classes. By this method we have to read through the Use cases, interviews, requirements specification, the problem statements looking for noun and noun phrases(61). Finally chose the candidate class for the proposed system.

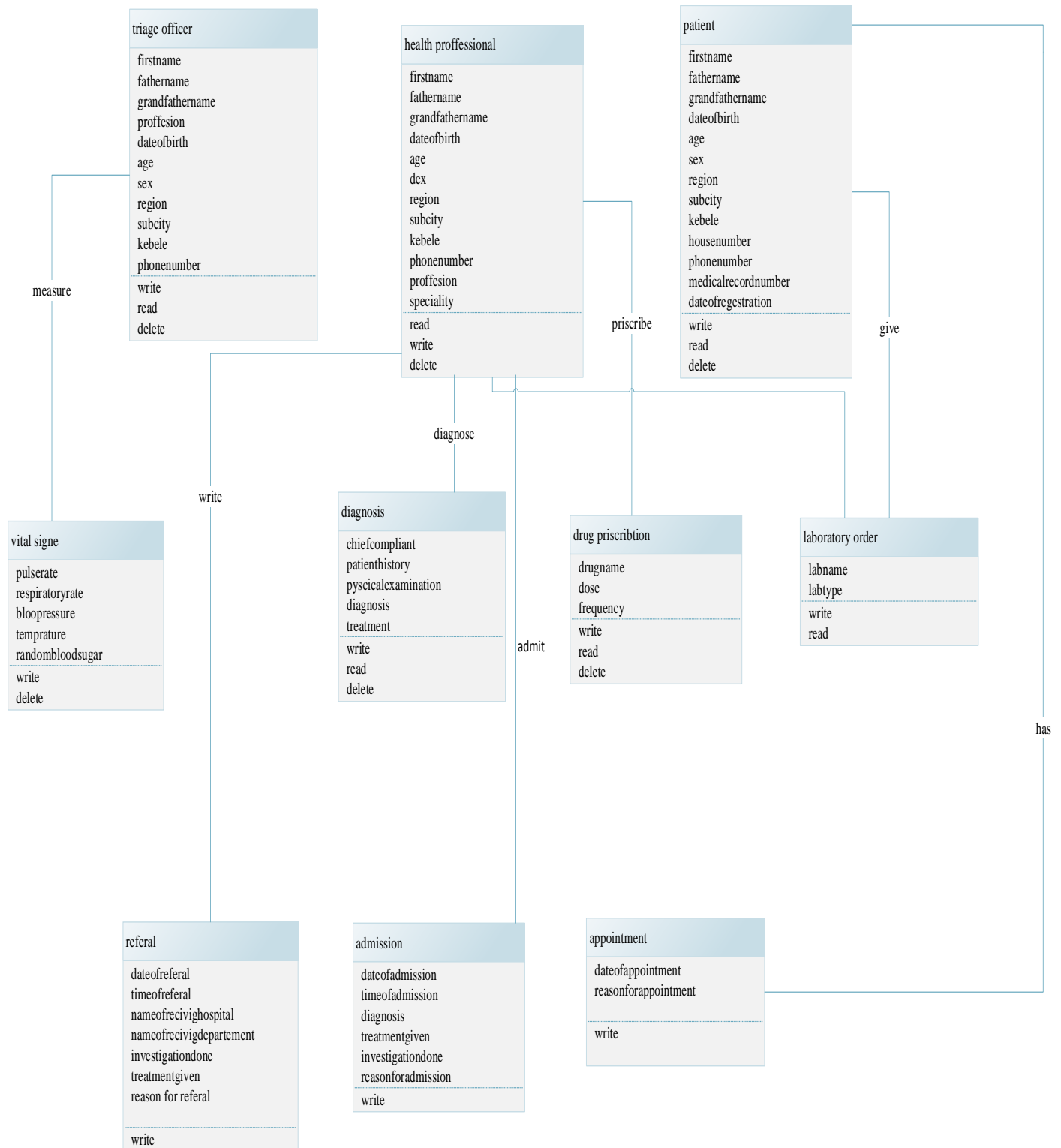


Figure 12: Analysis level class diagram, January to May 2017.

4.5 System Design

System design is the third phase of the SDLC where the description of the recommended alternative solution is converted to logical and physical system specifications(52). The design phase of the SDLC uses the requirements that were gathered during analysis to create a blueprint for the future system and to determine the overall system architecture which include hardware, software, people, and communication channels to satisfy the system's essential requirements. The purpose of the analysis phase is to figure out what the business needs while the design phase is to decide how to build it(62).

4.5.1 Class Diagram

A class is a specification of structure, behavior, and the description of an object(61). Objects are instances of a class with its own attributes and methods. Attributes describe the state of the objects and method is a set of operations executed by an object(63). UML class diagram are used to design and illustrate the structure of software system. It's a very important tool to understand the basic structure of a system. Class diagrams consist of classes in the form of rectangles the classes are related to each other by connecting lines and divided into sections with the name of the class, attributes and operations(64).

In UML class diagrams

- Top compartment contains name of the class
- Middle compartment contains class's attributes or instance variables
- Bottom compartment contains class's operations or methods
- Plus sign shows public methods indicates the method is accessible to all system objects.
- Minus sign shows private methods. It indicates private variables and methods are accessible only to objects of the class in which they are declared.

As a rule of thumb, instance variables should be declared private and methods should be declared public and attribute names are written followed by colon followed by attribute type(61).

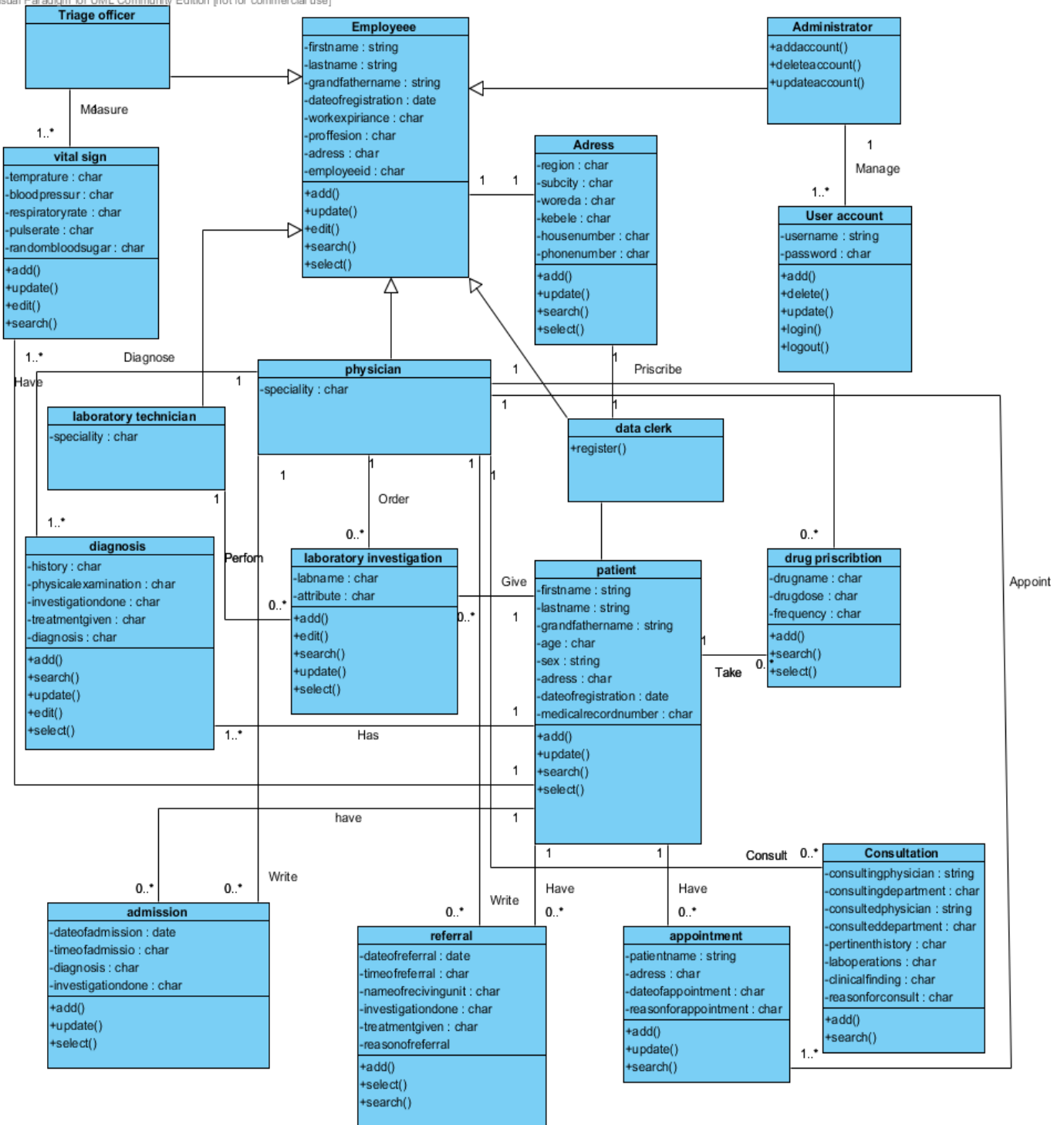


Figure 13: Design level class diagram.

4.5.2 Sequence Diagram

Sequence diagram is one of the well-known UML diagrams, which represents system dynamics helps to organize messages in correct sequence(53). UML sequence diagrams are used to represent object oriented software system or model the flow of messages, events and actions between the objects or components of a system. Sequence diagrams describe how objects, or groups of objects, interact within a system(65). Sequence diagram Show the order of the interaction visually by using the vertical axis of the diagram to represent time what messages are sent and when. Each class (object) in the interaction is represented by its named icon along the top of the diagram. A Message is represented as an arrow going from the sender to the top of the focus of control. A synchronous message indicates the sender waits for the message to be handled before it continues but in asynchronous message the sender does not wait for the message before it continues and reply is return message from another message(66).

In sequence diagram modeling:-

- ✓ The dotted line extending down from an object rectangle is that an object life line which represents the progression of time
- ✓ A solid arrow extending from the sending object to the receiving object represents message between the object
- ✓ An activation shown as a thin vertical rectangle indicates that an object is executing
- ✓ Dotted line with a stick arrow head represents return message(66).

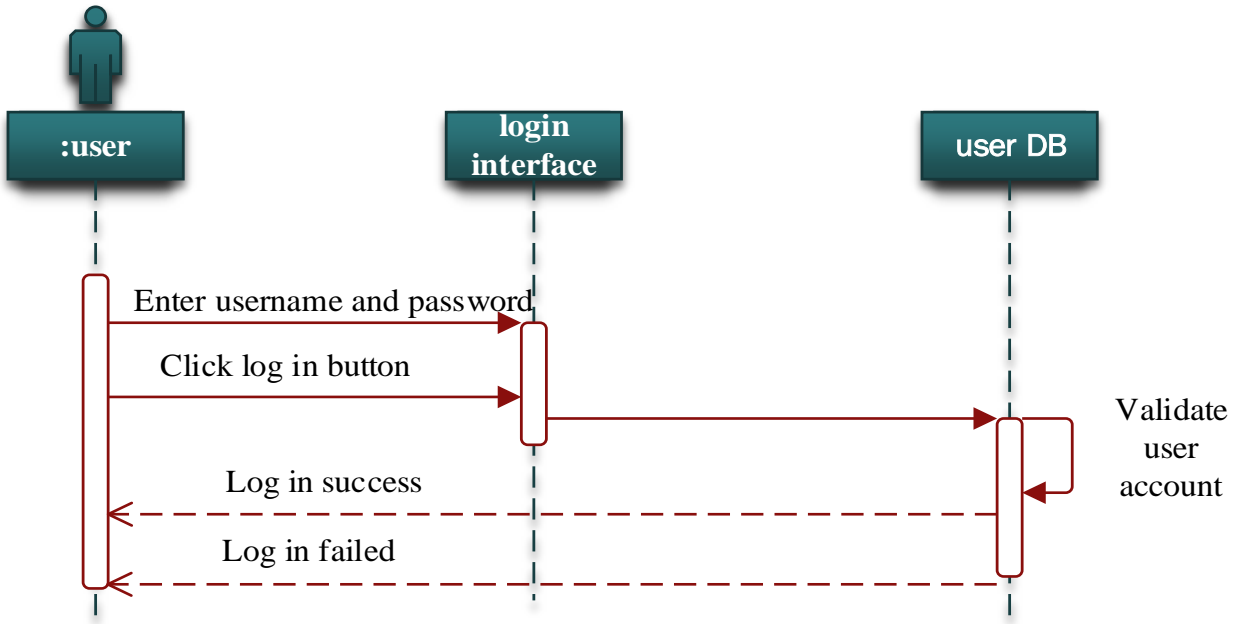


Figure 14: Sequence diagram for EMR login.

