ADDIS ABABA UNIVERSITY

SCHOOL OF INFORMATION SCIENCE

AND

SCHOOL OF PUBLIC HEALTH

M.Sc. in Health Informatics Programme

DESIGN ELECTRONIC MEDICAL RECORD MANAGEMENT SYSTEM FOR NEONATAL INTENSIVE CARE UNIT OF YEKATIT 12 HOSPITAL MEDICAL COLLEGE

A Project Submitted to the School of Information Science and Public Health of Addis Ababa University in Partial Fulfillment of the Requirement for Degree of Master of Science in Health Informatics

By

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Dedication

This work is dedicated to my beloved husband Ato Solomon Tsegaye, whose encouragement and support gave me strength to successfully finish this course.

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List of Acronyms

AIDS	Acquired Immune Deficiency Syndrome
ARR	Annual Reduction Rate
ARV	Anti-Retro Viral Treatment
CDC	Communicable Disease Control
CDO	Care Delivery Organization
CDSS	Computerized Decision Support System
CPOE	Computerized Physician Order Entry
DHS	Demographic health survey
EBF	Express Breast Feeding
EC	Ethiopian Calendar
eHealth	Electronic Health
EHR	Electronic Health Record
EMR	Electronic Medical record
FF	Formula Feeding
FMOH	Federal Ministry of Health
HIS	Health Information System
HIT	Health Information Technology
HIV	Human Immune Virus
HMIS	Health Management Information Science
HSTP	Health Sector Transformation Plan
ICT	Information Communication Technology
ICU	Intensive Care Unit
MDG	Millennium Development Goal
MMRS	Mosoroit Medical Recording System
NICU	Neonatal Intensive Care Unit
NOPD	Neonatal Outpatient Department
OO	Object Oriented
SQL	Structured Query Language
TUTAPE	Tulane University Technical Assistance Program for Ethiopia
U5MR	Under Five Mortality Rate
UML	Unified Modeling Language
WHO	World Health Organization

Abstract

Background: Electronic Medical Record is defined as a computerized medical record used to capture, store, and share information among healthcare providers in an organization, supporting the delivery of health services to patients. It is perceived as a way to improve healthcare quality through improving work flow, reducing medical errors, minimizing cost and treatment time, increasing revenue, improving patient care by creating a better linkage to all care givers.

Most medical records are kept on paper. This makes it difficult to use the available information for management of care, measuring of quality of care and improving care delivery. The healthcare industry is mostly data driven and it depends on the accuracy and availability of the data and since most of the data is on paper format, this limits access to the data by healthcare providers.

Objectives: The General Objective of this project is to design an EMR management system and to develop prototype of an EMR management system for Neonatal Intensive Care Unit of Yekatit 12 Hospital Medical College.

Methodology: This project used the Object-oriented analysis and design system development technique and different data collection tools (interview, document analysis and observation) were used to collect requirement for the system to be developed. Analysis and design of the proposed system was done by using the Unified Modeling Language and the tools used were, Microsoft Visio 2013, Visual paradigm, Microsoft visual studio 2012 and SQL database server.

Summary: The designed NICU Record Management System consists of registration of different Neonatal patient data such as patient demographic data, clinical data such as Vital signs, Diagnosis, Treatments, Progress note, Discharge summery, Nursing care plan, laboratory results and patient appointments and provides decision support for vital signs and laboratories. Generally the designed NICU Electronic Medical Record Management System could enhance accessibility of data or patient information with the reduction of the unnecessary time wasted to search patient information and to compile reports, and it makes timely use of information by decision makers, which improves the current service.

CHAPTER ONE

INTRODUCTION

1.1 Back ground

Neonatal period is defined as up to first 28 days of life and further divided into very early (birth to less than 24 hours), early (birth to less than 7 days) and late neonatal period (7 days up to 28 days) (1). The first 28 days life of the neonatal period represent the most vulnerable time for a child's survival. In 2012, around 44% of under-five deaths occurred during this period, up from 37% in 1990. As overall under five mortality rates decline, the proportion of deaths occurring during the neonatal period is increasing. This highlights the crucial need for health interventions that specifically address the major causes of neonatal deaths, particularly as these typically differ from the interventions needed to address other under-five deaths (2).

Evidence-based estimation of child mortality is a cornerstone for tracking progress towards child survival goals and for planning national and global health strategies, policies and interventions on child health and well-being (3). The health information system is one of important tool which provides the underpinnings for decision-making and has four key functions: data generation, compilation, analysis, synthesis and communication. 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 (4).

According to Ethiopian FMOH, in order to build a flexible and efficient eHealth capability, Ethiopia should go on a strategy of national eHealth coordination and alignment. This will involve the establishment of national frameworks and infrastructural components that can be leveraged at national, regional and local levels to deliver solutions that are able to be integrated and share data across geographic and health sector boundaries (5).

Currently in Ethiopia, the Health Sector Transformation Plan (HSTP) is the next five-year national health sector strategic plan, which covers 2008-2012 E. C (July 2015 – June 2020). The sector has identified transformation agendas one of the transformation agenda is information revolution. The main objective of information revolution is to enhance the use of timely, accurate and reliable

information for decision-making at the local level across the sector. This includes revolutionizing the data management from patient level data to national level reports. The routine systems that are built for collection of data should be supported with appropriate technology to efficiently operate across the line (6).

Implementing EMR System is the priority agenda not only in developed countries but also in many developing countries. EMR is defined as a computerized medical record used to capture, store, and share information among healthcare providers in an organization, supporting the delivery of health services to patients. It is perceived as a way to improve healthcare quality through improving work flow, reducing medical errors, minimizing cost and treatment time, increasing revenue, improving patient care by creating a better linkage to all care givers, reducing the need for file space, supplies, and workers for the retrieval and filing of medical records (7).

1.2 Overview and Background of the Organization

This project was conducted at Yekatit 12 Hospital Medical College Neonatal Intensive Care Unit. It is one of the oldest Hospitals under the Addis Ababa City Administration Health Bureau. The hospital was established in 1915 with the aim of providing health care services. The Swedish physician Dr Hanner was among the founders of the Hospital. He was also the first medical director of the Hospital during 1926-1936. At the time of establishment, the Hospital had one physician, 2 Nurses and 3 Health assistants. Currently, the Hospital has more than 595 health professionals and 466 supportive staffs. The Hospital is located in northern part of Addis Ababa in Arada Sub-City (Yekatit 12 Hospital Medical College Annual report).

Neonatal Intensive Care Unit of the hospital officially began in 1998 E.C by, Dr. Mulualem Gessese (Neonatologist) with five beds and three Nurses. With the vision of "delivering the best quality newborn care in order to achieve the highest quality outcomes for all newborns" and the mission of the unit are: establishing Neonatology department in Yekatit 12 Hospital Medical College, facilitating the establishment of NICU in other Hospitals and Health centers in Addis Ababa and also other regions, Providing Neonatal care training to medium and higher level health professionals and creating government and public awareness on newborn health through the use of public and private media.

Currently the Unit fulfills NICU of international standard by increasing its capacity with international standard facilities such as incubators, ventilators, separate rooms for septic and non-septic neonates, an outpatient room, a Kangaroo Mother Care room, a procedure room and a separate phototherapy room. And also the unit serves as a teaching center for different students. 3 Pediatricians, 5 General Practitioners, 28 nurses and 8 supportive staffs are giving service in the unit (The Journey to save the innocent little, by Dr. Mulualem Gessese, 2014).

1.3. Statement of the Problem

Most medical records of Hospitals are kept on paper. This makes it difficult to use the available information for management of care, measuring quality of care and improving care delivery. The healthcare industry is mostly data driven and it depends on the accuracy and availability of the data and since most of the data is on paper format; this limits access to the data by healthcare providers and is a challenge to healthcare delivery. Moreover, if a paper-filled medical record needed to be seen by a different care provider or someone at a different location, that paper file would have to be hand delivered to this new location, which is time-consuming and inefficient (8).

According to report of WHO 2013, countries should invest in improving the collection and quality of birth and death registration systems and consider innovative mechanisms for gathering data, registration of newborn deaths should be accompanied by programmatically-relevant categorization of the causes of deaths. Quality and completeness of data need to be monitored continuously and the data should be disseminated as the basis for planning. It is also important to track disability outcomes (such as retinopathy of prematurity, deafness and cerebral palsy) particularly for countries expanding neonatal intensive care unit (9).

EMR systems provide the basic infrastructure upon which other electronic health solutions can be laid. In developing countries, there are evidences to show that EMR are gaining ground in the health sector. For instance, in Kenya the OpenMRS developed by the Regienstrief Institute and Partners in Health, provides a user-friendly interface for electronically storing medical data and has been very successful. The Mosoroit Medical Record System (MMRS), which was implemented at a primary care rural health center in Kenya, provides patient registration and patient visit records management with capability to handle information of over 60,000 patients (10). After MMRS implementation, patient visits were 22% shorter, they spent 58% less time with

providers and 38% less time waiting. The MMRS reports have also facilitated detection of clustering of sexually transmitted diseases in one village and lack of immunization in another village and this lead to a team of health personnel being dispatched to the villages to carry out appropriate interventions (11).

The other electronic medical record which is succeeded in developing countries include the Lilongwe EMR used for a wide range of clinical problems in a pediatric department of the Central Hospital in Malawi; the system runs over a local area network built on Linux/ MySQL with Visual Basic TM for the client programs. Physicians, Nurses and pharmacists perform all data entry using touch screens, including medication orders. Data are collected on patient demographics, medication, laboratory tests and X-rays (12).

However, currently in Neonatal Intensive Care Unit of Yekatit 12 Hospital, health care providers document patient data using paper records. Therefore, different problems are existed, some of the problems are: Incompleteness of patient data, huge amount of paper records which is documented by different health professionals (Nurses, Interns, General practitioners, pediatric Residents and pediatricians) accumulated on patient chart which is difficult to manage and leads to searching previous patient history is boring and time taking, consumption of large space for storage, difficulty to retrieve useful information from stored data, inaccuracy of information, illegible hand writing in records, and also poor quality of service delivery. The other problems in this Unit are loss of patient charts which leads to loss of previous history and duplication of records. In addition, there is no decision supports for health professionals even if newborns are unique normal ranges and thresholds. Because of the above reason there is problem with decision making process and quality of care.

Therefore, it is high time to build systems for quality information to end preventable Neonatal mortality.

1.4. Objectives

1.4.1 General Objective

- The General Objective of this project is to design An EMR management system and to develop prototype of the EMR management system for Neonatal Intensive Care Unit of Yekatit 12 Hospital Medical College.

1.4.2 Specific Objectives

- To design an EMR management system.
- To develop prototype of the EMR management system.
- To evaluate the prototype.

1.5. Scope and Limitation of the Project

The scope of this EMR project was to analyze requirement and to design an EMR Management System for NICU (Neonatal outpatient and inpatient) of Yekatit 12 Hospital Medical College, which enables electronic recording and managing of different patient information, such as registration of patient basic personal information, medical History, physical examination findings and diagnosis, laboratory orders and results, vital signs, treatments, daily progress note, discharge summery, referral, Nursing care plan, appointment scheduling, report generating features and it could have also decision support for vital sign and laboratory.

The project covers only the design of EMR Management System for NICU and laboratory Unit and also the development of the prototype of the system. The project doesn't cover areas regarding Record room, delivery and maternity, pharmacy, imaging and finance, because of time limitation and financial constraints.

1.6. Significance of the Project

The ultimate goal of this project is to analyze requirement and to design EMR Management System in the Neonatal Intensive Care Unit and laboratory department of Yekatit 12 Hospital. Designing this system could have the following significances.

For Patients: Since the primary goal of the hospital is to give quality service for patients, patients could be benefited from the system by getting quality service which includes good documentation of their records, quality and complete record and prevent their records from damage or loss.

For Health Professionals: This EMR management system may have a better significance for health professionals by solving the problem of illegible hand writing in records and easy access of patient information by different professionals. Moreover, because of the unique aspects of newborn, definition of normal ranges for laboratory result and thresholds for vital signs are different from adults, so the system includes alerts for vital sign and laboratory, which helps the health care providers as a decision support. Additionally, all information of the patient are organized in proper format and readily retrievable when needed which helps for saving time. loss of information containing papers would also be avoided.

For the Hospital: This EMR management system could have a benefit for the Hospital for giving a better health care service, generate quality information on time which helps for planning of resources, budget and timely decision making.

For Policy makers and Regional Health Bureau: The data generated from this electronic medical record helps for their decision making and for appropriate planning.

For Researchers: The collected data can be used for research purpose. It helps to eliminate the manual tasks of extracting data from charts, because the data needed for a study can be derived directly from the electronic record.

CHAPTER TWO

Literature Review

2.1. Introduction

Neonatal Mortality Rate (NMR) is defined as the number of deaths in the first 28 completed days of life per 1000 live births. Neonatal morbidity and mortality are major global public health challenges with approximately 3.1 million babies worldwide dying each year in the first month of life (13). Most newborn deaths occur in low- and middle-income countries. Two-thirds of all newborn mortality occurs in 12 countries, six of which are in sub-Saharan Africa (9).

According to the 2014 World Health Statistics Report, Ethiopia has achieved MDG 4 target three years earlier by reducing under-five mortality by 67% from the 1990 estimate. The UN Inter Agency Group's 2013 mortality estimate reported that Ethiopia's under-five, infant and neonatal mortality rates were 68, 44 and 28 per 1000 live births respectively. The reduction in mortality in neonatal age groups (48%) is not as impressive as that of childhood mortality (6).

Although countries with the highest death rates also tend to be those with the fewest data available, estimates of numbers of neonatal deaths by cause are not enabling policy makers, health professionals and researchers to improve targeting of interventions to reduce neonatal mortality in the short, medium and long term (14).

Sound and reliable information is the foundation of decision-making across all health system building blocks, and It is essential for health system policy development and implementation, governance and regulation, health research, human resources development, health education and training, service delivery and financing (4). Health care Providers generate and process information as they provide care to patients. Managing that information and using it productively is still continuing to be a challenge. Health information technology (health IT) has the potential to significantly increase the efficiency of the health sector by helping providers manage information. It could also improve the quality of health care and ultimately, the outcomes of that care for patients (15).

Health planners and decision-makers need different kinds of information including: health determinants (socio-economic, environmental, behavioral, genetic factors) and the contextual environments within which the health system operates, inputs to the health system and related processes including policy and organization, health infrastructure, facilities and equipment, costs, human and financial resources, health information systems, the performance or outputs of the health system such as availability, accessibility, quality and use of health information and services, responsiveness of the system to user needs, and financial risk protection, health outcomes (mortality, morbidity, disease outbreaks, health status, disability, wellbeing (16).

Improving data collection is first step in creating health systems data flows to appropriate points for effective decision-making. Better data collection leads to better health policies and health outcomes. In particular, the use of ICTs creates efficiencies in data collection as well as improves health information flows and data quality. This allows timely and accurate depictions of disease burdens and resource flows, enabling policy makers to effectively allocate limited resources (17).

Well-organized and comprehensive medical record is critical to high quality patient care. It can provide complete, accurate and easy access to diagnoses, treatments, results and care plans in chronological order, thus enhancing quality and efficiency of care. Studies have indicated that medical record systems in low-income countries are lacking. In Ethiopia, only 14% of returning patients could locate their medical records and only 6.5% of medical records contained complete patient information. In Ghana, 30% of patients have multiple folders. In Pakistan, only 39% of hospital departments recorded 75% or more required information (18).

Other medical records studies also found similar problems such as duplication, incompleteness and inaccuracy of clinical information. However, many studies have also shown that with relatively little investment low-income country hospitals, can improve medical records management system (19).

2.1.1. Information System

Information systems are combinations of hardware, software, databases, telecommunications, people, and procedures configured to collect, manipulate, store and process data into information (20). An information system is a group of interrelated components that work to carry out input, processing, storage, output and control actions in order to convert data into information that can

be used to support forecasting, planning, control, coordination, decision making and operational activities in an organization (21).

Information Systems play a strategic role in the life of organizations, it provides the management with appropriate information and in the right place and time to help the management to do various functions of planning, organizing, directing and control and decision-making. Every business organization needs information system to keep track of all business activities. Information system transform data to information and summarized the information to meaningful and useful forms as management reports to use it in managerial decision making and support management activities (22).

2.1.2. Health Care Information System

The World Health Organization (WHO) over the last decade has developed a health systems strengthening framework focused on 6 building blocks that form the fundamental inputs to improve access, quality, cost effectiveness and responsiveness of health systems. The building blocks include service delivery, leadership and governance, healthcare financing, health workforce, medical products and technologies, information and research. Despite a renewed focus on strengthening health systems, inadequate attention has been directed to a key ingredient of high-performing health systems (23).

A well-functioning HIS should produce reliable and timely information on health determinants, health status and health system performance, and be capable of analyzing this information to guide activities across all other health system building blocks. Thus, HIS enables decision-makers at all levels of the health system to identify progress, problems, and needs; make evidence-based decisions on health policies and programs; and optimally allocate scarce resources (24).

Health care information system refers to systems that are used to process data, information and knowledge in healthcare environments. The prognosis for successful healthcare information systems (HIS) implementation is increasing. It is expected to increase legibility, reduce medical errors, shrink costs and boost the quality of healthcare (25).

2.1.3. Information Communication Technology (ICT) in Health Care

Information Communication Technologies (ICT) are defined as tools that facilitate communication and the processing and transmission of information by electronic means. Today the range of possible applications of information and communication technologies (ICT) in the health sector is enormous. The technology has progressed significantly and many estimate that ICT implementation can result in care that is both higher in quality, safer, and more responsive to patients' needs and, at the same time, more efficient (26). HIT can be implemented in the form of Electronic Health Record (EHR), Electronic Medical Record (EMR), Computerized Physician Order Entry (CPOE), Clinical Decision Support System (CDSS), etc. or in some cases combination of two or more of the above (27).

Studies have shown that, ICTs have clearly made an impact on health care. They have: improved dissemination of public health information around major public health threats, enabled remote consultation, diagnosis and treatment, improved the efficiency of administrative systems in health care facilities. This translates into savings in lives and resources, and direct improvements in people's health. In Peru, Egypt and Uganda, effective use of ICTs has prevented avoidable maternal deaths. In South Africa, the use of mobile phones has enabled tuberculosis patients to receive timely reminders to take their medication. In Cambodia, Rwanda, South Africa, and Nicaragua, multimedia communication programs are increasing awareness of how community responses to HIV and AIDS can be strengthened. In Bangladesh and India, global satellite technology is helping to track outbreaks of epidemics and ensure that effective prevention and treatment methods can reach people in time (28).

2.1.4. An Analysis on Medical Record Terminologies

Many terminologies such as Electronic Medical Record, Electronic Health Record and Electronic Patient Health Record are in use in medical informatics to refer to a digitalized patient health data. Although these terminologies share some common attributes, the distinctions between their definitions, contents, sources and storage medium are significant\ and the nature of implementation also differs from one system to another (29).

2. 1.4.1. The Electronic Health Record

EHRs are defined as "a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. The EHR represents the ability to easily share medical information among stakeholders and to have patient's information follow him or her through the various modalities of care engaged by that individual. It is the aggregate of health-related information on an individual that is created and gathered cumulatively across more than one health care organization and is managed and consulted by licensed clinicians and staff involved in the individual's health and care (30), (31).

2.4.1.2. The Electronic Personal Health Record

The Electronic Personal Health Record (ePHR) contains medical information and it is owned by the patient. Information contained in the ePHR may have been created by any number of sources including the patient, a lab, a physicians practice, a hospital or an insurance company. The contents of an ePHR are determined by the patient and stored in the manner he or she wishes. They may be stored on a local computer, a thumb drive (small personal hard drive), or through an online service (32).

2.4.1.3. The Electronic Medical Record (EMR)

EMR is the legal record created in hospitals and ambulatory environments that is the source of data for the EHR. It is equivalent to the paper based medical record that a health care provider maintains for a patient. The EMR is an electronic record of health-related information on an individual that is created, gathered, managed, and consulted by licensed clinicians and staff from a single organization who are involved in the individual's health and care. It is owned by the organization. The contents of EMR include demographic information patients' histories, family histories, risk factors, findings from physical examinations, vital signs, test results, known allergies, immunizations, health problems and responses to therapy (33), (34).

2.1.5. Electronic Medical Recording System (EMR) use in Health Care

It is widely believed that the introduction and the adoption of electronic medical records will result in cost savings for healthcare industries, reduce service errors and improve quality of care. The electronic medical records (EMR) systems when coupled with network systems, offers means of transferring information between doctors as part of improving the quality of care. The employment

of computerized systems in healthcare is seen as a foundation of a national health information network that will advance medical knowledge (35).

EMR is referred to as managing patient medical records electronically from a variety of sources. It deals with patient treatment, diagnosis, laboratory test, imaging, history, prescription and allergies that can be accessed from various sites within the organization with the protection of security and patient privacy (36). The main advantages of Electronic Medical record When compared to manual record, electronic medical record (EMR) are greater accuracy and a higher proportion of correct information, time saved in locating information, more economical use of financial resources; and greater ease and speed of recovery of patient data (37).

Using EMR has demonstrated a number of benefits in the improvement of health care services. Such as decreased storage space requirements and reduced efforts in searching for the records of the patient. The physician can utilize various templates including demographic information, medical conditions sheets, orders, prescription, image requirements, follow-up notes, etc. By picking up and using the right template, the physician can effectively save time, make fewer mistakes, and chart a patient's details more compressively than when using paper recording system. Moreover, they would improve the legibility of clinical notes and provide decision support for drug ordering, including allergy warnings and drug incompatibilities. They also provide reminders to prescribe drugs and administer vaccines and warnings for abnormal lab results (38), (39).

Moreover, the use of electronic medical records offers many advantages for carrying out clinical research. It helps to eliminate the manual tasks of extracting data from charts or filling out specialized datasheets. The data needed for a study can be derived directly from the electronic record, making research-data collection a byproduct of routine clinical record keeping (40). It is a new technology in the health and hospital information field where clinical, demographic, and management information is entered in a computerized record. Computers facilitate the speed of communication, accuracy of information, capacity for information storage and data retrieval. (41), (42).

Hospitals, in developed countries continue to implement electronic medical records to lower costs and to improve quality of care. For instance In United States of America, $1.2 billion grant was unveiled to facilitate adoption of electronic health records in all hospitals by 2014. With the

adoption of electronic medical records, patient information will be electronically captured in any care delivery setting. This is aimed at increasing Health Information Exchanges (HIEs) and eventually maintaining a Nationwide Health Information Network (NHIN), which aims to provide a secure and interoperable health information infrastructure that allows stakeholders, such as physicians, hospitals, payers, state and regional HIEs, federal agencies, and other networks, to exchange health information electronically (12).

Compared with other developed nations, New Zealand's use of information technology (IT) in health care is among the highest in the world. All of the country's 1,100 general practices use an electronic medical record system with comprehensive functionality to manage patient's problem lists, enter clinical progress notes, perform electronic prescribing, and order laboratory tests and x-rays, among other tasks. Physicians are also increasingly using information technology to communicate with patients and allow them to schedule appointments (43).

Canadian EMR adoption rates are increasing annually. In the 2010 NPS, 16% of Canadian physicians reported using EMRs exclusively and another 34% reported using a combination of EMRs and paper charts. Overall adoption rates have increased from about 20% of practitioners in 2006 to an estimated 62% of practitioners in 2013. The most commonly reported uses of EMRs were to look up patient notes (39%), electronic reminders for patient care (20%), and electronic drug interaction checking software (20%). Clerical and medical staff who have adopted EMRs appreciate that the long-term advantages outweigh the short-term pain in establishment (44).

2.1.6. Existing EMR in Developing Countries

In developing countries introducing an electronic medical records (EMR) system is one way to improve health care. Because of the potential benefits it present for health systems, For example, EMR systems information is used locally (within the health system), ease collection of data for surveillance and allow medical personnel to access patients' records including records of previous care. They also improve medical personnel's efficiency by reducing the time required for data management and record keeping, giving staff more time for patient care. In addition to improving care for individual patients, an EMR system can improve the overall health care system (45).

Countries like Kenya, India, and Haiti have been gaining the benefits which can also be seen as potential benefits of EMR systems in other developing countries. Such systems have been shown

to provide greater accuracy, efficiency and cost benefits. Though these benefits are significant there are still more inherent advantages to EMR such as; Facilitates speed and accessibility in obtaining consultations from distant specialists, Makes clinical notes and documentation legible, reducing clinical errors associated with illegible handwriting, Provides reminders to routine screenings, prescriptions, administration of vaccines and other health maintenance benefits, Generates warnings for abnormal laboratory results. Supports program monitoring, including reporting outcomes, budgets and supplies (46).

2.1.7. Challenges of Implementing EMR System in Developing Countries

According to different studies, many challenges exist for developing countries. Such as: Lack of user training, poor initial design limiting capabilities and expansion potential, systems difficult or complex to use, dependence on one individual (champion), lack of involvement of local staff in design and testing, lack of perceived benefit for users who collect data, lack of back-up systems in the event of computer loss, Poor system security leading to viruses and spyware, unstable power supplies and lack of technical support are listed as challenges (46).

2.1.8. Special EMR System Considerations for Neonatal Patients

The use of EMR system is more critical in case of the intensive care department. It can help to provide immense benefits to the clinician such as shortening the recording time so that more time is directed to patient care; while at the same time, improving the quality of the documentation and care rendered through the form of alerts, risk information, error reporting, Some of these features could be lifesaving in the intensive care units (39).

Pediatric patients have been identified as a high-priority, high-risk population due to differences in physical characteristics and developmental issues. Providing care and medication management is more complex due to: patient physiology and the complex nature of common or routine tasks. These unique pediatric characteristics influence the clinician's selection of: factors to consider for appropriate care, parameters on which to base decisions, goals attempt to achieve, and tasks to implement that are required to achieve these goals. Therefore these characteristics and the clinician's preferred course of action influence how the user interface of an EMR must be designed to accommodate and support the cognitive and decision-making requirements of the clinician. This is why the unique aspects of pediatric care make selection and arrangement of information

displays, definition of “normal” ranges and thresholds for alerts differ among many other display and user interface considerations, more challenging to design and implement (47).

Moreover, Neonatal infants require special considerations as a category In particular, more and unique information is needed for much quicker decision–making cycles by physician, Nurses, and other care providers, which enable efficient creation of newborn records, support updating information that is initially inaccurate or unknown. (Information is often not immediately available in the NICU or labor and delivery, such as last Names, sex, and weight), and also should contain information about maternal infections, blood type, and pregnancy complication (48).

2.2. Related Works

In Germany, one successful example of the use of ICT in health care is the Medical Online Portal in Ingolstadt Hospital. It is a communication platform that connects all the health care professionals in the hospital. It interconnects the hospital's databases, including radiology, patient records and patient administration via web services. The doctors enter data into different forms using a tablet PC. As this information can be retrieved any time and by all the professionals, the duplication of data gathering can be avoided. It is estimated that 2 000 hours of work time is saved annually due to improved administration procedures resulting in more time for actual health care activities. Furthermore, due to the enhanced search for medical information, approximately 35 000 euro per year is saved. In addition, the risk of entering and receiving wrong information is reduced (49).

In 1996, Partners In Health (PIH) started an open source web system in Peru that was backed by an Oracle database. The system serves 4300 patients. Physicians fill out forms, and nurses and their assistants enter medication data. The medication order entry system has shown 17.4% fewer errors than the previous paper approach. Drug requirements analysis tools that are based on the medications prescribed matched the usage data in the pharmacy to within 3%. This EMR demonstrates the strength and flexibility of a web based approach (38).

In Brazil, The Brazilian public health system uses the ‘Computerized System for the Control of Drug Logistics (SICLOM)’ to deliver ARV treatment to over 100 000 patients – by far the largest group in the developing world. The system had Separate EMR databases on each physician’s

desktop periodically connect to the central server by dial-up to update records. The system serves More than 100 000 patients to support prescribing and track medication supplies (50).

In Uganda, a team at the US Department of Health and Human Services has developed a medical record system to support HIV treatment via the Care ware system. The system run over a local area network and Stand-alone database built with MS Access. The data's or information's are filed out direct by users, both on paper forms and computers this includes the patient personal information, laboratory results, and medication data the system provides comprehensive tools for tracking HIV patients and their treatment, including clinical assessment, medications and billing data. It is widely used in health centers and hospitals in the US, and has recently been internationalized and deployed in Uganda (51).

In Rwanda, a new inpatient medical record system was implemented in the ICU (Intensive Care Unit). The system includes a set of standardized clinical forms. The standardized clinical forms contain vital signs, physician orders, discharge summary and others specific to the ICU's clinical needs, which allows clinicians to record specific clinical information on corresponding standardized forms. All similar information can be aggregated under one tab. For example, all patient vital signs are recorded on vital sign forms and placed under the vital sign tab. If a clinician desires to trend vital signs, all vital sign information can be found in one, clearly marked location a post-intervention evaluation showed, they found the new medical record format significantly improved clinician satisfaction and significantly reduced the time required for physicians to locate clinical information.(18).

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). Dire Dawa region has successfully deployed this system for building and maintaining electronic medical records, which will improve both the quality of health information as well as patient care (52)

CHAPTER THREE

Methodology

3.1 Study Area and Setting

The study was conducted at Neonatal Intensive Care Unit (NICU) of Yekatit 12 Hospital Medical College. Currently, the Hospital has 595 health professionals and 466 supportive staffs. The neonatology unit of this Hospital have more than 50 beds for admission of neonates, 3. Pediatricians, 5 General Practitioners, 28 Nurses and 8 supportive staffs are giving service and at the laboratory departments 35 laboratory Technicians are working.

3.2 Study Period

The study was conducted from December 2016 to May 2017.

3.3 Study Design

An Object Oriented (OO) methodology with an Iterative and incremental approach was used to analyze the requirement and to design the electronic medical record management system to Neonatal Intensive Care Unit of Yekatit 12 Hospital. This method is selected because it is an appropriate method to design systems which is emphasizing to capture the structure and behavior of information systems. In addition Object Oriented (OO) analysis and design is a way to develop information system by building self-contained modules (Objects) that can be more easily replaced, modified and reused. Object-oriented analysis and design (OOAD) is also used for analyzing and designing information system by applying the visual modeling throughout the development life cycles which has an advantage of better stakeholder communication and product quality.

