Addis Ababa University

School of Information Science

And

School of Public Health

M.Sc in Health Informatics program

Designing an Electronic Medical Record System for Amanuel Hospital

By;-

Getnet Alem

June, 2014

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A project Paper submitted to the school of Graduate Studies of Addis Ababa University in partial fulfillment of the Requirements for the Degree of Masters of Science in Health Informatics.

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   Advisor Signature

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3. _____ _____

   Examiner Signature

4. _____ _____

   Examiner Signature

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Dedication

I dedicate my dissertation work to God _ who allowed me to start and finish this journey

And

My family _ for their unreserved support.

Acknowledgments

I am indebted to many individuals who contributed to the successful completion of this project.

First and for most my deepest gratitude goes to the Almighty God, who enable me to finalize this project successfully.

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List of Abbreviations and Acronyms

ARV= Anti Retro Viral

BPR=Business Processing Re-engineering

CDC=Communicable Disease control

DFD= Data Flow Diagram

EMR=Electronic Medical Record

ER= Entity Relationship

FMOH=Federal Ministry of Health

HIT=Health Information Technologies

HSDP=Health Sector Development

ICT=Information Communication Technology

IT= Information Technology

MCH=Maternal and Child Health

MDGs=Millennium Development Goals

MMRS= Mosoriot Medical Record Systems

MOH= Ministry of Health

NACP= National AIDS Control Programme

OOAD=Object-oriented Analysis and Design

PHID= Public Health Infrastructure Directorate

SQL= Structured Query Language

TUTAPE= Tulane University's Technical Assistance Program for Ethiopia

UML=Unified Modeling Language

Abstract

Introduction: EMR is a computerized system of accessing the history of a patient's care within a single practice. The content of an EMR is analogous to the paper record, but the electronic format creates usable data in medical outcome studies, improves the efficiency of care, and makes for more efficient communication among providers and easier management of health plans.

Objective: The objective of this project was to Design an Electronic Medical Record System for Amanuel Mental Specialized Hospital.

Method: The project used structured system analysis and design methodology with the incremental Water fall approach which includes requirement collection, analysis and design phases. Requirement was collected using the following tools (interview, observation and relevant document review techniques) to collect sufficient data needed for the system to be developed. Analysis and design of the proposed system was performed using tools like the data flow diagram, ER diagram, and flow chart diagram.

Discussion of result: The current business process in Registration, Outpatient, Laboratory and Pharmacy departments of the hospital was described detail. According to the assessment most of the staffs didn't take training on basic computer skill and EMR system. The infrastructure of the hospital is difficult to run the system and the internet connection is good however most of time it is interrupted. The numbers of hardware are not enough to run the system. The new system will have functionalities such as register users of system and patient personal information, search patient information, record patient diagnosis and treatment data, register patient laboratory and medication order. The system will have also non functionality requirements such as security, availability, maintainability and user interfaces issues.

Conclusion: Electronic medical record significantly reduces medical errors, solve illegible hand writing of records, improve the quality and completeness of data and increase patient satisfaction by reducing patient waiting time. The requirements of the new system were collected using data collection tools and techniques. The business process of the current system, functional and non functional requirement and system requirement were described. The analysis of the proposed system were analyzed using the analysis model (use case diagram and use case description) and process model (contextual and DFD). The data model of the system was presented using the Entity relationship diagram. Therefore designing the EMR system at the hospital will lead to significant change in giving quality of patient care and solve the current problems.

Chapter One

Introduction

The main objective of a health care system is to improve access and equity of healthcare services. This would require availing quality and timely patient information at various levels of clinical services and decision points. In this respect, Electronic Medical Record technology will play a significant role in increasing the quality, accuracy and timeliness of patient information and is widely considered as a potential to improve the effectiveness of health care systems (1).

EMR is a computerized system of accessing the history of a patient's care within a single practice. The content of an EMR is analogous to the paper record, but the electronic format creates usable data in medical outcome studies, improves the efficiency of care, and makes for more efficient communication among providers and easier management of health plans (1).

EMR makes data easily accessible and enables physicians to use data to improve quality of care. It can also generate automated appointment reminders for periodic checkups and for monitoring chronic diseases and conditions. Successfully implementing EMR into an office practice can bring improvements in both quality of patient care and practice profitability (2).

EMR system has many benefits. Among the benefits; improve the legibility of clinical notes and provide decision support for drug ordering, including allergy warnings and drug incompatibilities. It also provides reminders to prescribe drugs and administer vaccines and warnings for abnormal lab results. It support clinical research and help with the management of chronic diseases such as diabetes, hypertension, and heart failure (2).

1.1 Background

Amanuel Mental Specialized Hospital, in Ethiopia, is one of the oldest and the only mental health hospital established in 1930 E.C. by the Italian invades. It is located in western part of Addis Ababa in Addis Ketema Sub-city. There are 250 health professionals and 344 supportive staffs currently working in the hospital (3).

The hospital has 259 beds for inpatient and outpatient services. An average of 400 out-patients clients gets medical and counseling services every day.

The mission of the hospital is to reduce morbidity, mortality and mental disability through provision of quality, curative and rehabilitative health service as well as capacity building through training and research.

The vision of the hospital is to be one of the best centers for comprehensive health care, mental health research and training institute in Eastern Africa by 2015. The core values are giving priority to community collaboration, commitment, change, trust and professional efficiency. The hospital provides different levels of trainings and skills on mental health for health professionals. To expand and scale up mental health services, training in Masters and B.Sc programs in Psychiatry was started in collaboration with Gondar, Jimma, Haromaya and Mekele Universities since 2001. The common mental and neurological disorders seen in the hospital included Schizophrenia, Epilepsy, Depression, Acute Psychotic Disorder and Mania among others.

The key programs of the hospital are providing quality mental health service, research and training, integrate mental health service and support mental health activities through supportive supervision at facility level in different regions in the country. Since 2001 the hospital managed to integrate the clinical service through renovation and expansion of facilities, decentralization of mental health care while excelling the service (3).

1.2 Statement of the Problem

The use of EMRs within healthcare organizations is already a common and well-appreciated practice. It facilitates the documentation process required for medico-legal reasons, administrative procedures, and bio-clinical research. It also increases the availability of clinical data at the point of care.