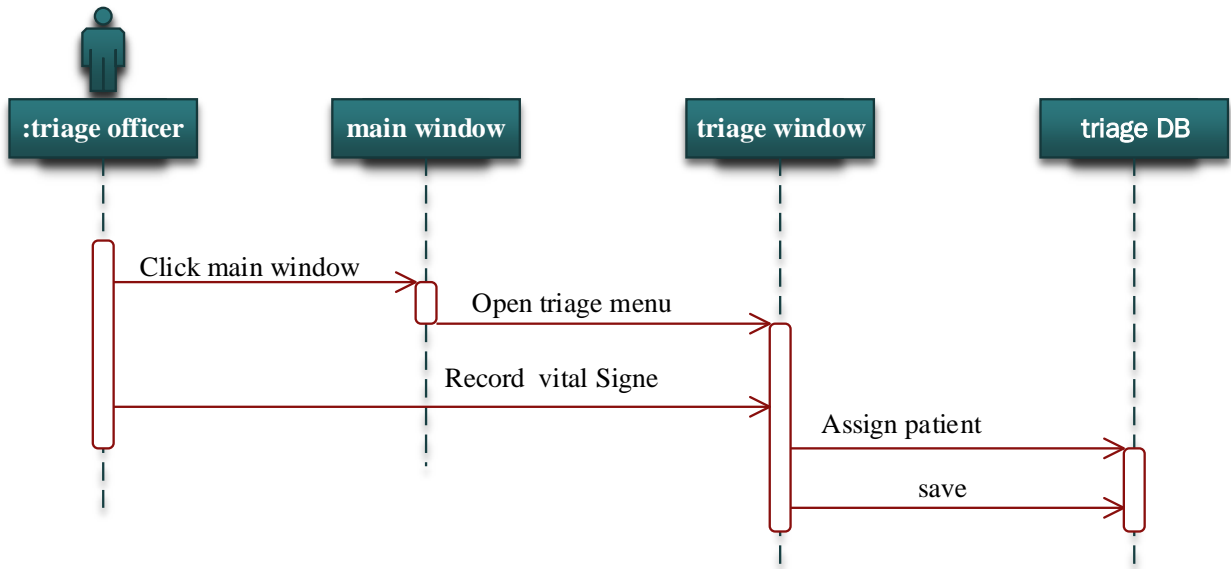


Figure 15: Sequence diagram to assign patient.

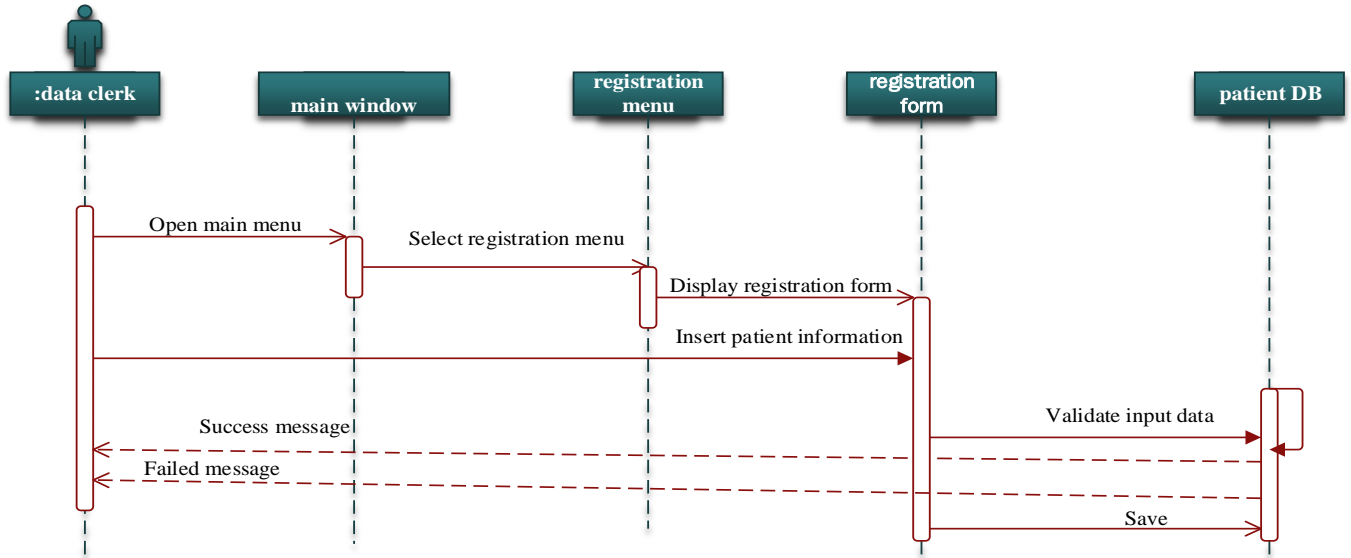


Figure 16: Sequence diagram for EMR patient registration.

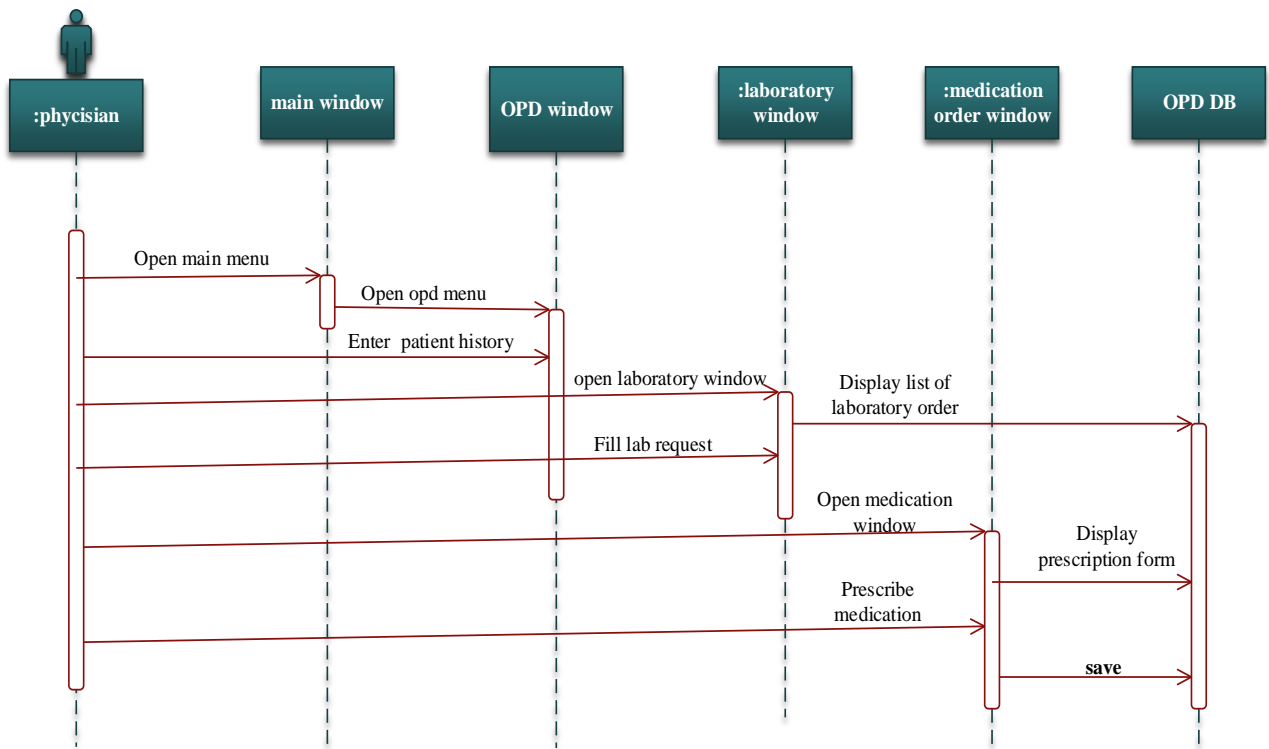


Figure 17: Sequence diagram for EMR to register diagnosis and treatment of patient.

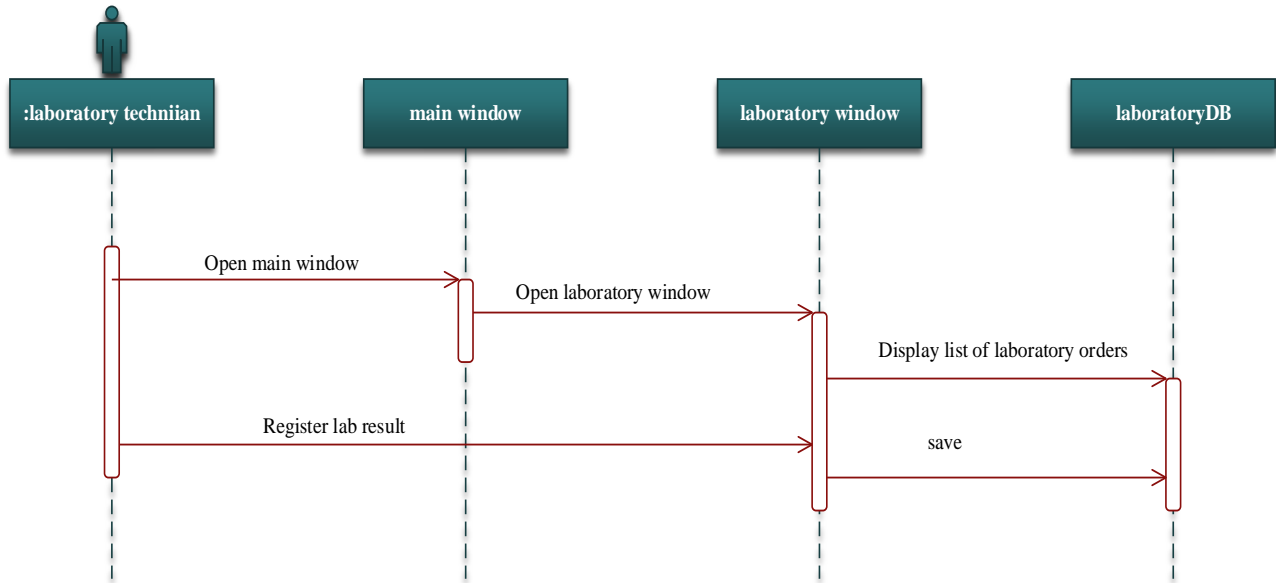


Figure 18: Sequence diagram for EMR to register laboratory request.

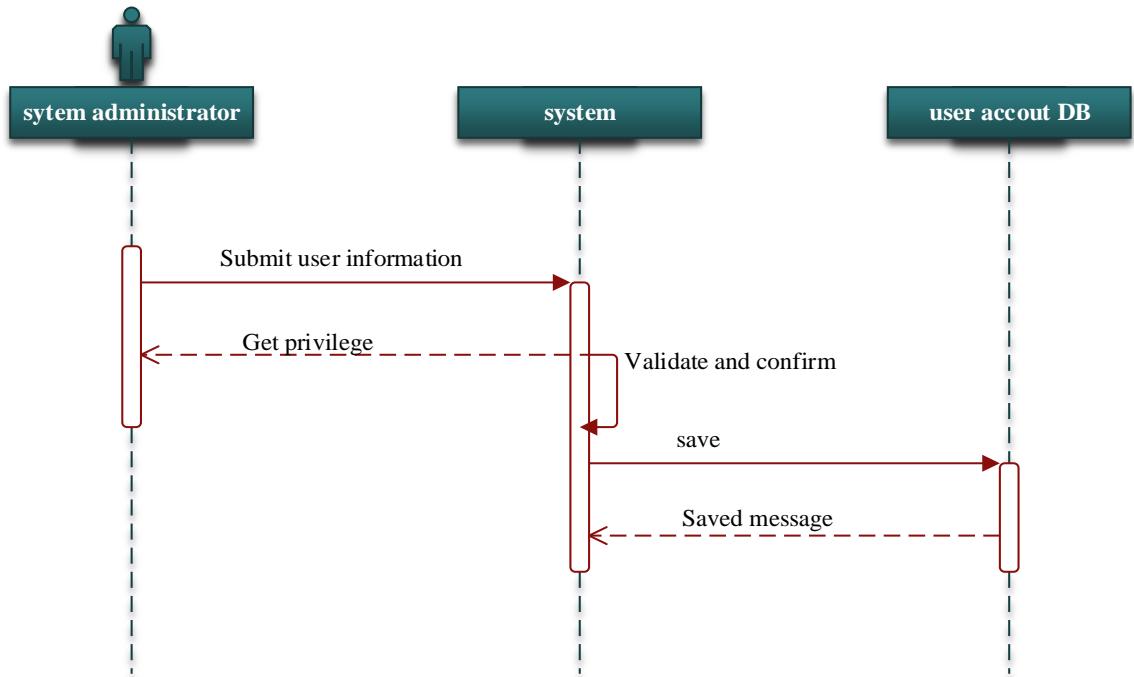


Figure 19: Sequence diagram for EMR user account.

4.5.3 Sub System packaging /decomposition

Decomposition is the process of breaking down a system into its smaller components. Subsystem decomposition is collection of classes, associations, operations, events and constraints that are closely interrelated with each other and modeled as packages in UML modeling(67). In order to make system design and development easy, the system is decomposed into smaller parts called subsystems. In this stage, classes with similar functionality are grouped into a single subsystem. The major subsystems identified are:-

Login interface: This user interface is responsible for providing the authentication and authorization of the users to the different functionalities that the system provides.

Registration interface: This user interface enables the user (data clerk) to register and save patient data.