3.4. Study Population

The study includes Yekatit 12 Hospital Medical College staffs, particularly Neonatal Intensive Care unit Staff members, HMIS officers, Laboratory Department staffs, Head of the Department and Medical Director of the hospitals.

3.5. Sample Size Determination

A total of 22 participants were included in this study, (15 health professionals who are working at NICU, 5 Lab technicians, 2 HMIS officer and medical director of the hospital) were purposively selected.

3.6. Data Collection Tools and Techniques

Data was collected through in-depth interview, by document analysis and on-site-observation. Primary data was collected by interview and observation. Secondary data was collected through document analysis.

Interview

Medical directors, HMIS focal persons, health professionals working in the neonatal intensive care unit and lab technicians were interviewed about the current paper based system. To find out what difficulties they encountered with the existing system and its option.

Document Analysis

Document review was made including patient charts, registers, tally sheets, periodic reports from the records to assess routine data recording, processing, reporting and compile document formats.

Observation

The current business process, the data flow of the current system in general and the day today activities was observed in order to identify problems with the current system using observational checklist To augment the information obtained by interview and document analysis. And also Observation techniques have many advantages; it gives more detailed and context related information, it permits the collection of information on facts not mentioned in the interview and View operations of a program as they are actually occurring.

3.7. Data Quality Management

In order to ensure the quality of data during the data collection process, data collection instruments (interview guide semi structured questionnaire), was prepared according to the informational need of the project. The process of Pretesting the semi structured interview guide was held by the principal investigator.

3.8. Data Analysis and Design Technique

The Unified Modeling Language (UML) technique is the primary modeling language used to analyze, specify, and design the system .The data collected through interview, observation and document review were summarized by UML modeling at varies phases. Accordingly, for analysis of the requirement essential use case diagram, essential user interface and Class Responsibility Collaboration modeling technique were used. For analysis of the system, system use case diagram and analysis level class diagram were used. For modeling the system design sequence diagram, design level class diagram and deployment diagram were used.

3.9. Analysis and Design Tools

Tools that were used during analysis and design were Visio 2013 and visual paradigm 10.2. In the development of the prototype, Microsoft visual studio 2012 development environment for development of the interface and C# programming language were used to connect the user interface to the data base. SQL server 2012, was used as a back end server to create the tables and save various data on them. The tools that are selected for the designing and development are mainly on the basis of their ease of use, availability and supportability of the system environment.

3.10. Ethical Consideration

The project was carried out after getting Ethical clearance from Addis Ababa University research and ethical committee of college of health Science School of Public Health and Permission from Yekatit 12 Medical Director was obtained before requirement gathering. In addition a consent form was given to all of the respondents prior to giving any information for the requirement collection.

3.11. Dissemination of Results

The result of the project will be disseminated by using formal report to Addis Ababa University school of Information science and school of public health for partial fulfillment of MSc. degree in health informatics and for Yekatit 12 Hospital.

CHAPTER FOUR

Business Area Analysis and Requirement Definition of the system

4.1. Introduction

Collection and analysis of the requirement is one of the basic and essential steps in the software development life cycle. Analyzing the existing system will lead to identify all the functional and non-functional requirements of the new system to be designed and the way to identify problems in the existing system. Therefore, in this chapter the current system is examined to identify the functionalities and problems of the existing system. The functional and non-functional requirements are identified and essential use case diagram, CRC and essential user interface are used to model the requirements.

4.2. Business Area Analysis

According to the response of the medical director of the Hospital, there is a plan to implement the EMR system and to purchase computer and provide training on computer usage for the staffs to improve the current system. In the existing system there is no software and computer network for sharing information. Currently patient information is collected through pen and paper, and kept manually on chart forms.

The key findings from interview, document review and observation are described in the following sub sections.

4.2.1. Major Functions/Activities of the Existing System

The major functions/activities of the existing system are presented one by one in the following section:

i. Patient Registration

Purpose: The purpose of this activity is to register new patient for medical service.

Input: The main input for this activity is basic patient personal identification information and registration form.

Process: The patient is first registered at record room by data clerk and come to NICU with chart. when a Patient arrive at NICU, the nurse accept the patient and the chart, then the nurse register the patient basic personal identification information in the registration book of NICU. After registering the patient basic personal information, the chart is given to the physician to write the patient medical history, diagnosis and treatment and other necessary information.

Output: Patient is registered at NICU.

ii. Vital Sign

Purpose: Vital signs are used to communicate a patient's condition and severity of disease. These vital signs, serially measured and recorded, help nurses and physicians to identify patient condition, helps for diagnoses, assess interventions, and make decisions concerning the response of patients to treatment.

Input: Vital sign form and vital sign information like temperature, respiratory rate, weight, random blood sugar of the patient is used as an input for this activity.

Process: The Nurse Measure vital signs (temperature, respiratory rate, pulse rate, random blood sugar, oxygen saturation and weight) and the result of vital signs recorded on the vital sign form. According to the finding of the vital sign the Nurse continue patient care as needed and report to the physician for further evaluation.

Output: Output of this function is recorded vital sign information of the patient.

iii. History taking, physical examination and diagnosis

Purpose: The patient history and physical examination may provide most of the information for diagnosis in most patients. Therefore, the purpose of this activity is to take and record patient's medical history and physical examination finding and problem list (diagnosis) which helps for patient treatment.

Input: The main inputs of this activity are diagnosis form and list of patient medical history, physical exam findings and problem list.

Process: In this activity, the physician take medical history, perform physical examination, identify the problem and record the finding in the chart. According to the identified problem the physician may give the following decision.

- Write prescription and send home to take the treatment at home.
- Write referral if patient cannot be treated at the unit it may be due to lack of bed or the service is not available.
- Admit to the inpatient ward if patient condition needs admission
- Order laboratory test; if the patient's problem needs laboratory investigation and decide after analyzing the result.

Output: The output from this activity is diagnosis information or problem list of the patient and/ treatment/ referral /admission/appointment.

iv. Patient laboratory investigation

Purpose: The purpose of this activity is to invest0igate the patient by laboratory to know the problem/diagnosis of the patient.

Input: The inputs for this activity are diagnosis, laboratory request forms and the type of test needed (example, stool, urine, blood etc...)

Process: After patient is seen by a physician different laboratory tests are requested as needed for the patient by the physician**,** patient go to laboratory with laboratory request form, then the lab technician accept the paper and write result after lab test is performed and the lab technician send the result back to the physician.

Output: The output from this function is laboratory result.

v. Treatment order

Purpose: The purpose of this activity is to write treatment order and to administer for the patient.

Input: Patient diagnosis information, drug prescription paper and treatment order form are used as input.

Process: The physician write treatment by using prescription paper for the patient or the family to buy from pharmacy and also if patient is admitted at the ward, the physician write treatment order in order form to be carried out (administered) by a Nurse.

Output: Treatment recorded in the order form and prescription are an output for this activity.

vi. Admission to the inpatient ward

Purpose: The purpose of this activity is to admit a patient to the inpatient (NICU ward) for treatment and care.

Input: Admission form, information like room number, bed number and reason for admission are an input for this activity.

Process: If the physician decide to admit the patient in to the ward, the physician will check the availability of free bed, then admission information (patient identification information, reason of admission, bed no, room no, name and signature of admitting physician) is filled by admission form and patient will be admitted for further treatment and care.

Output: The output for this activity will be patient admission information recorded in the admission form and patient is admitted.

vii. Nursing care plan for the patient

Purpose: The purpose of nursing care plan is to record nursing assessment and nursing care plan for the patient, to follow the condition of patient and to act accordingly, the care plan include feeding type, amount, and if the patient is on intravenous fluid the type and amount of intravenous fluid and if specific cares are needed.

Input: The inputs for this activity are nursing care plan form and physician order for the patient which is carried out by a nurse and nursing care plan and assessment of a patient.

Process: The Nurse assesses the patient status (about feeding, intravenous fluid amounts and type, output and nursing care given and plan for care) and record the nursing assessment information by using nursing care plan form.

Output: The nursing care plan information and nursing assessment are recorded on the nursing care plan form.

viii. Progress Note

Purpose: Progress note is a concise record, that provides a series of daily notes to show changes in the patient's condition or treatment and follow-up, after patient is admitted and treatment is started, to know whether the patient is improving or not and also to decide if further investigation

and change of treatment is needed, may be written on a day-to-day basis. This is also very important for continuity of care during each shifting time.

Input: The inputs used for this activity are progress note form, patient previous and current status information, current investigations and treatments and updated investigations and treatments.

Process: Physician re-examine all over patient status after admission to the ward and after treatment is started including (admission history, diagnosis, and current patient status) to determine whether patient condition is worsening or improving and to know if there is new problem. According to patient condition the physician may decide to change treatments / to do additional investigations/ to continue with the same treatment or to discharge the patient if treatment is finished and patient is improved.

Output: The output from this activity is record of progress note information (patient status,) on the progress note form.

ix. Discharge Summery

Purpose: Discharge summary provides a summary of the patient's hospital stay, medical history, physical examination, important lab findings, treatment given, patient's condition and specific care need at home.

Input: The inputs for this activity includes summery writing form, information about admission history, physical examination findings, investigations, diagnosis, treatment given, if any treatment during discharge, discharge instruction, and condition during discharge.

Process: The physician will write the patient summery information before patient is discharged, by referring medical history of patient, physical findings, investigations and treatment given.

Output: The output for this activity is recorded patient summery information.

x. Appointment

Purpose: This activity is used for appointing the patient for follow up after patient is discharged from the hospital or after patient is seen at NOPD, to know the status of the patient after patient discharged from the hospital.

Input: The inputs are appointment form, diagnosis information, treatment given and appointment date.

Process: The nurse write appointment for the patient for next follow up.

Output: The output of this process is appointment paper with necessary information.

xi. Referral

Purpose: This activity is used if the patient is referred to other hospital, because of lack of bed or if the service is not available at the unit. For example, if surgery is needed.

Input: The inputs for referral, referral paper, patient personal identification information, diagnosis, reason for referral, if any treatment given and name and signature of referring physician.

Process: If the physician decide to refer a patient to other hospital, the physician must be first communicate with phone for the availability of bed or service to the liaison office or to the receiving hospital. If the receiving hospital is willing to accept a patient, the physician will write the referral and send the patient with the hospital ambulance.

Output: Referral paper with necessary referral information

xii. Generate Report

Purpose: This function is used to generate report from different services by summarizing different registration paper form it can be collected daily, weekly, monthly and annually.

Input: The input includes report form and all recorded information at NICU.

Process: Collect and compile the data from the registers and make a report

Output: The outputs are generated report, which includes, Number of new patient seen at NOPD, number of patients seen with appointment, number of referred patients, and admitted patient, transfer to other wards, number of death, number of discharged patients, total duration of hospital stay and disease classification.

4.2.2. Forms used in the Existing System

In the existing system different kinds of forms and documents are used to manage patient information. This forms are carefully examined in the analysis phase. Therefore, The forms used for data entry are listed below by explaining its purpose, contents and users of the form:

A. Registration Form

Purpose: This form is used to record patient basic personal identification information.

Content: Contents of this form are name of patient, age, sex, address and date of registration.

User: It is filled by a Nurse.

B. Vital sign form

Purpose: This form is used to record patient vital sign information

Content: The contents of this form are personal identification information, date, time, and type of vital sign (temperature, respiratory rate, pulse rate, weight, blood pressure, oxygen saturation and random blood sugar) of the patient.

User: This form is mainly filled by a nurse.

C. Diagnosis form

Purpose: This form is used to record patient, medical history (prenatal, perinatal and postnatal history), physical examination and diagnosis/Assessments.

Content: The content of this form is personal identifications information, medical history of patient which include prenatal, perinatal, postnatal history and physical examination finding and diagnosis.

User: The user of this form is a Physician.

D. Laboratory Request Form

Purpose: It is used for requesting laboratory investigation and receiving the result from the laboratory department by the physician, and also it is used by laboratory technician for receiving the lab request and to write the laboratory result.

Contents: The content includes patient personal identifications, hematology, chemistry, serology, bacteriology, Blood request form, transfusion form, urine analysis and stool.

Users: The user of laboratory forms are physicians and lab technicians.

E. Order form

Purpose: This form is used to record different treatment orders of the patient, treatment order includes order of medicine and supportive treatment like (oxygen, intravenous fluid and feeding with frequency and amount needed).

Contents: The content of this form includes, patient personal identification information, list of orders like, type of medicine, dose, and frequency, type of intravenous fluid if needed, feeding order, and specific care needed according to patient condition.

User: It is used by Physician

F. Medication Administration Form

Purpose: It is used to write and follow treatment administration information.

Content: Include patient personal identification information, allergy information, and diagnosis type of treatment, time, dose, route and frequency of administration.

User: It is used by a Nurse.

G. Prescription Form

Purpose: This form is used to prescribe medicine to the patient to collect from the pharmacy.

Content: It contains patient personal identification information, drug name, strength, dosage information, frequency and duration, name of prescriber's and title.

User: It is used by physician to write a medicine order and for the pharmacy technician to dispense the treatment to the patient.

H. Progress Note Form

Purpose: It is used by physician to record the status of the patient after admission and treatment started, to know whether the patient condition is improving or worsening it helps to decide if additional investigations are needed and if treatment is changed**.** Moreover, it is used to document Patient's condition at the end of each shift to provide continuity of care.

Content: The content includes admission diagnosis, current status of patient, current treatment and investigations and if there are changed and added treatment.

User: The user of this form is physician.

I. Nursing Care Plan Form

Purpose: This form is used to follow and record nursing assessment, nursing care plan and nursing note. Nursing note is about all over status of patient condition, care and treatment given at the end of each shift which provides continuity of care between nurses from shift to shift.

Content: The contents are personal information, type and amount of feeding, type of IV fluid, summery of subjective data, summery of objective data, name and signature of nurse who are admitting a patient.

User: The user of this form is a nurse.

J. **Discharge Summery Form**

Purpose: This form is used to record summarized information of the patient during hospital stay when the patient is discharged.

Content: Its content include personal identification information of the patient, date of admission, date of discharge, diagnosis, procedures, laboratory findings, treatments given, specific care at home, condition during discharge and name of discharging physician.

User: It is recorded by Physician.

K. Appointment Form

Purpose: This form is used to give appointment for patient follow up.

Contents: The contents of this form are personal identification information of the patient, diagnosis, treatment given and date of appointment.

User: It is recorded by a Nurse.

L. Referral Form

Purpose: This form is used to transfer a patient to another hospital, if bed or service is not available.

Content: The content includes name and department of the referring hospital and hospital to be referred, date, personal information of the patient, clinical findings, diagnosis, investigation result, treatment given, reason for referral and name of referring physician.

User: It is used by physician.

4.2.3. Reports Generated in the Existing System

In the existing system of NICU, reports are prepared from the record of HMIS (Health Management Information Science) registration book and it is reported daily, weekly, monthly, quarterly and annually. These reports mainly includes: Number of patient seen at NOPD, number

of patients seen with appointment, number of referred patients, number of admitted patient, transfer to other wards, number of death, number of discharged patients, total duration of hospital stay and disease classification. These reports are prepared by a Nurse and lab technicians and submitted to HMIS office of the hospital by using paper forms.

4.2.4. Players of the Existing System

Player represents a person or an organization that has a major roll on the overall process of the organization. The main players identified in the existing system of Neonatal Intensive Care Unit of Yekatit 12 Hospital Medical College are listed in the table below.

Table 1. Players of the existing system.

Identified players	**Descriptions and Their Roles**
Data clerk	who works at medical recording room and responsible for registering patient at medical recording department and preparing a patient chart and sending a patient to NICU for treatment
Physician	A Physician is a health professional may be general practitioner, resident, pediatrician have a role of diagnosing, requesting lab investigations, treating and referring a patient
Nurse	A Nurse is a health professional who have different role such as: register patient, admitting a patient, follow vital sign, administer treatment and provide nursing care for the patient and consulting a physician.
Laboratory Technician	Laboratory technician is a health professional who has a role of performing laboratory test and recording result of the test and sending the result to the physician.
Pharmacy Technician	Pharmacy technician is a health professional whose role is accepting prescription which is written by a physician and dispensing medicine according to the order by explaining to the patient

4.2.6. Identified Problems from Existing System by Using PIECES Framework

Since the hospital used paper based system different problems are existed: Some of the problems identified are presented by using PIECES framework.

A) Performance related problem

- In the current Manual system, the time needed to compile reports is too long.
- Since all the work is done manually, it takes a lot of time to register new patients and to retrieve the charts of previously registered patients. And also searching previous patient information is boring and time taking due to lots of paper records.

B) Information related problem

a) Input

- Data is not accurately captured, due to illegible hand writing.
- There is a problem of Information duplication because, if previous patient charts are lost another chart is prepared (multiple charts).
- Loss of information containing papers for example laboratory results from individual patient charts are a frequent problem.

b) Output

- Timely and accurate reporting is impossible because they used tally sheet which is time taking to count the cases from registration forms.
- Prone to human error. During counting of cases, there is also a probability of miss counting, recounting or tallying of information.
- Poor decision making due to unreliable data and data on paper format is difficult for different analysis.

c) Stored data

- Patient charts are not easily accessible and also may be lost totally which leads to loss of patient information.
- Data is stored manually in file folders, which results in high resource consumption such as storage space, manpower to store, search and retrieve
- Accessibility of accurate information from the past record is difficult due to illegible hand writing in records.

- Data is not flexible: Since the system is manual, it is often difficult to update and edit data stored redundantly without losing data consistency.

C) Economy

- Cost of storing, retrieving and updating data is done redundantly and repeatedly by personnel, and manual system also needs to much stationary materials which leads to unnecessarily high cost.

D) Control (Security)

- Patient information is not secured, it can be stolen by anyone who has access to the place where papers are kept.

E) Efficiency

- Health professionals waste time in searching patient information
- Manually generating the report will eliminate personnel hours, and the report is not timely ready for use.
- Materials like Papers and pens required for recording is too much.
- Data may be lost: some of the paper files and lab results are usually lost due to the large volume of papers handled every day.

F) Service

- Paper based recording system is not used for integrating to other departments for facilitating communication between different care providers and departments.
- Laboratory test results are collected by Patients, relatives or by staff members which are time taking, difficult of timely decision making and decrease customer satisfaction.

4.2.7. Options to Address the Problems of the Existing System

Options have been evaluated to address the problems of the existing system. The major options include:

Option 1 (Standalone): Helping the existing system with automating only the inpatient room in order to have at least an electronic storage of inpatient data. By this option, all admitted NICU patient data will be entered in the system using standalone computers by physicians and nurses.

Option 2 (Networked)

Automating and integrating the inpatient, outpatient and laboratory department by developing software application and implement the system in a networked environment that allows integrating NICU (inpatient, outpatient) and laboratory department to enter and retrieve the data.

Option analysis and the proposed new system

The first option is to automate only the inpatient of NICU to solve some of the problem identified in the previous section. In this case, some of the problems under the manual patient monitoring system can be solved to some extent with better speed of retrieval availability of information and security.

The second option in addition to solving the existing problems has additional benefits in creating smooth communication between NICU (inpatient, outpatient) and laboratory department.

The two options have been compared and evaluated in the table below.

Table 2. Option analysis.

Characteristics	Option 1	Option 2
Portion of System Computerized	Computerize the records office and the pharmacy implement in a stand-alone computers	Computerize the records office, physicians and the pharmacy implement in a networked environment
Benefits	Solve all stated problems	Solve existing problems and additional benefits
Servers and Workstations	2 to 3 workstations	1 server and about 8 additional work stations
Software Tools Needed	Operating system, database management system and system development software	Network operating system, database management system and system development software

Application Software	An electronic medical record management system that supports patient registration, diagnosis and treatment	An electronic medical record system that supports patient registration, diagnosis and treatment.
Method of Data Processing	Batch processing by a data entry clerk.	Online processing
Output Devices and Implications	Printer, preformatted reports	Printer, preformatted reports and network
Input Devices and Implications	Keyboard mouse, data entry clerk	Keyboard mouse, data entry
Storage Devices and Implications	Hard disk drives, back up storage using CD-ROMs and external hard disk	Hard disk drives, back up storage using CD-ROMs and external hard disk and in the server using share drive for all department or unit

4.2.8. The Proposed System

The Investigator selected the second option to overcome the drawbacks found in the existing system and also in the first option. The proposed system or the second option is important because it reduce the possibility for loss of patient information, because the system store data on the server and helps ensure that patient records, test results and other patient data kept electronically, it will help to retrieve patient information easily and with short time, reduce error due to illegible hand writing, it also integrate NICU and laboratory departments for easy communication between these departments. The generation of precise and timely report from the system will also enable a sound decision making by the health care providers and decision makers.

The system works on computers via local area network. There is a centralized database server to store the patients data' as well as to integrate the Units, Neonatal OPD, NICU inpatient rooms

(non-septic ICU, septic room ward A and B, phototherapy room) and also integrate from laboratory department.

4.2.9. Practices to be preserved from the Existing System

In the existing system all operations of the system are done manually. But some of these functions are still continued as it is, need to be exercised:

Hospital Patient Chart: in the existing system, patient is registered at the record office and come to NICU with chart. This chart is preserved in the new system because it is used as a backup for keeping copy of patient information from the computer system and return back to record office when patient is finished his treatment.

Prescription to Pharmacy: This process will also continue in the same way.

4.3. Requirement Analysis

The purpose of requirement gathering and analysis is to define what the new system should do. Since the system will be built based on the information gathered in this step, any errors made in this stage will result in the implementation of a wrong system.

4.3.1. Functional Requirements

A Functional requirements mainly deal with explaining what has to be done by identifying the necessary task, action or activity and functionalities the system should provide to users and the tasks that must be accomplished (53). This EMR management system is designed to enables the users to maintain record facilitate communication and generate report. Accordingly the functional requirements are described as follows:

Table 3. Functional Requirement.

RQ-ID	UC_ID	Description of the requirement
RQ-1	UC-1	The system should allow the user to log in according to their privilege.
RQ-2	UC-2	The system should be able to register patient basic personal identification information like Name, age, sex, address and medical record number.
RQ-3	UC-3	The system should register vital sign information and alarm for abnormal result.
RQ-4	UC-4	The system should allow to record patient history, physical examination and diagnosis
RQ-5	UC-5	The system should allow to record admission information
RQ-6	UC-6	The system should allow to record patient laboratory investigation order
RQ-7	UC-7	The system should allow to record the Lab result and high light abnormal test result
RQ-8	UC-8	The system should allow to register treatment order
RQ-9	UC-9	The system should register Medication Administration
RQ-10	UC-10	The system should allow to register Nursing care plan information
RQ- 11	UC-11	The system should allow to register progress note of the patient
RQ-12	UC-12	The system should be able to register the discharge summery information
RQ-13	UC- 13	The system should allow to record patient referral information
RQ-14	UC-14	The system should allow to record the appointment information
RQ-15	UC -15	The system should enable generation of report based on the users need
RQ-16	UC-16	The system should allow the administrator to maintain user account

RQ- Requirement, UC- Use Case

4.3.2. Non-functional Requirements

Non-functional requirements define the overall qualities aspect of the system. The non-functional requirements correspond to the process of explaining the features, characteristics, attributes, and constraints of the information system. These characteristics include how easy the software is to use, how quickly it executes, how reliable it is, and how well it behaves when unexpected conditions arise. The nonfunctional requirements define these aspects about the system (54)

The following are the non-functional requirements of the proposed EMR management system:

Security: Since the system is going to handle personal information which is confidential, it should be protected from unauthorized users, no one can log into the system without a registered user name and corresponding password.

Performance: performance is an important issue for the system because one of the drawbacks of the paper based system is performance issue. So this system makes the activities fast by making the server and the software to respond in real time.

Availability: since the unit gives services for 24 hours, the system should be available 24 hours/day and 7 days a week. So there should be 24 hours/day of electricity and back up source such as generator to make the system work without interruption.

Maintainability: The system should be maintainable by the developer as well as other authorized trained person. The system should also be modifiable at any time to enhance features based on the office needs. The system could be enhanced by adding new functionalities without necessarily changing the basics. These issues should be addressed by availing modular functionality, user guideline and detail design documentation, therefore the developer as well as authorized trained person can modify the system.

Error handling: the system is expected to handle errors encountered during run time. Errors could arise from users and from the system. Errors that occurred from the wrong doing of users will be handled by appropriate exception handling mechanisms.

Service: - The system must improve service provision to the users and quality of service to patients by reducing loss of patient cards or data and smooth flow of information.

Usability: The system should be easily understood, learned, and used by its intended users.

4.3.3. Use Case Modeling

Use case models are made up of two main types of UML element – Actors and Use Cases. Often used during the initial phases of the development process, use case models are a basic tool used to formalize functional requirements. They are particularly helpful during dialog with users. An actor is an entity outside the system that needs to directly interact with it. An actor can represent a human user or any material or software device. An actor represents a role played in the context of the system. A physical user can play several different roles successively depending on how the system is used. A use case represents an interaction between actors and the system, with the aim of meeting a fundamental requirement. It is described by a set of scenarios that specify the dialog between the system and the actors. (55)

4.3.3.1. Essential use case Modeling

An Essential Use Case is defined as a structured narrative, expressed in a language of the application domain and of users, comprising a simplified, generalized, abstract, technology free and independent description of one task or interaction that is complete, meaningful and well defined from the point of view of users in some role or roles in relation to a system and that embodies the purpose or intentions underlying the interaction. An Essential Use Case is thus a form of dialogue between user and system which supports better communication between developers and stakeholders. It enhances requirements gathering as it only allows specific detail relevant to the design to be captured (56).

Accordingly the following Essential use cases and Actors are identified and use case diagram are used to capture the requirement of the system and descriptions of each use cases are presented.

Identified Essential use cases in the NICU of Yekatit 12 Hospital

1. Register patient
2. Vital sign
3. diagnosis (History, Physical exam, diagnosis)
4. laboratory Investigation Order
5. Laboratory investigation result registration
6. Treatment Order
7. Prescription
8. Treatment Administration
9. Progress note
10. Nursing assessment and care plan
11. Discharge or death summery
12. Appointment
13. Referral
14. Report (daily, weekly, monthly, quarterly and yearly)

Table 4. Identified Actors and their role in the existing system.

Nurse	Refers to a health Professionals who register the patient, give and record nursing care to the patient, administer treatment and generate report
Physician	Refers to a health professional who diagnose and treat patient
HMIS officer	Refers to a person who generate a report from the system
Laboratory technician	Refers to a person who perform laboratory test.

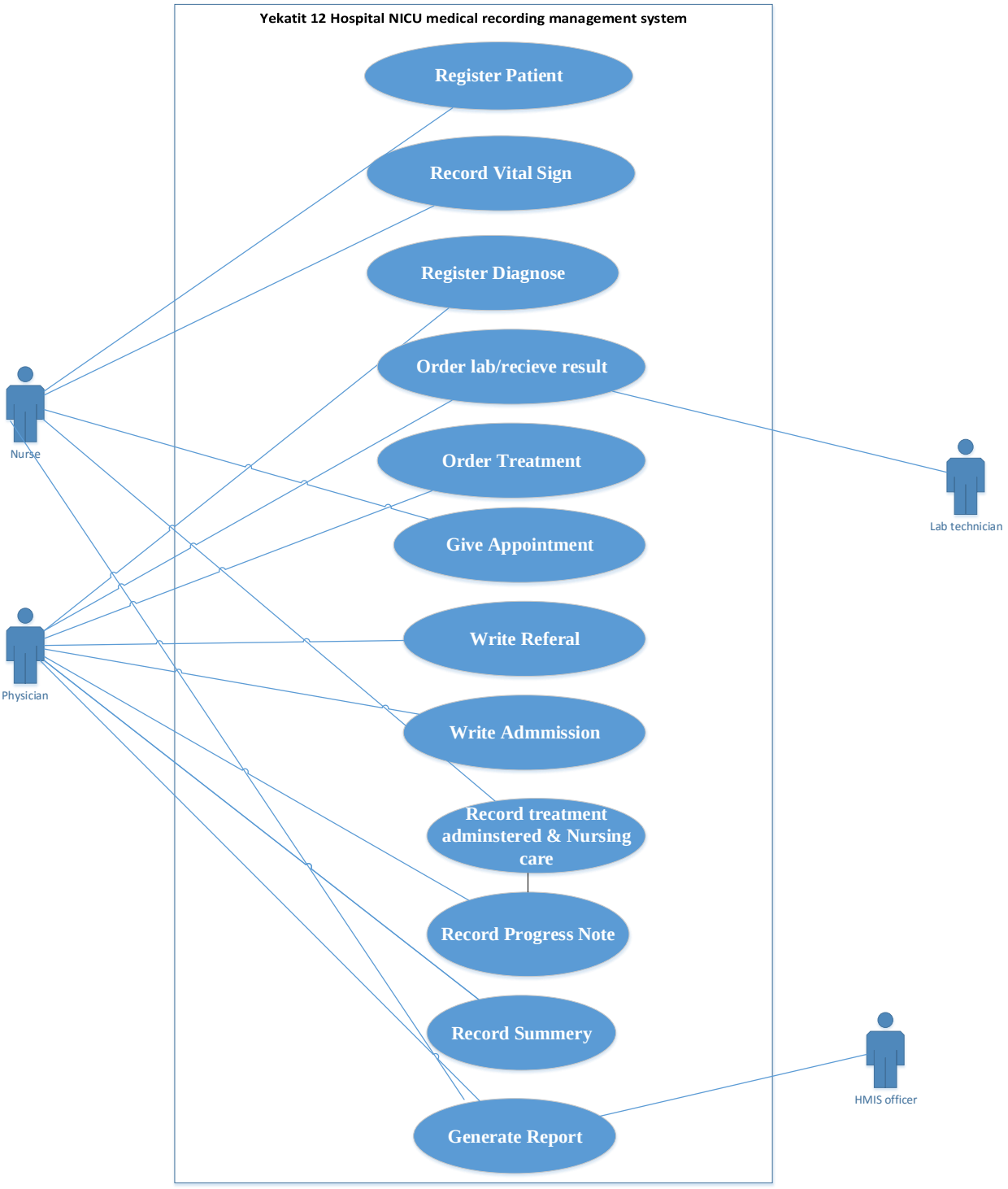

Figure 1. Essential Use Case Diagram.