However, currently in Amanuel mental specialized hospital health providers document and deliver care using paper records. However, there are many problems with the paper based medical records as found from the observations and interviews with the staffs and managers in the hospital. Some of the problems identified are; data pertaining to patients are not complete, some patient records are lost, they are disorganized and in general they have problems with data quality and completeness of the patient records, illegible hand writing in records and prescriptions is also a big problem.

Currently, as the hospital is using paper based patient records, scheduling problems happen. While some health professionals make appointment using calendars, some others appoint patients after some months or weeks without indicating the exact date. One to this, patients and their caregivers get inconvenienced as the date may fall on a weekend or a holyday.

The other problems in this hospital are duplication of records and medical errors, problems with accuracy of diagnosis and health treatments and problems with data confidentiality and security.

Therefore it is hoped that designing an EMR can resolve some of the above problems and improve the quality of health delivery and customer satisfaction.

1.3 Objective of the Project

1.3.1 General Objective

The general objective of this project was to design an EMR for Amanuel Mental Specialized Hospital.

1.3.2 Specific Objectives

- To collect requirements for the EMR system.
- To analyze the requirements for the EMR system.
- To design the EMR system.
- To design user interface prototyping of the EMR system.

1.4. Significance of the Project

The purpose of this project is to design EMR in Amanuel Mental Specialized 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:

The EMR system may have a better significance for health professionals by solving the problem of illegible hand writing in records and prescriptions. It would also help the health professionals by availing for utilities that make appointment easy. Duplication of information or records would also be avoided.

For the hospital:

The EMR could have a benefit for the hospital for giving a better health care service, for adequate planning and budgeting, for keeping adequate records, with diagnosis and service reporting purposes as a source of relevant information.

For Policy makers and FMOH:

Policy makers and FMOH will use data generated from electronic medical records for their decision and for appropriate planning, it would also improve the effectiveness and efficiency of the Health Information System in the country.

1.5 Project Scope and Limitations

The scope of this EMR project was to design an EMR for Amanuel hospital in the registration, outpatient, laboratory and pharmacy departments which will provide a patient registration feature, electronic order entry and clinical data entry of the registered patient, drug information

and consumption of pharmaceuticals, laboratory test results, messaging and report generating business process. The project was conducted from March to May 2014 in Amanuel hospital. This project used the Structured Analysis and Design methodology.

Due to time and resource constraints, only requirements collection, analysis and design phase were performed covering only the registration, outpatient, laboratory and pharmacy departments.

Chapter two

Literature review

2.1 General Literature

2.1.1 Introduction

Nowadays information technology has offered great advantages to improve efficiency and effectiveness in many industrial fields across the world, such as commercial business, airlines, manufactures, and so on (4). Despite well-established evidence seen in other industries, the acceptance of Information Technology in health care organizations has been growing slowly (5). Such delayed implementation implies some certain obstacles are dismaying willingness of health care provider to take part in this movement.

Information technologies have been introduced to health care organizations throughout decades, some examples of those information technologies are, computerized physician order entry system, clinical decision support system, picture achieving and communication system, laboratory results management, drug information and consumption of pharmaceuticals and others. Among these technologies, Electronic Medical Records are sketching much attention from the general public, health and information technology professionals, stakeholders, managers as well as policy-makers (6). This reflects recognition of EMR's role in improving health care quality which is one of the fundamental concerns in the delivery of health care services. EMRs are expected to solve problems that occurred while using paper-based records, such as, inaccuracy, errors, illegibility, incompleteness, expensive storage, difficult to retrieve and get needed information and so on (7).

EMR is a computerized system of accessing the history of a patient's care. The content of an EMR is related to the paper based records, but the electronic system creates usable data in medical outcome studies, improves the efficiency of care, and makes for more well-organized communication among providers and easier management of health plans and policies (8).

Currently health care organizations in developing countries have interest in the adoption of EMR system. Computer-based health information technologies are ways to solve many issues within the current health care system. Such as decreasing physician settlement, increasing overall costs of health care, and an increasingly uninsured and underinsured population, this exchange of ideas is shifting from simply managing costs to include quality improvement (9).

EMR system makes data easily accessible and enables health professionals to use their own data to improve quality of care. EMR systems can generate automated appointment reminders for periodic checkups and for monitoring chronic diseases and conditions. Monitoring patient responses to these reminders enables practices to follow up with patients who need medical attention but are not responding to the practice's automated messages. Successfully

implementing Electronic medical record system in health care organizations can bring improvements in both quality of patient care and practice profitability (9).

Some of the benefits of EMR are, 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. Moreover, they help support program monitoring, including reporting outcomes, budgets, and supplies. They support clinical research and help with the management of chronic diseases such as diabetes, hypertension, and heart failure (10).

The electronic medical record system is a multifunctional document that is used to communicate and document critical information about patients' medical care among health care professionals (11). Comprehensive medical records are a cornerstone in the quality and efficiency of patient care during the hospitalization and in subsequent follow-up visits, as they can provide complete and accurate information of treatments, patient results and future plans for care (12). Despite the importance of medical records to high quality and efficient care, management of medical records, particularly in developing countries, has not been a priority. Whereas in many high-income countries the medical records function is supported by extensive use of information technology, medical records in developing countries are generally inadequately supported and poorly managed. Although there are some exceptions with new open-source medical records systems becoming available, these are yet not widely used (13).

Recently HIT has started to receive much attention since it is a newly emerging field. Among the attentions that have shown a lot of promise is the EMR. Initially conceived used to document patient records electronically; later EMR has expanded in a matter of years to enable quick and easy acquisition and retrieval of all of a patient's medical information (14). As a result of a great deal of expansion in Internet and cellular technologies, there has been a lot of research done to find new and innovative ways for such technology to expand the scope of EMR systems even farther beyond just data entry during a hospital visit. Despite much growth in terms of technology development, however, there seems to be no standard framework for EMR. This problem can be seen most prevalently in the United States, where the health care system is highly diverse and decentralized. As a result, it is difficult for data to be easily translated electronically across various different systems. Additionally, medical practitioners have and continue to use various different methods to document rendered care (14).