Assign patient interface: An interface that enables the triage officer to screen patient and assign accordingly.

Diagnosis and treatment Registration interface: Enables the physician to register the different diagnosis and treatments results of patient during each visit.

Register laboratory result interface: Enables the laboratory technician to register and save laboratory result of the patient.

Manage user account interface: Enables the system administrator to provide various privileges that the user needs and also helps the system administrator to enable or disable the users in the system.

Generate report interface: Enables the user to generate the required report from the system.

View subsystem: Enables the different users of the system to view the patient data.

Update subsystem: Enables the different users of the system to update necessary patient information.

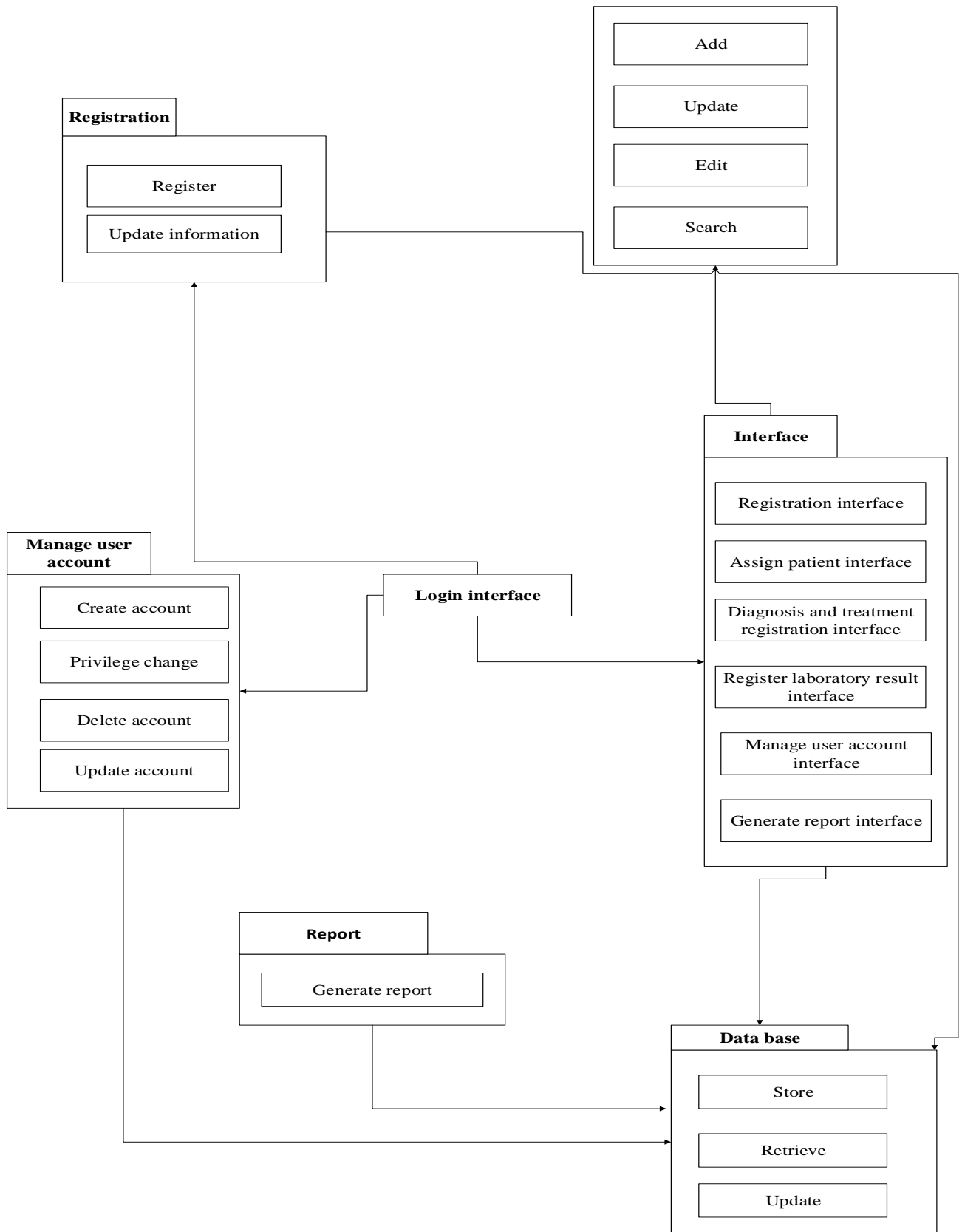


Figure 20: Sub system decomposition diagram.

4.5.4 Deployment diagram

Deployment diagram show the configuration of hardware that will be used to implement the system and the links between different items of hardware. Model physical hardware elements and the communication paths between them. It shows what and who will connect to or interact with system, what hardware and software will users directly interact with and Plan the architecture of a system(68). System architecture is composed of three layers, the user interface layer, the application logic layer and the database layer. The three-tier architecture aims to solve design and development problems. Hence to make the application development work more easily and efficiently(69).

I. Front-end tier / user interface/

The first tier is the user interface tier this tier manages the input/output data and their display with the intention of offering greater convenience to the user. Offers the user a friendly and convenient entry to communicate with the system. The system involves users from different care giving unites that have the right to access and retrieve patient data. This tier is available on the user's computer. Since, patient data is sensitive the system is available only to authorized users and to the level that they are authorized. For this each user has unique username and pass word provided by the administrator.

II. Middle tier / Application Server /

The application logic tier is the middle tier, which bridges the gap between the user interface and the underlying database, hiding technical details from the users. It communicates with the user interface and interacts with the database retrieving data from the database. This layer of the system holds the business logic and the rules in which the system has to perform. In this tier the business process of the EMR is placed. The servers hold all the application code that make possible the communication between the database and the front end. The middle-tier contains most of the application of the system and translates the information in to database for storage. The applications in this tire contain patient data including, registration, diagnosis, laboratory investigation and treatment that can be accessed and updated to facilitate and increase service provided by the system. It acts as a bridge between the user and the database.

III. Back-end tier / Database Server /

The database tier is responsible for modeling and storing information needed for the system and for optimizing the data access. Data needed by the application logic layer are retrieved from the database, then the computation results produced by the application logic layer are stored back in the database. The backend tier is the database that stores and provides patient data and different formats that are required for the full functionalities of the system. In this layer the whole information starting from registration to treatment is stored and delivered to end users through the interface layer

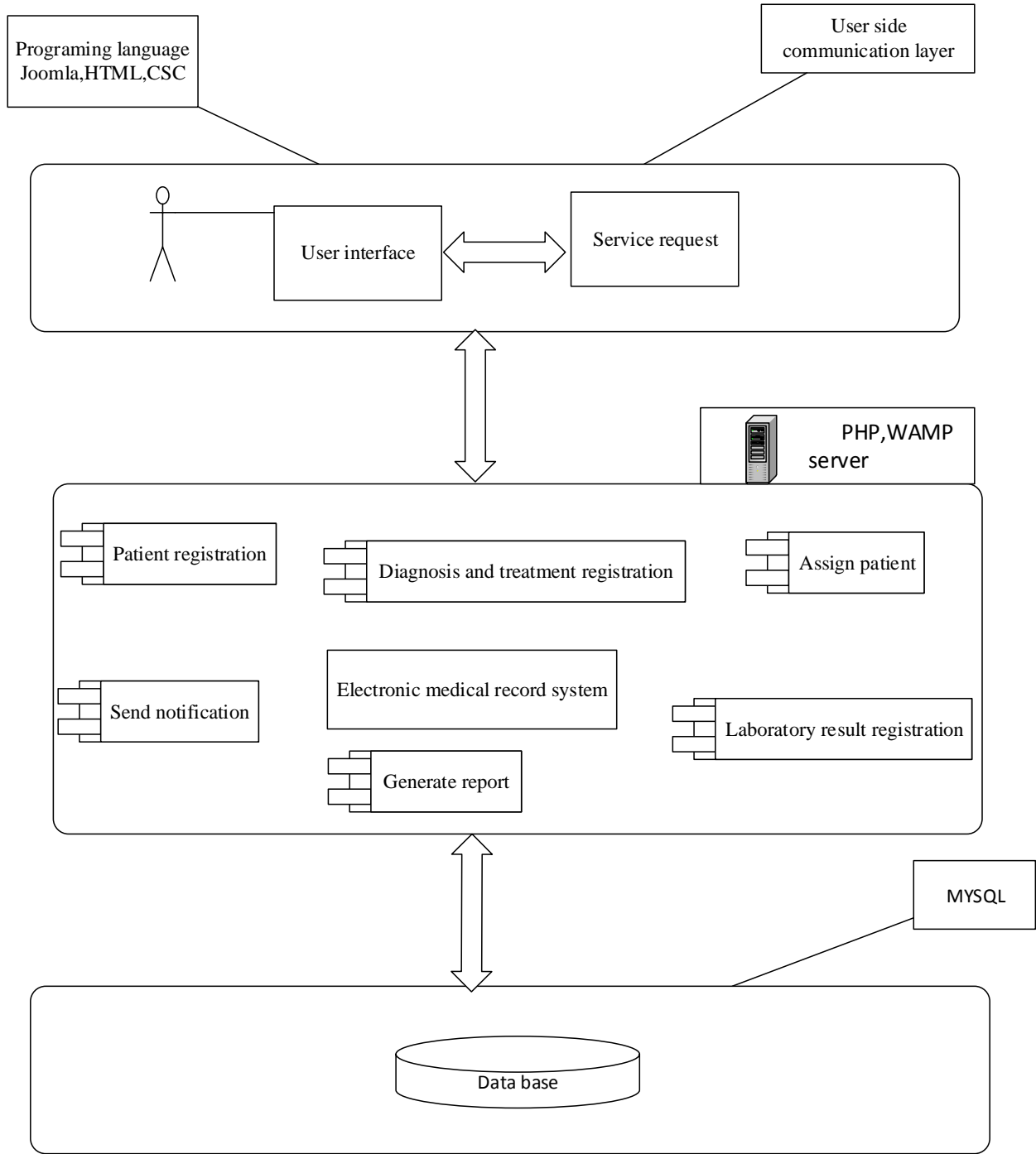


Figure 21: EMR Deployment diagram.

CHAPTER FIVE

Interface Prototyping and Discussion of Results

5.1 Interface Prototyping

Prototyping is designing and building a scaled down but working version of a desired system(52). User interface prototyping, refers to the activity of creating prototypes that is incomplete versions of the pages displayed by an application being developed or modified. A prototype typically simulates only a few aspects of the final solution(70). Prototypes is an important part of all iterative approaches .User interface prototyping is a testing and evaluation approach generally considered as an excellent approach for facilitating communication among users of the system. Prototyping is not only helps to visualize design concepts in an interactive way, but also supports expressing new requirements and expectations towards a prospective system(71).

5.2 User interface flow diagram

User interface flow diagram are a diagram that shows major UI elements. It offer a high level view of the interface of a system(72). It enable users of the EMR system to understand easily how the system is expected to work.

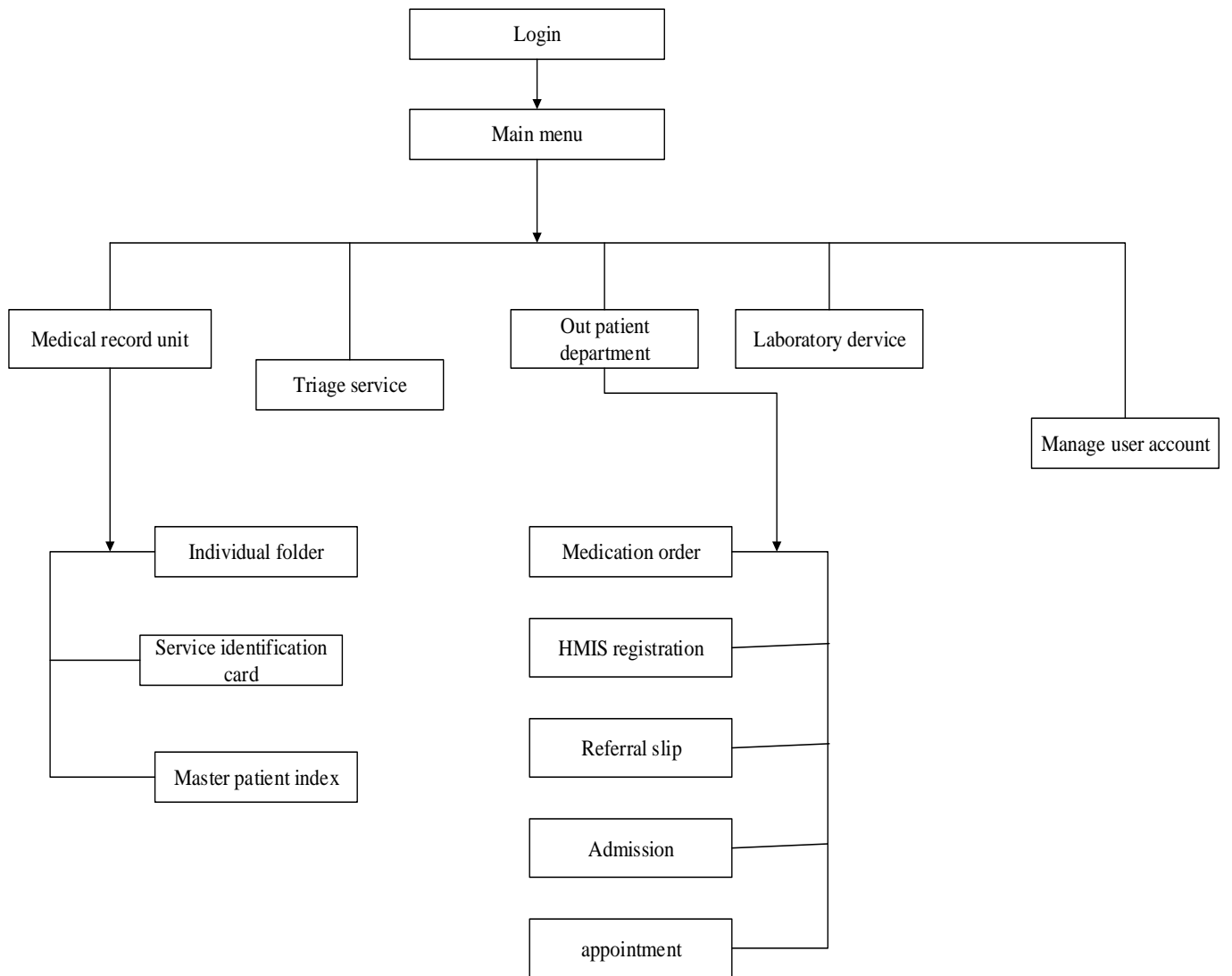


Figure 22: User Interface flow diagram.