4.3.3.2. Essential Use case scenarios

Use case scenario is a textual representation of the course of events encountered when an actor is interacting with the system. A use case's scenarios make up a sequence that describes the dialog between the system and one or several actors. (57) The scenario of each essential use case is listed below.

Table 5. Registration Essential Use Case.

Use case ID	UC-2
Use Case Name	Register patient
Use case Description	This use case describes how a patient personal information and address are registered
Primary Actor	Nurse
Pre-Conditions	The Patient should be first registered at the record office
Post-Conditions	The Patient registered in to the registration book of NICU
main success scenario	1.The Patient arrives at NICU with chart 2.The Nurse registers the patient with necessary details (name, age, sex and address) 3. Use case end.
Alternative courses	-

Table 6. Record Vital Sign Essential Use Case.

Use case ID	UC-3
Use Case Title	Vital sign
Use case Description	This use case describes patient Vital sign information recording process
Primary Actor	Nurse
Pre-Conditions	The patient should be registered and vital sign recorded
Post-Conditions	The vital sign status information recorded in to the vital sign form
Main success scenario	1. The Nurse wants to document vital sign information 2. The Nurse measures vital signs

	3. The Nurse records the vital signs finding by using Vital sign form 4. The Nurse acts according to the finding if there is abnormal result and also inform to the Physician. 5. Use case ends
Alternative Path	-

Table 7. Record Diagnosis Essential Use Case.

Use Case ID	UC_4
Use case Name	Diagnosis (Patient history, physical examination and diagnosis) use case.
Primary actor	Physician
Summary description	This use case describes the process used to record history, physical examination and diagnose data.
Precondition	The Patient is registered
Post condition	The patient history, physical examination, investigation and diagnosis are registered.
Main success scenario	1. The physician wants to document the patient history, physical finding and diagnosis information. 2. The physician asks patient or patient family about medical history, perform physical examination and list diagnosis/problem. 3. The physician records finding by using diagnosis form. 4. Use case ends
Alternative path	3a. If the patient needs laboratory investigation the physician order lab and send to lab. 3b. If the patient needs referral the physician write referral to other hospital. 3c. If the patient needs treatment the physician write prescription to the pharmacy. 3d. If the patient needs appointment the patient will be given appointment. 3e. if the patient needs admission the patient will be send to inpatient for admission.

Table 8. Write Admission Use Case

Use Case ID	UC_5
Use case Name	Admission
Primary actor	Physician
Summary description	This use case describes the process used to record Admission information (example cause of admission and name of admitting physician)
Precondition	The patient should be diagnosed.
Post condition	The patient admission information is registered.
Main success scenario	1. The physician wants to document the patient admission information 2. The physician records admission information like admission date, admission diagnosis and other necessary information. 3. The physician sends the patient to the ward. 4. Use case ends
Alternative path	

Table 9. Order lab investigation Use Case.

Use Case ID	UC_6
Use case Name	Order laboratory investigation
Primary actor	Physician
Summary description	The use case describes the process used to order investigation (Which include laboratory order
Precondition	The patient should be diagnosed first.
Post condition	Lab Investigation order is registered.
Main success scenario	1. The physician wants to order investigation 2. The physician selects the test type to be done 3. The physician sends the request to the laboratory department with patient family. 4. Use case end
Alternative path	

Table 10. Register Lab Test Result essential Use Case.

Use Case ID	UC_7
Use case Name	Register lab test result
Primary actor	Lab technician
Summary description	The use case describes the process used to record laboratory result.
Precondition	Lab investigation is ordered.
Post condition	Investigation result is registered.
Main success scenario	1. The lab technician wants to register investigation result 2. The lab technician takes sample according to the lab order requested 3. The lab technician perform the lab test 4. The laboratory technician records the result to the lab request form and to the Lab registration book. 5. The lab technician sends the result to NICU department. 6. Use case ends
Alternative path	

Table 11. Record Treatment order Essential use case.

Use Case ID	UC_8
Use case Name	treatment order use case
Primary actor	Physician
description	The use case describes the process used to Order treatment
Precondition	The patient should be diagnosed.
Post condition	Medication order is recorded in the treatment order form.
Main success scenario	1. The Physician wants to record treatment order 2. The Physician selects treatment order form 3. The Physician records the treatment order. 4. The Physician gives the treatment order for assigned Nurse to be carried out and administered to the patient. 5. Use case end.
Alternative path	4a. If treatment is needed from the pharmacy, the physician write prescription to the patient.

Table 12, Record Use Case for Medication Administration.

Use case ID	UC-9
Use Case Title	Medication administration record use case
Use case Description	This use case describes treatment administration information (type of treatment, time of administration, dose, frequency and allergy) information.
Primary Actor	Nurse
Pre-Conditions	The physician should first order the treatment.
Post-Conditions	The medication should be administered and recorded in the medication form.
Main success scenario	1. The Nurse wants to record medication administration information 2. The Nurse selects the medication administration registration form 3. The Nurse fills medication administration form with required information 4. Use case ends
Alternative Path	

Table 13. Record Nursing Care Essential Use Case.

Use case ID	UC-10
Use Case name	Nursing care plan
Use case Description	This use case describes how the nurse record care plan information of the patient (about feeding, IV fluid type amount, care needed)
Primary Actor	Nurse
Pre-Conditions	The patient should be admitted.
Post-Conditions	The Nursing care plan information registered to the nursing care plan form.
Main success scenario	1. The Nurse wants to record nursing care plan of the patient 2. The Nurse selects the nursing care plan documentation form 3. The Nurse fills the nursing care plan information. 4. Use case end
Alternative Path	-

Table 14. Recording Progress Essential Use Case.

Use Case ID	UC_11
Use case Name	Record Progress note use case.
Primary actor	Physician
Summary description	This use case describes the process used to record the progress note.
Precondition	Patient should be admitted to the ward.
Post condition	The Patient progress note is registered.
Main success scenario	1. The Physician wants to document the patient progress note 3. The Physician selects progress note form 4. The Physician records the progress note in the progress note form. 5. Use case ends
Alternative path	

Table 15. Record discharge Summary Essential Use Case.

Use Case ID	UC-12
Use case Name	Discharge Summary use case.
Primary actor	Physician
Summary description	This use case describes the process used to document summery of patient information during hospital stay when discharged.
Precondition	The Patient should be admitted.
Post condition	The patient summery note is registered.
Main success scenario	1. The Physician wants to document Discharge summery 2. The Physician selects summery sheet 3. The Physician records summery data. [Alt1, Alt2]. 4. Use case ends
Alternative path 1	3a. If Appointment is needed 3b. The physician fills the appointment date and informs the patient.
Alternative path 2	3a. If the patient needs referral 3b. 1. The physician fills the referral information and refers the patient.

Table 16. Record Appointment Essential use case

Use Case ID	UC_ 13
Use case Name	Appointment
Primary actor	physician
Summary description	The use case describes the process used for register the appointment information of the patient.
Precondition	The patient should be diagnosed
Post condition	The patient appointment information should be registered and appointment paper given to the patient.
Main success scenario	1. The Nurse wants to record the patient appointment information 2. The Nurse selects appointment form 3. The Nurse records the appointment information 4. The Nurse gives appointment paper for the patient 5. Use case ends
Alternative path	-

Table 17. Generate Report Essential Use Case.

Use Case ID	UC_ 14
Use case Name	Generate report
Primary actor	physician, Nurse, HMIS officer
Summary description	The use case describes the process used to generate report.
Precondition	
Post condition	The user generates report from the system.
Main success scenario	1. The HMIS Officer, Nurse, Physician wants to generate report 2. The HMIS Officer, Nurse, Physician Counts the cases from the registration book. 3. The HMIS Officer submit the generated report for HMIS office. 4. Use case ends
Alternative path	-

4.3.4. Class Responsibility and Collaboration Modeling

CRC (Class-Responsibility-Collaborator) Card Modeling is a simple yet powerful object oriented analysis technique. CRC modeling often includes the users, analysts, and developers in the modeling and design process, bringing together the entire development team to form a common understanding of an OO development project. It is one of many tools that should be used in the collaborative design of a system (58).

A CRC Model is a collection of cards (usually standard index cards or larger) that are divided into three sections.

1. Class
2. Responsibility
3. Collaborator

Class: A Class represents a collection of similar objects. Objects are things of interest in the system being modeled. They can be a person, place, thing, or any other concept important to the system at hand. The Class name appears across the top of the CRC card.

Responsibility: A Responsibility is anything that the class knows or does. These responsibilities are things that the class has knowledge about itself, or things the class can do with the knowledge it has.

Collaborator: A Collaborator is another class that is used to get information for, or perform actions for the class at hand. It often works with a particular class to complete a step (or steps) in a scenario. The Collaborators of a class appear along the right side of the CRC card (59)

Nurse <<Actor>>	
Name ID NO Position Register patient Measure vital sign Write nursing care plan	Patient Physician

Physician <<Actor>>	
Name ID no Specialty Diagnose patient Request lab investigation Write treatment Write progress	Nurse Patient Lab technician

Vital sign <<UI>>	
Date and time Temperature Respiratory rate Pulse rate Oxygen saturation Weight Record Edit Update Search	Diagnosis

Lab technician<<Actor>>	
Name ID NO View lab order Write result	Physician

Patient registration <<UI>>	
First Name Last name Address MRN Add search Update edit	Nurse Physician Lab technician

Diagnosis <<UI>>	
MRN Date of diagnosis History and physical finding Add Update Edit Search	Investigation Vital sign

Treatment order <<UI>>	
MRN Type of medication Dose of medication Frequency Route of administration Record Update Search	Diagnosis Progress Medication Administration

Report <<UI>>	
Date of report Type of report Disease classification No of admission No of discharge No of death No of referral Search	Registration Diagnosis

Treatment administration <<UI>>	
Date and hour of administration Type of medication Dose of medication Frequency of administration Route of administration History of allergy Record Update Search	Diagnosis Treatment order

Nursing care plan <<UI>>	
Date Input (feeding, iv fluid) Out put Record Update Search	Diagnosis Investigation Treatment Vital sign Progress

Discharge Summery <<UI>>	
Admission date Discharge date Record Search Update	Diagnosis Investigation Treatment

progress <<UI>>	
Subjective data Objective data Assessment plan Record Search Update	Diagnosis Investigation Treatment Vital sign

4.3.5. Essential user interface

Essential UI prototypes represent UI requirements in a technology independent manner. It models UI requirements; requirements evolved through analysis and design to result in the final user interface for the system. It represents the general idea behind the UI, but not the exact details (60). Accordingly, in this project essential UI modeling are presented as follows:-

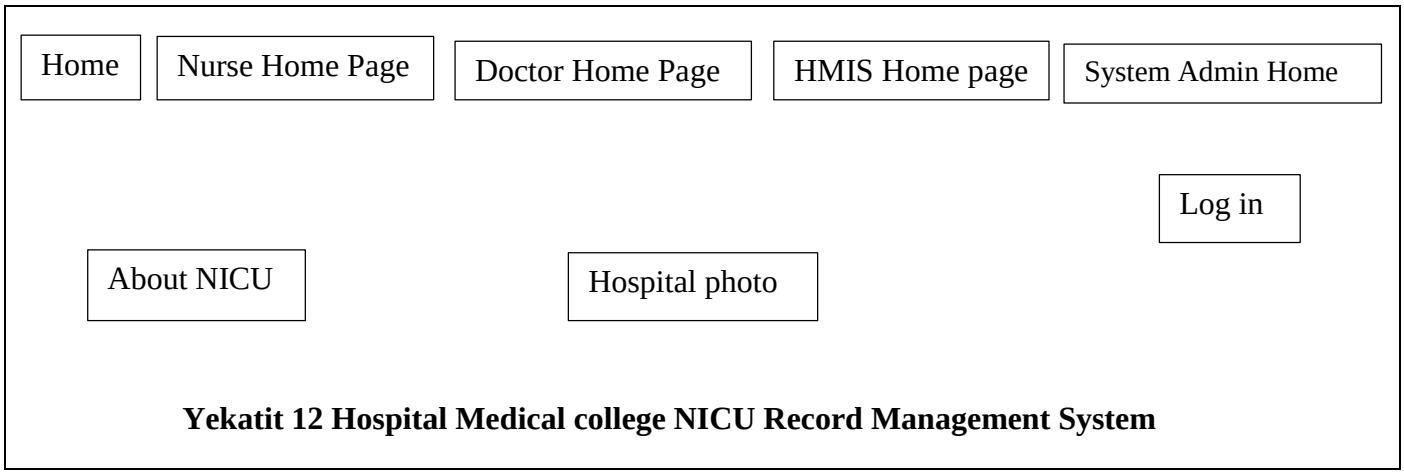

Figure 2. Home page essential user interface.

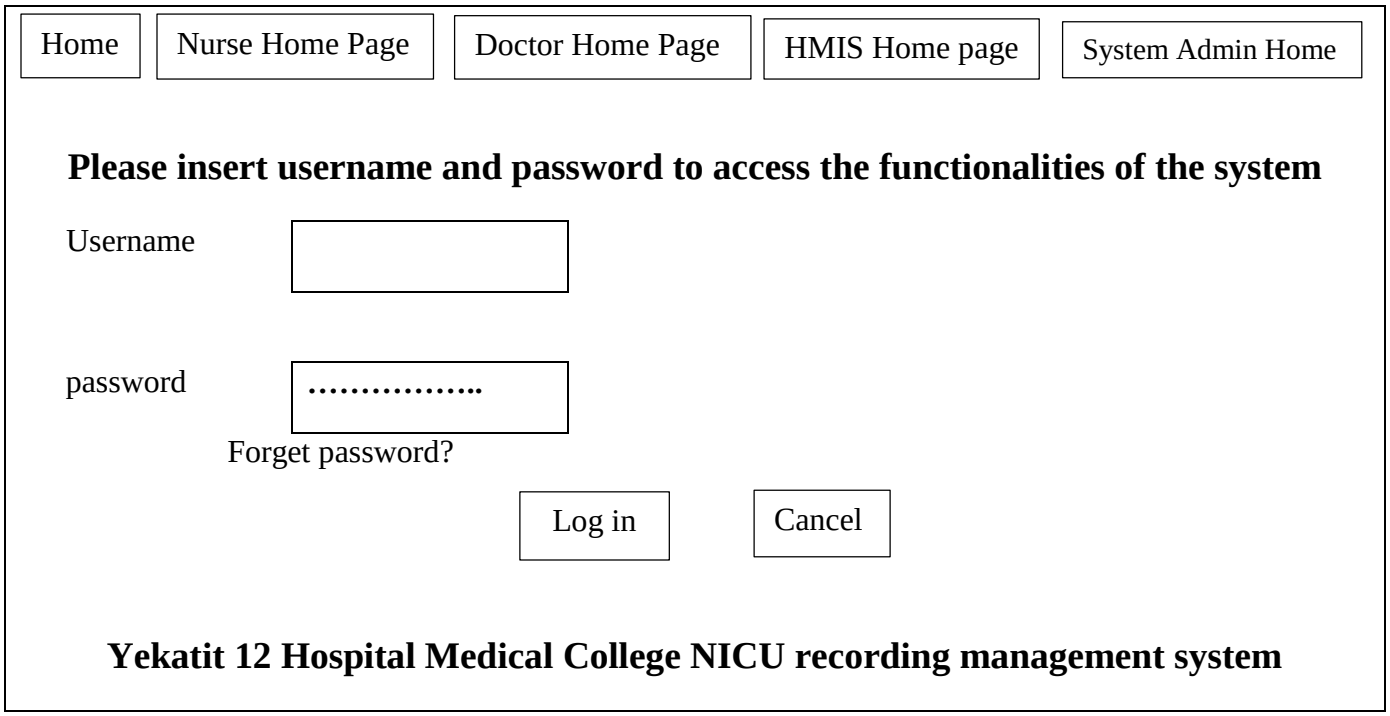

Figure 3. Log in Essential user interface screen.

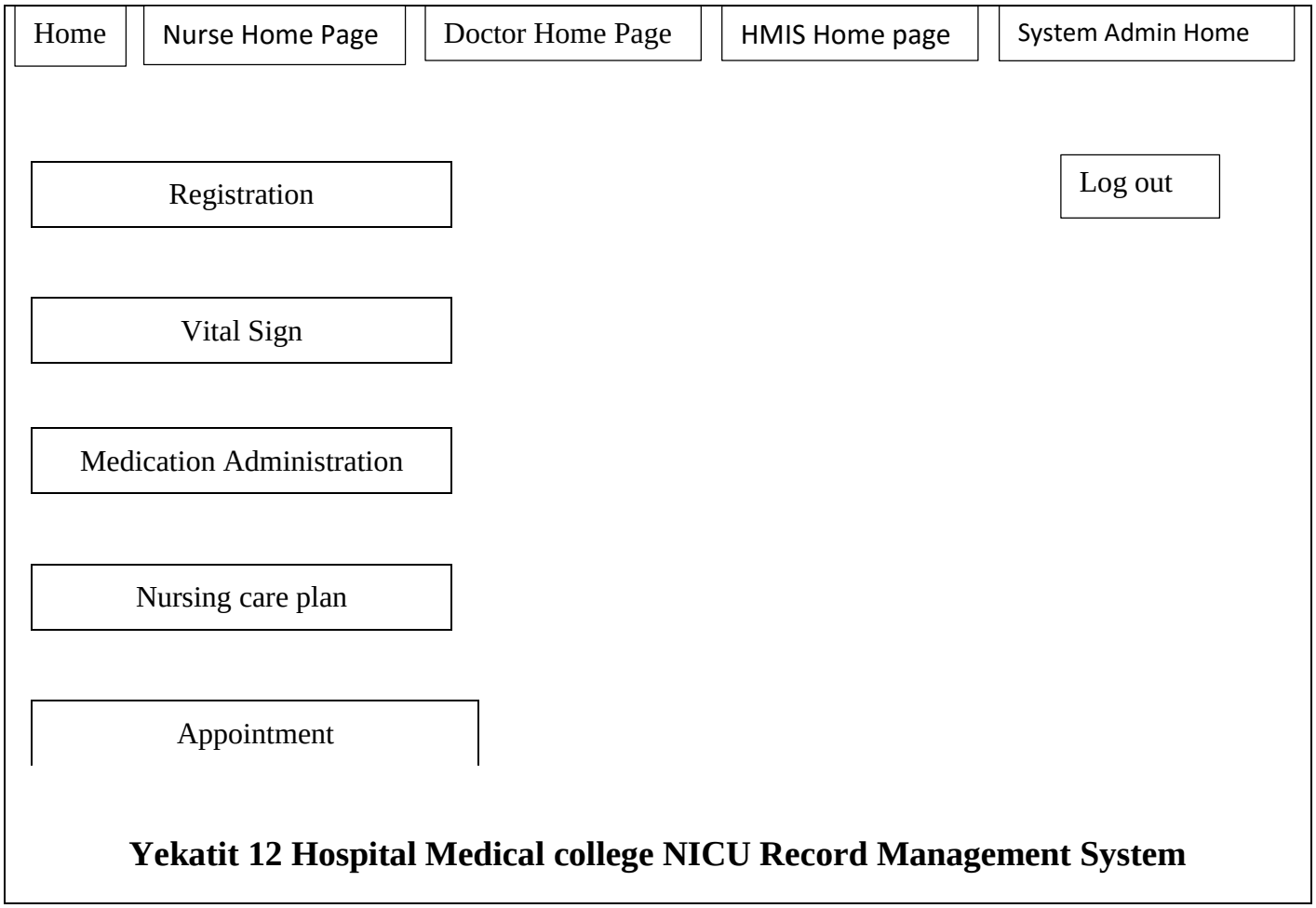

Figure 2. Nurse's Home page essential user interface

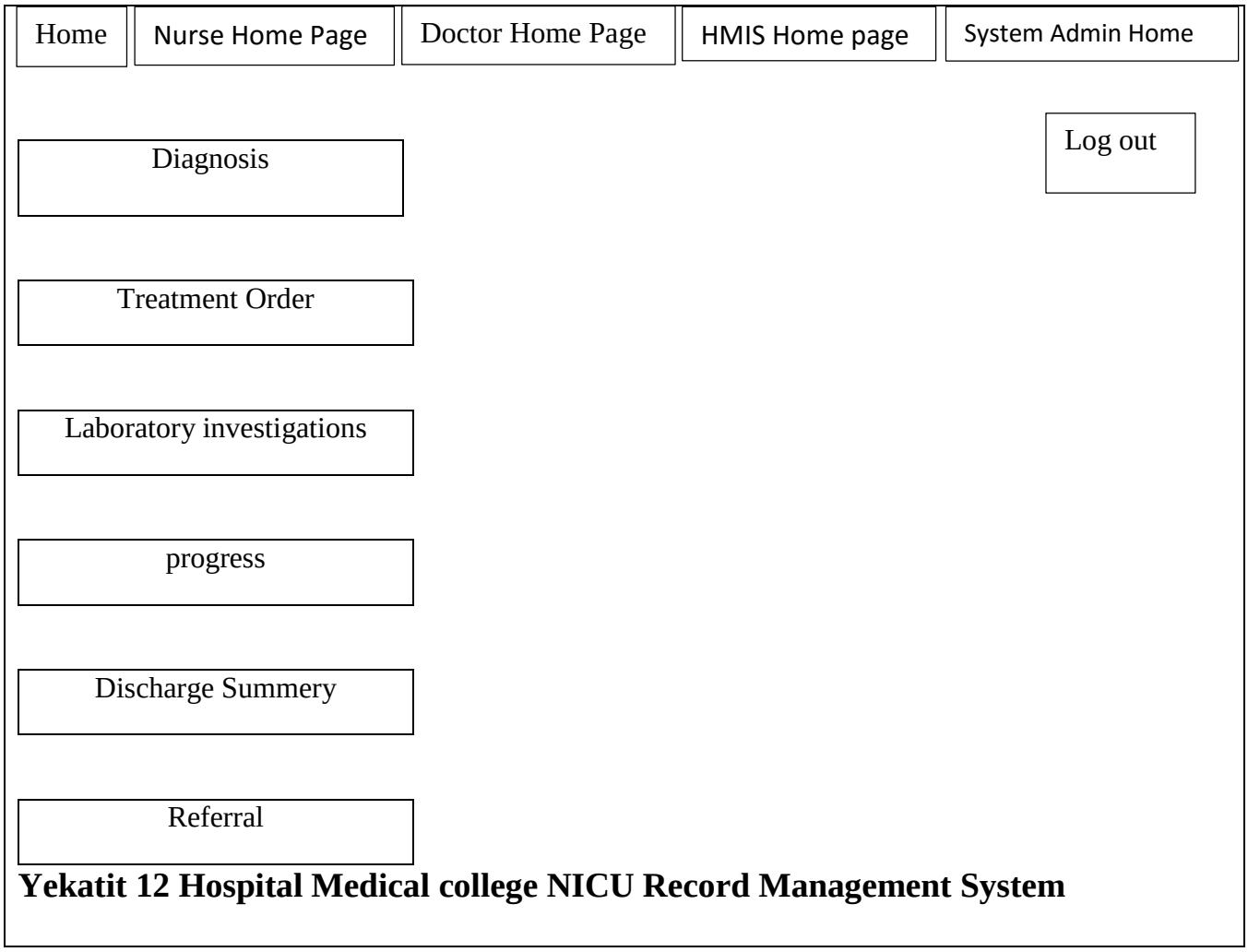

Figure 3. Doctor's Home page essential user interface.

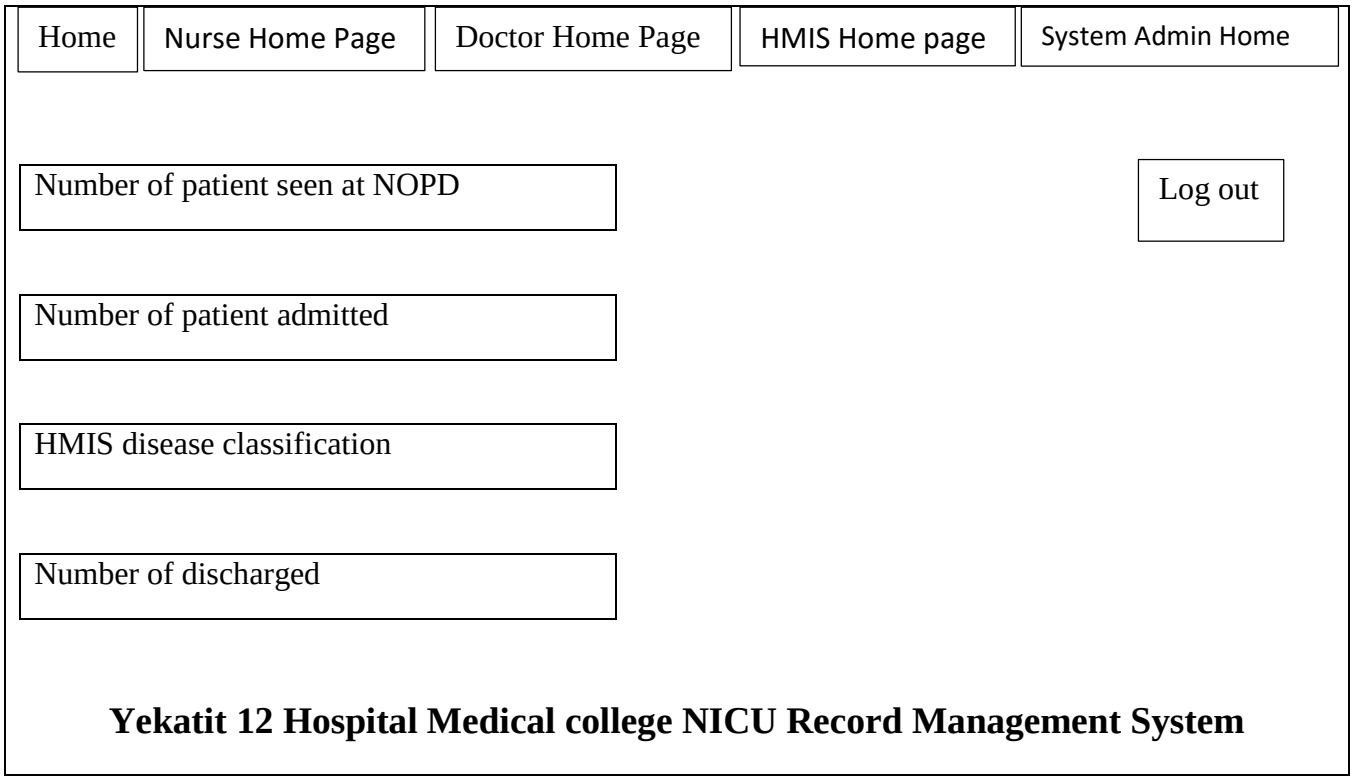

Figure 4. HMIS officer's Home page essential user interface.

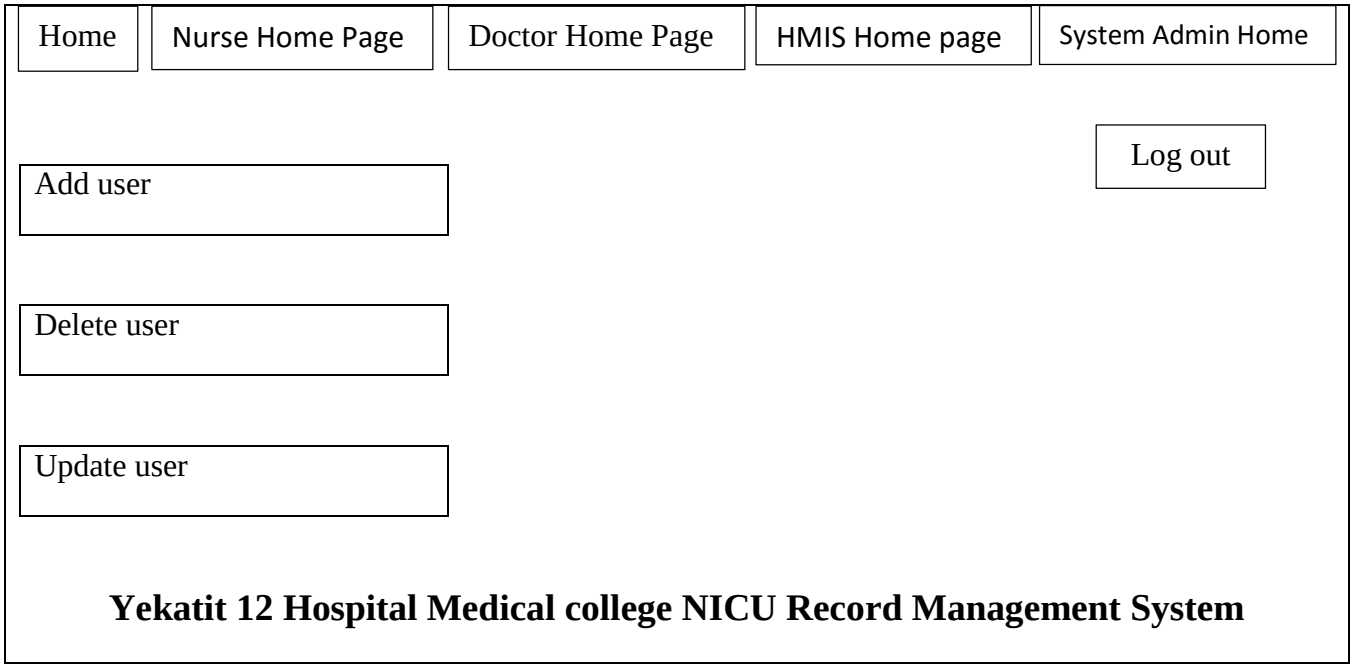

Figure 5. System administrator essential user interface.

CHAPTER FIVE
Object Oriented Analysis Models

5.1. Introduction

During Object Oriented analysis, the most important purpose is to identify objects and describe them in a proper way. If these objects are identified efficiently, then the next job of design is easy. The objects should be identified with responsibilities. Responsibilities are the functions performed by the object. Each and every object has some type of responsibilities to be performed. When these responsibilities are collaborated, the purpose of the system is fulfilled (61). In this chapter, system use case modeling and analysis level class diagram is used for modeling the analysis.