There are many instances and additional problems in the developing world, which make the implementation of any sort of EMR challenging, including limited resources, lack of health care infrastructure, and a need for proper training of health personnel (15).

In order to adopt, develop and install EMR systems in health care organizations, promising ideas are not enough: they need to be validated in the field. It is important to look closely at

systems that have been successfully deployed in challenging environments, and any available evaluation data. The introduction of IT systems to remote sites with no communication should provide good opportunities to evaluate the impact of data management and/or communications tools. Specific outcomes should be measured, such as time to change patient management in response to new laboratory results, or better monitoring of patient compliance (16). There is some evidence of benefit to patient care from access to communication, including the use of telemedicine consultations to improve diagnostic accuracy and reduce unnecessary patient transfers. Improvements in drug supply management using medication data from EMR systems could offer the most measurable cost benefits at present; a well managed drug supply also improves availability and quality of patient care (17).

2.1 .2 Existing EMR system Developing Countries

Currently the developed and developing countries are using EMR system however they are struggling to adapt new system, and at the current time only 9% of hospitals in the United States have adopted electronic medical record keeping (18). This figure is in stark contrast to the 60% of Indian Hospitals which are using electronic medical record keeping in their surgery rooms (19).

“In Kenya, the Mosoriot Medical Record System (MMRS) was developed and the system serves 60,000 patients, and runs Microsoft Access on two networked computers. These are powered by an Uninterruptable Power Supply and backed up with a solar battery. Patients register in the system on their arrival to the clinic and travel through the clinic with a paper visit form. In comparison with the clinic before and after the system was implemented, there were great improvements. Patients visits were 22% shorter, provider time per patient was reduced by 58%, patients spent 38% less time waiting in the clinic, clinic personnel spent 50% less time interacting with patients, 67% less time interacting with each other, and more time in personal activities. The downside is that clerks must perform the registration and transcribe visit data, which is prone to errors (20).”

“In Uganda, the NACP and MOH participated in the demonstration project, choosing three sites differing in size, location, and university affiliation: Mbarara Regional Hospital affiliated with the Mbarara University of Science and Technology, Masaka Regional Hospital and Mbale Regional Hospital. HIV clinicians from these hospitals attended the April 2006 meeting in Kenya. Mbarara already had an MS-Access database (for data copied from patients’ clinic notes) to support collaborative research with the University of California, San Francisco (UCSF). They contracted with a computing consultant at Makerere University in Kampala to install and maintain Open MRS at all three Ugandan sites.

Each Ugandan site developed local encounter forms that captured data required by the Ugandan NACP and data that local clinicians needed to manage HIV-infected patients. The computing

consultant installed Open MRS at each site and programmed it to capture data from encounter forms and produce Patient Summary Reports and required reports to the NACP and MOH.

Currently, Open MRS use continues at all three Ugandan sites. But Masaka has had problems paying for printing encounter forms, and data managers at all sites are being paid with research funds from Indiana University as part of an NIH funded global HIV/AIDS epidemiology network (21)."

"In late 2005, leaders of the National AIDS Control Programme (NACP) of Tanzania expressed interest in participating in Open MRS demonstration. At the time, the NACP had implemented a paper-based HIV/AIDS registry that collected a core set of data on enrollment and at each visit, including vital signs, lab data, and treatments. The NACP had an electronic database for this registry, but few of these forms had been entered into the database or analyzed. Subsequently, there was scant information to support program management and strategic planning. NACP leaders selected three sites Open MRS for that varied in size, location, and experience with electronic data: Morogoro Regional Hospital (a large referral hospital), Tumbi Special Hospital (a district hospital), and Ocean Road Cancer Institute (the site of care for AIDS related malignancies). Neither of the latter two sites had any experience with electronic records of any kind.

Among these three sites, Open MRS was first implemented at Morogoro in January of 2008. By the demonstration project's end in December of 2008, Open MRS had been successfully deployed at all 3 sites, more than 11,000 patients had been enrolled, and Open MRS had captured data from more than 58,000 visits. Patient Summary Reports were printed for most visits (21)."

"In Ethiopia Health Management Information System (HMIS) was established to "support informed strategic decision-making by providing quality data that help managers and health workers plan and manage the health service system." As of 2008, a comprehensive electronic HMIS has been developed in conjunction with doctors associated with Tulane University and is now being deployed to health facilities in several regions of the country (22)

In June 2008, the FMOH began a large, nation-wide development initiative to reform the Ethiopian HMIS. Health care informatics development is also occurring in the area of telemedicine, including teleradiology. Ethiopia's Black Lion Hospital in Addis Ababa was one of the initial test sites for development of the telemedicine component of the Pan-African e-network, a joint project between India and the African Union to provide telemedicine and teleradiology services to over 50 African nations. The Pan-African e-network is an integrated satellite, fiber optics, and wireless network (23).

In 2011 FMOH organized an eHealth workshop in order to begin developing appropriate health informatics standards and an architectural framework for interoperability and scalability of the various eHealth initiatives in the country. The "WoredaNet", the e-government communication

backbone developed by the Ethiopian Telecommunication Corporation, promises to be a major enabler for rapid ICT development in the country (22).

Ethiopia has seen a significant deployment of the Smart Care system used in Zambia. Over 100 clinics and hospitals in the Dire Dawa region, covering the entire area, have 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 (24).

Computerized applications for healthcare include: SMARTCARE Ethiopia – an electronic health record system that supports longitudinal recordkeeping for a clinical care, especially for HIV/AIDS treatment, TB care, VCT, and antenatal care. The system is being rolled out nationally and provides clinical decision support and data portability via the use of smart cards. Smart Care's most attractive features include the ability of Smart Care to personalize Patient's medical record by using Smart Cards. Smart Cards are pocket/credit card sized plastic cards embedded with an electronic memory chip capable of storing Patient's information.

Furthermore, Smart Cards are used as an ID for a patient so that it will easier to filter and retrieve his/her record and history during the follow-up sessions or visiting different point of services like reception, laboratory, pharmacy and so on (25)."

A mental health information system (MHIS) is a system for collecting, processing, analyzing, disseminating and using information about a mental health service and the mental health needs of the population it serves. The MHIS aims to improve the effectiveness and efficiency of the mental health service and ensure more equitable delivery by enabling managers and service providers to make more informed decisions for improving the quality of care. In short, an MHIS is a system for action: it exists not simply for the purpose of gathering data, but also for enabling decision-making in all aspects of the mental health system.