The different user interface prototypes are listed below. First the users of the system get the main menu prior to getting access to the different menus and functionalities of the system.

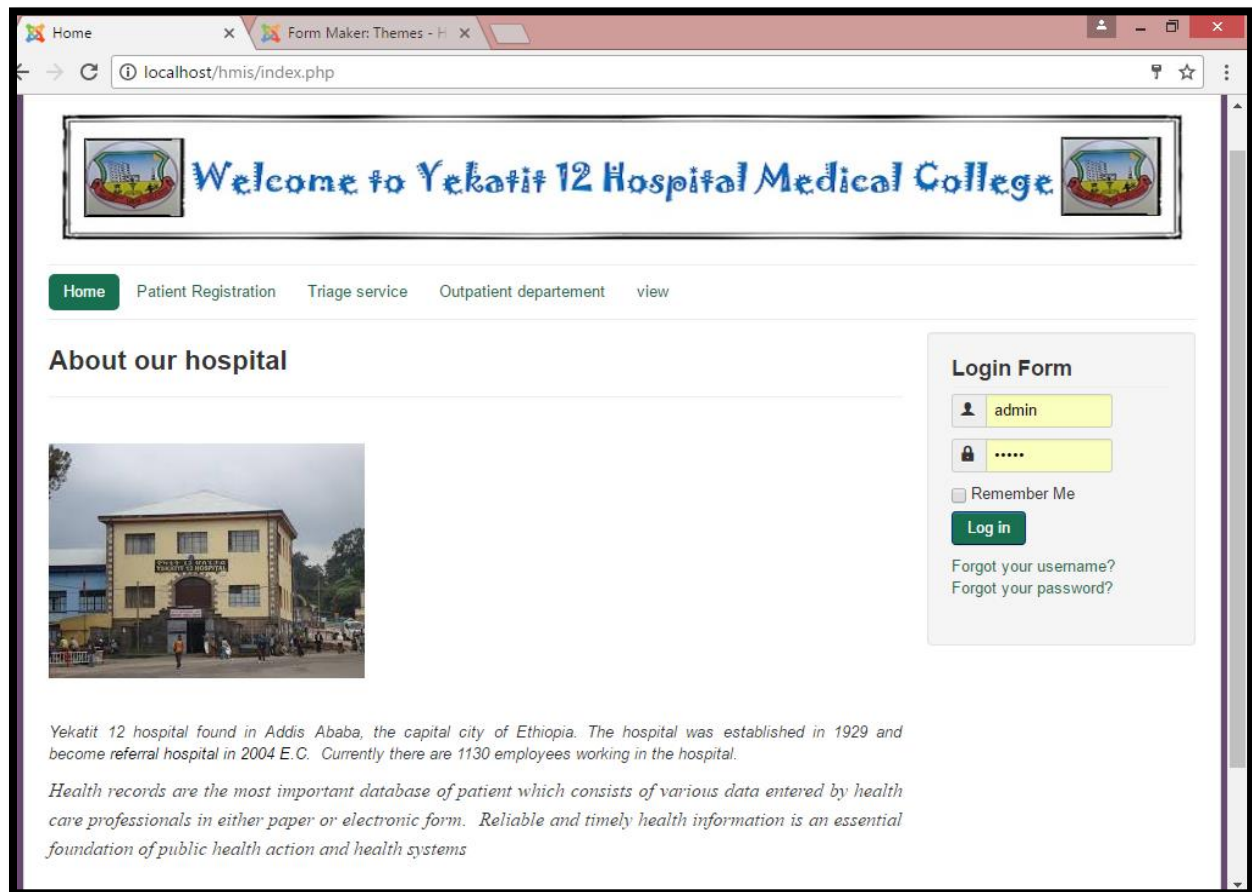


Figure 23: Main menu user interface.

The main menu has different information about the designed system including login button. When the user logs in to the system different functionalities of the system displayed such as patient registration, the triage service, outpatient department and view menu that allows the user to see entered patient data. The user can click on home to go back to the main menu.

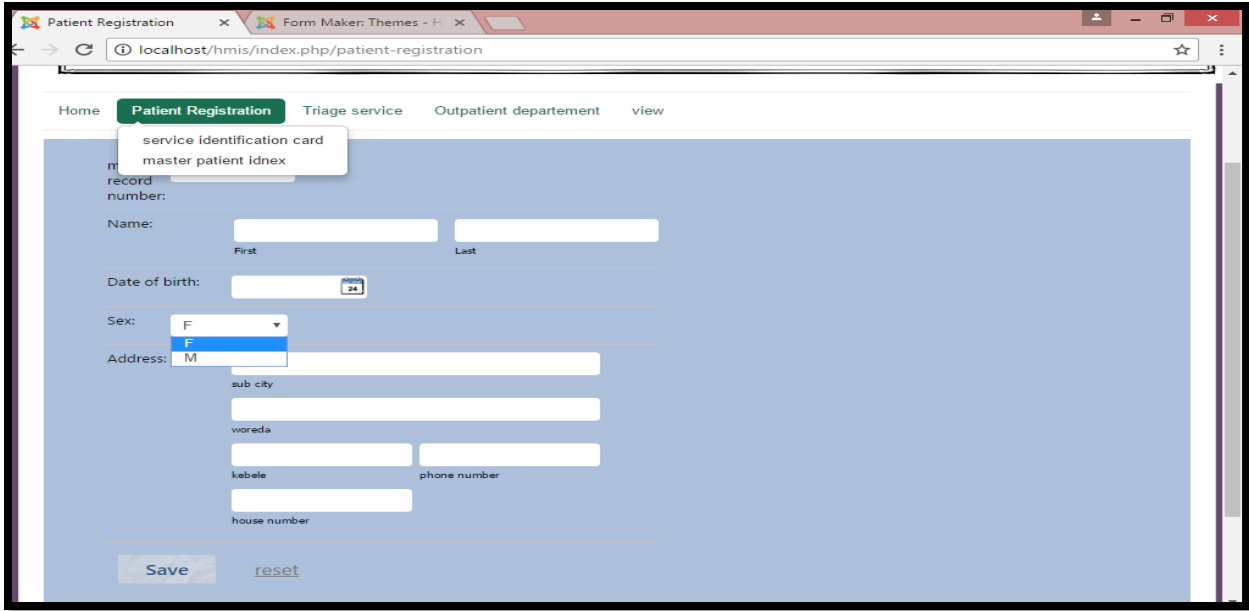


Figure 24: Patient registration interface.

After login to the system for patient registration, the data clerk click patient registration menu, the system display the registration form including individual folder, service identification card and master patient index card for patient tracing when they lost their service card.

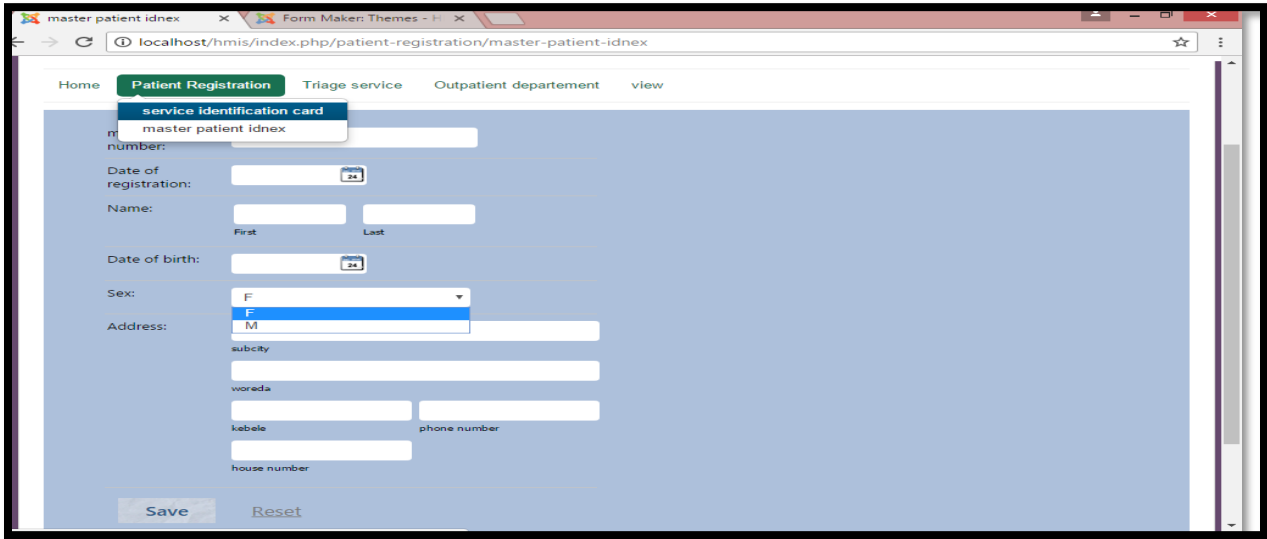


Figure 25: Service identification card.

A card used to search patient data in the system by medical record number each patient has unique medical record number used to search patient information or medical record.

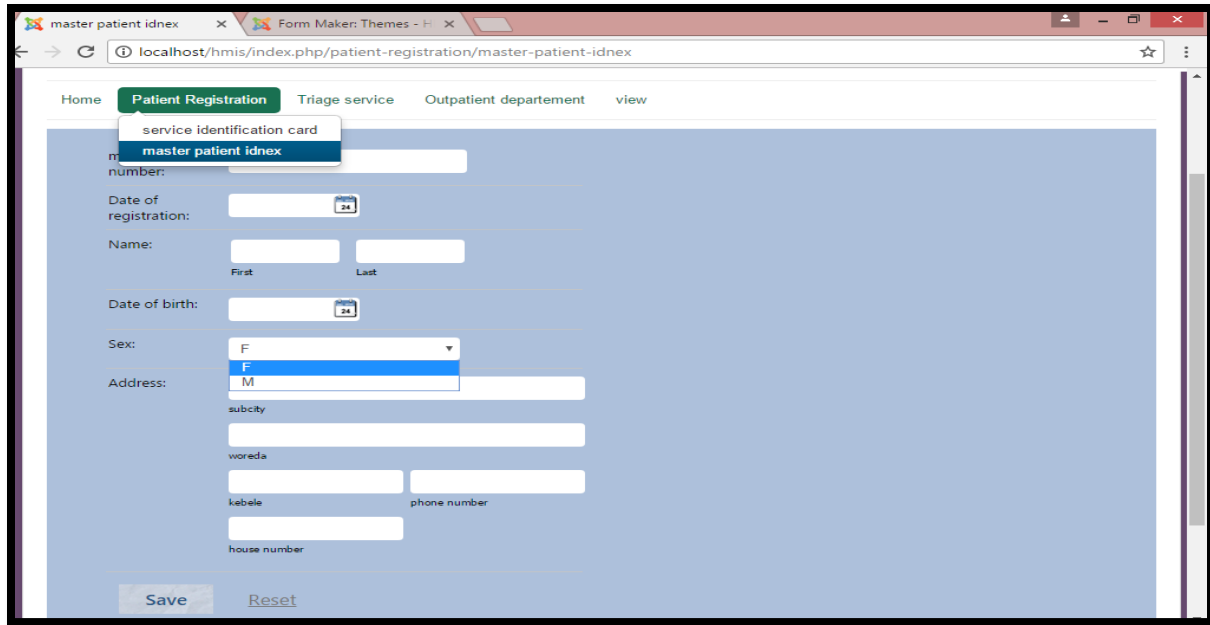


Figure 26: Master patient index card.

A card for patient tracing placed in medical record unit.