5.1.1. System Use Case Modeling

System use case describes a certain piece of desired functionality of an application system. Use cases make it clear what a system is going to do and, by intentional omission, what it is not going to do it is constructed during the analysis stage. It shows the interaction between among actors, with the system. It does not specify how the system carries out the task (62). The use case diagram is a simple graphical model for representing the primary relationships within a system. It is used to identify the primary entities (people and things that achieve results) and processes that form the system. The primary entities that interact with the system are termed "actors" and the processes or functions are called "use cases." The use case diagram shows which actors interact with what use cases (63).

An association between a use case and an actor mean that an actor participates in the behavior described by the use case. In addition, if a use case includes another one, the actor necessarily interacts with the included use case. Moreover, an extension of a use case is a use case which introduces an alternative course not specified in the base use case. The actor connected to the base use case participates in the extending version. (64)

Identified system use cases

1. Log in
2. Register patient
3. Vital sign
4. diagnosis (History, Physical exam, diagnosis)
5. laboratory Investigation Order
6. Laboratory investigation result registration
7. Treatment Order
8. Prescription
9. Treatment Administration
10. Progress note
11. Nursing care
12. Discharge summery
13. Appointment
14. Referral
15. Report (daily, weekly, monthly, quarterly and yearly)
16. Manage user account

Table 18. Identified System Actors and their Description.

Nurse	Refers to a health Professional who register the patient, give nursing care to the patient, administer treatment and generate report
Physician	Refers to a health professional who diagnose and treat patient
System administrator	Refers to who administer the system and maintain users account
HMIS officer	Refers to a person who generate a report from the system
Laboratory technician	Refers to a person who perform laboratory test.

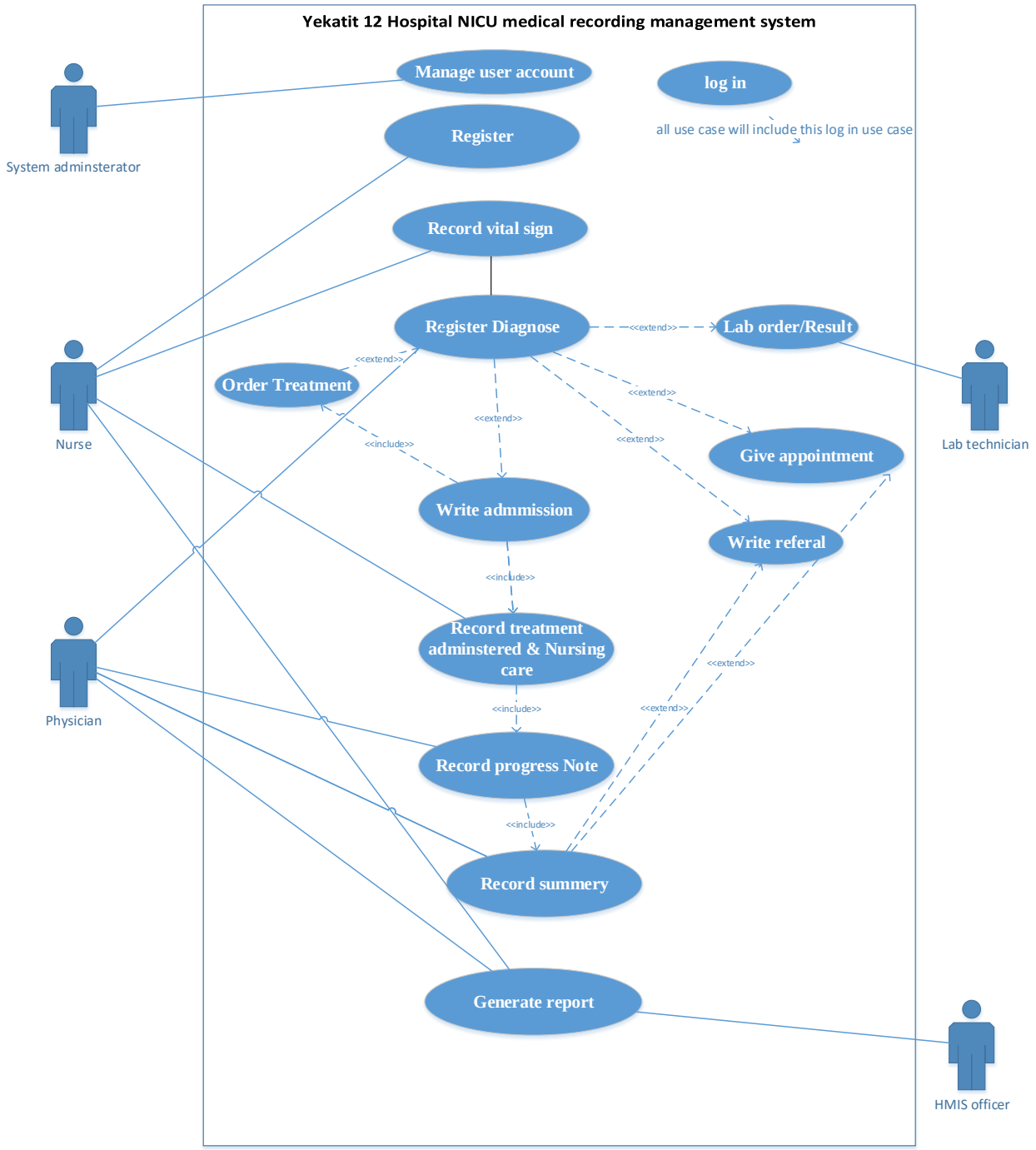

Figure 6. System Use case Diagram.

5.1.2. System use case Scenarios

Table 19. Log in system Use Case.

Use Case ID	UC_1
Use case Name	Login
Primary actor	Physician, Nurse, Lab technician, HMIS officer and system administrator (users of the system)
Use case description	This describes how the user logs into the system to obtain the different functionalities of the system.
Precondition	The user must have user Name and password
Post condition	The user logs into the system
Include	None
Extend	None
Main success scenario	1. The user wants to log in to the system 2. The user initiates the system 3. The system will displays the login screen 4. The user enters a username and password. 5. The system will validate the information is correct. 6. The system will set access permissions. 7. The system will displays the main screen. 8. The user selects the desired function 9. Use case ends
Alternative path	5a. If the username or password is not valid, an error message is displayed. 5a1. The user clicks an ok button. 5a2. The user is returned to login screen and re-enters user name and password.

Table 20. Registration System Use Case Scenario.

Use case ID	UC-2
Use Case Name	Register patient
Use case Description	This use case describes how a patient personal information and address is registered
Primary Actor	Nurse
Pre-Conditions	The Nurse should be authenticated
Post-Conditions	The patient registered in to the database
Include	Log in
Extend	None
main success scenario	1. The Nurse wants to register patient 2. The Nurse logs into the system 3. The System displays the main menu 4. The Nurse selects registration form from the Main Menu 5. The System displays the registration form 6. The Nurse enters personal identification information and demographic information of the patient. [ALT] 7. The Nurse clicks on save button. 8. The system validates the input data and saves to the data base. [ALT] 9. Use case ends.
Alternative path	6a. If the patient is already registered or came with appointment. 6a1. The Nurse enters the patient Name or ID of the patient and searches the patient. 6a2. The System displays the patient data. 6a3. The Nurse updates patient visit. 8a. If the Nurse makes error while entering the data or if all required information is not filled 8b. the system displays error message that informs to fill all the required information.

Table 21. Record Vital Sign System Use Case Scenario.

Use case ID	UC-3
Use Case Title	Vital sign
Use case Description	This use case describes patient Vital sign information recording process
Primary Actor	Nurse
Pre-Conditions	The Nurse should be authenticated
Post-Conditions	The system stored patient current vital sign status information in to the database
Include	Log in
Extend	None
Main success scenario	1. The Nurse wants to document vital sign data 2. The Nurse logs in to the system 3. The System displays main menu 4. The Nurse selects vital sign user interface 5. The System displays the vital sign registration form. 6. The Nurse fills Vital sign information. [ALT] 7. The Nurse clicks on save button. 8. The System saves the data and send successfully submitted message. [ALT, 8a and b] 9. Use case ends
Alternative path	6a. If the patient already have previous vital sign information 6 a.1 The Nurse enters patient card number to the system and request the system to retrieve pervious patient information 6a.2 The system updates the vital sign result 8a. If the Vital sign information contains abnormal (high or low) result the system display alert which helps the Nurse for further action. 8b1. If the Nurse skips essential information unknowingly 8b2. The system displays error message

Table 22. Record Diagnosis System use case Scenario.

Use Case ID	UC_4
Use case Name	Diagnosis (Patient history, physical examination and diagnosis) use case.
Primary actor	Physician
Summary description	This use case describes the process used to record history, physical examination and diagnose data.
Precondition	The physician should be authenticated
Post condition	The patient history, physical examination, and diagnosis are registered.
Include	Log in
Extend	Lab order, Referral to other hospital, Appointment, Treatment and Admission to ward
Main success scenario	1. The physician wants to document the patient history, physical finding and diagnosis information. 2. The physician logs in to the system 3. The system displays the main menu screen 4. The physician selects diagnosis user interface from the main menu 5. The system displays diagnosis record form 6. The physician enters patient history, physical finding and diagnosis [Alt1] 7. The physician clicks on save button. [Alt 2] 8. The system saves the data on the system. 9. Use case ends
Alternative path	6a. If the patient needs laboratory investigation the physician order lab 6b. If the patient needs referral the physician write referral. 6c. If the patient needs treatment the physician write prescription 6d. If the patient needs appointment the patient will be appointed 6e. If the patient needs admission the patient will be send to inpatient for admission. 7a. If the physician makes error when entering the information 7b. the system displays error message

Table 23. Write Admission System Use Case Scenario.

Use Case ID	UC_5
Use case Name	Admission
Primary actor	Physician
Summary description	This use case describes the process used to record Admission information (cause of admission, room number and bed number)
Precondition	The physician should be authenticated
Post condition	The patient admission information is registered.
Include	Log in
Extend	None
Main success scenario	1. The physician wants to document the patient admission information 2. The physician logs in to the system 3. The system displays the main menu screen 4. The physician selects admission form from the main menu 5. The system displays admission record form 6. The physician enters admission information like admission date, admission reason and other necessary information. 7. The physician clicks on save button. 8. The system saves the data on the system. [ALT] 9. Use case ends
Alternative path	8a. If the physician makes error when entering the data 8b. The system sends error message 8c. The physician clicks on ok and re- enter the data.

Table 24. Order Lab investigation System Use Case Scenario.

Use Case ID	UC_6
Use case Name	Order laboratory investigation
Primary actor	Physician
Summary description	This use case describes the process used to order Laboratory investigation
Precondition	The physician should be authenticated
Post condition	Investigation order is registered.
Include	Log in
Extend	None
Main success scenario	1. The physician wants to order investigation 2. The physician logs in to the system 3. The system displays the main menu screen 4. The physician selects investigation order list 5. The system displays the investigation order form 6. The physician selects the type of test to be done and send to laboratory department [ALT] 7. Use case end
Alternative path	6a. If the physician makes error when selecting 6b. The system sends error message 6c. The physician clicks on ok and re- select the lab order.

Table 25. Register Laboratory test result System Use Case Scenario.

Use Case ID	UC_7
Use case Name	Register lab test result
Primary actor	Lab technician
Summary description	This use case describes the process used to record laboratory result.
Precondition	The Laboratory technician should be authenticated.
Post condition	Investigation result is registered.
Include	Log in
Extend	None
Main success scenario	1. The lab technician wants to register investigation result 2. The lab technician logs in to the system. 3. The system shows laboratory test order messages 4. The laboratory technician clicks on the message button. 5. The system displays lists of laboratory orders. 6. The laboratory technician selects the message 7. The system displays the test request form. 8. The laboratory technician fills lab results on the lab order entry form and click save and send button [ALT 8a, 8b] 9. The system sends lab result to the NICU department. 10. The system saves the data on the system. 11. Use case ends
Alternative path	8a. If the result is out of reference range (abnormal) the system displays alert and highlighted for abnormal result. 8a1. The Physician receive the highlighted result. 8b. If the laboratory technician makes error while enters the result, the system displays error message. 8b1.The laboratory technician clicks an ok button. 8b2.The system informs the laboratory technician to re-enter the data.

Table 26. Write Treatment order System Use Case Scenario.

Use Case ID	UC_8
Use case Name	treatment order use case
Primary actor	Physician
description of use case	This use case describes the process used to Order treatment
Precondition	The physician should be authenticated
Post condition	Medication order is recorded.
Include	Log in
Extend	None
Main success scenario	1. The physician wants to records treatment order 2. The physician logs into the system 3. The system displays the main menu screen 4. The physician selects treatment record form 5. The system displays the treatment order form 6. The Physician enters the treatment order. 7. The Physician clicks on save button. 8. The system saves the data and displays successfully submitted message. [ALT] 9. Use case end.
Alternative path	8a. If the Physician makes error while ordering the treatment, 8b. The system displays error message. 8a1.The Physician clicks on ok button. 8a2.The system informs the Physician to re-enter treatment order 8a3.The physician re-enters the treatment

Table 27. Record Medication Administration System Use Case Scenario.

Use case ID	UC-9
Use Case Title	Medication administration record use case
Use case Description	This use case describes treatment administration information (type of treatment, time of administration, dose, frequency) and if allergy information.
Primary Actor	Nurse
Pre-Conditions	The Nurse should be authenticated
Post-Conditions	The system should save the medication administration record form.
Include	Log in
Extend	None
Main success scenario	1. The Nurse wants to record medication administration information 2. The Nurse logs in to the system 3. The system displays the main menu screen 4. The Nurse selects medication administration registration form 5. The system displays medication administration registration form. 6. The Nurse fills medication administration recording form with required information [ALT] 7. The Nurse clicks on save button 8. The system saves the entered data and send successful message 9. Use case ends
Alternative Path	6. If the Nurse makes error while entering the data. 6a. The system sends error message. 6b. The Nurse clicks on ok button and re- enter the data

Table 28. Record Nursing Care plan System Use Case Scenario.

Use case ID	UC-10
Use Case name	Nursing assessment and care plan
Use case Description	This use case describes how the Nurse record patient assessment and care plan information of the patient (about feeding, IV fluid type amount, care needed,)
Primary Actor	Nurse
Pre-Conditions	The Nurse should be authenticated
Post-Conditions	The system stored completed Nursing care plan information to the database.
Include	Log in
Extend	None
Main success scenario	1. The Nurse wants to record Nursing care plan of the patient 2. The Nurse logs in to the system 3. The System displays main menu screen 4. The Nurse selects the Nursing care plan documentation form 5. The System displays Nursing care plan documentation new form. 6. The Nurse fills the Nursing care plan information. [ALT] 7. The Nurse clicks on save button 8. The System displays successful message 9. Use case end
Alternative Path	6a. If the Nurse makes error when entering the data 6b. The system displays error message 6c. The Nurse clicks on ok 6d. The system informs to re- enter the data. 6e. The Nurse re-enters the data.

Table 29. Record Progress Note System Use Case Scenario.

Use Case ID	UC_11
Use case Name	Record Progress note use case.
Primary actor	Physician
Summary description	This use case describes the process used to record the progress note.
Precondition	The Physician should be authenticated Patient is registered and admitted
Post condition	The patient daily follow up (progress note) is registered.
Include	Log in
Extend	None
Main success scenario	1. The physician wants to document the patient progress note 2. The physician logs in to the system 3. The system displays the main menu screen 4. The physician selects progress note form 5. The system provides the physician progress note form 6. The physician enters the progress note. 7. The physician clicks on save button.[ALT] 8. The system saves the data and display successful message. 9. Use case ends
Alternative path	7a. If the physician makes error while entering the data. 7a1. The system displays error message 7a2. The physician clicks on ok button 7a3. The system informs to re-enters the data.

Table 30. Record discharge Summary Use Case Scenario.

Use Case ID	UC-12
Use case Name	Discharge Summary use case.
Primary actor	Physician
Summary description	This use case describes the process used to document summery of patient information during hospital stay
Precondition	Patient admitted and The physician is authenticated.
Post condition	The patient summery note is registered.
Include	Log in
Extend	None
Main success scenario	1. The physician wants to document summery 2. The physician logs in to the system 3. The system displays the main menu screen 4. The physician selects summery form from the main menu 5. The system provides the physician discharge summery form 6. The physician enters summery data. 7. The physician clicks on save button. 8. The system saves the data and send successfully saved message. [ALT] 9. Use case ends
Alternative path	8a. If the physician makes error while entering the data. 8b. The system displays error message 9c. The physician clicks on ok 9d. the system informs to re- enter the data. 9a. if the patient needs referral 9b. 1. The physician fills the referral information and refer the patient.

Table 32. Record referral Use Case Scenario.

Use Case ID	UC-13
Use case Name	Referral use case.
Primary actor	Physician
Summary description	This use case describes the process used to document referral information of patient information during referring the patient to other hospital
Precondition	The physician is authenticated.
Post condition	The patient referral information is registered.
Include	Log in
Extend	None
Main success scenario	1. The physician wants to document referral information 2. The physician logs in to the system 3. The system displays the main menu screen 4. The physician selects referral form from the main menu 5. The system provides the referral form 7. The physician enters referral information. 8. The physician clicks on save button. 9. The system saves the data and send successfully saved message. [ALT] 10. The physician prints the referral and give to the patient 11. Use case ends
Alternative path	9a. If the physician makes error while entering the data. 9b. The system displays error message 9c. The physician clicks on ok 9d. the system informs to re- enter the data.

Table 33. Record Appointment Use Case Scenario.

Use Case ID	UC_ 14
Use case Name	Appointment
Primary actor	Nurse
Summary description	This use case describes the process used for register the appointment information of the patient.
Precondition	The Nurse has authenticated
Post condition	The user document the patient information of appointment
Include	Log in
Extend	None
Main success scenario	1. The Nurse wants to record the patient appointment information 2. Nurse logs in to the system 3. The system displays the main screen 4. The Nurse selects appointment form from the main menu 5. The system displays appointment form 6. The Nurse records the appointment information and click save. 7. The system saves the data and send successful message. 8. Use case ends
Alternative path	6a. If the Nurse makes error while entering the data 6b. The system displays error message. 6c. The Nurse clicks ok button 6c. The system informs to re-enter the data.

Table 34. Generate Report System Use Case Scenario.

Use Case ID	UC_ 15
Use case Name	Generate report
Primary actor	physician, Nurse, HMIS officer
Summary description	This use case describes the process used to generate report.
Precondition	The user has authentication to generate report
Post condition	The user generates report from the system.
Include	Log in
Extend	None
Main success scenario	1. The user wants to generate report 2. User logs in to the system 3. The system displays the main menu screen 4. The user selects report user interface 5. The system displays a report form that contains different report options (daily, monthly quarterly, annually). 6. The user selects type of reports needed. 7. The system generates the selected report. 8. Use case ends
Alternative path	

Table 35. Maintain User Account System Use Case Scenario.

Use Case ID	UC_ 16
Use case Name	Maintain user account
Primary actor	System administrator
Use case description	This use case describes how the administrator maintains the user account.
Precondition	The administrator should register as an authorized administrator.
Post condition	The administrator maintained user account/manage the system
Include	Log in
Extend	None
Main success scenario	1. The Use Case starts when the user starts the application. 2. The administrator enters in to login screen. 3. The system displays the login screen 4. The administrator enters user name and password 5. The System displays the user account form. 6. The administrator performs create new user, update user account 7. The System validates the information which the Administrator enters 8. Use Case end
Alternative path	4a. If the administrator username or password is not valid, an error message is displayed. 4a1. The administrator clicks an ok button. 4a2. The administrator is returned to login screen and re-enter user name and password.

5.1.2. Analysis Level Class Modeling

Class diagrams are used in both the analysis and the design phases. During the analysis phase, a very high-level conceptual design is created. At this time, a class diagram might be created with only the class names shown or possibly some pseudo code-like phrases may be added to describe the responsibilities of the class. The class diagram created during the analysis phase is used to describe the classes and relationships, but it does not suggest how the system is implemented. (65). Analysis-level classes, or simply analysis classes, are used to capture important concepts in the problem domain. By identifying them first, we can proceed towards the design more systematically. Noun/verb + CRC analyses are commonly used to identify them. Analysis classes should only contain key attributes and high level responsibilities (66).

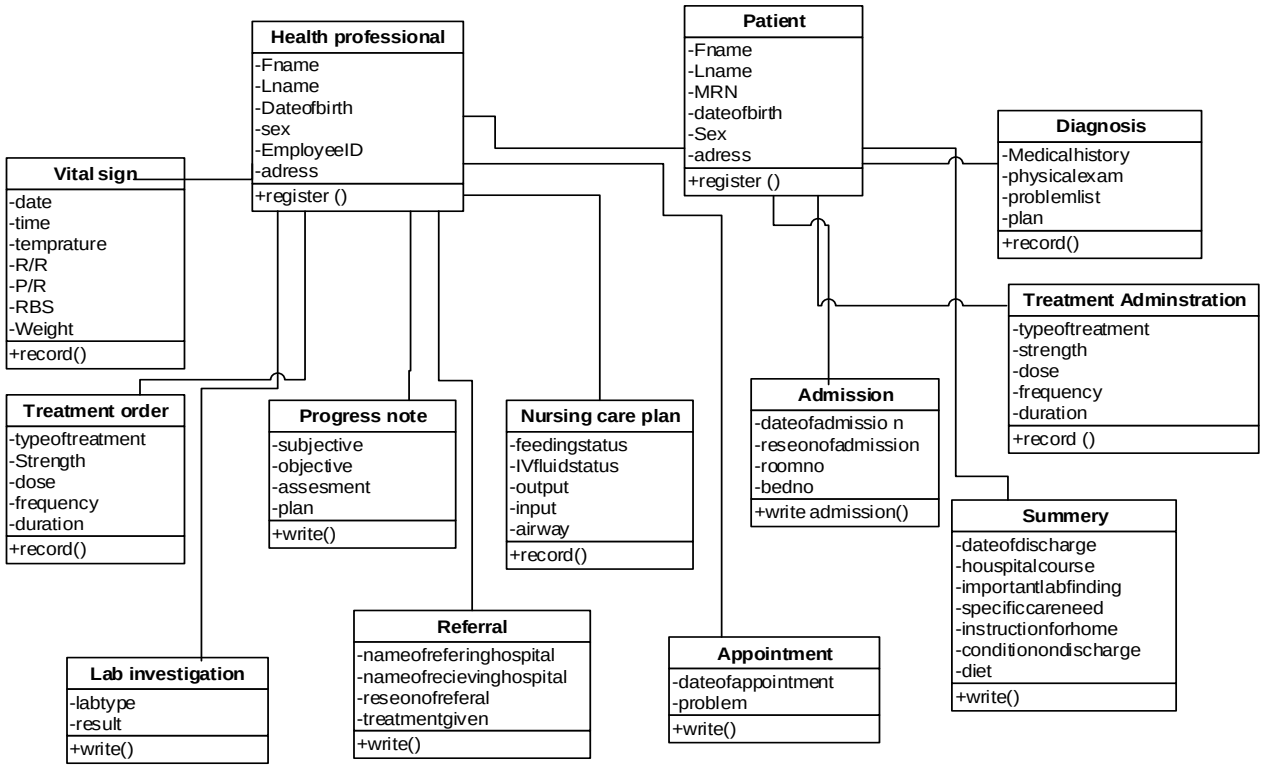

Figure 7. Analysis Level Class Diagram.

CHAPTER SIX

Designing of the system

6.1. Introduction

System design specifies the structure of how a software system will be written and function, without actually writing the complete implementation. A transition from "what" the system must do, to "how" the system will do it. What classes do we need to implement a system that meets our requirement (67). Accordingly, to design the system, the investigator used sequence diagram system modeling, design level class diagram and deployment diagram.

6.2. Sequence Diagram System Modeling

The Sequence diagram is one of the most effective diagrams to model object interactions in a system. A Sequence diagram is modeled for every Use Case. Sequence diagrams in the UML are primarily used to model the interactions between the actors and the objects in a system and the interactions between the objects themselves. As the name implies, a sequence diagram shows the sequence of interactions that take place during a particular use case or use case instance. The objects and actors involved are listed along the top of the diagram, with a dotted line drawn vertically from these. Interactions between objects are indicated by annotated arrows. The rectangle on the dotted lines indicates the lifeline of the object concerned (i.e., the time that object instance is involved in the computation). The sequence of interactions read from top to bottom (68), (69).

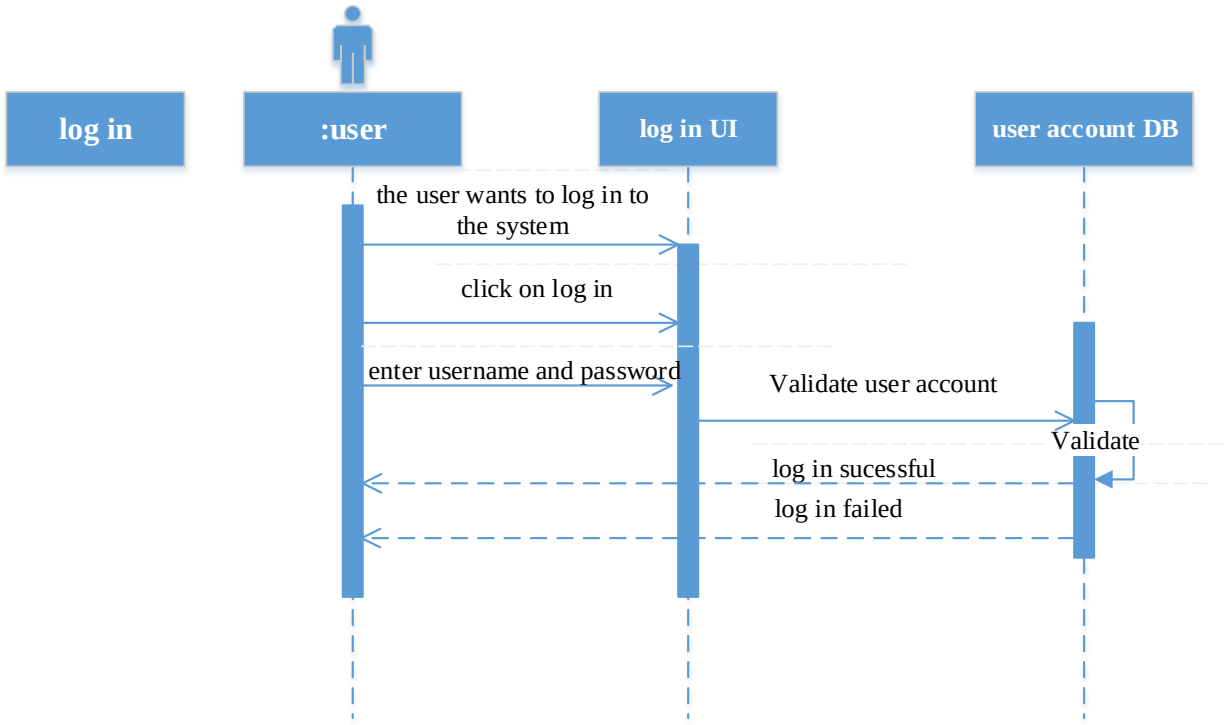

Figure 8. Sequence Diagram for Log in.

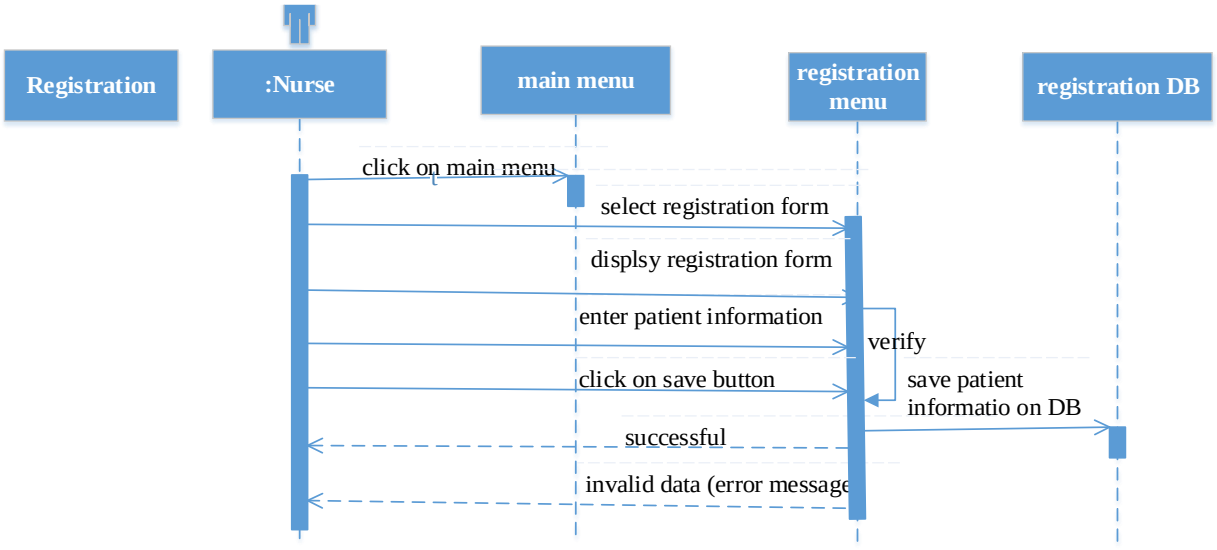

Figure 9 Sequence Diagram for patient Registration.