Mental health information systems (MHIS) are essential for all aspects of the mental health system. For policy-makers and planners, they provide a means of establishing goals and objectives for the country or region, and assessing whether those goals and objectives are being achieved. For mental health workers in the front line of service provision, such information systems provide a means of assessing the needs of service users and for monitoring their response to interventions. For people who use mental health services and for the wider population, they provide a means of being informed about the services they can receive and their likely outcomes (26).

A local-area clinical information system for mental health services must be capable of efficiently capturing and reporting data regarding the socio demographic and clinical profile of their patient population, the utilization of services, especially staff time and hospital beds, by those patients, and the effects of the provision of those services. In order to do this effectively

and efficiently systems for routine outcomes audit and review should be implemented. Such systems must be capable of capturing the data items required by the minimum data set together with a small number of additional data items related to the type of care being provided. The system must also be capable of recording a small number of data items describing each patient-related activity or occasion of service. Finally, the system must be capable of capturing, processing and reporting data collected using standardized assessment instruments, such as those reviewed and recommended by the consultancy report on the measurement of consumer outcome in mental health services (27).

Health services are organized to meet the needs of people with episodes of illness which, although acute in intensity, are circumscribed and relatively brief in duration. Such acute episodes are usually handled very well. However, people with chronic mental illnesses, such as schizophrenia, bipolar disorder, major depression and the more severe anxiety disorders, have needs which are complex and which are likely to extend over a long period of time, often many years. Since the 1960s significant reforms in the way mental health services are delivered have been made. Unfortunately, the community-based health and other support services needed by people with chronic mental illness are fragmented and inadequate. This fragmentation of services means that access to the services needed over extended periods an in accordance with one's changing needs is the critical real issue for persons with chronic mental illness. What is required is continuity of care - long-term access to the range of services needed, unrestricted by organizational or structural barriers (28).

The Minimum Data Set (MDS) that has been approved by the National Health Information Management Group for collection from all psychiatric hospitals and all designated psychiatric units or services in acute care hospitals from 1 July 1997 comprises the following data items: establishment identifier; person identifier; sex; date of birth; country of birth; aboriginality; marital status; area of usual residence; type of usual accommodation; employment status; pension status; type of episode; problem status; admission date; discharge date; total leave days; mode of separation; source of referral; referral to further care; total psychiatric days in care; mental health legal status; principal diagnosis; additional diagnosis; diagnostic related group; major diagnostic category; intended length of stay (29).

2.1.3 Organizational and user issues

Data quality and completeness

"Data quality and completeness are critical to the success of any information system. Achieving high standards is a particular challenge in sites with limited computer literacy and experience. It is important to design systems that are easy to use and have good instructions and training. The system should collect the minimum data necessary for the task, and data items should be structured and coded where possible to simplify data checking and optimize reuse. This does

not mean that free text must be excluded; doing so prevents the system from capturing any data that do not fit the normal pattern. Such data will either be lost or recorded in hard-to-locate paper records. Structured data such as laboratory test results might benefit from double entry. In some projects physicians and other staff enter data directly (30). This has the advantage of avoiding transcription errors, and also allows order entry systems to be deployed to check for potential medical errors. A well-trained local data manager is fundamental in maintaining data quality. They need good communication skills as well as technical training. In addition to training and supervision they should perform regular surveys of data quality and investigate problems. Maintaining regular communication with users through a data manager and meetings is also important. While some users will offer unsolicited information about data issues, many do not (31).

Data security and confidentiality

Views of medical data security and confidentiality vary in different developing countries. In some sites, the use of electronic databases is treated with great suspicion; in other sites staff thinks nothing of emailing sensitive medical data. Patients can face serious risk if their communities discover their HIV status or other sensitive medical information. It is imperative that healthcare providers protect this information. However, it has been suggested that the very limited access to health care makes it critical to avoid barriers that might be created by excessive adherence to principles of confidentiality (31)."

The capability to look up patient details securely in a web-based EMR removes the need to send patient information by non-secure email, a potential problem in many countries. Users can simply click on a link to open the web page and log in. Nevertheless, as it is difficult to abolish completely the use of non-secure clinical email (even if a better, more secure alternative system is available), organizations should consider setting up their own secure web-based email systems.

2.2 Related Works

Electronic medical records (EMRs) are increasingly deployed in countries across the globe. They enable critical, real-time information services that empower both patients and health care workers. Just a few years ago, the use of EMRs in resource-poor, developing nations was experimental at best. Few organizations believed that using EMRs was realistic in these regions and fewer still had deployed such systems. Times are rapidly changing. Information technology is more widely available in resource-poor areas, and it is allowing health advocates tackling difficult challenges such as managing HIV/AIDS and drug-resistant tuberculosis. Successful EMR projects are now operating in such diverse locales as Zambia, Peru, Haiti, Rwanda, Kenya and Malawi. Future expansion is predicted. The global market for electronic medical records is expected to grow an astounding 23.8 percent by 2012, including EMR projects in both the developed and the developing world.

Despite the difficulties in deploying information systems in developing countries, several have successfully integrated into clinical workflows. While none represent a complete or ideal solution, their successful use over several years, with combined patient records numbering in the hundreds of thousands, offers valuable insights into successful future deployments. This is not intended to be an exhaustive list; other systems might contain important ideas and designs but need to be validated in appropriate environments. Some brief descriptions of systems deployed in developing countries are mentioned below.

Cameroon

"MEDCAB is a locally designed EMR system for primary healthcare practitioners in Cameroon. Which was released at the beginning of 2003.It is important to note that as with any other place in sub Saharan Africa, the public sector is the principal healthcare provider. MEDCAB was designed after in-depth observations and interviews, and modeling of the provider–patient encounters. Using the International Classification for Primary Care (ICPC-2) disease classification, and Visual Basic 6 programming language, the system development platform was Microsoft Windows, i.e. MS-Access and My SQL as the system's databases. The system consists of many user interfaces with multiple functionalities including; users' administration, medical encounter, patient registration, appointment management, report generation, patient card generator, diagnosis, etc (32)."