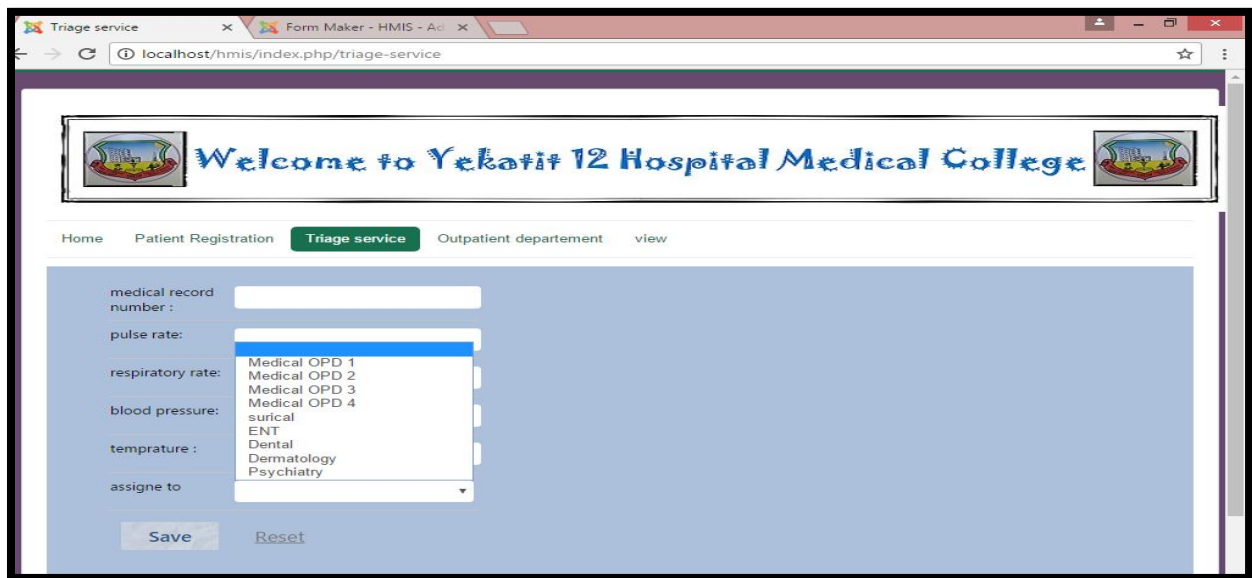


Figure 27: User interface to assign patient.

After patient is register in medical record unit the data clerk send patient information to triage officer who screen and assign the patient to OPD. Triage officer after login to the system for assigning patient he/she clicks triage service menu then the assign patient form will be displayed.

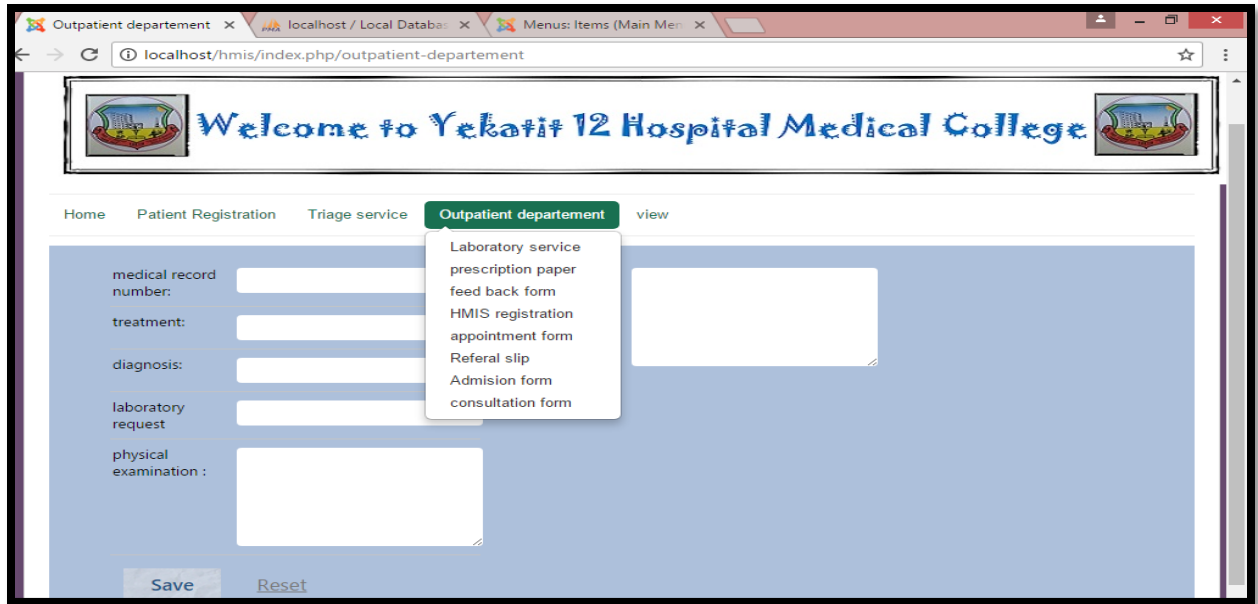


Figure 28: Outpatient department user interface.

The Physician after login to the system click on outpatient department menu the system display different formats necessary for patient diagnosis and treatment.

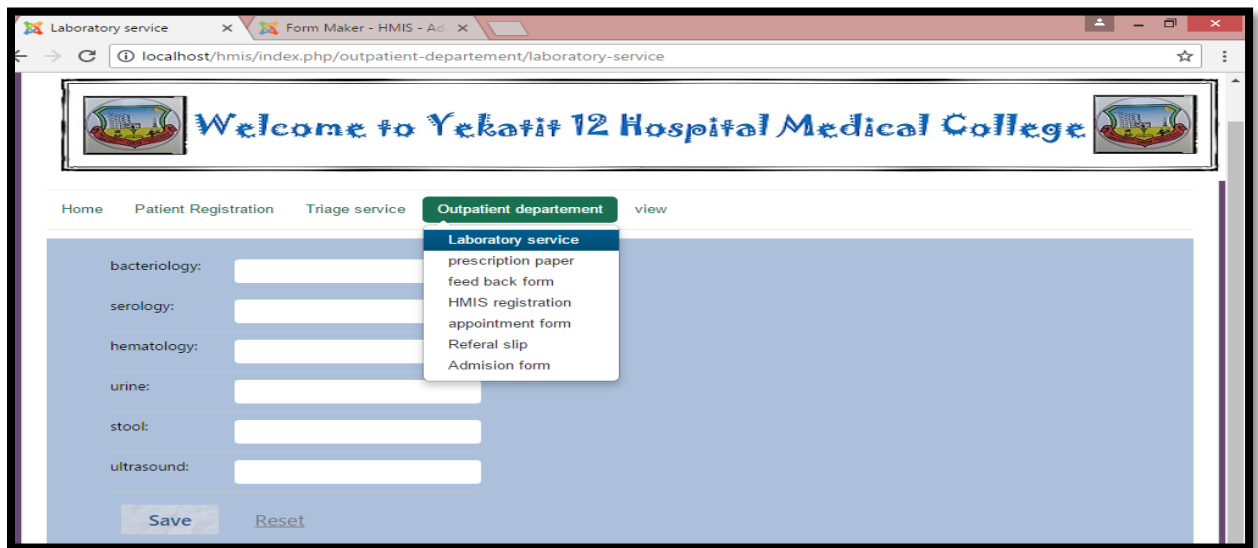


Figure 29: Laboratory order user interface.

The Physician after login to the system for laboratory order he/she clicks on outpatient department menu and the system display different option the physicians selects laboratory service menu and clicks on it, the system displays laboratory order forms so that they can select what they want to order.

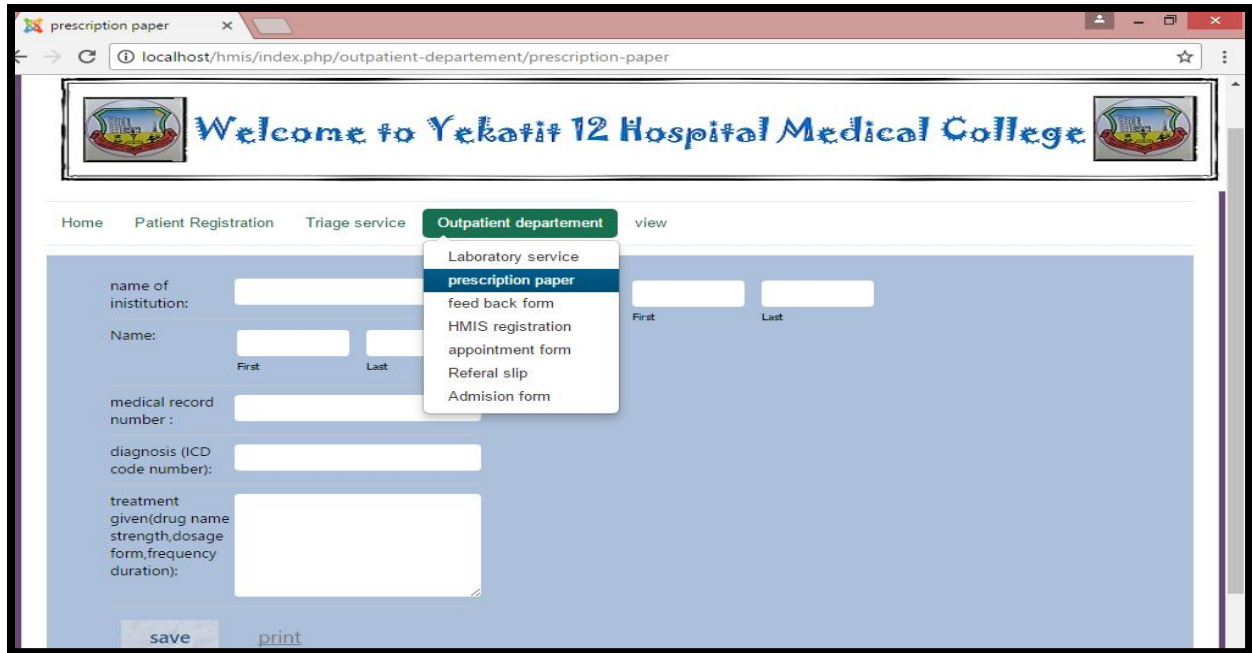


Figure 30: Prescription order user interface.

The Physician after login to the system to order medication he/she clicks on outpatient department menu and the system display different option the physicians selects prescription order and clicks on to display the prescription form so that they can order medication.

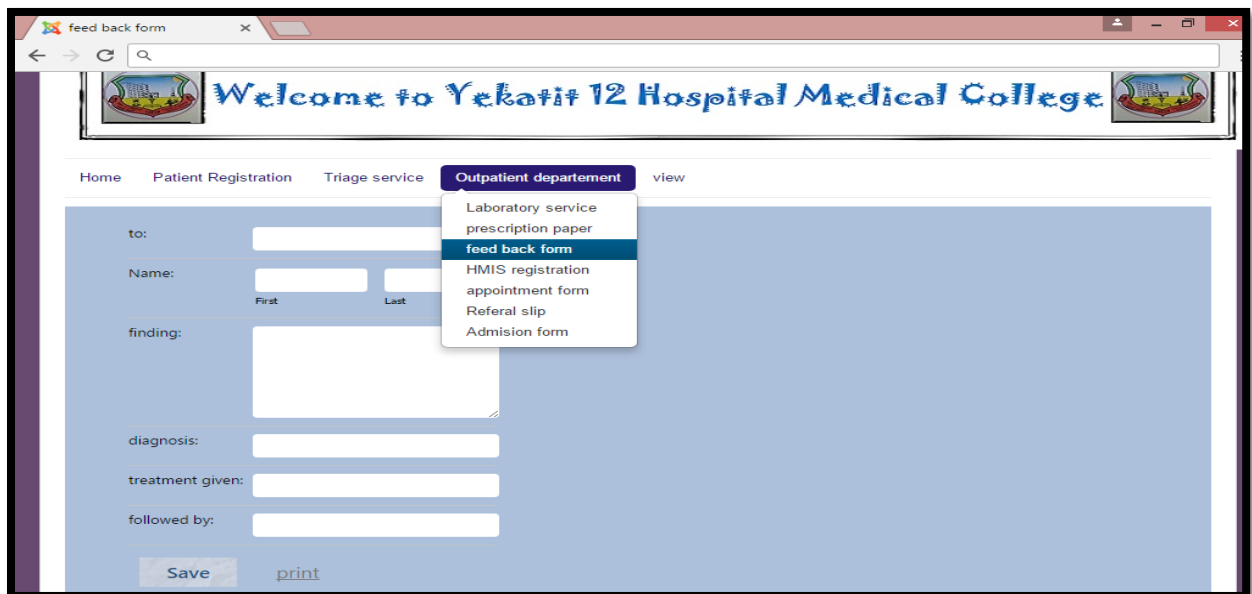


Figure 31: Feedback form.

This user interface is used to write a feedback about patient stay time at the hospital.