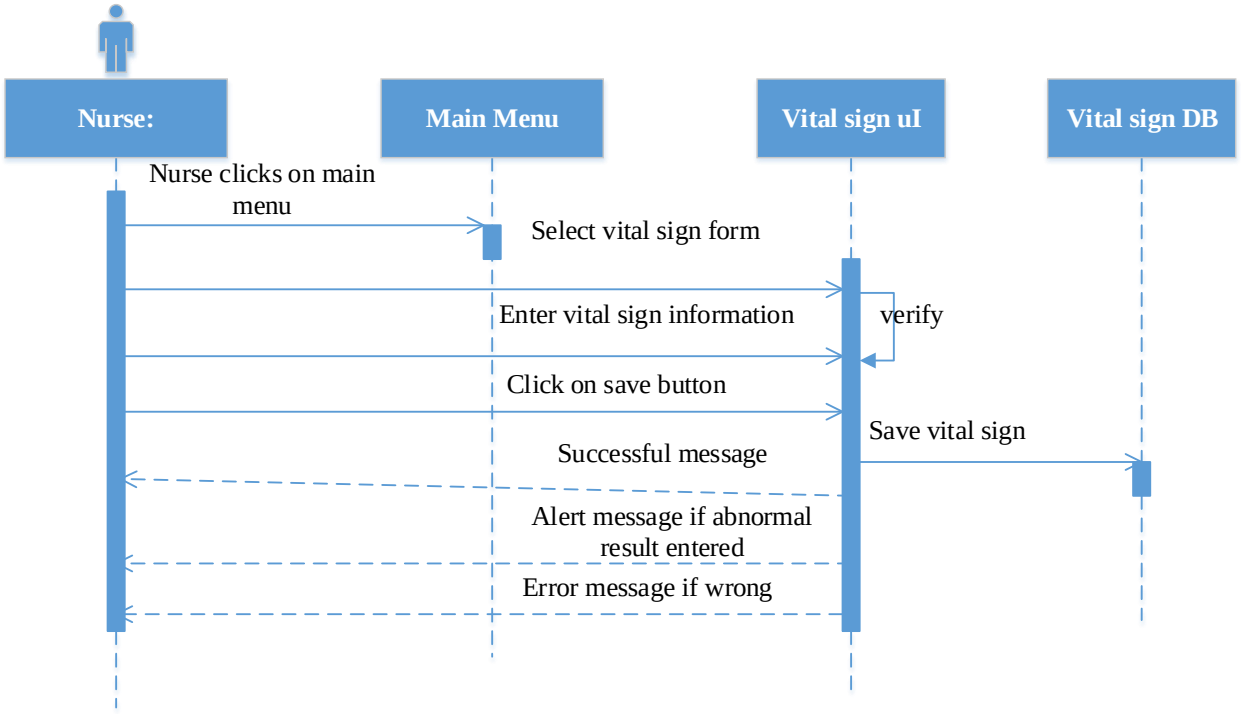

Figure 10 Sequence diagram for vital sign.

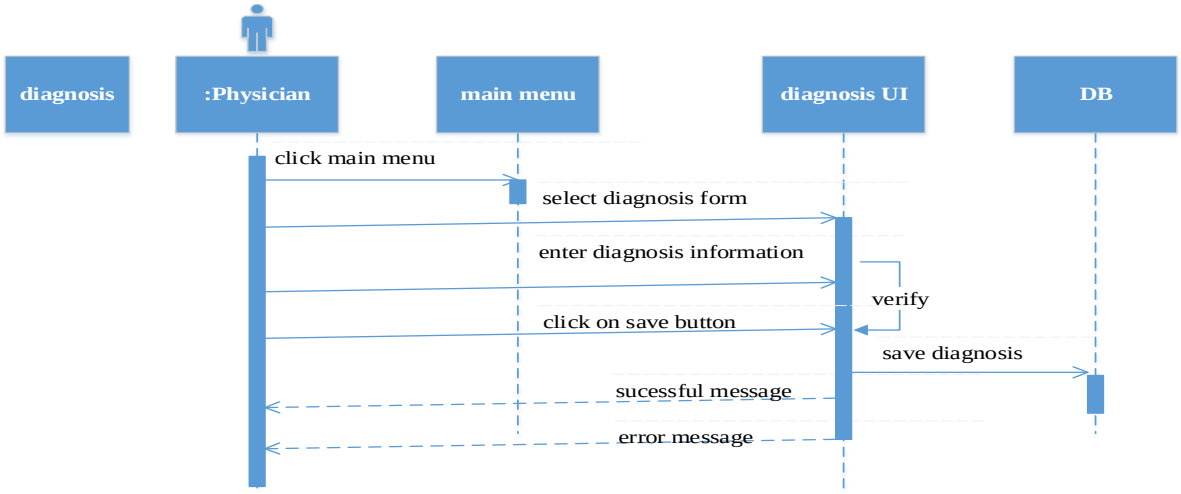

Figure 11. Sequence Diagram for Diagnosis.

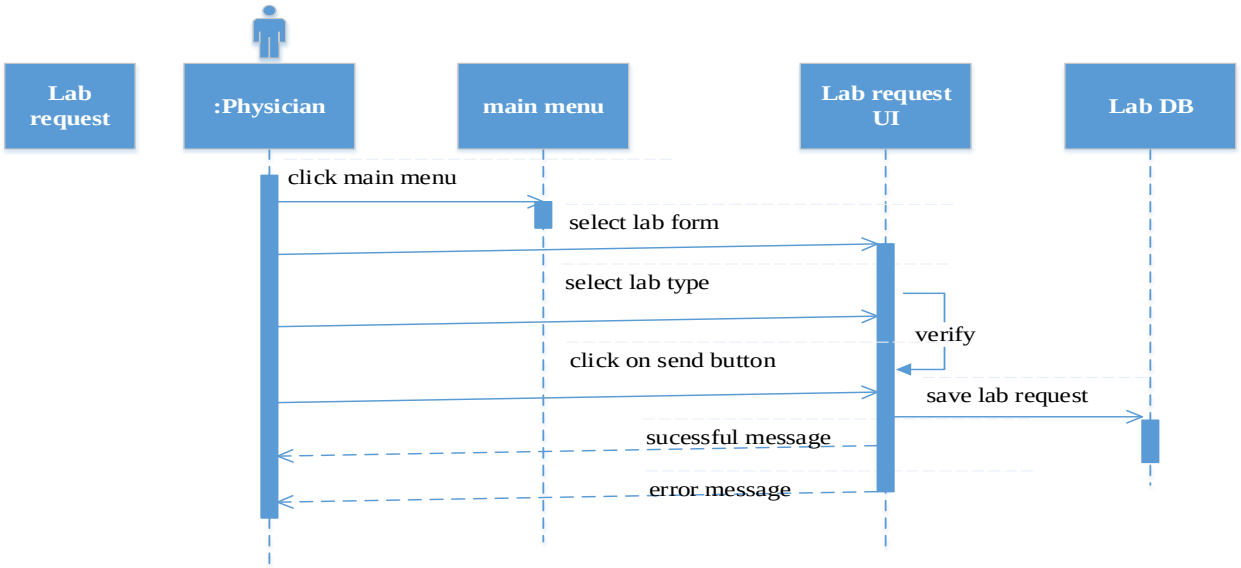

Figure 12. Sequence diagram for lab request.

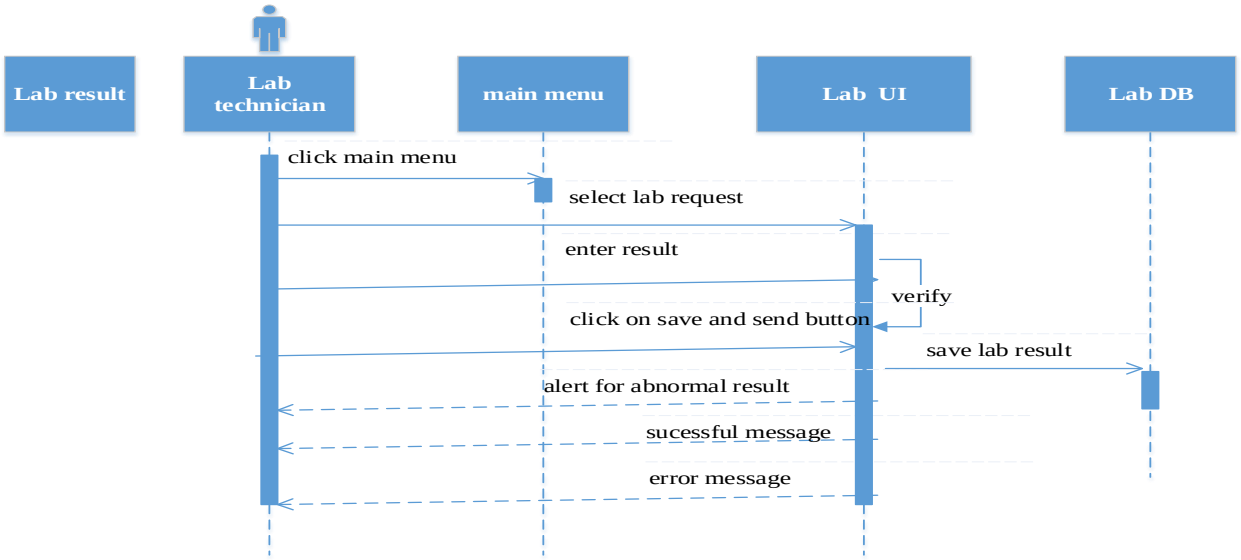

Figure 13. Sequence diagram for lab result.

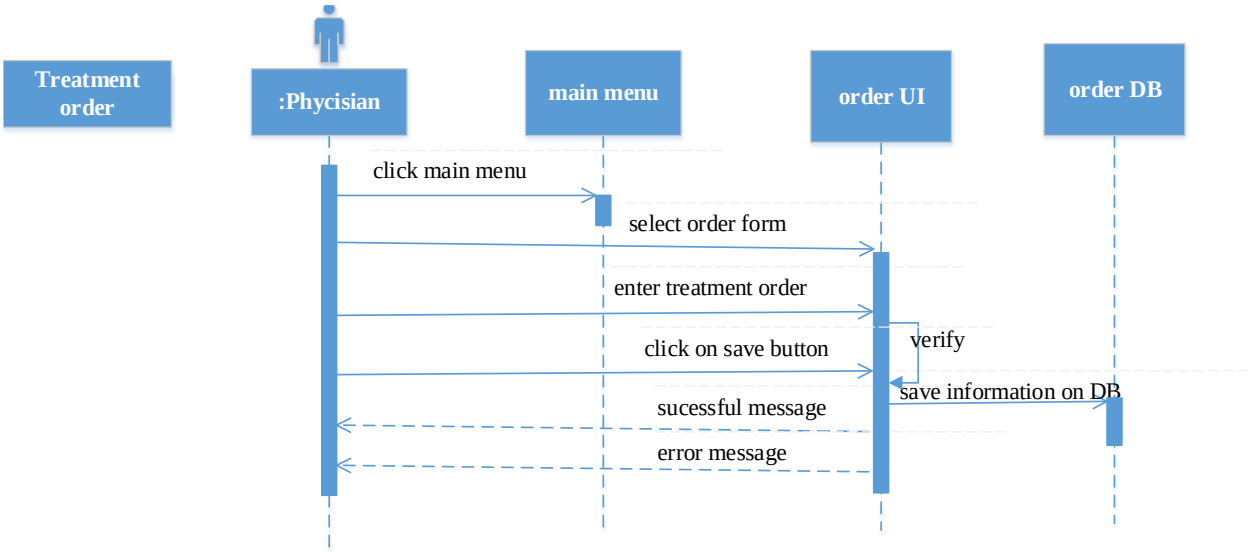

Figure 14. Sequence diagram for treatment order.

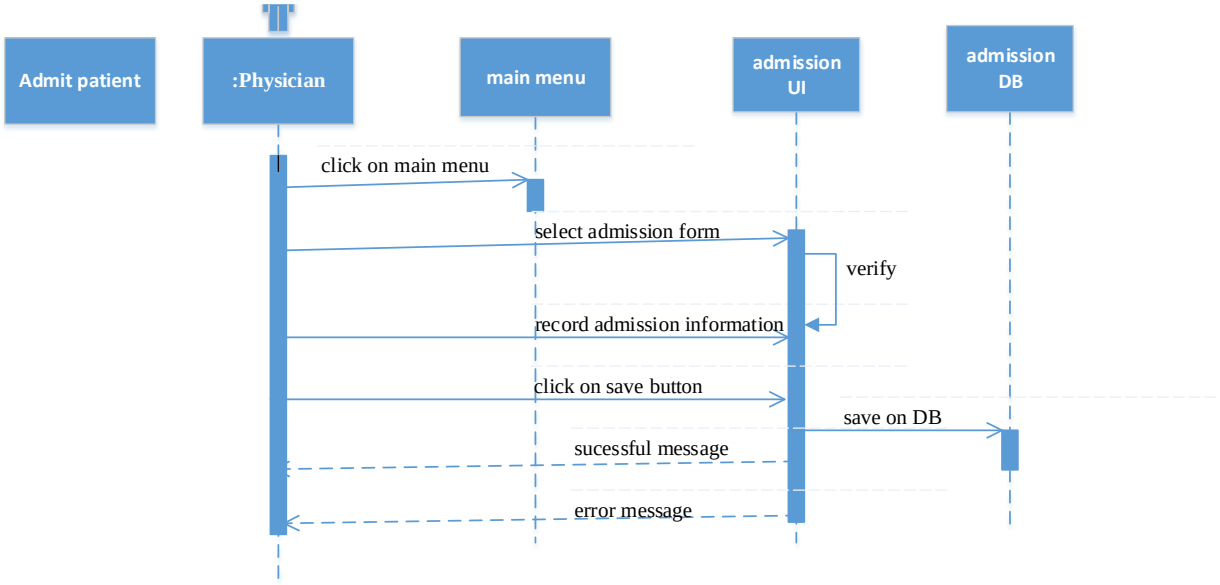

Figure 15. Sequence diagram to admit a patient.

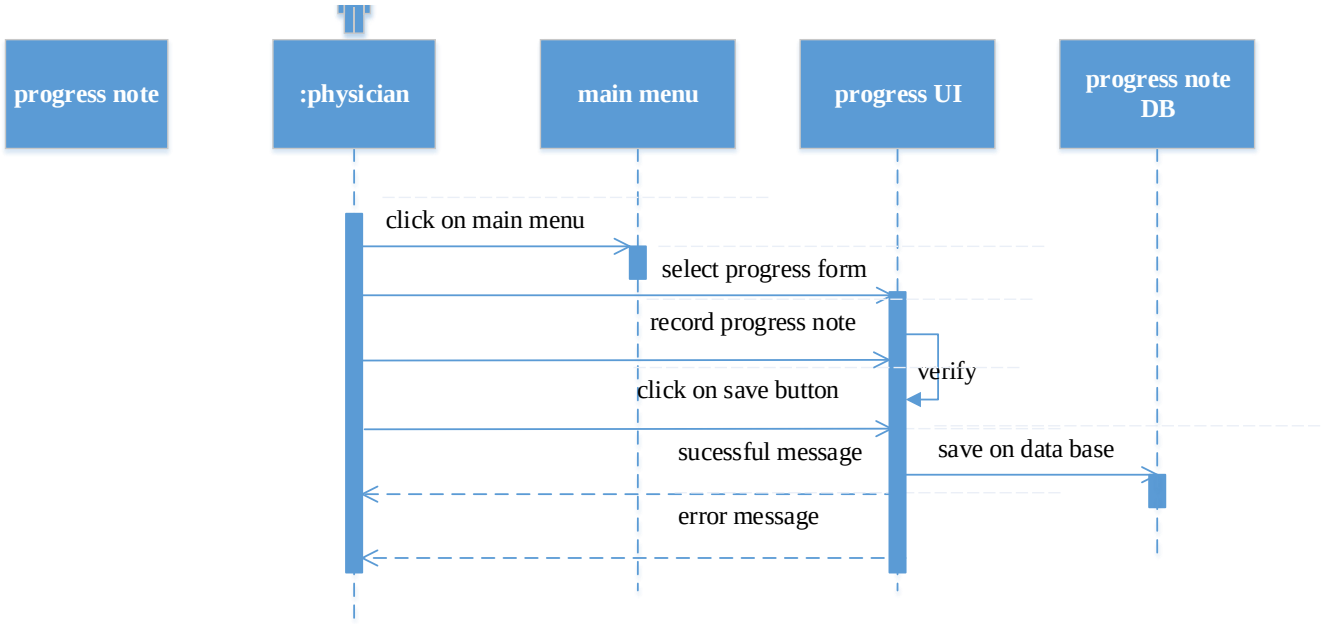

Figure 16. Sequence diagram for progress note.

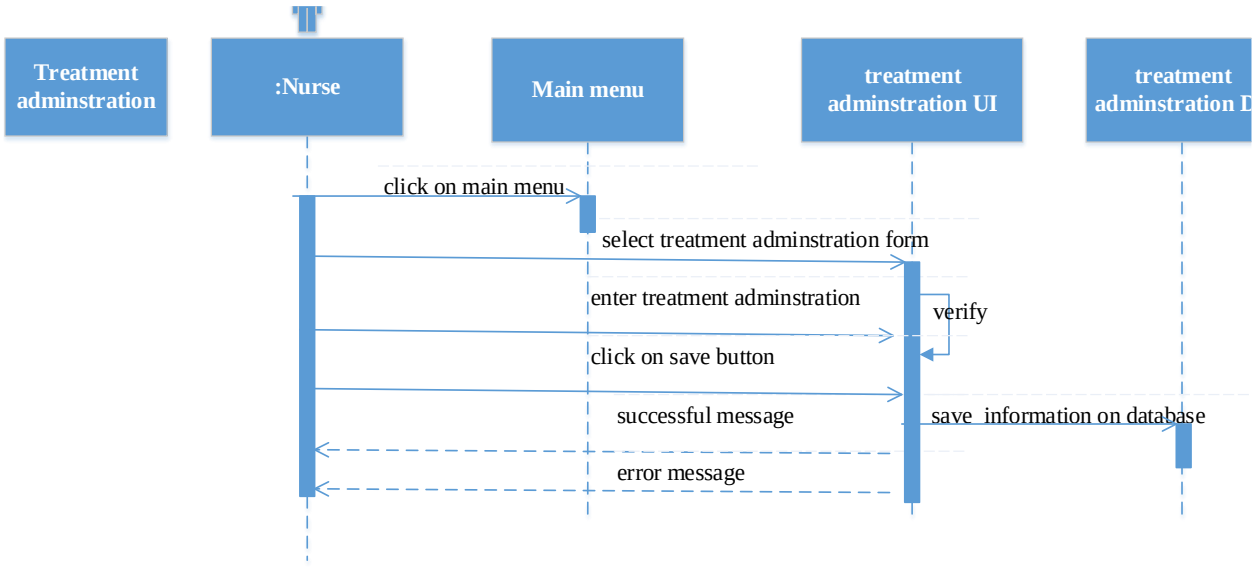

Figure 17. Sequence diagram for treatment administration.

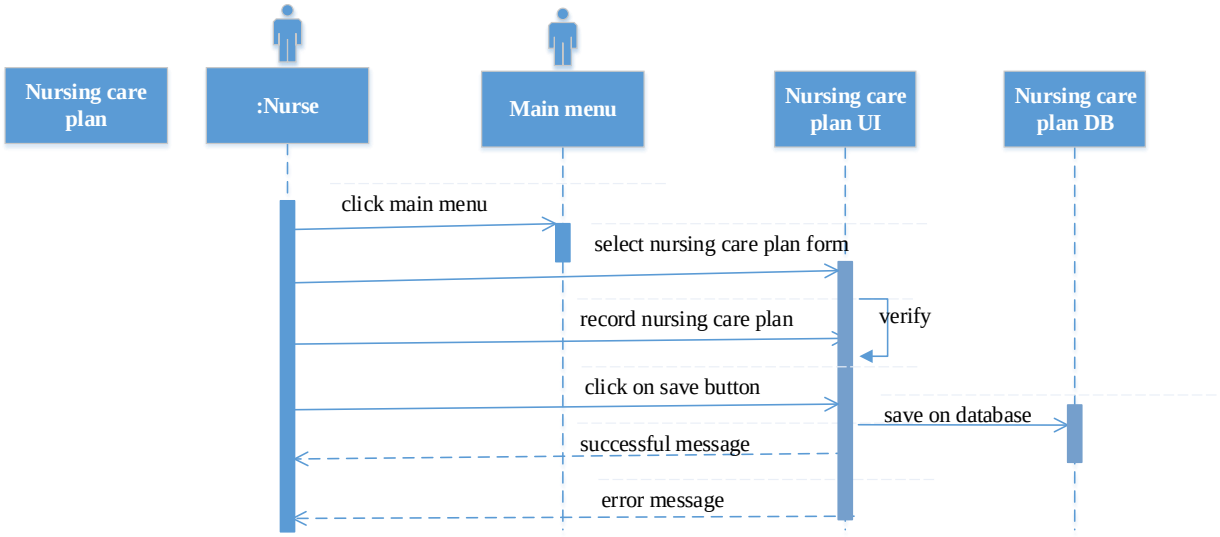

Figure 18. Sequence diagram for Nursing Care Plan.

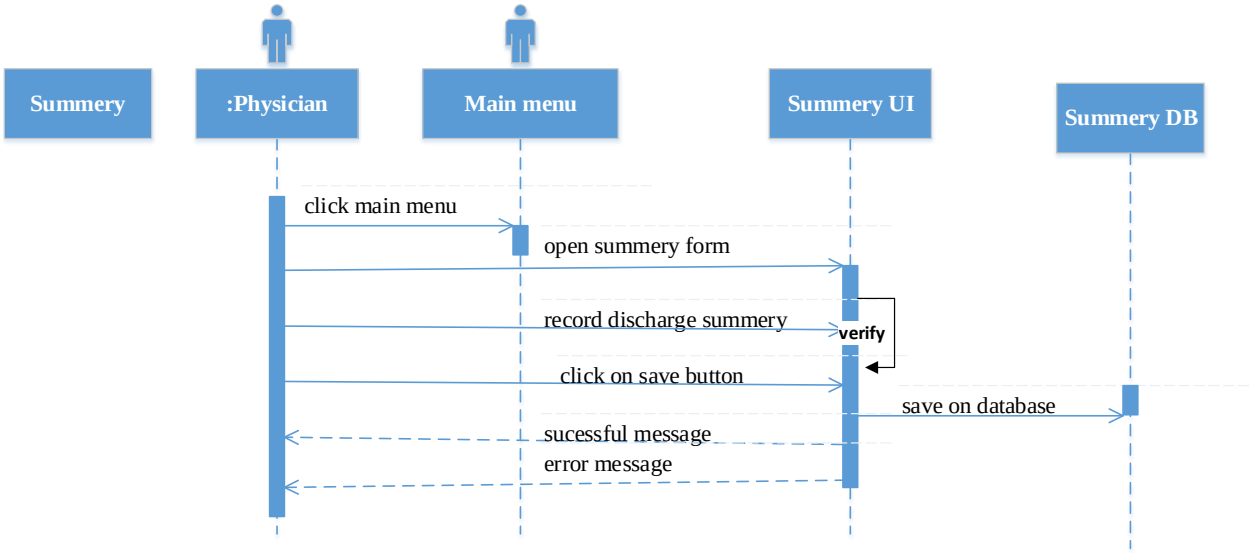

Figure 19. Sequence diagram for discharge summery

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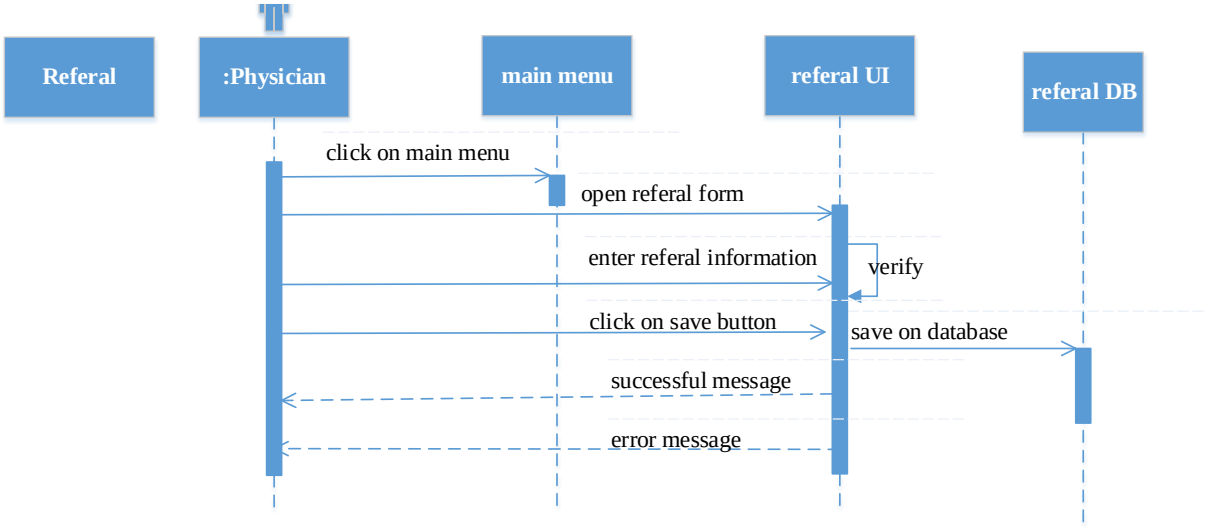

Figure 20. Sequence diagram for referral.

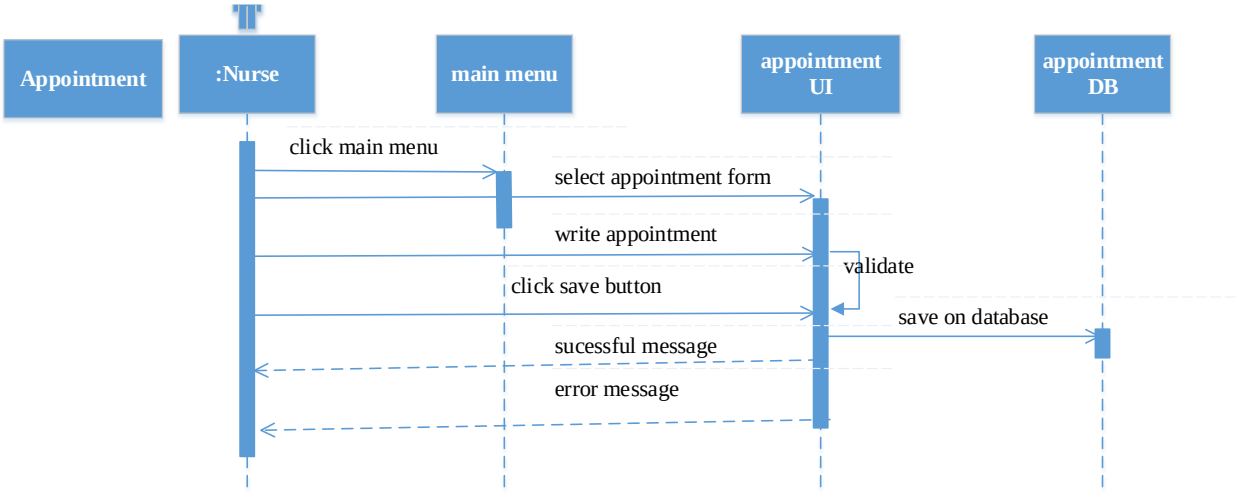

Figure 21.Sequence diagram for Appointment.

6.3. Designing Level Class Modeling

Class diagram is an integral part of the unified modeling language. It is a structure diagram that is used to show the classes and their association with each other. The class diagram includes the notations such as classes, attributes, operations and associations. (70) It can be used as to provide a general overview of the system objects and their interactions. An association is a link between classes that indicates that there is a relationship between these classes. Each class is drawn by using three part-rectangles with the class's name at the top, attributes in the middle, and methods (also called operations) at the bottom (71).

Class: - The main building block of a class diagram is the class, which stores and manages information in the system. A class in UML consists of three compartments which contain class name, attributes and operations.

Attributes: - are properties of the class about which we want to capture information.

Operations: - are actions or functions that a class can perform

Visibility: - of the attribute on the diagram. Visibility relates to the level of information hiding to be enforced for the attribute. The visibility of an attribute can either be public (+), protected (#), or private (-). A public attribute is one that is not hidden from any other object. As such, other objects can modify its value. A protected attribute is one that is hidden from all other classes except its immediate subclasses. A private attribute is one that is hidden from all other classes. The default visibility for an attribute normally is private (67).

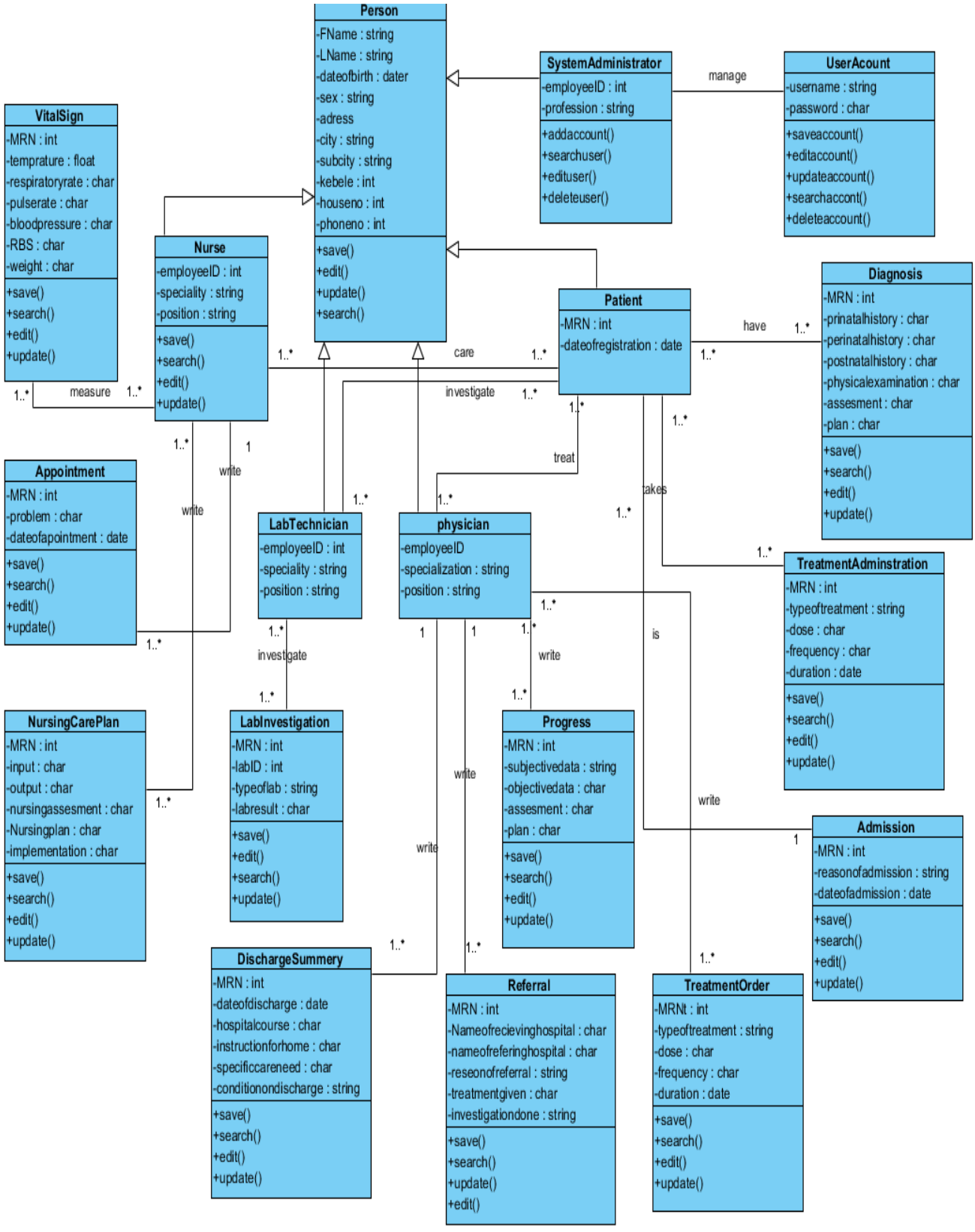

Figure 22. Design Level Class Diagram

6.4. Deployment diagram

A deployment diagram is a diagram that shows the configuration of run time processing nodes and the components (hardware, software & middleware on hardware) that live on them that is used to model the static deployment view of a system (topology of the hardware). In other words, deployment diagrams show the hardware requirement for the system, the software installed on that hardware, and the middleware used to connect the disparate machines to one another (72).