Haiti

"Since 1999, PIH has run a community based HIV treatment programme in Haiti with its sister organisation Zanmi Lasante, expanding to seven public health clinics in an area with virtually no roads, electricity or telephone service (33).

Design; Based on the PIH-EMR. Satellite-based internet access at each site supports email and web communication. Open source web system backed by an Oracle database (the same as the PIH-EMR) with an additional offline client for data entry and review. Bilingual English and French.

Data entry; Doctors enter case histories and medications directly, whereas technicians enter laboratory results and pharmacists enter stock records. The data entry staff is being expanded. ***Functions;*** The system functions were history, physical examination, social circumstances and treatment recorded. Decision support tools provide allergy and drug interaction warnings, and generate warning emails about low CD4 counts. An offline component of the EMR was developed to overcome unreliable internet communications in some sites. This allows data entry and case viewing when the network is down, and has proven to be reliable and popular with clinical staff

Significance; the HIV-EMR shows the feasibility of implementing a medical record system in remote clinics in a remote area with virtual no infrastructure and limited technical expertise."

Kenya

"Indiana University School of Medicine and Moi University School of Medicine have been collaborating for over 15 years. In February 2001, this collaboration led to the Mosoriot Medical Record System (MMRS). The MMRS was installed in a primary care healthcare centre in rural Kenya. In November 2001, the MMRS software was adapted to support the AMPATH (Academic Model for the Prevention and Treatment of HIV/AIDS) project and renamed to AMRS (34).

Design; two networked computers running Microsoft (MS) Access, powered by a UPS with solar battery back-up. For the AMPATH project, the network has expanded to seven networked computers linked to a single MS Access database.

Data entry; In the MMRS, patients are registered in the system upon arrival, travel through the clinic with a paper visit form, and present the visit form as they depart. Clerks perform the registration and transcribe visit data. AMRS data are collected on paper forms at each visit, delivered to a central location for data entry, and then returned to the patient's paper chart. ***Function;*** MMRS provides both patient registration and visit data collection functions. Data are collected on all patients seen in the medical clinic, including their laboratory results and medications. AMRS supports comprehensive HIV care as well as mother-to-child transmission prevention, while serving as a rich database for quality improvement and answering research questions.

Significance; The growing AMRS and MMRS databases serve both clinical and research needs, generating clinical summary reports for providers and providing a centralized source of data for epidemiological research. The next generation of the database, called AMRS, has a completely revamped data model, and uses new technology (MySQL, Python-based Zope and Plone, and MSInfoPath to allow web-based data entry)."

PIH-EMR, Peru

"In 1996 Partners in Health (PIH) started a treatment programme for drug-resistant tuberculosis in the slums of Lima, Peru. A patient that is multi-drug resistant is infected with bacteria resistant to isoniazid and rifampin, the two most efficacious anti-tuberculosis drugs.) The PIH-EMR is a web based EMR developed to support the two-year treatment regimen for these patients. It was implemented in 2001 (35).

Design; Open source web system backed by an Oracle database with an additional offline client for data entry and review. Bilingual English and Spanish.

Data entry; Forms filled out by the chest physicians, as well as laboratory result forms. Medication data is entered by the nurses and their assistants who manage the patients in each district on advice from the chest physicians.

Function; The PHI-EMR includes a clinical record with initial history, physical examination, laboratory results and medications on all patients receiving individualized treatment for MDR-TB. The custom medication order entry system provides advice on potential problems and feedback to the nurses, who can consult the physicians if, for example, a patient has new evidence of resistance to the drug they have been prescribed. Laboratory tests for second-line drug resistance are entered in Boston and Peru and accessible by staff in both sites.

The PIH-EMR is also used to create monthly reports for the Global Fund and the Health Ministry. There is an extensive suite of web-based analysis tools for reporting and outcome monitoring. These include graphs of culture conversion rates (time until sputum culture becomes negative) and search tools for patients with particular resistance patterns and drug regimens. Analysis tools are used to assess drug requirements based on the medications prescribed. The system is being extended to include all MDR-TB patients in Peru and linked to the main tuberculosis laboratories there. The PIH-EMR demonstrates the strength and flexibility of a web-based approach when internet connectivity is available."

Care ware, 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 (36).

Design; They system run over a local area network and Stand-alone database built with MS Access.

Data entry; 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's.

Function; the system provides functions 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 in October 2003.

Significance; Care ware is an example of a US-based stand-alone EMR that is being adapted to developing country environments. An internet-accessible version that is under development will allow local data entry offline but provide networked communications and back-up."

Lilongwe EMR, Malawi

"Kamuzu Central Hospital located in Lilongwe, Malawi has made extensive use of a touch screen patient management information system for a wide range of clinical problems in the 216-bed pediatric department since 2001 (37).

Design; of the system runs over a local area network built on Linux/ MySQL with Visual Basic TM for the client programs.

Data entry; Physicians, nurses and pharmacists perform all data entry using touch screens, including medication orders.

Functions; Data are collected on patient demographics, medication, laboratory tests and X-rays. A potential limitation of the touch screen approach is that it is difficult to enter free text, though an 'on-screen' keyboard is available and has been used by local staff to enter all the patients' names.

Significance; the extensive use of this system directly by healthcare workers in a poor country with limited IT skills is a convincing demonstration of the potential of EMRs with user-friendly data entry mechanisms."

SICLOM, 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. They used Separate EMR databases on each physician's desktop periodically connect to the central server by dial-up to update records. Language: Portuguese. It used to support prescribing and track medication supplies (limited information available) and also it is considered a 'key factor(s) helping to overcome logistical challenges to delivery of antiretroviral treatment in Brazil' (38)."

Other EMR systems in developing countries

FUCHIA was developed by Epicenter, the epidemiology group of Me´decins Sans Frontie`res, to support their HIV treatment projects. It supports clinical care and long-term follow-up of patients, including scheduling of visits; it includes data on medications and investigations and generates reports. It was developed as a standalone system using MS Access and the Delphi programming language.

An information system was developed in Botswana to support the TB programme and is built using EpiInfo (a free stand-alone program from the US Centers for Disease Control [CDC] designed for data collection and analysis in developing countries). It includes reporting and analysis tools and has been successfully deployed to multiple sites in several countries.