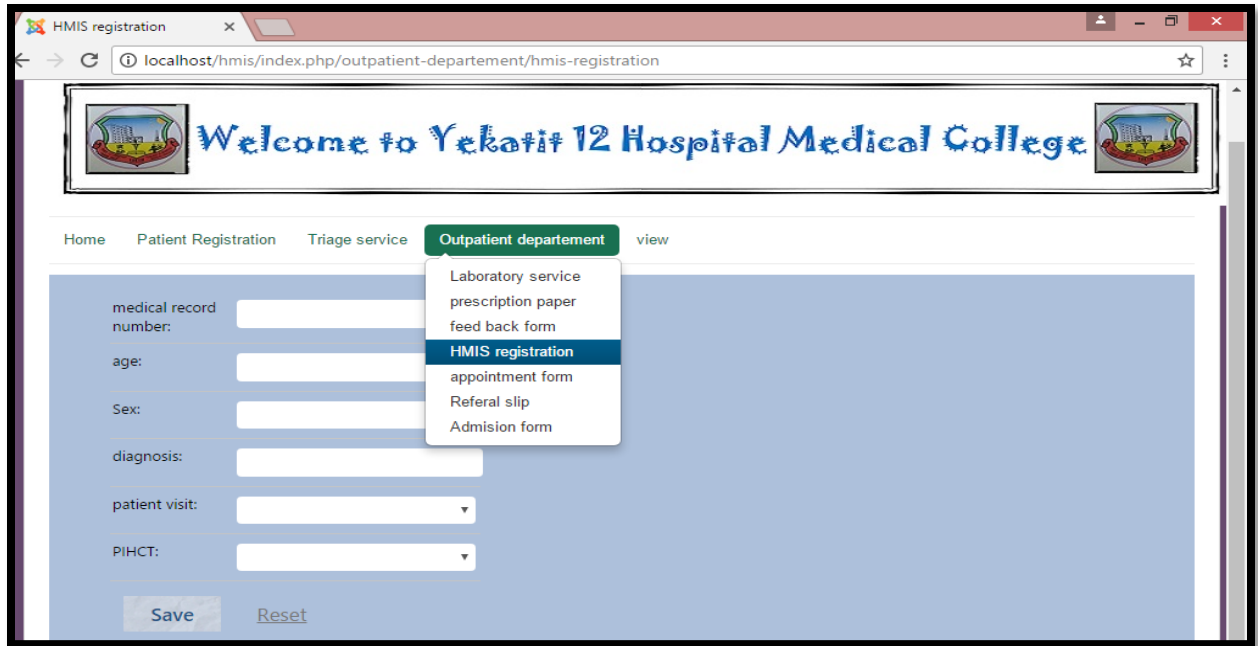


Figure 32: HMIS user Interface.

The Physician after login to the system for disease registration he/she clicks on outpatient department menu and the system display different option the physicians selects HMIS registration and clicks on it the system display the registration form.

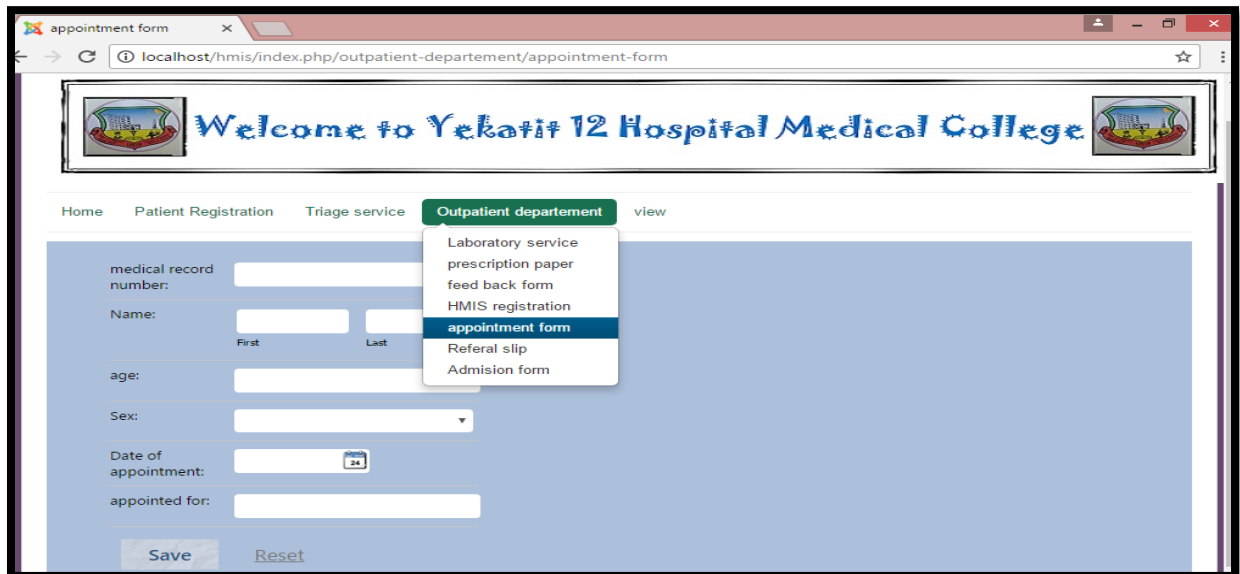


Figure 33: Appointment form.

A form user to appoint patients for follow up.

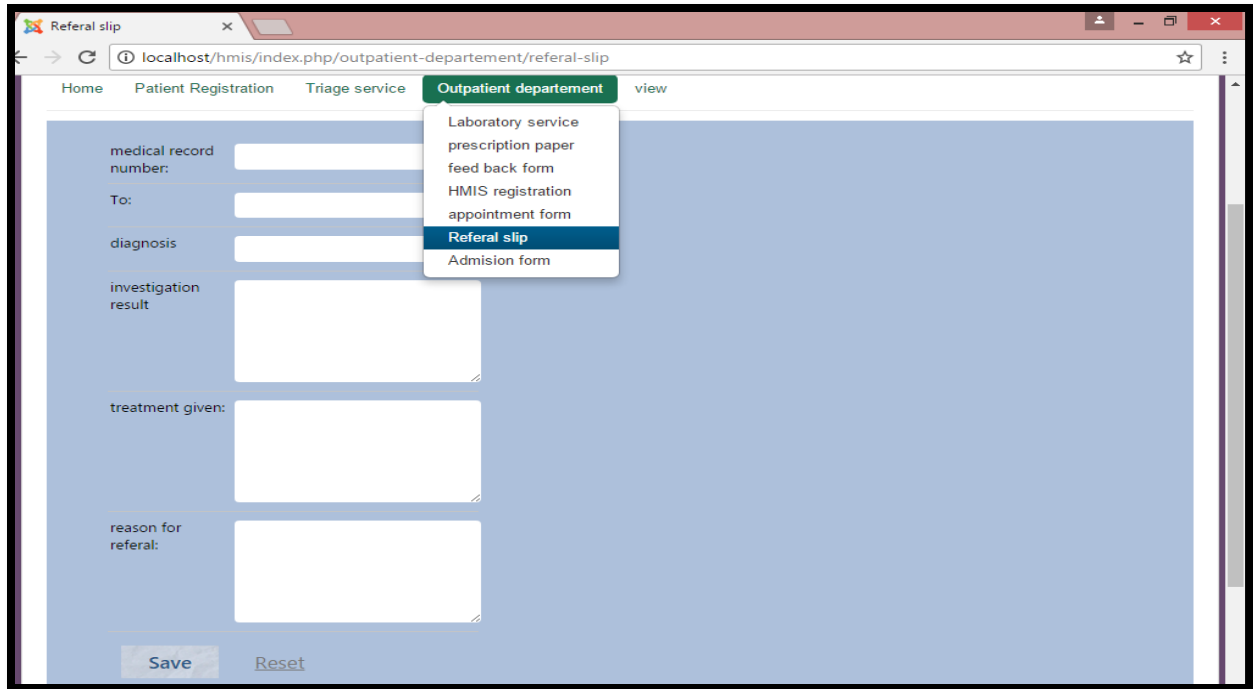


Figure 34: Referral slip.

A form used to refer patients to other facility for better diagnosis and treatment.

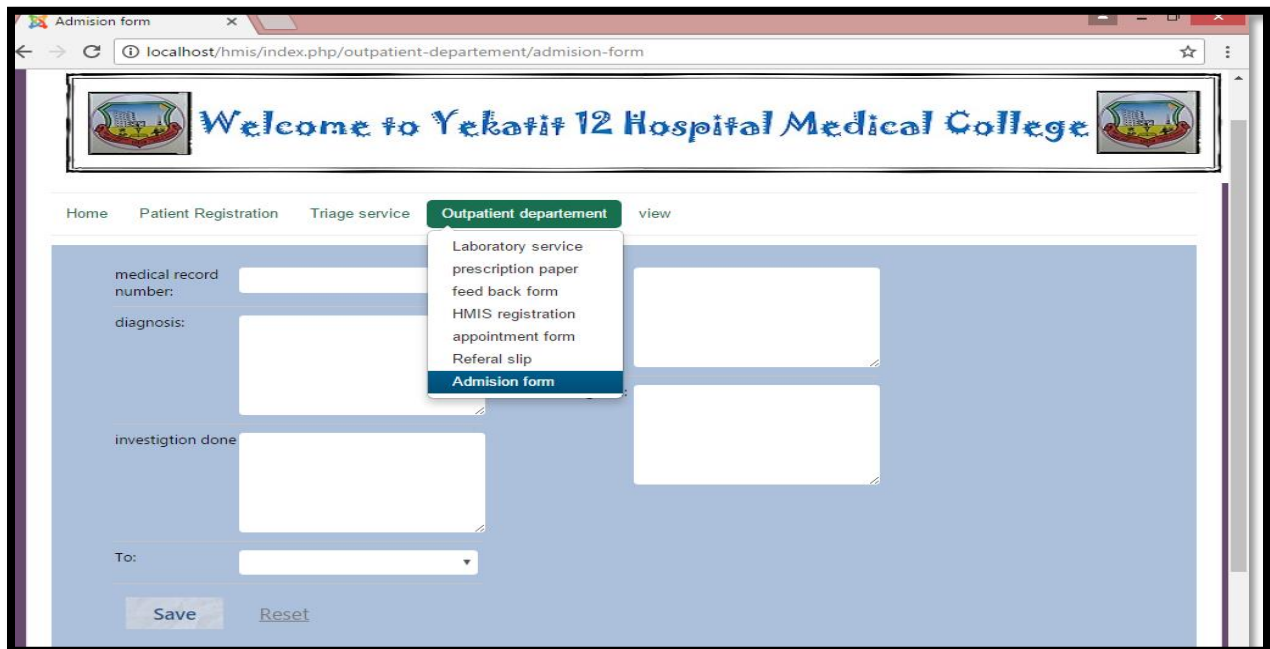


Figure 35: Admission form.

A form filled by the physician to admit patients for inpatient care.

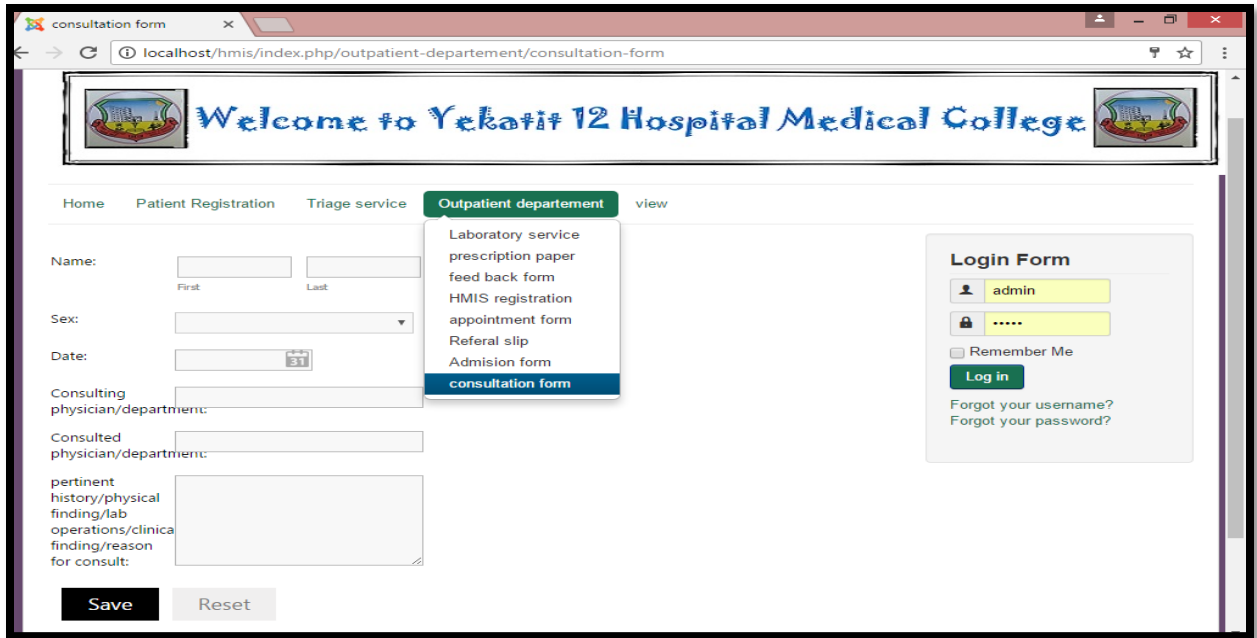


Figure 36: Consultation form

A form used to consult other department or physician.