The proposed architecture for this system is 3-Tier client-server architectures. It have 3 essential components: the first front layer or Client PC which contains presentation logic, the middle layer or an Application Server to manage communication between components and the third or back end layer of the system stores and provides the different data that are required for the full functionalities of the system. In this layer the different data that are collected via registration, patient clinical data, demographic data used for retrieval. This architecture provides greater application scalability, high flexibility, high efficiency, lower maintenance, and reusability of 25. Since each tier runs on a separate machine, it improves systems performance.

Figure 25, shows the 3- tier system deployment diagram design for Yekatit 12 HMC, NICU record Management System

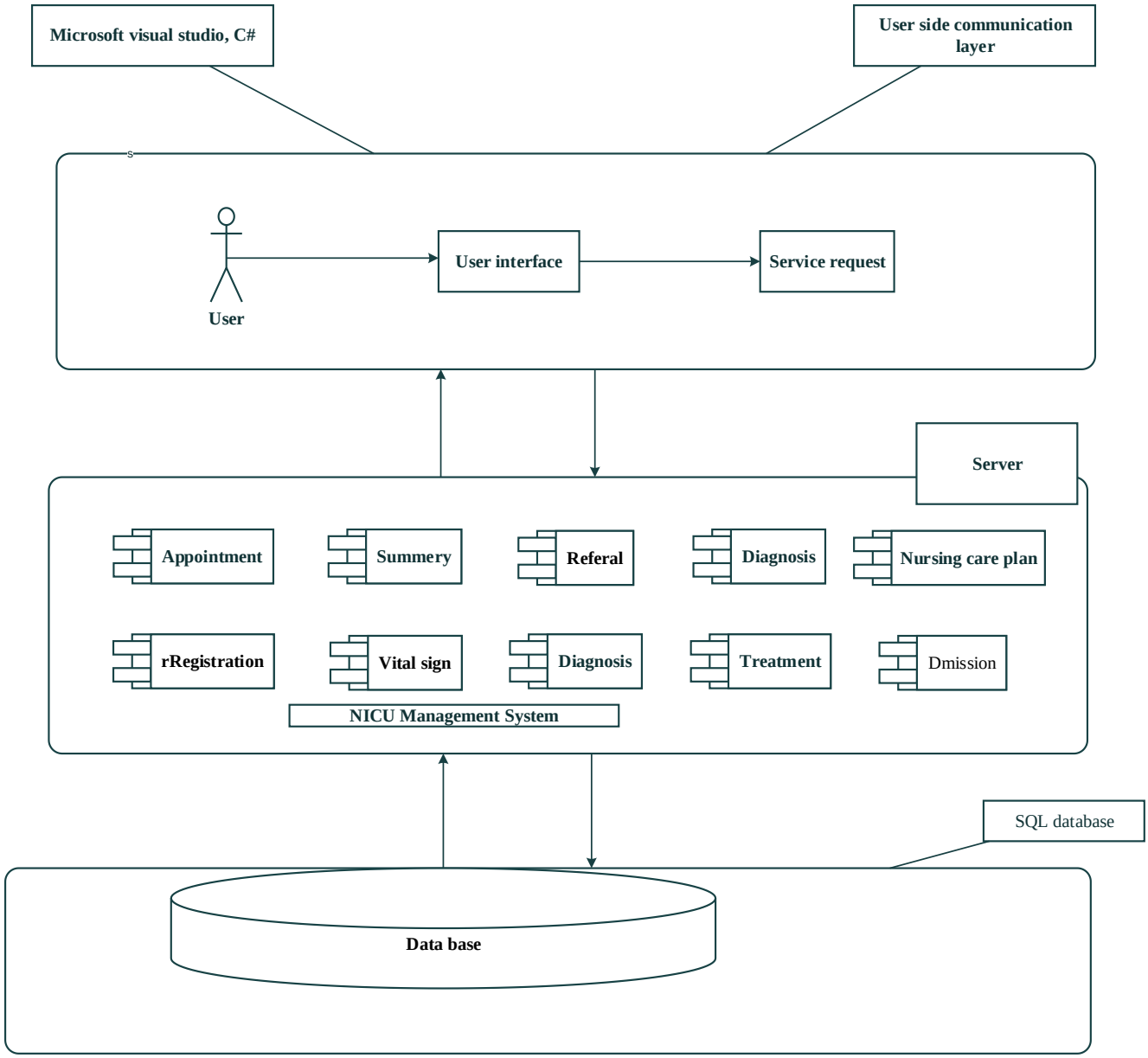

Figure 23. Deployment Diagram.

6.5. User interface prototyping

User interface prototyping is an iterative analysis technique in which users are actively involved in the making-up of the UI for a system. It is a working model that does not normally have all the required features or provide all the functionality of the final system. It uses as an analysis artifact that enables developers to explore the problem space with the stakeholders. And also used as a design artifact that enables system developer to explore the solution space of the system. The user interface prototype helps the user to test the system at early stage of the system development (73). The below diagram provides an architectural view of how each users in the system is allowed to use and access different functionalities and data entry usage based on their own administrator assigned privilege.

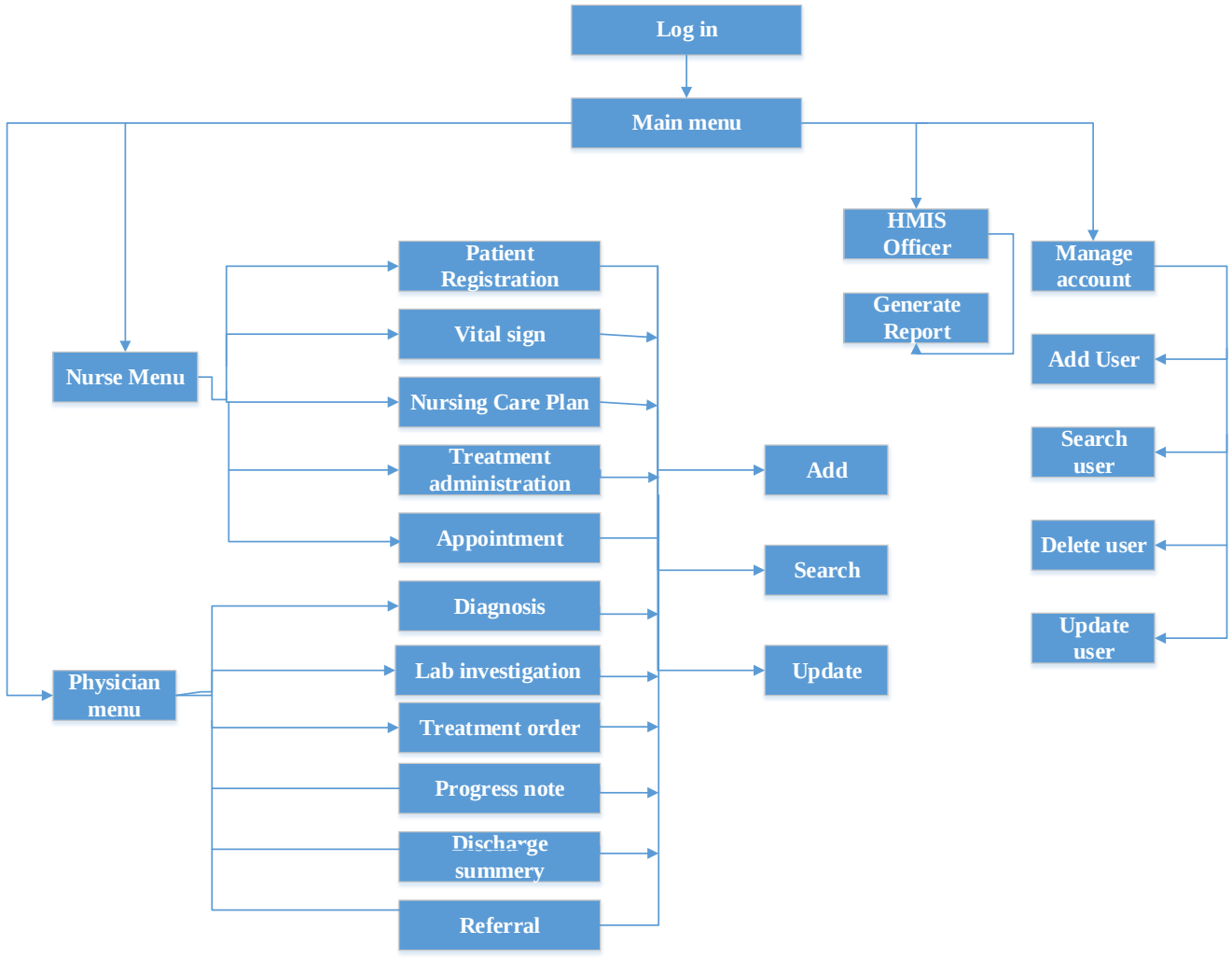

Figure 24. User interface flow diagram.

Figure 25. Home page User interface

The home page provides the different information about the services, contains different home pages that the system has. The home pages that are found at the top, each one of them lead to different locations and provide different functions. Most importantly in order to get the required services from the system the user must login into the system thus the user have to click on the Log In button.

Figure 26. Login user interface.

This user interface is a gate way to the different functionalities of the system. Each user before logs into the system must have the appropriate password and user name and privilege assigned by the administrator of the system.

Figure 27. Nurses, Home page user interface.

The Nurses home page provides different registration functionalities that NICU Nurses uses for register NICU patients. The hyperlinks that are found at the top, each one of them lead to different locations and provide different functions.

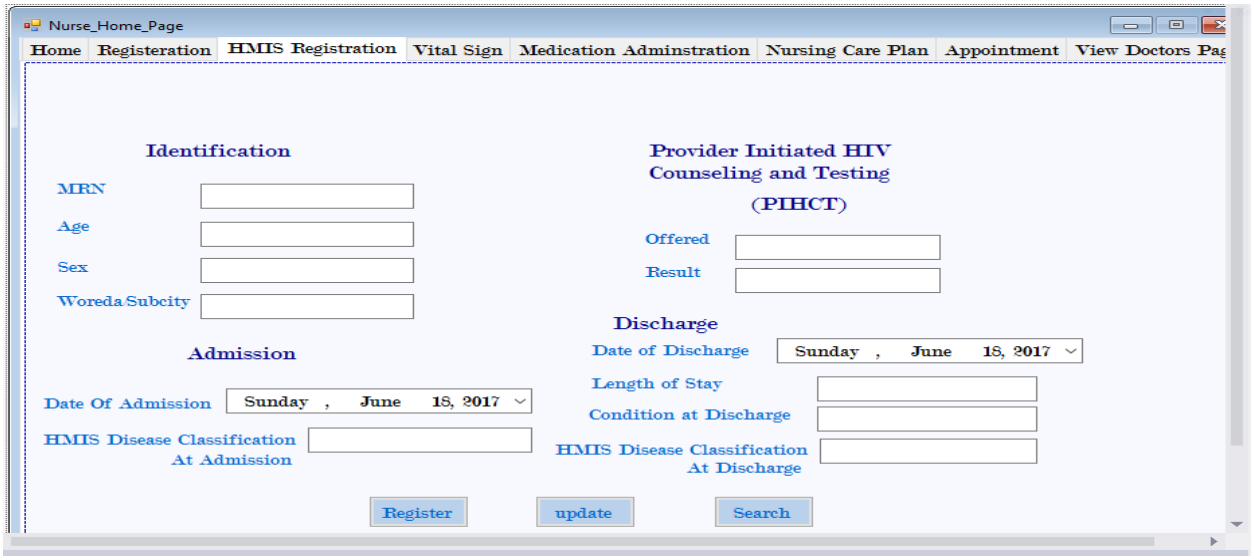

Figure 28. User interface for Admission/discharge HMIS registration

The user interface of the HMIS registration provides a registration functionality of patient personal information, address and HMIS disease classification.

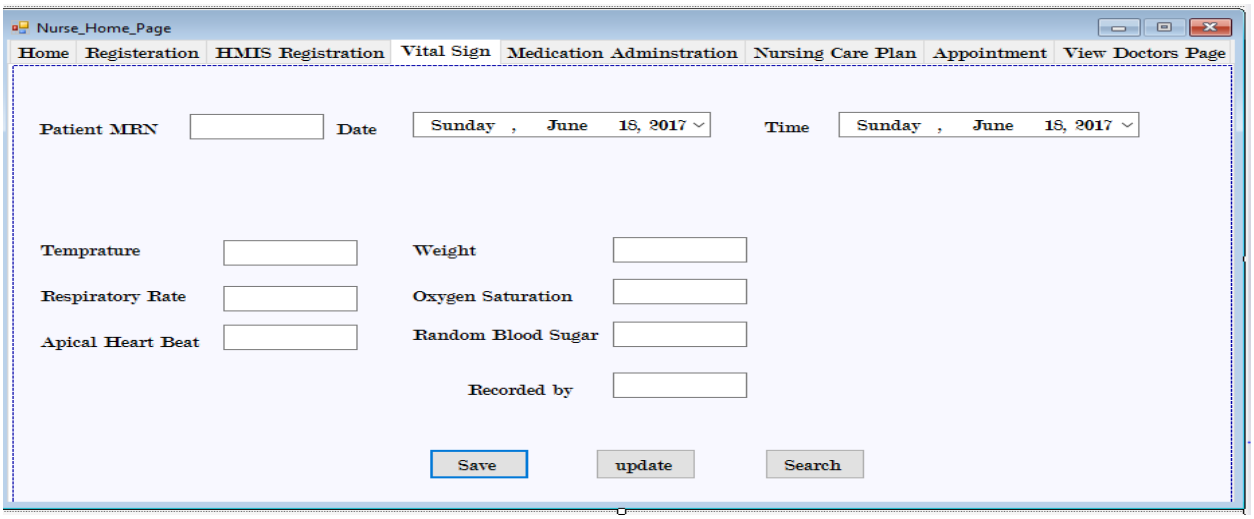

Figure 29. User interface for vital sign.

The user interface for vital sign registration provides a registration functionality to the vital sign of the Neonatal patient. So that the health professionals of the unit can access the vital sign information easily.

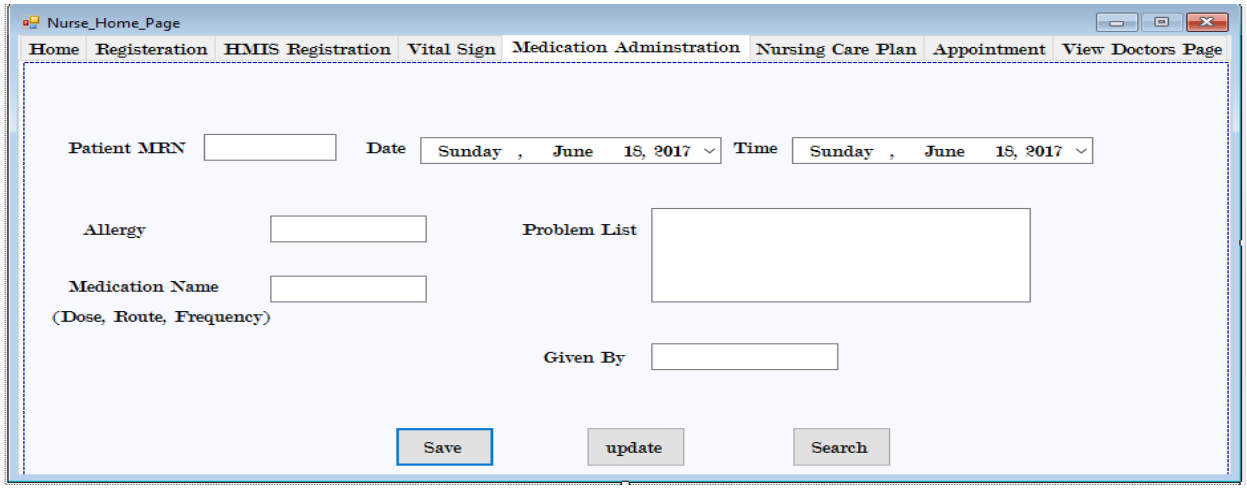

Figure 30.User interface for Medication administration.

The user interface of the Medication adminstration provides a registration functionality to the adminstered treatment in the inpatient ward.

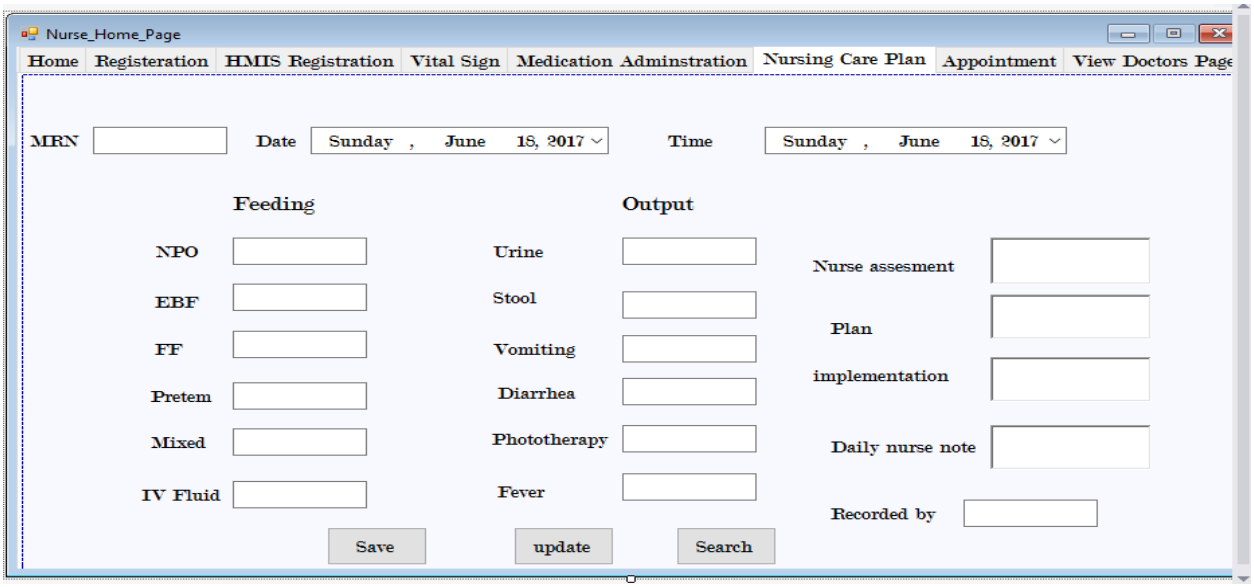

Figure 31. User interface Nursing Care plan.

The user interface for Nursing Care plan provides a registration functionality to Nurses about feeding status, output, patient assesment, plan, implementation and nursing note about patient condition in the inpatient ward.

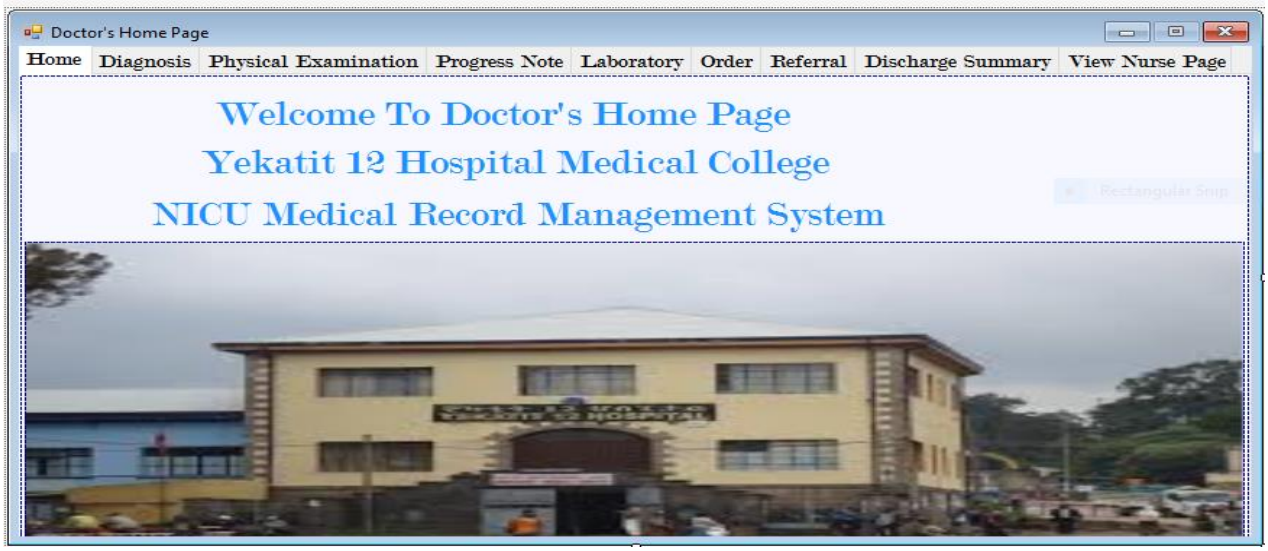

Figure 32. Doctor's Home Page.

The Doctor's (Physician) main menu provides different registration functionalities that NICU Physicians uses for registering Neonatal patients data. The hyperlinks that are found at the top, each one of them lead to different locations and provide different functions.

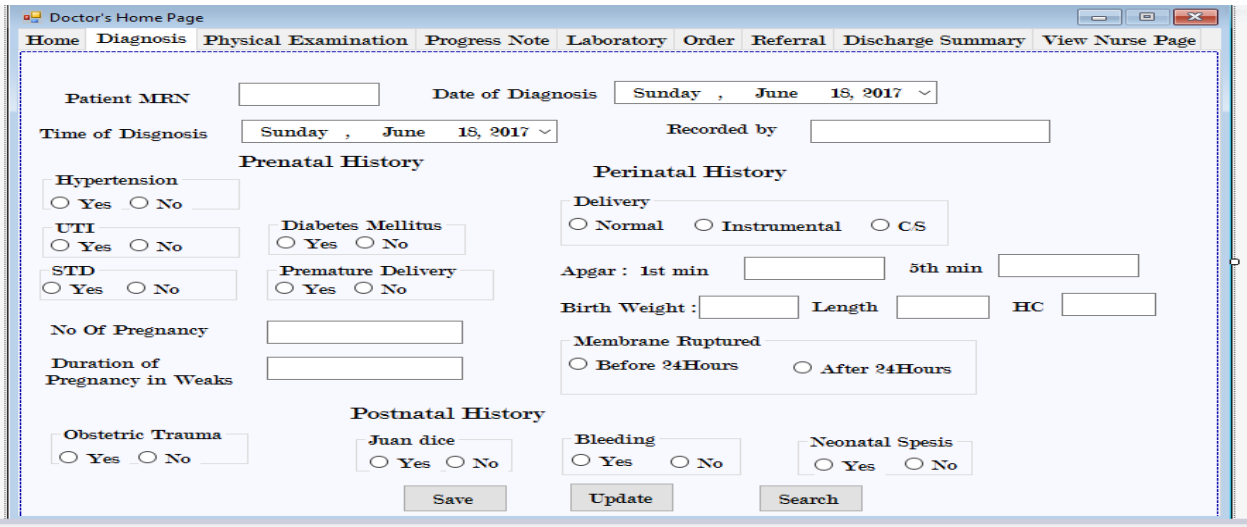

Figure 33. User interface for registering history of patients

The Diagnosis interface provides registration of prenatal, perinatal and postnatal history of the neonatal patients.

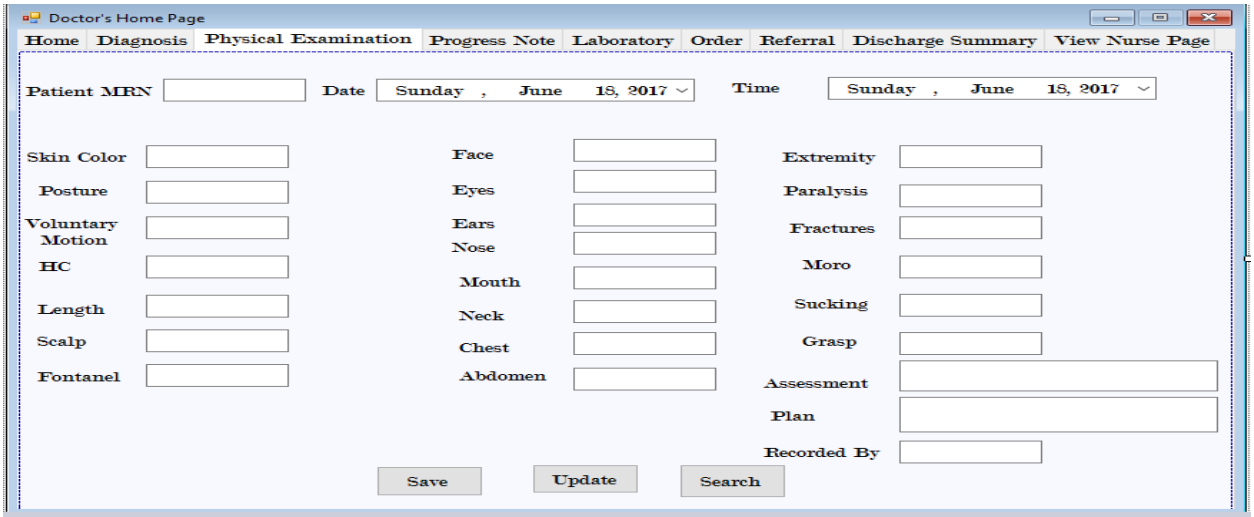

Figure 34. Physical examination recording user interface.

The Physical examination interface provides registration of physical examination findings of the Neonatal patients, by NICU Physicians.

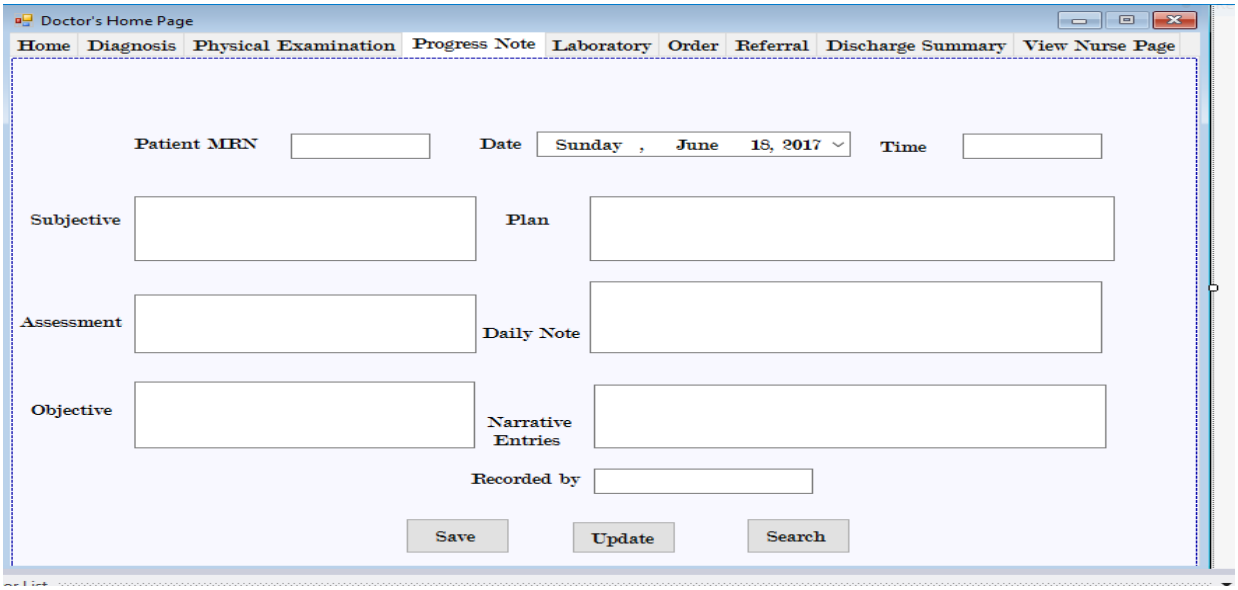

Figure 35. Progress note user interface.

The progress note user interface provides registration of the day to day condition of the neonate after admission to the ward.