Palm systems

A variety of PDA-based medical information systems have been proposed or implemented for projects in developing countries on the basis that handheld devices will be easier to use and support in remote sites. Such devices would seem to provide particular benefits for community health care, being simple and relatively unobtrusive to carry around. Palm-based devices tend to

be favored due to their excellent battery life and generally lower cost. In KwaZulu Natal, South Africa, a Palm-based system allows secure access to HIV results in remote clinics. In rural India, a Pocket PC-based system has been used to store health records for community nurses visiting remote villages. Palm or Pocket PC systems can be easily set up to view pages offline from a web-based EMR, though care is required to maintain data security. Satellife is using the mobile phone network in Uganda to link PDA-based medical records to a central site. Local healthcare workers collect data on Palm Pilots TM and then connect to a local battery-powered server that connects to a central database via a mobile phone modem (39).

Web-based collaboration and telemedicine systems

The web allows data sharing for remote consultation, and several projects have established systems that can be used to support diagnosis and treatment decisions in remote sites with limited bandwidth. The RAFT project permits remote collaboration, case discussion and data sharing over low-bandwidth networks between Geneva University Hospitals and Bamako, Mali. The IPATH server is a web-based tool for image sharing in pathology and radiology being used in South Africa and the Pacific as well as Switzerland. Telemedmail is a secure email and web-based telemedicine system under evaluation in South Africa and Peru.

Ethiopia

The FMOH is undertaking different reform programs through BPR principles to ensure the implementation of HSDP and MDG. For the support of this vision, the PHID has been piloting and implementing different HIT projects to support the national health program. The desires to have efficient HIT systems have defined the need for EMR system in Ethiopia. EMR system could improve the process of data collection resulting in better quality and more reliable health information.

The FMOH, supported by its technical partners, is involved in a number of ICT projects and services which could improve the quality of care for patients and decision support systems.

In Ethiopia, the implementation of EMR is through software called Smart Care. Tulane University's technical assistance program for Ethiopia (TUTAPE) developed the Smart Care software in partnership with Tulane University, CDC and federal ministry of health Ethiopia. Ethiopia thus adopted Smart Care as the preferred EMR application (40).

Chapter three

Methodology

3.1 Study Area/ Setting

The study was conducted in Amanuel Mental Specialized Hospital. It is one of the oldest and the only mental health hospital established in 1930 E.C.by the Italian invades. It is located in western part of Addis Ababa in Addis Ketema Sub-city. Currently there are 250 health professionals and 344 supportive staffs currently working in the hospital. The hospital has 259 beds for inpatient and outpatient services. An average of 400 out-patient clients get medical and counseling services every day. The hospital provides different levels of trainings and skills on mental health for health professionals.

The common mental and neurological disorders seen in the hospital include Schizophrenia, Epilepsy, Depression, Acute Psychotic Disorder and Mania among others. The key program of the hospital is providing quality mental health service, research and training, integrate mental health service with other practices and support mental health activities through supportive supervision at facility level in different regions, in the country. Since 2001, the hospital has managed to integrate the clinical service through renovation and expansion of facilities, decentralization of mental health care while excelling the service.

3.2 Source Population and Study Population

The source population of the study was individuals working at Amanuel Hospital. In addition documentary sources and literatures were used as source of the study. The study populations were managers (Chief Executive Officer, Medical directors), HMIS officer and health professional working in the hospital.

3.3 Data Collection

The data collection was carried out in Amanuel Hospital starting from February 2014. And the requirements for the project were collected from the hospital personnel, in order to gather facts and opinions through interview, observation and document review techniques;

Interview

In this project, Managers, HMIS focal persons and senior health professionals were interviewed about the current paper based system and related business. Among the managers according to their position and overall controlling system the chief executive officer (CEO), Medical director, Pharmacy department, Laboratory department and Registration department heads were interviewed. In addition to this, since the work flow and process are followed by the HMIS, HMIS focal person were interviewed. Finally interviews were conducted with all of the health professional those who have an extensive experience on the field which is the clinical task.

Observation

The current business process, the data flow of the current system in general and the day today activities were observed in order to identify problems with the current system using observational checklist.

Document review

Some literature reviews, formats which are patient registration, history taking, diagnosis, treatment, laboratory investigation and medication /prescription formats were reviewed to understand and define problems.

In addition to the above techniques after securing permission from the officials of the institution, the ICT infrastructures were visited.

The tools used for the data collection were:

- Interview: for interviewing managers and individuals.
- Observational checklist: for assessing the ICT infrastructure of the hospital.
- Inventory sheet: for the hardware and software availability.

3.4 Data Analysis and Design

3.4.1 Methodology

The project used structured analysis and design methodology. Because it is an appropriate description notation to design the system hence it provides a clear requirement statement that everyone can understand and is a firm foundation for subsequent design, it is simple and easy to understand and use, to manage due to the rigidity of the model, to arrange tasks, understandable by the users and developers, well defined activities and specify the sequence and interaction of the activities and the process and results are well documented. The method used for this project was the incremental water fall approach (41).

3.4.2 Incremental methodology

The Incremental methodology is an evolution of the Waterfall model, where the Waterfall model is incrementally applied using the iterative philosophy of prototyping. With Incremental development the project is designed, implemented and tested incrementally with a little more is added each time until the product is finished. The product is defined as finished when it satisfies all of its requirements (41).

Iterative and incremental software development begins with planning and continues through iterative cycle involving continuous user feedback and the incremental addition of features concluding with the deployment of completed software at the end of each cycle.

3.4.2 Data Analysis design (tools and techniques)

After requirement was captured using the interview, observation and document review the result was analyzed. The result of the system modeling that helps to understand the system models used for analysis of the system was done using the use cases, contextual diagram, flow chart and Data flow Diagram (DFD).

3.4.2.1 Tools

The tool used for analysis and design in this project was:

- Microsoft Visio 2003:whcich was used for analysis of the system by providing the modeling of the system such as the system use case, contextual diagram and data flow diagram and also for the design of the system like the ER diagram and database diagram.

3.4.2.2 Techniques

The techniques used for analysis and designs in this project were:

Data flow diagram: used for a graphical representation of the logical flow of the data and it contains four graphical symbols for source, data flow, process and storage.