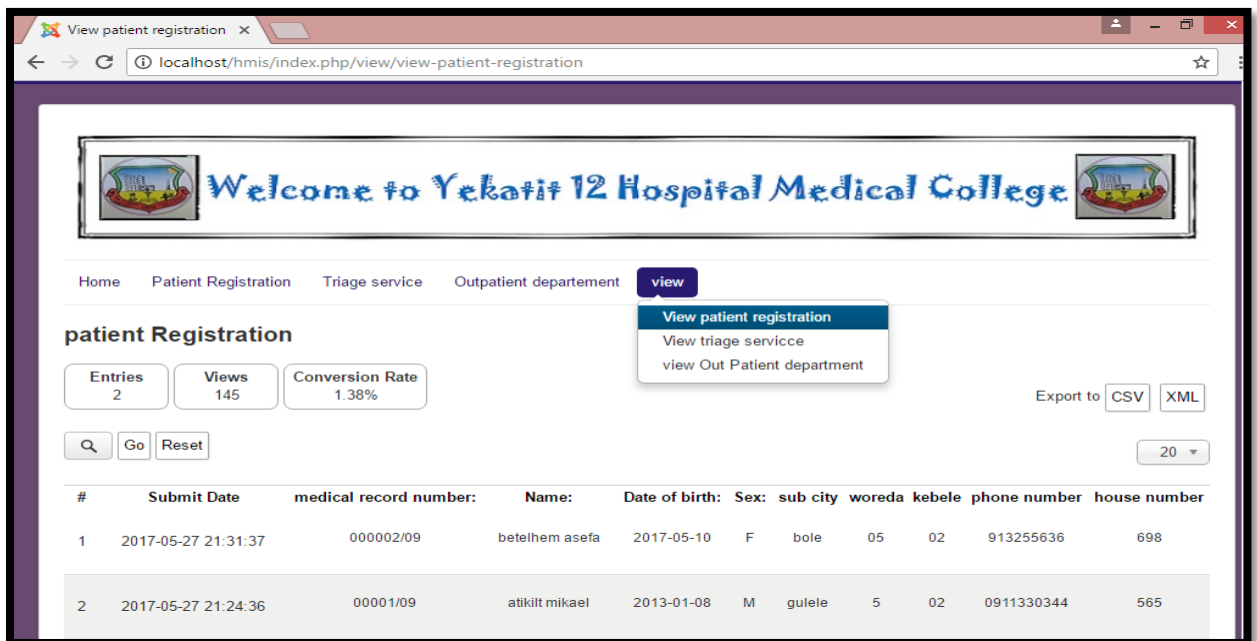


Figure 37: view patient registration screen

An interface used to view register patient.

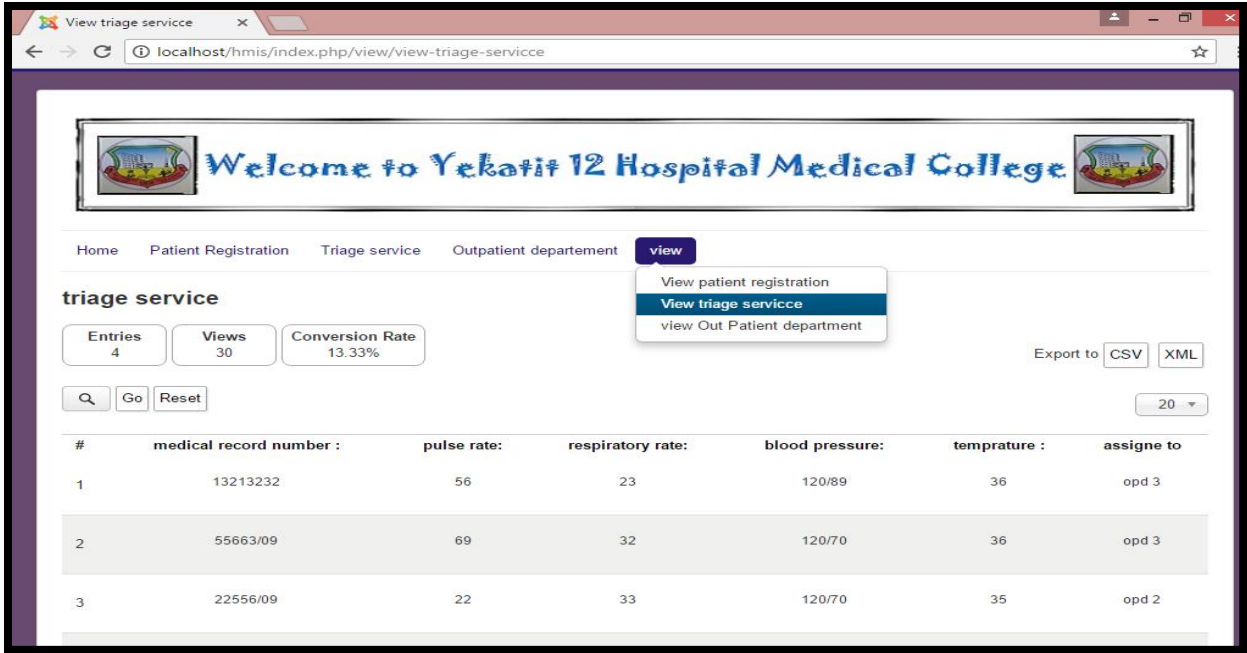


Figure 38: View triage service screen.

Interface to view the number of assign patient to each department.

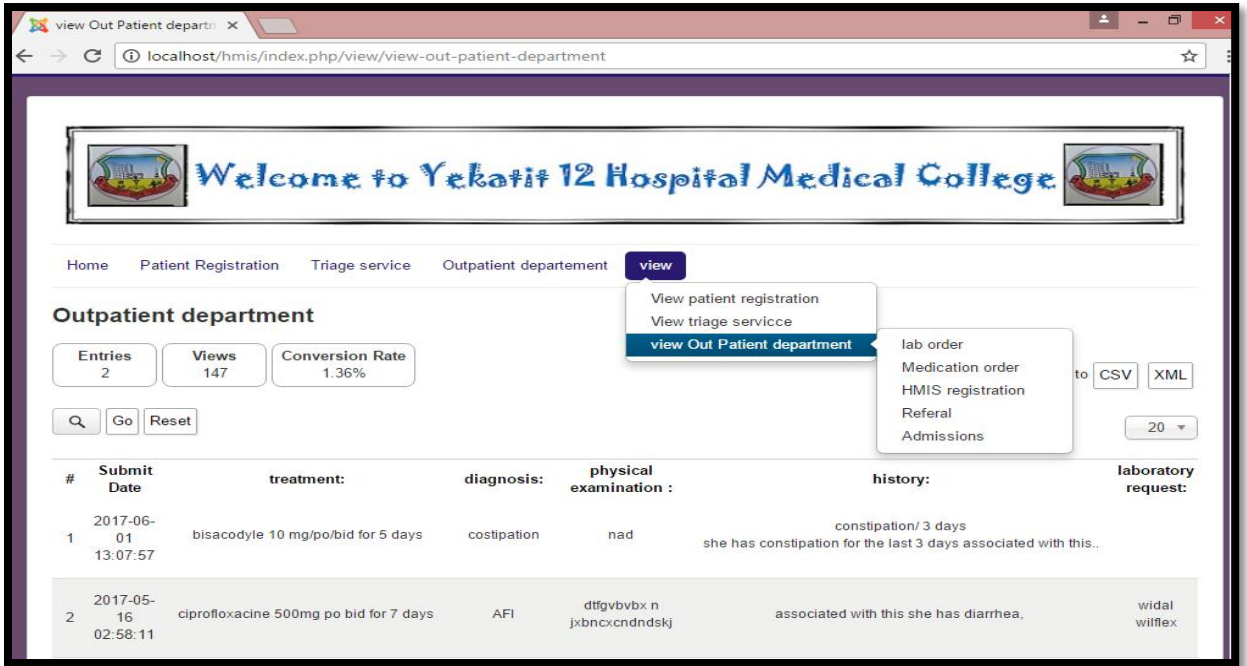


Figure 39: View outpatient department window.

An interface used to view different functionalities at OPD.

5.3 Usability Evaluation

Usability is a quality or characteristic of a product that denotes how easy this product is to learn and to use, the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use(73). Usability indicates to what extent a system is easy to use, efficient in performing a specific task, and satisfactory for end users. Usability evaluation has been conducted to diagnose problems of system development and to enhance system interface by better reflecting user viewpoints(74).

As shown in the table below the evaluation of the newly designed EMR system was done by 9(nine) participants considering their computer background and understanding of the system.

For this a questionnaires' were prepared that will help to identify problems and to make system improvements. The result of user interface evaluation was done by based on likert scale with a value of Strongly Agree =5, Agree=4, Neutral=3, Disagree=2, strongly Disagree=1. The final result shows most of the respondents that is 94.3% agreed that the system prototype has a good user interface and easy to use and work user friendly.

Table 15: User interface evaluation.

No		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	The system is easy to open and access the different options menus				1	8
2	The system is easy to choose from the different options in the system				1	8
3	The system is easy on using the different functionalities in the given privilege			1	1	7
4	The system display the required information in a format			1	3	5
5	The system saves entered data properly			1	3	5
6	The system Views saved data accurately			1	3	5
7	The System response time while saving searching is acceptable			1	3	5
8	All the fonts on the system are readable				0	9
9	All the system input fields button locations are consistent				2	7
10	Overall, the interface is pleasing and easy to use				1	8
	Average result			5	17	68
	Result percentage			5.5%	18.8%	75.5%

5.4 Discussion of Results

EMR is computerized medical record system that collect, store and display patient information comprises a system of recording, processing, storing, and transferring health information electronically. It requires less personnel, time and physical storage space(5). The newly designed system in comparison to the previously existing paper based system can minimize the various time and resource consuming business process in Yekatit 12 medical college hospital. In addition to these the new system can provide information that are complete, organized, and easily accessible for authorized users. Allows, individual patient data to be collected and accessible at the point of care that support clinicians to easily access previous patient records for future clinical management.

Due to extensive changes in medical technology and increased expectation of patients, hospitals need to have hospital information system(10). So, designing electronic information system in hospitals is mandatory this project tries to address this issue.

Smart Care software development in Ethiopia happened in collaboration with the Smart Care team in Zambia and the United States. However this system have limitation, the software is closed application and it's owned by TUTAPE Ministry of health doesn't have direct access to make modifications, add modules or improve the system. (14). This project was designed after requirement gathering and analysis of the existing system to identify the problems and users need. The system is maintained by the developer and by authorized trained personnel in the hospital and modifiable at any time to enhance features based on the hospital needs. The whole activities in the system starting from the registration of patient up to the generation of report is done using the support of computer. That is, each of the user of the system will have a personal account provided by the administrator of the system that enable them to use the specific functionality of the system accordingly to their authority. The system achieves data security system requirement.

Generally the system can help users in medical record unit, triage, laboratory and outpatient department of the hospital in registering, processing and displaying of patient data and information .The registration of the different diagnosis and treatments data are made easily accessible and the problems associated with paper based record will be decreased. In addition it generates report and sends notification message for emergency reportable disease. Facilitate decision making process at each level of health care delivery service.

CHAPTER SIX

Summary and Recommendation

6.1 Summary

Since there are different factors that affect the quality of health care for this EMR is considered as one factor that improves the quality of health care. This project attempts to develop electronic medical record system at Yekatit 12 hospital. The previously existing patient recording system in the hospital is functioning manually using different paper based formats. Based on the responses of participants, the existing paper based manual recording system has different problems like invisibility, incomplete, inaccurate and duplication of records, security and backup problems. In addition to this it requires separate huge building for storage of patient record that limits accessibility of patient information. This project can contribute to improve the hospital business process by bringing better understanding of the use of EMR system and by solving the current problems.

Requirements for the project were gathered through interview, observation and document analysis. After requirement gathering system use cases were used to describe the basic functions of system and illustrate detailed description of the activities. Some of the functional requirements are patient registration, diagnosis and treatment registration, update patient visit, search, generate report and send notification for emergency reportable disease. From non-functional requirements security, availability, maintainability, reliability and system performance were considered.

The analysis and design of the system was made by object oriented system analysis and design methodology. For this unified modeling language (UML) was used as a standard tool. From the different types of the UML tools, use case, sequence and class diagram were used.

Finally from requirement analysis and design a prototype to the system was designed to show the working model of the system. The user interface prototype design shows part of the system which the user interact to the system. It includes different components of the system like main menu that allows the user navigate to different functionalities of the system.

6.2 Recommendation

During the study of this project it was found that the hospital is using manual systems to keep patient record which has its own problems. An attempt was made to designing an EMR system to support the existing paper based patient record system that will benefit both the physicians and patient when it is implemented.

Based on the finding of the study the following recommendations were drawn and should be taken in consideration by Yekatit 12 medical college hospital managing bodies and other stakeholders which are concerned for hospital information system to solve the existing constraints regarding the current patient record system.

The hospital allocate the needed resources for implementation of the proposed system. Provide the necessary technical and administrative support. Collaborate the rest of departments (inpatient department, pharmacy, finance, and human resource) while implementing the system for full functionality of the hospital information system.