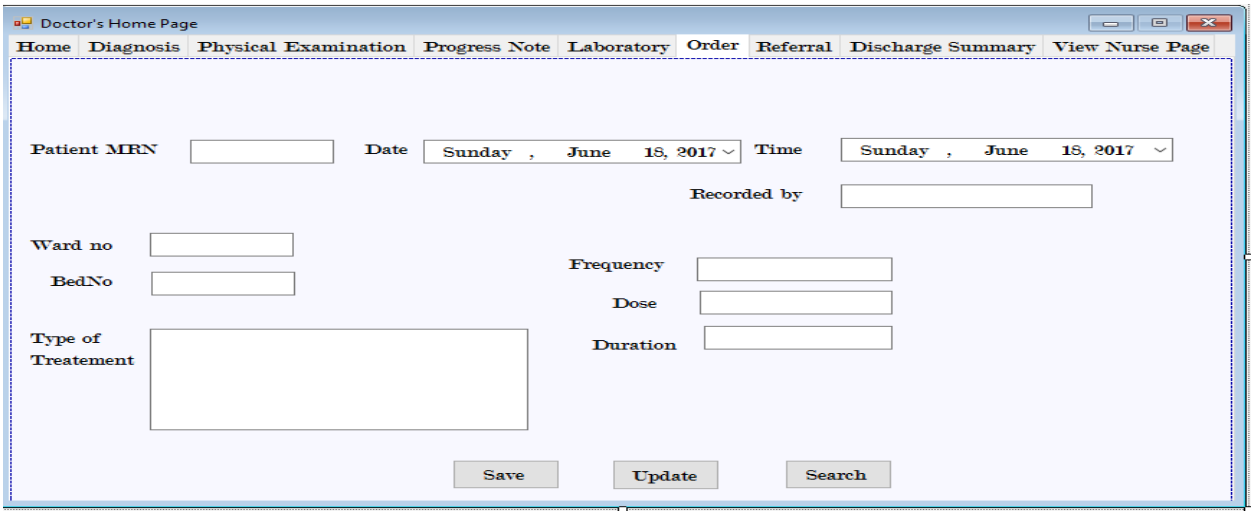

Figure 36. Treatment order user interface.

The treatment order user interface provides registration of different treatment such as medicine and supportive treatments such as, oxygen, IV fluid and other necessary treatments.

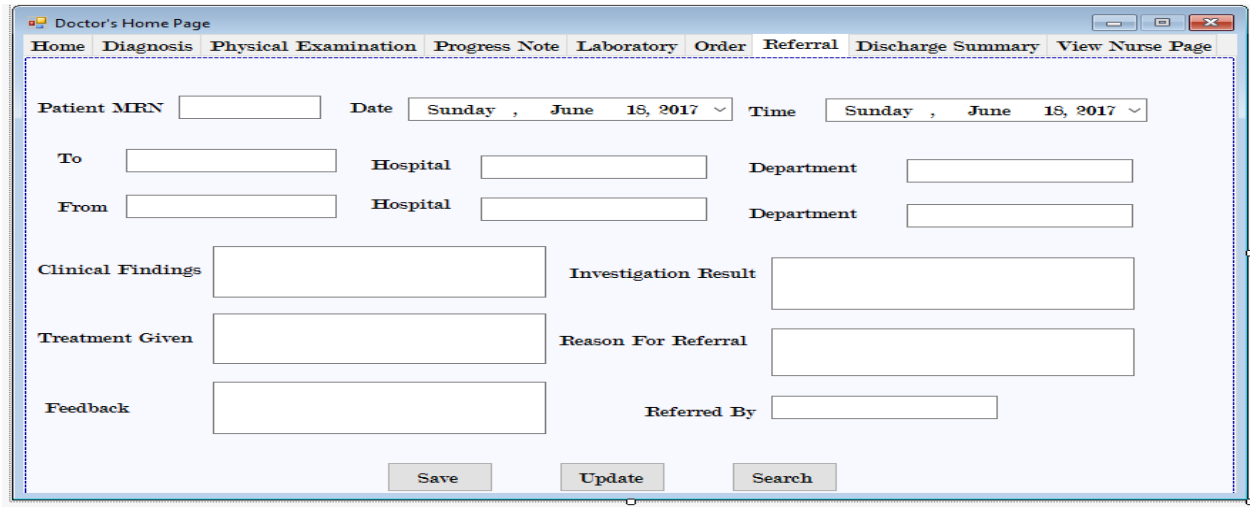

Figure 37. Referral user interface.

The referral user interface provides registration of referral information if the patient is referred to other hospitals.

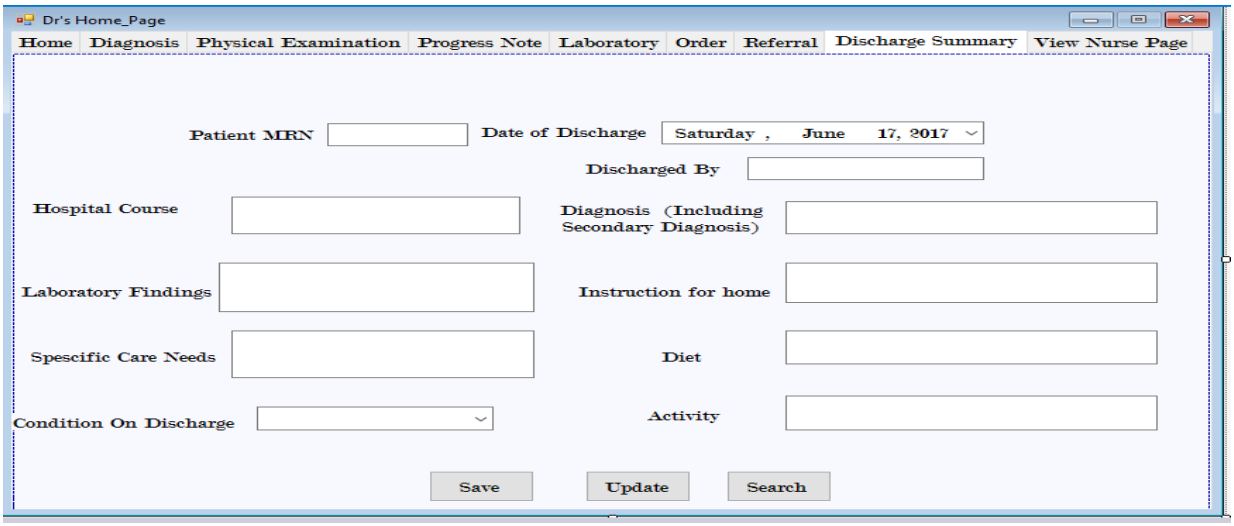

Figure 38. Discharge summery user interface.

The discharge summery user interface is used to provide registration of summery information when the patient is finished treatment and discharged from the unit.

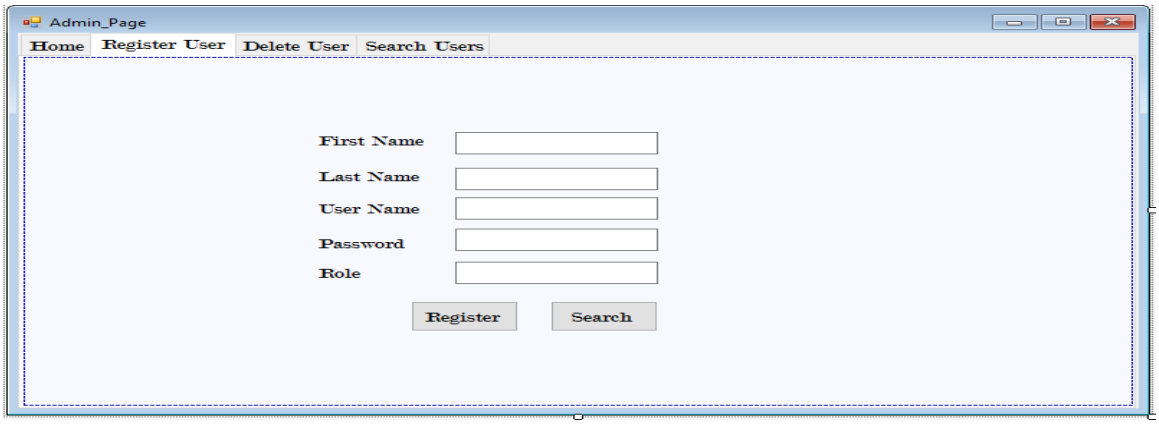

Figure 39. System administration user interface.

The system administration user interface is used to provide the different users of the system their respective user privilege. Thus the users can access the different functionalities that are required from the system according to their job assignment and responsibility.

6.6. User Interface Evaluation

Heuristic evaluation Method was used to evaluate the prototype user interface. It is one of the most commonly used evaluation methods due to its low cost. It is an inspection method that can identify problems with a user interface, indicate the severity of the problems (74). To evaluation the interface for NICU medical recording management system questionnaire were used has been adopted and used, for it is cost effective.

Table: 35. User interface evaluation of NICU recording management system

No	Evaluation questions	Strongly dis agree	Dis Agree	Neutral	agree	Strongly agree
1	The system is easy to open and access			1	1	8
2	The system is easy on using the different functionalities in the given privilege				1	9
3	It was clear to save the different data onto the database					10
4	Overall, the system provided adequate functions for registration and data retrieval					10
5	was the system Used familiar words				1	9
6	The system search results are accurate					10
7	Overall, the interface is attractive and easy to use			1	1	8
8	All the fonts on the system are readable			1	1	8
9	All the system input fields buttons locations are consistent			1		9
10	It was clear to access the different options menus			2		8
	Result percentage			6%	5%	89 %

As shown on the table above a questioner were given for total of 10 respondents. The value of the responses was taken based on the likert scale. The values for all attributes in the table are fixed as: Strongly agree = 5, Agree = 4, Neutral= 3, Disagree = 2 and Strongly Disagree. According to the result of user interface evaluation most of the respondents that is 89 % strongly agreed that the system prototype has an easy to use, attractive and clear informational and functional explanation regarding the major functionalities of the system.

Chapter Seven

Summary and Recommendation

7.1. Summary

The existing Medical recording system in Yekatit 12 Hospital Medical College NICU, was functioning manually. According to the respondents of the study, this manual system made problems regarding updating, retrieval, recording, and processing the reports of the patient data. Moreover, it also leads to poor quality of data due to duplication of records, incompleteness and illegible hand writing,

The requirements that are used to develop the system are gathered from the staffs who have been directly involved. Besides the gathered requirement, the developed requirements were analyzed and presented by using essential use case modeling and essential user interface to make easily understandable and to evaluate at the early stage of the system design. They confirmed that the issues they raised were addressed in the requirement.

Based on the analyses of the requirements, the design of the system was accomplished. The design of the system was by using object oriented system analysis and design methodology Based on the requirements developed the system modeling was done by the use of unified modeling language (UML). From the different types of the UML designing tools majorly use cases which describe the major functionalities, scenarios and actors of the system; class diagram which shows the database structure and tables and sequence diagram which shows how the time and object interaction were designed. In order to implement the system three tired system architecture was proposed.

According to the requirement analysis and design, a prototype to the system was designed to show the working model of the system. The user interface prototype consisted of the display, different functionalities of the system. The user interface prototype evaluated.

The newly designed NICU Electronic Medical Record management system includes registration of patient's basic personal identification information, clinical forms such as vital signs, diagnosis forms, physical examinations, treatment orders, laboratory forms, progress note, discharge summery, referral, Nursing care plan, treatment administration and appointment form. The

admission/discharge HMIS registration form is also included to the system to make the registration standardize.

Generally the designed NICU Electronic Medical Recording Management System could enhance accessibility of data or patient information with the reduction of the unnecessary time wasting to search patient information and to compile reports, and it makes timely use of information by decision makers, which improves the current service.

7.2. Recommendations

From the finding of the study, the following recommendations are forwarded to the concerning bodies.

A. For the Hospital

- The hospital should work on the implementation of the system
- The hospital should provide hardware and software in order to install the system

B. The Federal Ministry of Health and Regional Health Bureau

- The Federal Ministry of Health and regional health bureau of Addis Ababa should support the hospital and NICU for implementation of the system and should support with necessary hardware, network infrastructure for the system. In addition, assigning sufficient budget and manpower is necessary for the sustainability of the system.

C. Students / Researchers

- Researchers or students should continue the project to complete all the rest part of system implementation and also integration of the system to other departments for easy communication between departments, by using this project as an input for next phase of software development process.

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Annexes

Annex - l

Consent form

Addis Ababa University School of Information Science and School of Public Health MSC in Health Informatics Program

My Name is Sosena Mitiku. I am post graduate student of health informatics program in Addis Abeba University. I am doing project on designing of EMR management system for Neonatal Intensive Care unit of Yekatit 12 Hospital Medical College. The following interview is designed in accordance to strengthen the informational need of the project on how to design, implement and achieving the organizational mission and goals. Thus you are kindly requested to provide genuine and correct answers for the questions posed by the principal investigator. The information you provide are confidential and will be used only for the purpose of this study. 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 assessment. I kindly ask you to provide your genuine willingness. Besides, you have the right to turn down if you are not voluntary to participate on the interview, thus you can fill/mark the **NO** box.

If you are voluntary or not mark **'X'** on your opinion **YES** ☐ ☐ **NO**

THANK YOU IN ADVANCE FOR YOUR COOPERATION

Data collection interview guide lines tools used for Design of NICU Electronic Medical Recording Management system to identifying requirement of the system and to analyze the system

A. Interview Guide for Medical Directors and department heads

This Interview guide is to assess the EMR program in, Yekatit 12 Hospital Medical College. The information acquired will help to inform decision on how to design, implementation and achieving the institution mission.

1) What is the currently used recording system in the hospital?
2) What is the problem in the current recording management system?
3) Is there a planned approach to automate the current system
4) Please describe your general opinion on the EMR Program?
5) What are the key divers to apply an EMR in your institutions?
6) Please describe the resource available to run EMR program (human resources, infrastructure, finance)
7) Is a budget, enough staff in place to implement, provide support for the EMR system?
8) Do you have enough staff in place to implement, provide support for, and maintain the new EMR system?

B) ***Interview Guide for User of EMR Program at neonatal intensive care unit***

1) What is the current service given in the unit?
2) Who give the service?
3) What are the role of person in the unit?
4) Has all essential information been recorded,
5) Are all entries signed and dated?
6) Are daily admissions and discharge list produced?
7) What are the formats used to record and report data?
8) Is there a problem with duplicate medical records?
9) If the patient's medical record cannot be found, although the patient has attended the hospital previously what do you do?

10) When you use the currently available recording system in your facility did you see any problem?
11) What do you think the solution for the problem?
12) Do you think EMR program is helpful to your activities? Please describe?
13) What are your experiences or concerns of the deployment of the EMR program?
14) Please provide your recommendations or suggestions of how to further improve the medical record system?
15) Do you have a computer?
16) How many?
17) 32. For what purpose do you use it?

Interview guide for HMIS office staffs

1. Do you have any software used to prepare the reports? Which software?
2. Do you have computer network for sharing of the information such as reports?
3. What are the formats used to collect report?
4. Is there a problem in the quality of collected data?

Observation *guide check list*

	Process to be observed	Yes	No	Remark
1	Patient registration carried out according to standard			
2	Patient health records are placed in its place?			
3	Retrieval of patient record is it time taking?			
4	Is there any lost patient record?			
5	Do all health professionals document according to the standard format?			
6	Does report generating process time taking?			

Annex II

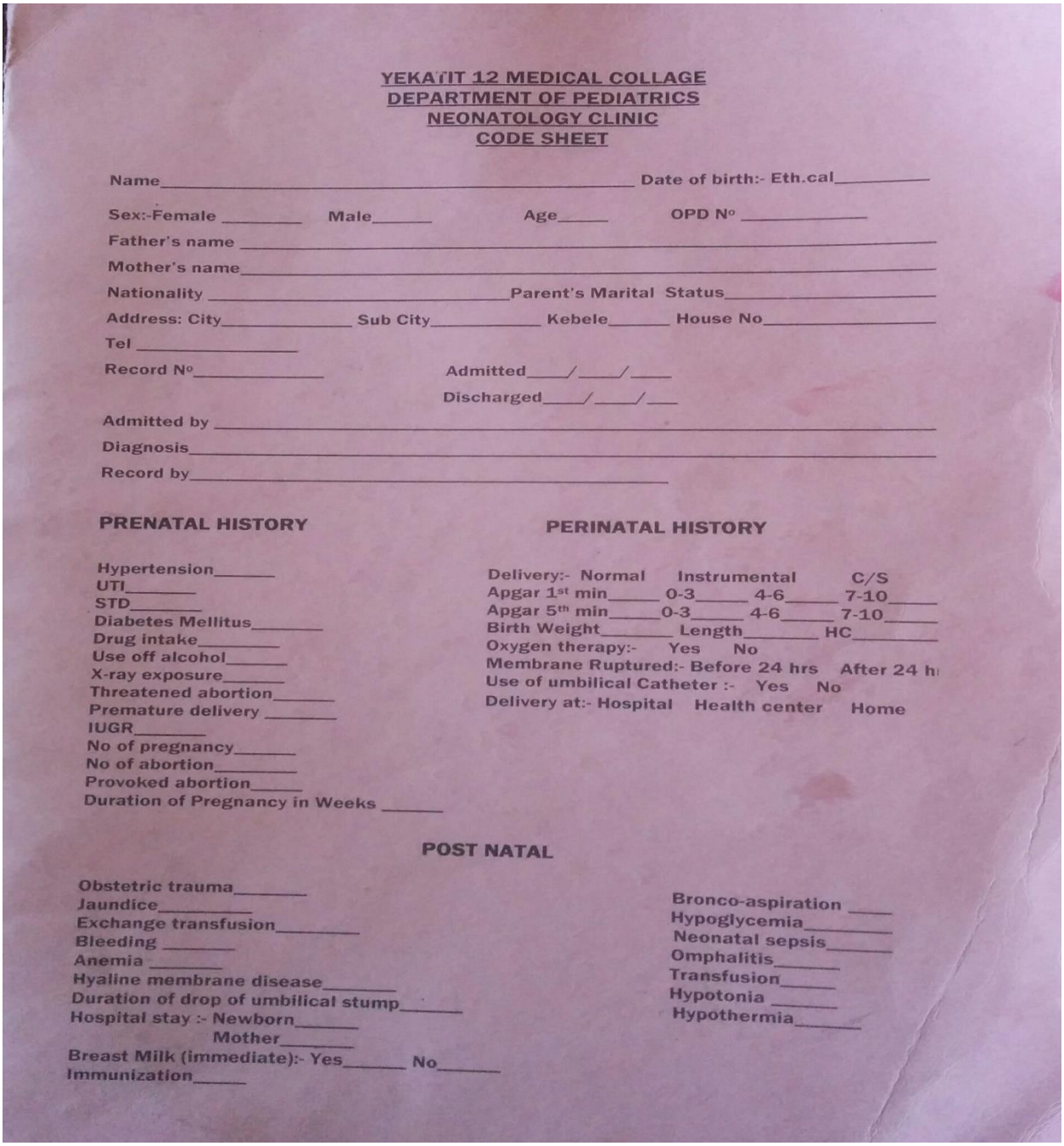
User interface evaluation question

The below mentioned table was developed to collect the required response from the stakeholders of the system to help in assessing and evaluating the user interface for the newly developed system prototype

No	Rate your agreement with the following statements (Place a X in the appropriate column)	Strongly dis agree	Dis Agree	Neutral	agree	Strongly agree
1	The system is easy to open and access					
2	The system is easy on using the different functionalities in the given privilege					
3	The system saves Entered data properly					
4	The system Views saved Data Accurately					
5	The System response time while saving searching is acceptable					
6	The system search results are accurate					
7	Overall, the interface is pleasing and easy to use					
8	All the fonts on the system are readable					
9	All the system input fields buttons locations are consistent					
10	The system validates wrong input of data types all the time					
	Average Result					
	Result percentage					

Annex III

Forms used to design the system



YEKATIT 12 MEDICAL COLLAGE
DEPARTMENT OF PEDIATRICS
NEONATOLOGY CLINIC
CODE SHEET

Name_____ Date of birth:- Eth.cal_____

Sex:-Female _____ Male_____ Age_____ OPD Nº _____

Father's name _____

Mother's name_____

Nationality _____Parent's Marital Status_____

Address: City_____ Sub City_____ Kebele_____ House No_____

Tel _____

Record Nº_____ Admitted____/____/____

Discharged____/____/___

Admitted by _____

Diagnosis_____

Record by_____

PRENATAL HISTORY

Hypertension_____
UTI_____
STD_____
Diabetes Mellitus_____
Drug intake_____
Use off alcohol_____
X-ray exposure_____
Threatened abortion_____
Premature delivery _____
IUGR_____
No of pregnancy_____
No of abortion_____
Provoked abortion_____
Duration of Pregnancy in Weeks _____

PERINATAL HISTORY

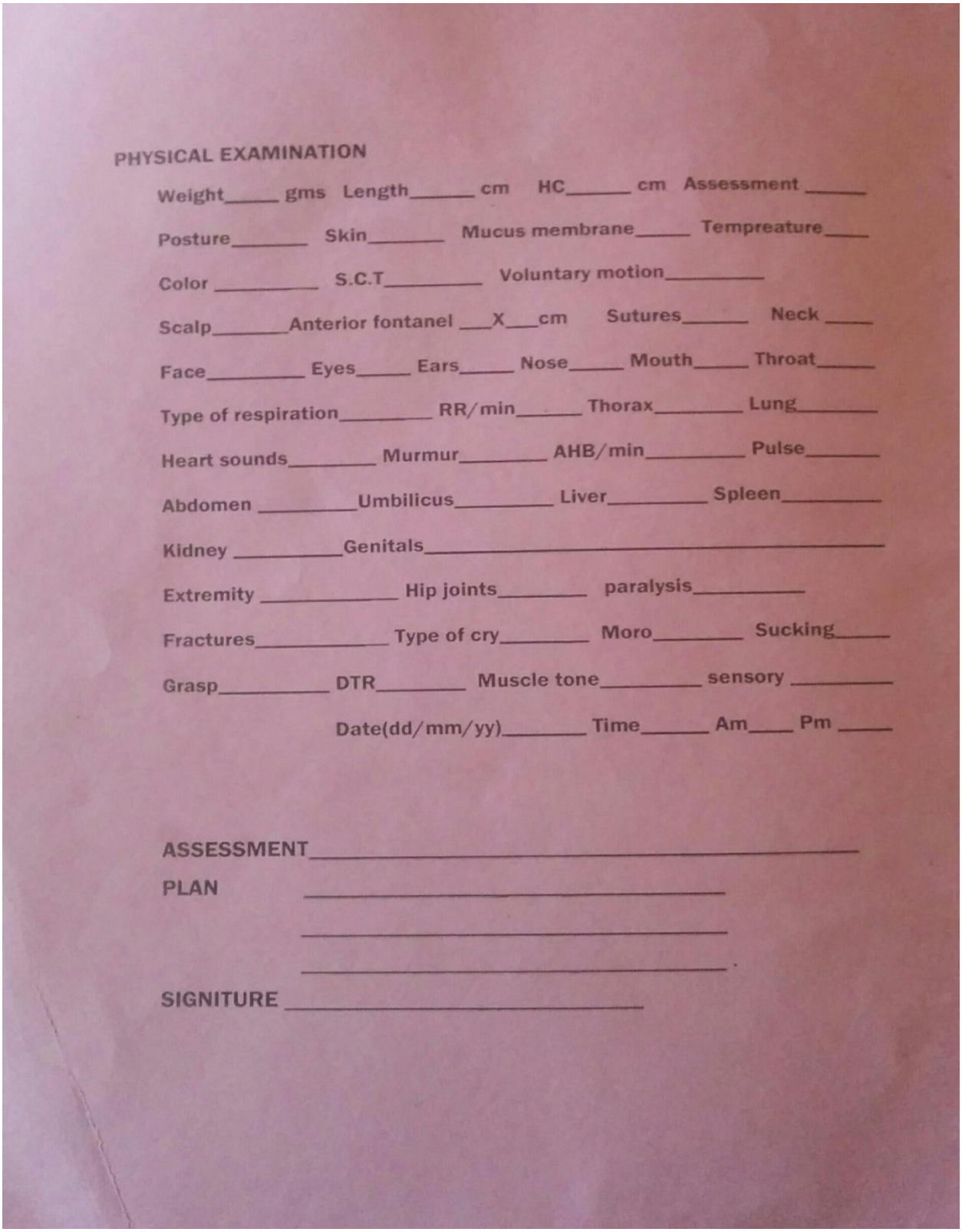
Delivery:- Normal Instrumental C/S
Apgar 1st min_____ 0-3_____ 4-6_____ 7-10_____
Apgar 5th min_____0-3_____ 4-6_____ 7-10_____
Birth Weight_____ Length_____ HC_____
Oxygen therapy:- Yes No
Membrane Ruptured:- Before 24 hrs After 24 h
Use of umbilical Catheter :- Yes No
Delivery at:- Hospital Health center Home

POST NATAL

Obstetric trauma_____
Jaundice_____
Exchange transfusion_____
Bleeding _____
Anemia _____
Hyaline membrane disease_____
Duration of drop of umbilical stump_____
Hospital stay :- Newborn_____
Mother_____
Breast Milk (immediate):- Yes_____ No_____
Immunization_____

Bronco-aspiration ____
Hypoglycemia_____
Neonatal sepsis_____
Omphalitis_____
Transfusion_____
Hypotonia _____
Hypothermia_____

Neonatal history form



PHYSICAL EXAMINATION

Weight_____ gms Length_____ cm HC_____ cm Assessment _____

Posture_____ Skin_____ Mucus membrane_____ Tempreature____

Color _____ S.C.T_____ Voluntary motion_____

Scalp_____Anterior fontanel ___X___cm Sutures_____ Neck ____

Face_____ Eyes_____ Ears_____ Nose_____ Mouth_____ Throat_____

Type of respiration_____ RR/min_____ Thorax_____ Lung_____

Heart sounds_____ Murmur_____ AHB/min_____ Pulse_____

Abdomen _____Umbilicus_____ Liver_____ Spleen_____

Kidney _____Genitals_____

Extremity _____ Hip joints_____ paralysis_____

Fractures_____ Type of cry_____ Moro_____ Sucking_____

Grasp_____ DTR_____ Muscle tone_____ sensory _____

Date(dd/mm/yy)_____ Time_____ Am____ Pm _____

ASSESSMENT_____

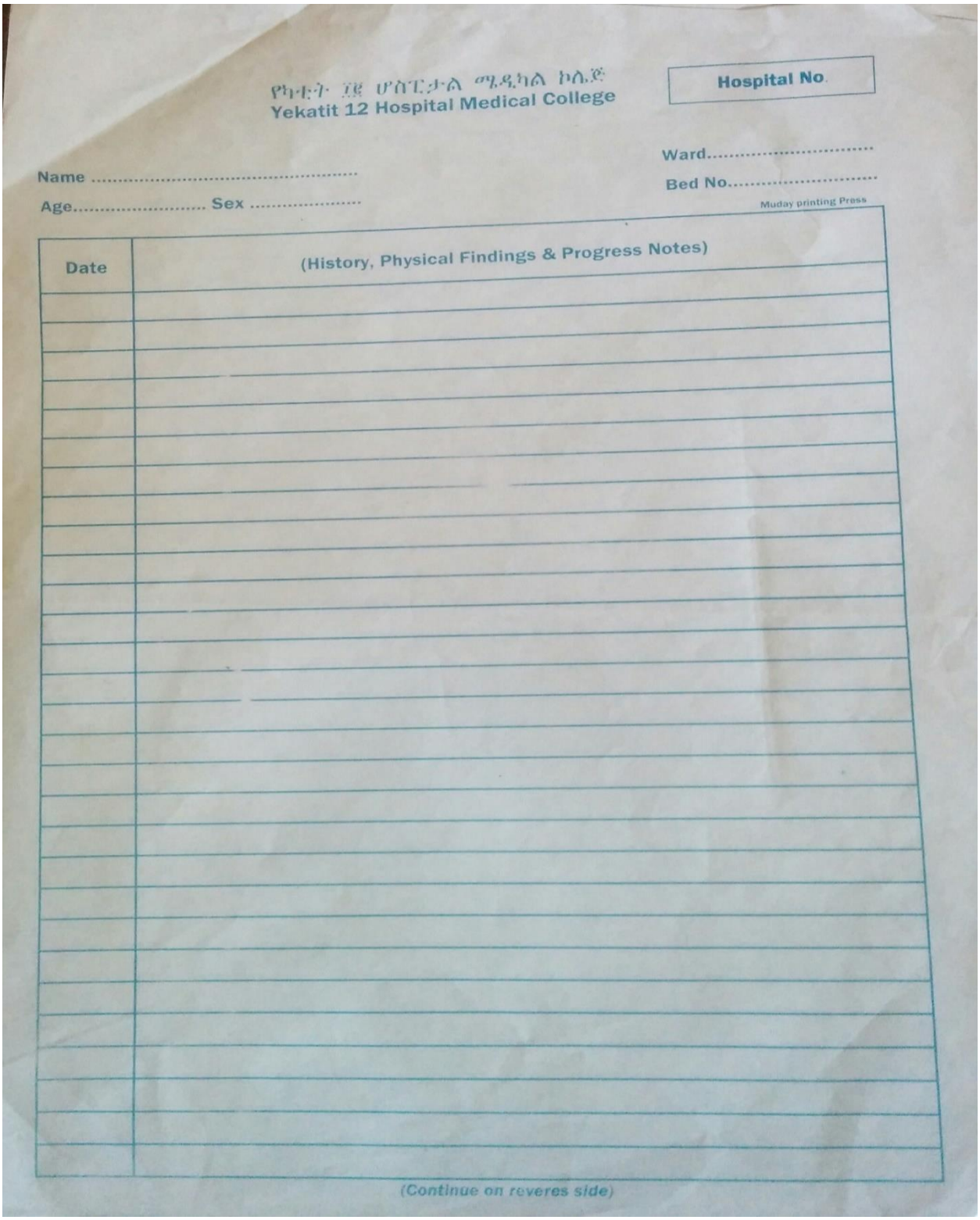
PLAN _____

_____

_____ .

SIGNITURE _____

Physical examination form



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Yekatit 12 Hospital Medical College

Hospital No.

Name .....

Ward.....