ER diagram; used for design of the database diagram of the system.

The method, techniques and tools used in each phase of the project are summarized below in the table.

Table 1: Method, Techniques and Tools

Phases of the software development	Techniques	Tools	Methods
Feasibility, requirement gathering /planning phase	Interview Observation Document review	Questionnaire Observation checklist Inventory sheet	Incremental water fall approach
Analysis phase	Data flow modeling Contextual diagram	Microsoft Visio 2003	
Design phase	ER diagram Relational data base design	Microsoft Visio 2003	

3.5 Methods of Dissemination of Result

After the study is completed, the report will be forwarded to Amanuel Mental Specialized Hospital where the study was conducted and to AAU as partial fulfillment of MSc degree in Health Informatics.

3.6 Operational Definition

Data flow diagram: Is a graphical representation of the "flow" of data through an information system, modeling its *process* aspects and also it used for a graphical representation of the logical flow of the data and it contains four graphical symbols for source, data flow, process and storage.

Electronic Medical Record: Is defined as a patients' medical record which holds mental health information electronically and accessible by computers on a network for the primary purpose of providing health care and health-related services in mental health institution.

Entity relationship diagram: An entity-relationship diagram (ERD) is a data modeling technique that graphically illustrates an information system's entities and the relationships between those entities.

Out Patient Department: Part of a hospital where different clients get different services as an outpatient.

Quality of care: The degree to which care is expected to increase the likelihood desired health outcomes and is consistent with standards of health care.

SSADM: Structured systems analysis and design methodology (SSADM) is a set of standards for systems analysis and design.

Use case diagram: Is a graphic depiction of the interactions among the elements of a system.

User Interface Design: Is concerned with how users add information to the system and with how the system presents information back to them.

3.7 Ethical Consideration

Prior to data collection, ethical clearance was obtained from School of Public Health and school of Information Science of AAU. In addition, concerned bodies and staffs in the hospital were informed about the study.

Chapter four

Discussion of Results

Analysis and Design of the System

4.1 Analysis

Introduction

In this chapter the current system, the business process, the functional and non functional requirements, use cases, process models, data models, and the design of the system are presented.

4.1.1 Current System

Within the existing system at Amanuel mental specialized hospital, the patient information was collected through conventional pen and paper, and kept manually on printed forms. These data on printed forms are, then entered into the hospital information system by an administrative assistant. When a patient arrives at the departments, for example at outpatient department, initially a nurse/physician fills about the patient history information onto the outpatient department form, and diagnoses the problem according to the diagnosis; the patient get treatment and the treatment and diagnosis information are register on the patient card file. The overall business process description of the departments is presented as follows.

Registration department business process:

- The patient presents in the registration department.
- If the patient is new the data clerk asks the patients full information from the patient as well as from families of the patient
- The data clerk and registers full patient information and next kin of the patient information on the registration form.
- The data clerk gives identification number.
- The patient makes payment.
- The data clerk sends the patient to the triage office.
- The triage officer screens the patient.
- After screening, the patient sends to the outpatient department.

Where as if the patient is repeat or comes with appointment,

- The patient goes to the registration department and gives the card to the data clerk.

- The data clerk receives the identification card from the patient and modifies some in formations like date.
- The data clerk sends the patient to the outpatient department which is the patient visited before.

Outpatient department business process of the outpatient department:

- The patient arrives at the outpatient department with patient card.
- The physician/nurse/Ho/Msc takes the identification information which includes the socio demographic, visit and ID of the patient.
- The physician performs the chief compliant activities from the patient side, if the patient has insight and from the family if the patient does not have insight.
- The physician takes/registers the history of present illness which includes family history (genetic factor, substance use, income, occupation) and patient history (early child hood, Adolescence, substance use, educational status, work performance, friend's status and martial relationship, support), per morbid history (aggressive, calm), mental status examination of the patient which include general appearance and attitude towards the examination, mood and affect, speech and thought disturbance like delusion.
- After the patient examine the diagnosis and differential diagnosis, if further investigation is needed the physician order laboratory investigation. According to the laboratory result the physician prescribe medication and psycho education takes place.
- If the patient doesn't need laboratory investigation the physician prescribe medication and appoint the patient to the next visit. Finally patient card is archived.

Laboratory department business process:

- The patient comes to the laboratory department with laboratory request.
- The receptionist accepts the laboratory request and asks the name of the patient from which department he/she came.
- The receptionist explain to the patient about the sampling (from where to take, why the sample needs and other related information) and takes sample.
- The receptionist tells to the patient to come back after some time to take his sample result.
- The receptionist registers the test order in a form which includes the department which ordered the test, name of the patient, sample id, date and the type of test.
- The receptionist distributes the sample to the sections (chemistry, parastology, urinalysis, hematology, serology CD4).
- Each section performs quality check of the machine or regent status.
- The laboratory technician in the section checks sample quality whether the sample mix for example urine mix with stool, stool mix with blood and so on.
- The sample examines and the result cross checked or review.

- The result records in the result form and send back to the receptionist.
- The receptionist put the result on a shelf and gives to the patient when the patient comes.

Pharmacy department business process:

- The patient arrives at the pharmacy department with prescription order.
- The pharmacist/evaluator accepts the prescription from the customer and evaluates the prescription legality, dose strength and other related information's.
- The pharmacist determines the price of the drug and writes the code of the price and the patient go to the casher to perform payment.
- The casher accepts the prescription and sees the price and calculates the total price and tells to the patient and the patient makes payment.
- The casher issued receipt and the patient come back to the pharmacist.
- The pharmacist/dispenser receives the prescription with the receipt and dispenses the drug to the patient with appropriate counseling.

Since the hospital used paper based system different problems occurred, some of the problems identified are; data pertaining to patients are not complete, some patient records are lost, they are disorganized and in general they have problems with data quality and completeness of the patient records, illegible hand writing in records and prescriptions is also a big problem.

According to the managers and health professionals response, the new system would have a great importance and will help to their activities and the key operational changes to see with the proposed Electronic Medical Record system are, to exist quality of data, reduce errors, proper documentation of diagnosis and treatment data of patients; in general to solve the problems that occurred currently while using the manual system.