The Federal Ministry of Health and regional health office in collaboration with the hospital work on the system implementation. Provide capacity building such as avail the necessary infrastructure, training for health professionals, monitoring and implementation process and plan for expansion of system to the respective health facility.

For further study the researches can undertake further development of the remaining parts of the system (inpatient, pharmacy, finance) by using this project as an input and on interoperability of system with other related system at regional, national and international level for information exchange to improve the overall health care system.

6.3 Implementation Strategy

A single failure on a transaction of patient information may cause a serious damage on the provision of care and also on the day to day activity of the physician at the hospital. The EMR system has to function 24 hours of a day and 7 days of a week. Ethical, legal and technical issues linked to accuracy, security confidentiality and access rights are set to increase the systems implementation. Throughout the deployment of the system there should be an IT personnel who

will be in charge of providing any technical and professional guidance. So, that any failure regarding the software can be handled.

Electric power supply may pose a constraint on a proper use of the system. So, a back source generator is important. In EMR system the process of backing up, refers to the copying and archiving of computer patient data to restore the original if data or information lost by various reason. So, the implementation process need to consider backing of documents.

6.3.1 Hardware and software

This portion provides the hardware and the software requirements needed for effective and efficient running of the system. As this system is using three tiered architecture for the full functionality of the system; best performance is needed thus the below listed are recommended for the implementation. In addition to these, security issues have to be taken into consideration thus it is recommendable that the servers have to put in a safe and secure room.

Table 16: Hardware and software requirements for EMR system implementation.

COMPONENT	RECOMMENDED
CPU	2Quad Core Intel® / Core i (X) or Xeon processors at 2.33 GHz – 3.5 GHz Series Processor (implementing 64 bits architecture)
Hard disk	3 TB SAS disk array at 10k rpm (3 TB).
DVD-ROM	48 DVD+/-RW
Memory	From 12 GB up to 64 GB
Screen/Video adapter	17" Flat Panel
Backup streamer	Digital tape streamer with the same capacity as the total disk space
NIC	1GB, Network card supported by the network installed 100 Mbps for best performance
Number of users	2,200 to 3,600 users available access the system. Database Engine With 2,200 to 3,600 users easily to manage.

Table 17: server side hard ware requirements for the EMR system.

COMPONENT	RECOMMENDED
CPU	Intel Pentium (R) Dual Core CPU ES400@ 2.33 GHz / 2.49 GHz Processor
Hard disk	160 GB SATA
RAM	2 GB or more of RAM
Screen/Video adapter	A monitor with a resolution of 1024 × 768
NIC	Network card supported by the network installed
Printer	Windows compatible printer

Table 18: Client side hardware requirements for EMR system.

COMPONENT	RECOMMENDED
Operating System (OS)	Windows Server 2003/2008 64bit (Server edition is required for networks with > 10 workstations)
Microsoft.NET Framework	.NET 3.5 SP1 is a requirement for SQL Server 2008 when you select Database Engine, Reporting Services, Master Data Services, Data Quality Services, Replication, or SQL Server Management Studio

Table 19: Server side software requirements for EMR system.

COMPONENT	RECOMMENDED
Operating System (OS)	Window XP /Vista/7
Anti-virus program	Licensed (updated).

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Annex

Annex one

Requirement collection tools

ADDIS ABABA UNIVERSITY
SCHOOL OF PUBLIC HEALTH AND INFORMATION SCIENCE
DEPARTMENT OF HEALTH INFORMATICS

Information sheet

My name is Alem wassie. I am a student at Addis Ababa University currently I am conducting a project for the partial fulfillment of master's degree in health informatics, entitled with designing EMR (electro medical record system) for outpatient department of Yekatit 12 hospital medical college. The purpose of this project is to design EMR system which can maintain information about health condition of the patient who was registered at Medical Record Unit, triage and laboratory and outpatient department.

The following interview is designed in accordance to strengthen the informational need of the project to identify problems of the current system to achieve the advanced patient data handling technology for the hospital. Thus you are kindly requested to provide genuine and correct answers. You can choose not to answer any individual question or all of the questions. I look forward for your full participation as the answers you give on this form will help in better understanding of the existing system of the hospital and will help to design appropriate EMR system to alleviate the problems related to patient data handling. Your participation, non-participation or refusal to answer the questions will have no effect now or in the near future on your professional activities and personal life. In addition the information's you provide are confidential and will be used only for the purpose of this project. Sir/madam, if you have anything, you want to be clarified do not hesitate to ask the investigator/the interviewer. Your full cooperation and participation until the completion of the interview is very necessary and crucial for the completion of the project.

May I get your permission to continue?

Yes Go to the consent form

No Stop

Consent Form

My name is Dr./Sr._____. I am informed that this questionnaire is part of project that proposes on designing of electro medical record system for Yekatit 12 hospital, I have been told that the project will help in better understanding of the situation about the existing system of the hospital and will help to design appropriate EMR system to alleviate the problems related to patient data handling. And I have been informed about how the data collection will proceed. I clearly understand that my participation/non participation, or refusal to answer the questions will have no effect now or in the future on professional work as well as personal life. At last I am assured that confidentiality of my response is maintained. Therefore, I am consented to participate in the study by signing this form.

The study participant's Signature_____

Investigator name_____

Date_____

Date_____

Code_____

Signature_____

Interview Guide questions for medical directors.

Purpose: The interview questions will help to assess the current system and to design future patient record system for yekatit 12 hospital.

1. What is the currently used recording system in the hospital?
2. Do you agree with the idea of using electronic medical record system?
3. Please describe your general opinion on the EMR program?
4. Please mention the feature you need in the new system?
6. What key operational changes would you like to see with the implementation of the EMR?
7. Are there resources to run EMR program (human resources, infrastructure, and finance)?

2. Interview Guide questions for User of EMR Program

Recipients User of EMR program (Physicians, Health Officers, Nurses)

1. Are medical records well documented?
 2. Do you think there are problems in the process of patient registration, treatment and report generation?
 3. Is any documentation problems identified?
 4. Do you agree with the idea of using electronic medical record system?
 5. Do you think EMR program is helpful to your activities?
 6. What type of information is collected/registered?
 7. Is there a problem related to patient information?
 8. Do you use a computer in your routine activity?
3. Interview guide questions for departments that record routine patient data (medical record unit).
1. Are medical records currently kept for all patients who receive the service?

2. What is the currently used recording system in the hospital?
3. What are the tools used to record patient data?
4. Is there a problem in the current system?
5. How are patients identified?
6. Do all clients have a unique identification number?

4. Interview guiding questions for HMIS officer

1. what type of report is needed?
2. What is the method used to collect reports from departments?
3. Who are the stake holders that you reports?
4. Do you need additional type of report to be generated ?

Observation guiding checklist

Department_____

Date_____

Process to be observed

1. How Patient registration is carried out?
2. How Patient health records are placed?
3. Is retrieval of patient record is time tacking?
4. Is there any lost/damaged patient health record?
5. Type of materials used for patient registration and diagnosis?
6. Do all physicians record patient clinical history?
7. Weather reporting generation process is time taking?
8. Type of report needed?
9. The activities that the patient pass through from entry up to exit?

Annex two

User interface evaluation questionnaire

No	Please rate your agreement with the following statements Place X in the appropriate column that you agreed up on.	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	The system is easy to open and access the different options menus					
2	The system is easy to choose from the different options in the system					
3	The system is easy on using the different functionalities in the given privilege					
4	The system display the required information in a format					
5	The system saves entered data properly					
6	The system Views saved data accurately					
7	The System response time while saving searching is acceptable					
8	All the fonts on the system are readable					
9	All the system input fields buttons locations are consistent					
10	Overall, the interface is pleasing and easy to use					

ENT 50

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SERVICE IDENTIFICATION CARD

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 MEDICAL RECORD NUMBER

ስም ጠገረካቤ ዕድሜ 54 ያታ F
 NAME ጠገረካቤ AGE 54 SEX F

12-2023


የቀጠሮ መስጫ ካርድ
Appointment Card

የጤና ድርጅቱ ስም HIWIRIH
 Facility Name

ስም Beduka An Zerihun
 Name

የሕክምና ካርድ ቁጥር 041585/06
 Medical Record Number

አፈላላጊ ካርድ
MASTER PATIENT INDEX(MPI)


 Federal Ministry of Health

የሕክምና ካርድ ቁጥር _____ የተመዘገቡበት ቀን _____
 MEDICAL RECORD NUMBER DATE OF REGISTRATION:
 (DD/MM/YY)

ስም _____ የአባት ስም _____
 NAME FATHER'S NAME

የአያት ስም _____ ያታ _____
 GRAND FATHER'S NAME SEX

የልደት ቀን _____ ወር _____ ዓ.ም _____ ዕድሜ _____
 DATE OF BIRTH MONTH YEAR AGE

አድራሻ: ክልል _____
 ADDRESS REGION

ወረዳ/ክፍለ-ከተማ _____ ጎጥ _____
 WOREDA/SUB-CITY GOTT

ቀበሌ _____ የቤት ቁጥር _____
 KEBELE HOUSE NUMBER

ዳርጋጋው ለሕዝብ አገልግሎት

PATIENT REFERRAL SLIP

No 4613

Reg> NO _____

Date _____

o _____ Hospital _____ Department

orm _____ Hospital/H.center _____ Department

me _____ Department

me of patient _____

ge _____ Sex _____ Occupation _____

ldress Woreda _____

inical Finding _____ Kebele _____ House No. _____

gnosis _____

stigation Result _____

given _____

ons for Referral _____

rred by _____

e of physician _____

ature _____

FEED BACK

No 4613

Reg. NO _____

Date _____

የካቲት 12 ሆስፒታል ሜዲካል ኮሌጅ
YEKATIT 12 HOSPITAL MEDICAL COLLEGE

Name.....

Age.....Sex.....

Physician

Hospital No.

URGENT

In patient WARD.....BED No.

Out Patient

Clinical diagnosis.....

Date Requested.....Time.....

Hct	%	• Promyelocytes	
Hb.	GM% ³	• Myeloblast	
R.B.C.	Per mm ³	• Normoblast	
WBC	Per mm ³	Platelets	Per mm ³
Differential	%	Reticulocytes	
• Neutrophils		ESR	1.hr. 2. hrs.
• Bands		Hemoparasites	
• Lymphocytes		Blood Group	
• Monocytes		Blood Morphology	
• Eosinophiles		MCV	
• Basophiles		MCH	
• Myelocytes		MCHC	
		RDW	

Date Performed.....

Signature.....

HAEMATOLOGY

Yekatit 12 Hospital

Name
Hosp.No. Ward/Dept. Specimen
Sex..... Age..... Date of collection Time
Address Clinical diagnosis

Physician.....

Antibacterial Therapy

- Request: Gram stain Acid fast stain
 KOH Culture and Sensitivity
 Wet smear Indiaink

LABORATORY REPORT

Gram stain
Indiaink.....

Wet Smear
KOH
Acid fast stain

DRUG SUSCEPTIBILITY READING

Bacteria Isolated	DRUG SUSCEPTIBILITY READING																S = Sensitive I = Intermediate R = Resistant								
	Ampicillin	Agumentin	Cephalothin	Chloramphenicol	Erythromycin	Gentamycin	Ceftazidime	Cloxacillin	Methicillin	Nalidixic Acid	Nitrofurantion	Amoxil	Penicillin G	Cefotaxime	Sulfadiazine	Tetracycline		Trimethoprim	Sulfamethoxazole	Ceftriaxone	Doxycyclin	Norfloxacin	Amikacin		

No. Date of report Signature

BACTERIOLOGY LOTS

BACTERIOLOGY
Zewdie Printing

PRSCRIPTION PAPER

Nº 229605 -

Name of the Health institution **YEKATIT 12 HOSPITAL MEDICAL COLLEGE**

Address; Region 14 City: Addis Ababa Tel. 011-155-30-66 P.O.Box 257

patient's Name.....

Age..... Sex..... Card No.....

Address:Region..... Kifleketema..... Kebele..... House No.....

In Patient

Out Patient

Diagnosis(ICD Code No.).....

Treatment given (Drug name Strength, dosage form, frequency duration)	Price of each item (for dispenser use only)	
RX		
	TOTAL	

Prescriber's
Full Name.....
Qualification.....
Registration.....
Date Prescribed.....

Dispenser's
.....
.....
.....

የካቲት 12 ሆስፒታል ሜዲካል ኮሌጅ
 YEKATIT 12 HOSPITAL MEDICAL COLLEGE

Name.....
 Age..... Sex.....
 Physician.....

Hospital No..... **URGENT**
 In patient WARD..... BED No.....
 Out Patient.....
 Clinical Diagnosis.....
 Date Requested..... Time.....

Muday Printing Press

WIDAL		R.A. Factor	
S.Typhi O		ASO titer	
S. Tyhi H		Coombs	
S.Para AO		Pregnancy test	
-AH		Prothrombine time	
-BO		V.D.R.L.	
-BH		L.E.Cells	
Well-Fellx			
OX-a			
OX-K			
OX-19			
Brucelle			

Date Performed..... Signature..... **SEROLOGY**