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

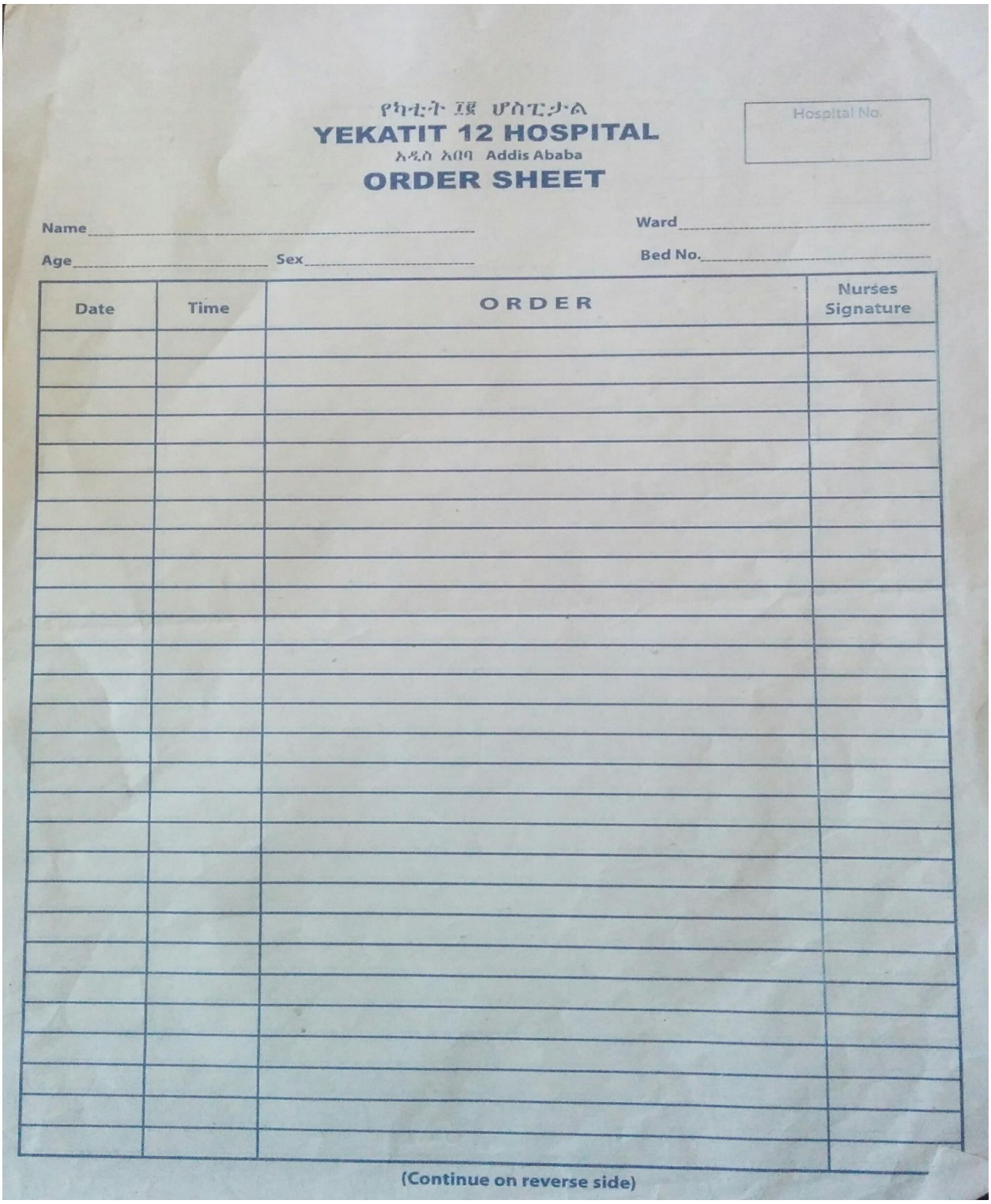
Bed No.....

Muday printing Press

Date	(History, Physical Findings & Progress Notes)

(Continue on reveres side)

Progress note form



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YEKATIT 12 HOSPITAL

አዲስ አበባ Addis Ababa

ORDER SHEET

Hospital No.

Name_____ Ward_____

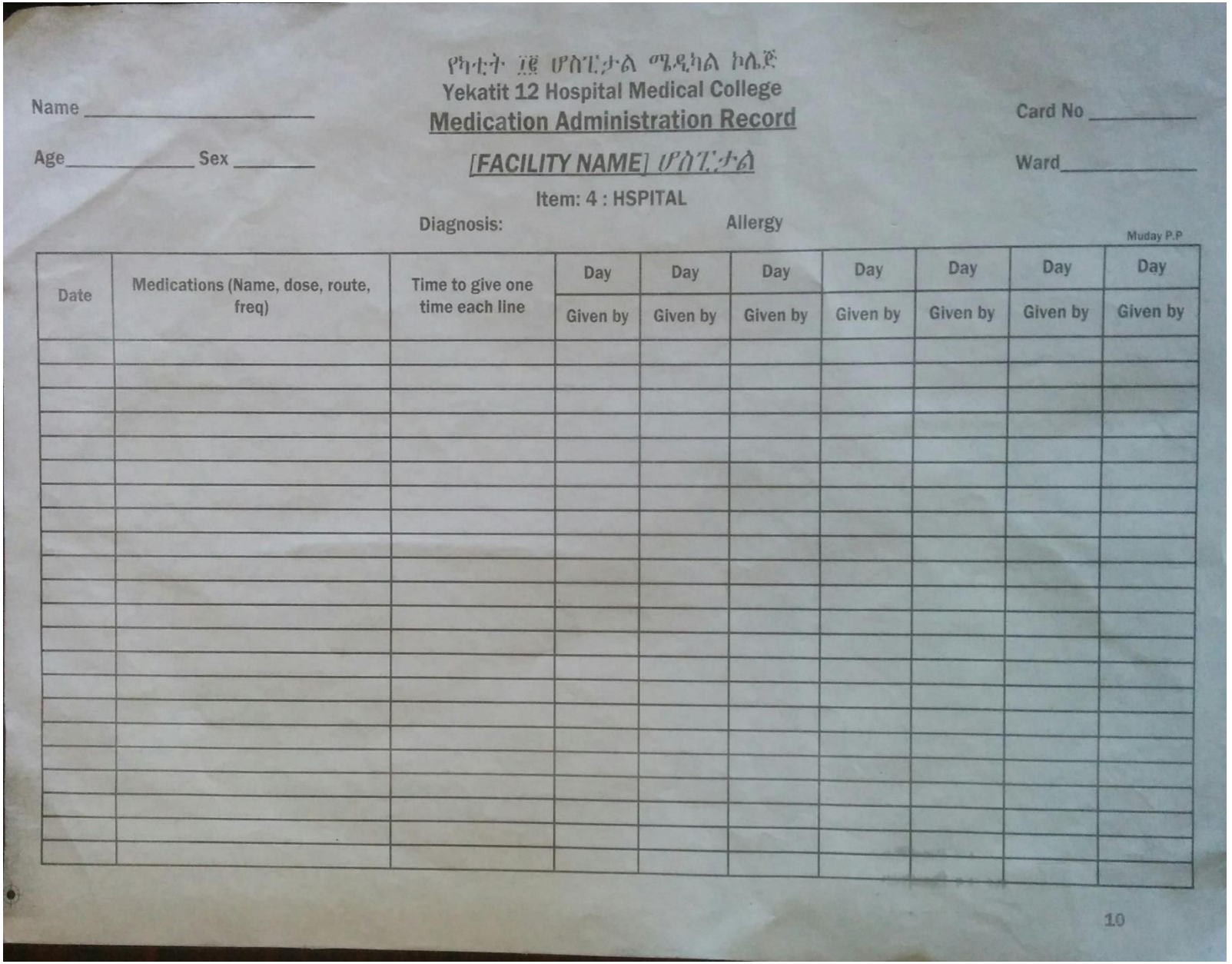
Age_____ Sex_____ Bed No._____

Date	Time	ORDER	Nurses Signature

(Continue on reverse side)

Treatment order form

Medication administration form



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Yekatit 12 Hospital Medical College
Medication Administration Record
[FACILITY NAME] ሆስፒታል
Item: 4 : HSPITAL

Name _____ Card No _____

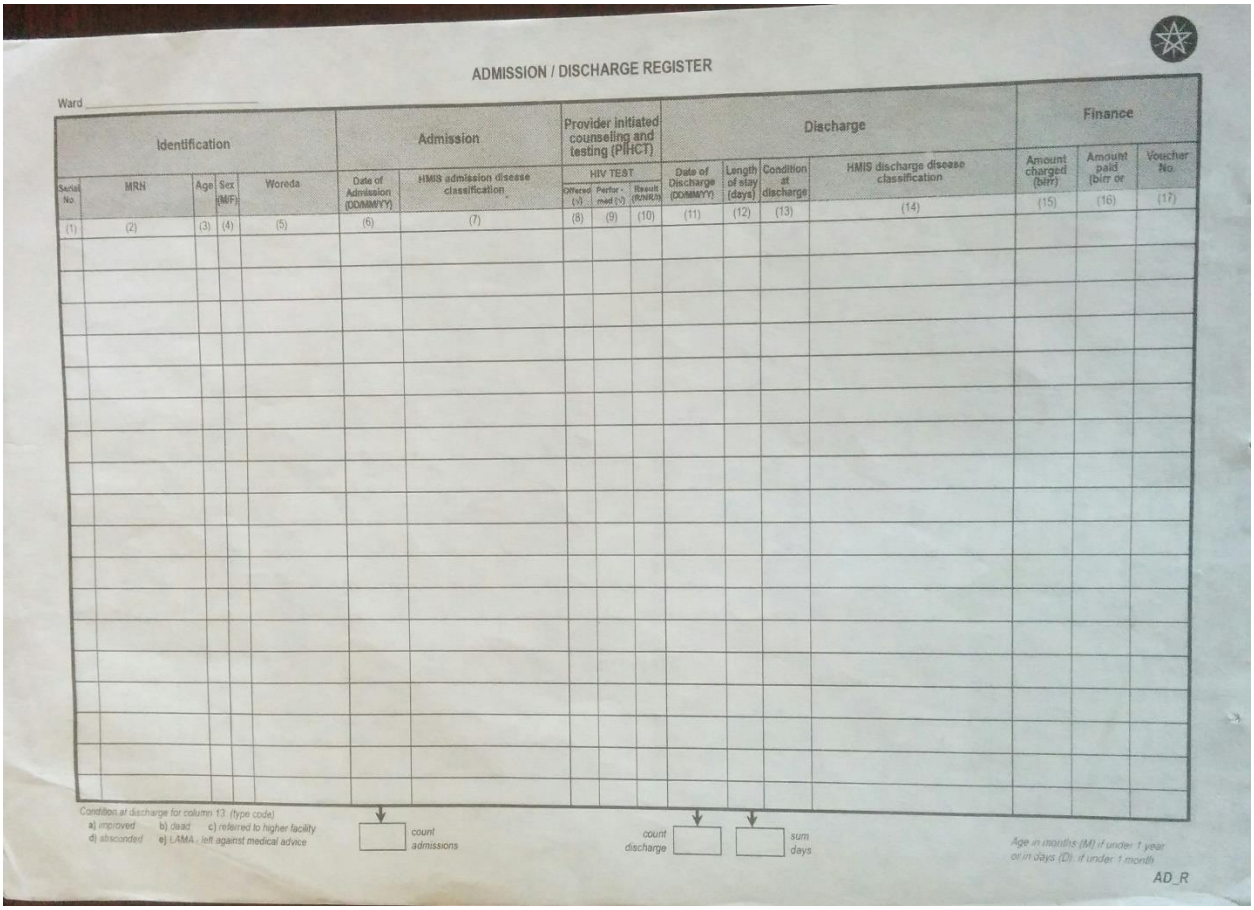
Age_____ Sex _____ Ward_____

Diagnosis: Allergy

Muday P.P

Date	Medications (Name, dose, route, freq)	Time to give one time each line	Day	Day	Day	Day	Day	Day	Day
			Given by	Given by	Given by	Given by	Given by	Given by	Given by

10



ADMISSION / DISCHARGE REGISTER

Ward _____

Identification					Admission		Provider initiated counseling and testing (PIHCT)			Discharge				Finance		
Serial No.	MRH	Age	Sex (M/F)	Woreda	Date of Admission (DD/MM/YY)	HMIS admission disease classification	HIV TEST			Date of Discharge (DD/MM/YY)	Length of stay (days)	Condition at discharge	HMIS discharge disease classification	Amount charged (birr)	Amount paid (birr or	Voucher No.
							Offered (√)	Performed (√)	Result (R/NR/I)							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)

Condition at discharge for column 13: (type code)
a) improved b) dead c) referred to higher facility
d) absconded e) LAMA - left against medical advice

count admissions

count discharge

sum days

Age in months (M) if under 1 year or in days (D) if under 1 month

AD_R

Admission/Discharge (HMIS) registration form

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Yekatit 12 Hospital Medical College

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Hospital No

VITAL SIGN SHEET

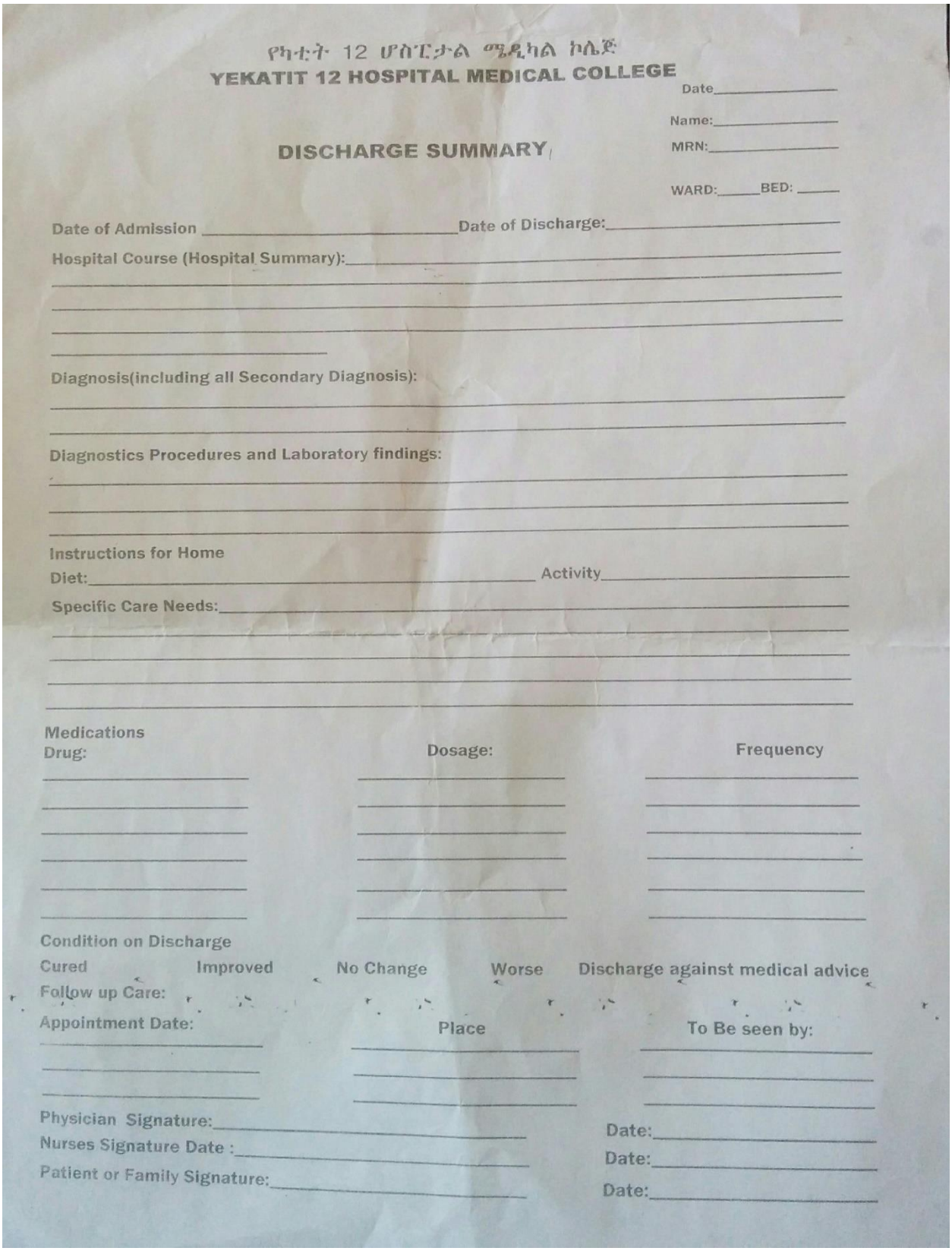
Name ..... Ward.....

Age..... Sex..... Bed No.....

Yeab sera printing press P.L.C

Date	Time	B.P	P.	R.	T	So	Observation, Medication and other remarks

vital sign form



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YEKATIT 12 HOSPITAL MEDICAL COLLEGE

Date_____

Name:_____

MRN:_____

WARD:_____BED: _____

DISCHARGE SUMMARY

Date of Admission _____Date of Discharge:_____

Hospital Course (Hospital Summary):_____

_____

_____

_____

_____

Diagnosis(including all Secondary Diagnosis):

_____

_____

Diagnostics Procedures and Laboratory findings:

_____

_____

_____

Instructions for Home

Diet:_____ Activity_____

Specific Care Needs:_____

_____

_____

_____

_____

Medications

Drug:	Dosage:	Frequency
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Condition on Discharge

Cured Improved No Change Worse Discharge against medical advice

Follow up Care:

Appointment Date:	Place	To Be seen by:
_____	_____	_____
_____	_____	_____
_____	_____	_____

Physician Signature:_____ Date:_____

Nurses Signature Date :_____ Date:_____

Patient or Family Signature:_____ Date:_____

Discharge summery form

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Yekatit 12 Hospital Medical College № 03394

Ref. No_____

PATIENT REFERAL SLIP

Date_____

To_____ Hospital_____Department

From _____ Hospital / H. center/_____Department

Time

Name of Patient_____

Age_____Sex _____occupation_____

Address: Woreda_____Kebele_____ House No_____

Clinical Finding _____

_____

_____

_____

_____

Diagnosis_____

Investigation Result _____

_____

Rx Given_____

_____

Reason for Referral_____

Referred by _____

Rame of Physician _____

*Signature*_____

№ 03394

FEED BACK

Ref. No_____

Date_____

To _____ Hospital / H. center_____Department

Name of Patient_____

Finding_____

_____

_____

_____

_____

_____

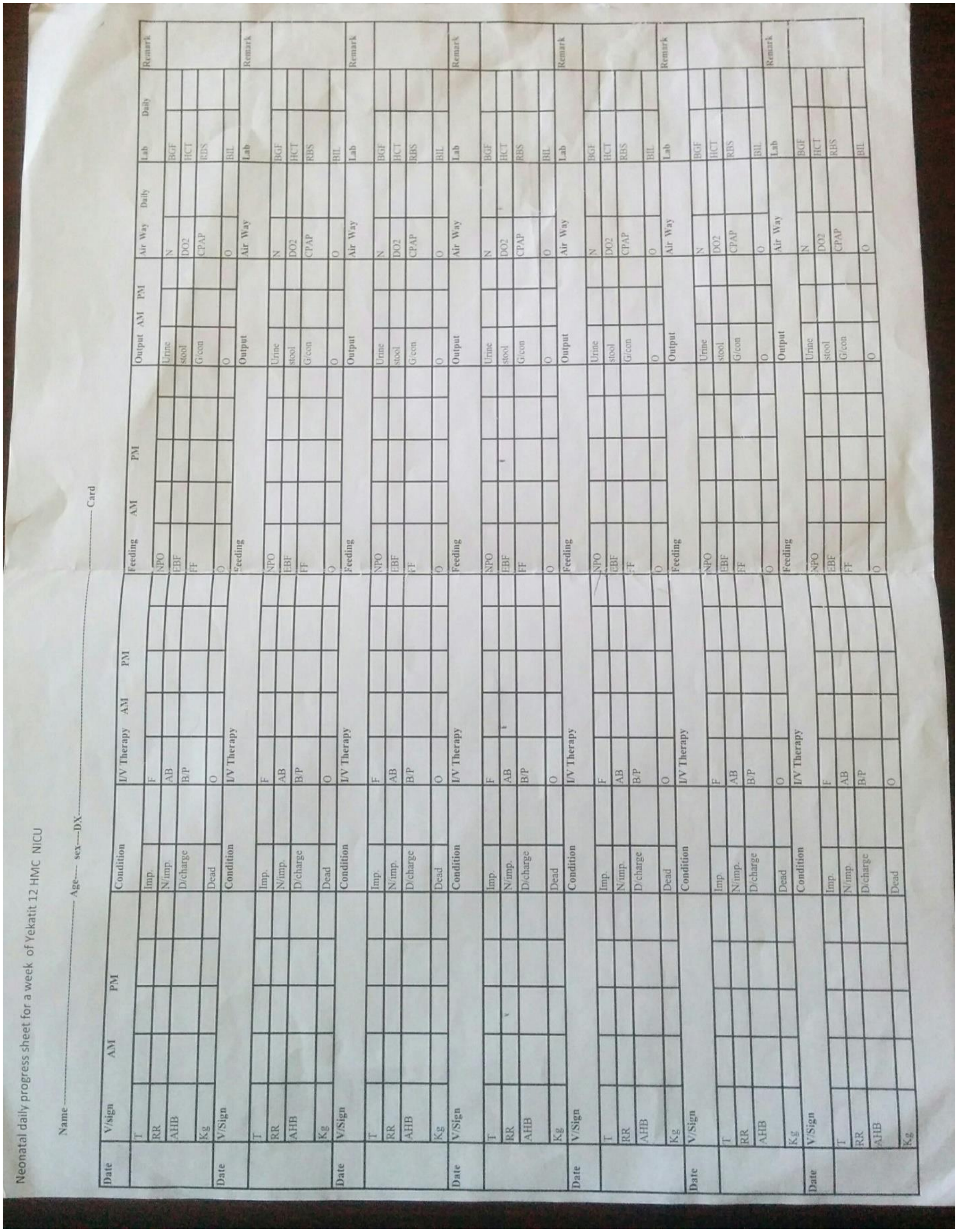
Diagnosis _____

Headnent Given_____

Followed By:- _____

_____

Referral form



Neonatal daily progress sheet for a week of Yekatit 12 HMC NICU

Name ---------- Age---- sex----DX---------- Card

Date	V/Sign	AM	PM	Condition	I/V Therapy	AM	PM	Feeding	AM	PM	Output	AM	PM	Air Way	Daily	Lab	Daily	Remark
	T			Imp.	F			NPO			Urine			N		BGF		
	RR			N/imp.	AB			EBF			stool			DO2		HCT		
	AHB			D/charge	B/P			FF			G/con			CPAP		RBS		
	Kg			Dead	O			O			O			O		BIL		
Date	V/Sign			Condition	I/V Therapy			Feeding			Output			Air Way		Lab		Remark
	T			Imp.	F			NPO			Urine			N		BGF		
	RR			N/imp.	AB			EBF			stool			DO2		HCT		
	AHB			D/charge	B/P			FF			G/con			CPAP		RBS		
	Kg			Dead	O			O			O			O		BIL		
Date	V/Sign			Condition	I/V Therapy			Feeding			Output			Air Way		Lab		Remark
	T			Imp.	F			NPO			Urine			N		BGF		
	RR			N/imp.	AB			EBF			stool			DO2		HCT		
	AHB			D/charge	B/P			FF			G/con			CPAP		RBS		
	Kg			Dead	O			O			O			O		BIL		
Date	V/Sign			Condition	I/V Therapy			Feeding			Output			Air Way		Lab		Remark
	T			Imp.	F			NPO			Urine			N		BGF		
	RR			N/imp.	AB			EBF			stool			DO2		HCT		
	AHB			D/charge	B/P			FF			G/con			CPAP		RBS		
	Kg			Dead	O			O			O			O		BIL		
Date	V/Sign			Condition	I/V Therapy			Feeding			Output			Air Way		Lab		Remark
	T			Imp.	F			NPO			Urine			N		BGF		
	RR			N/imp.	AB			EBF			stool			DO2		HCT		
	AHB			D/charge	B/P			FF			G/con			CPAP		RBS		
	Kg			Dead	O			O			O			O		BIL		
Date	V/Sign			Condition	I/V Therapy			Feeding			Output			Air Way		Lab		Remark
	T			Imp.	F			NPO			Urine			N		BGF		
	RR			N/imp.	AB			EBF			stool			DO2		HCT		
	AHB			D/charge	B/P			FF			G/con			CPAP		RBS		
	Kg			Dead	O			O			O			O		BIL		
Date	V/Sign			Condition	I/V Therapy			Feeding			Output			Air Way		Lab		Remark
	T			Imp.	F			NPO			Urine			N		BGF		
	RR			N/imp.	AB			EBF			stool			DO2		HCT		
	AHB			D/charge	B/P			FF			G/con			CPAP		RBS		
	Kg			Dead	O			O			O			O		BIL		

Nursing care (daily progress) form

Yekatit 12 HMC High Risk Appointment Card

Name_____

Sex_____ age_____

Diagnosis _____

Date of appointment __/__/__ Signature _____.

DX_____

Date of appointment ___/___/___signature_____

Next appointment ___/___/___signature_____

Next appointment ___/___/___signature_____

Next appointment ___/___/___signature_____

Next appointment __/___/___signature_____

Appointment form

Annexes IV

Sample code

Diagnosis code

```
// diagnosis

        string MRN = textBox1.Text;

        string dofdiagnosis = DateTime.Now.Date.ToShortDateString();

        string tofdiagnosis = DateTime.Now.ToLocalTime().ToShortTimeString();

        string recby = textBox4.Text;

        //string hypertension = textBox5.Text;

        string hypertension = string.Empty;

        if (radioButton8.Checked)

        {

           hypertension = radioButton8.Text;

        }

        else if (radioButton9.Checked)

        {

           hypertension = radioButton9.Text;

        }

        string UTI = string.Empty;

        if (radioButton17.Checked)

        {

           UTI = radioButton17.Text;

        }

        else if (radioButton16.Checked)

        {
```

```
    UTI = radioButton16.Text;
}

//string UTI = textBox6.Text;
//string STD = textBox7.Text;
string STD = string.Empty;
if (radioButton19.Checked)
{
    STD = radioButton19.Text;
}
else if (radioButton18.Checked)
{
    STD = radioButton18.Text;
}
//string dmellitus = textBox8.Text;
string dmellitus = string.Empty;
if (radioButton21.Checked)
{
    dmellitus = radioButton21.Text;
}
else if (radioButton20.Checked)
{
    dmellitus = radioButton20.Text;
}
//string Predelivery = textBox13.Text;
```

```
string Predelivery = string.Empty;
if (radioButton23.Checked)
{
   Predelivery = radioButton23.Text;
}
else if (radioButton22.Checked)
{
   Predelivery = radioButton22.Text;
}
string NofPregnancy = textBox15.Text;
string dofpregnancy = textBox18.Text;
string delivery = string.Empty;
if (radioButton5.Checked)
{
   delivery = radioButton5.Text;
}
else if (radioButton6.Checked)
{
   delivery = radioButton6.Text;
}
else if (radioButton7.Checked)
{
   delivery = radioButton7.Text;
}
string firstap= textBox10.Text;
```

```
string weight = textBox2.Text;
string length = textBox3.Text;
string hc = textBox9.Text;
string membraneraptured = string.Empty;
if (radioButton10.Checked)
{
   membraneraptured = radioButton10.Text;
}
else if (radioButton11.Checked)
{
   membraneraptured = radioButton11.Text;
}
string ObstetricTrauma = string.Empty;
if (radioButton1.Checked)
{
   ObstetricTrauma = radioButton1.Text;
}
else if (radioButton2.Checked)
{
   ObstetricTrauma = radioButton2.Text;
}
string juandice = string.Empty;
if (radioButton13.Checked)
{
   juandice = radioButton10.Text;
```

```
}
else if (radioButton12.Checked)
{
   juandice = radioButton11.Text;
}
string bleeding = string.Empty;
if (radioButton4.Checked)
{
   bleeding = radioButton4.Text;
}
else if (radioButton3.Checked)
{
   bleeding = radioButton3.Text;
}
string neonatal = string.Empty;
if (radioButton15.Checked)
{
   neonatal = radioButton15.Text;
}
else if (radioButton14.Checked)
{
   neonatal = radioButton14.Text;
}
string fiveap = textBox11.Text;
try
```

```
{
    string query = string.Format("insert into Diagnosis
(\"MRN\",\"Date\",\"Time\",\"Recordedby\",\"Hypertension\",\"UTI\",\"STD\",\"DiabetusMellitus\",\"P
rematureDelivery\",\"NoOfPregnancy\",\"Duration\",\"Apgar1stmin\",\"Delivery\",\"Apgar1stmin\",\"
Weight\",\"Length\"
,\"HC\",\"MembraneRuptured\",\"OpstericTrauma\",\"Bleeding\",\"JuanDice\",\"NeonatalSpsis\",\"Apg
ar5thmin\" values
('{0}','{1}','{2}','{3}','{4}','{5}','{6}','{7}','{8}','{9}','{10}','{11}','{12}','{13}','{14}','{15}','{16}','{17}','{18}','{19}','{
20}','{21}')", MRN, dofdiagnosis, tofdiagnosis, recby, hypertension, UTI, STD, dmellitus, Predelivery,
NofPregnancy, dofpregnancy, firstap, delivery, weight, length, hc, membraneraptured, ObstetricTrauma,
juandice, bleeding, neonatal, fiveap);
    SqlCommand insertCommand = new SqlCommand(query, con);
    con.Open();
    insertCommand.ExecuteNonQuery();
    con.Close();
    MessageBox.Show(" Physical Examination is Successfully Registered!");
}
catch (SqlException sqlException)
{
    con.Close();
    MessageBox.Show(sqlException.Message);
    Console.WriteLine(sqlException.StackTrace);
}
catch (Exception exception)
{
    con.Close();
    MessageBox.Show(exception.Message);
    Console.WriteLine(exception.StackTrace);
}
```