Regarding the infrastructure, availability of IT professionals, number health professional, training level towards basic computer skill and EMR system is described as follows.

The hospital has a power backup generator which used for a backup power source when there is interruption of electricity which has a good capacity. In addition there is availability of a local area network internet connection with a capacity of 522 KB. The hospital has not yet an IT professional but they planned to recruit IT professional in the future.

The numbers of technical staffs in the hospital were specialists 11, GPs 13, Health officers 19, Nurses 106, Pharmacists and druggist 30, Lab technicians 13 and data clerk 20.

The number of departments corresponding to the scope of the study was 18 departments 14 of them were out patient departments the rest 4 departments were registration, triage, laboratory and pharmacy departments.

The numbers and types of hardware and software in these departments are described as follows.

Table 2: Types of Hardware in Each Department

Department	Type of hardware	Quantity	Brand and model	Processor (GHz)	RAM (GB)	Hard disk (GB)	Network interface card /NIC		Purpose of the Computer
							Yes	No	
Registration	Computer	2	DELL	dual 2.49 GHz	1	160		-	To prepare report To register patient personal information
	Printer	1							
Triage	Computer	1	DELL	dual 2.49 GHz	1	160		-	To register patient personal information To prepare report
Outpatient	-	--	-	-	-	-			
Laboratory	Computer	2	DELL	dual 2.49 GHz	1	160		-	To prepare report
	Printer	1							
Pharmacy	Computer	1	DELL	dual 2.49 GHz	1	160		-	To prepare report
	Printer	1							

The type of software in these departments were Microsoft office 2007 and power geez 2005 used for storage data, word process, presentation and for local language.

According to respondents towards the internet access and usage, the speed of the internet was fast however most of time it didn't work.

Regarding training towards basic computer skill and EMR, about 87% of the respondents were didn't took training.

4.1.2 The Proposed System

Since the current system which is the paper-based has some problems with documentation and the proposed system works on computers via local area network in line with the requirements of departments. There is a centralized database to store the patients' EMRs as well as to integrate the department's registration, laboratory .pharmacy and outpatient departments. The users use computers to record and review the patient information.

4.1.2.1 System Requirement

In order to determine the hardware and software requirement of the proposed system some document were reviewed and visit hospitals (Ras Desta Hospital and Yekatit 12 Hospital and MOH, then by making modification the hardware and software requirements describes as follows.

Hard ware Requirements

The hardware requirements are in 2 groups. The first one is for server side and the second one is for client side.

These are hardware requirements for server side:

• Intel Pentium(R) Xeon (TM) CPU 4.00 GHz 4.00 GHz, processor

• 4GB Ram

• 1TB HDD Space

• Fast Internet connection

These are hardware requirements for client side:

• Intel Pentium (R) Dual Core CPU ES400@ 2.70 GHz 2.70 GHz processor

• 2GB Ram

• 280 GB HDD Space

• Internet connection

Software Requirements

The software requirements are in 2 groups. The first one is for server side and the second one is for client side.

These are the software requirements for server side:

• Windows Server 2003/2008

• Microsoft Frameworks 3.5

These are the software requirements for client side:

• Window XP /Vista/7

4.1.2.2 Functional Requirements

A functional requirement relates directly to a process the system has to perform or information it needs to contain. Accordingly the functional requirements are describes as follows.

- The system registers users of the system.
- The system should authenticate the user and assign privileges according to the assigned rights.
- The system should be able to register patient personal information, address and identification number or medical record number.
- The system searches patient.
- The system updates patient information
- The system updates user account.
- The system records patient assignation information.
- The system records patient diagnosis and treatment data.
- The system registers the appointment date of the patient.
- The system registers the patient laboratory order.
- The system records patient laboratory result.
- The system records medication order.

4.1.2.3 Non functional Requirements

A nonfunctional requirement describes user behavioral properties that the system must have, such as performance and usability. The non functional requirements correspond to the process of explaining the features, characteristics, attributes, and constraints of the information system used to limit the boundaries of the proposed solution. The following are the non-functional requirements of the proposed system:

Security; **-** Since the system is going to handle personal information which is confidential, it should be protected from an unauthorized users and intruders. No one can log into the system without a registered user name and corresponding password. The system has two groups of users: the data base administrator and Limited user. The data base administrator user has full privilege to perform on the system. Whereas the Limited users can only perform limited operations.

Table 3: Operations and User

Operations	Users role			
	Data clerk	Physician	Laboratory technician	pharmacist
View registration data	Allowed	Allowed	Allowed	Allowed
Modify registration data	Allowed	Not allowed	Not allowed	Not allowed
Delete registration data	Allowed	Not allowed	Not allowed	Not allowed
View outpatient data	Not allowed	Allowed	Not allowed	Not allowed
Modify outpatient data	Not allowed	Allowed	Not allowed	Not allowed
Delete outpatient data	Not allowed	Allowed	Not allowed	Not allowed
View laboratory data	Not allowed	Not allowed	Allowed	Not allowed
Modify laboratory data	Not allowed	Not allowed	Allowed	Not allowed
Delete laboratory data	Not allowed	Not allowed	Allowed	Not allowed
View pharmacy data	Not allowed	Not allowed	Not allowed	Allowed
Modify pharmacy data	Not allowed	Not allowed	Not allowed	Allowed
Delete pharmacy data	Not allowed	Not allowed	Not allowed	Allowed

Availability: - since the hospital give services for 24 hours, the system should be available 24 hours/day or 7 days a week, and there should be 24 hours/day of electricity and back up source such as generator for the system to work without interruption. In addition the system should be use English language since it is difficult to translate the diagnosis and medication of illnesses.

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 addressed by availing modular functionality, user guideline and detail design documentation, therefore the developer as well as authorized trained person can modify or upgrade the system easily.

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.

Performance; - performance is an important issue for the system because one of the drawbacks of the current system is performance issue. So this system makes fast the activities by making the server fast and the software should be fast enough to respond in real time.

User interfaces; - This is basically concerned on what kind of Graphical User Interface (GUI) the system should provide or what is the level of expertise of the user. Since the system is going to be used by different user categories, it should have a very simple and user friendly interfaces for everyone to understand the functionalities easily. Since the system is copied and have similar features like the paper based, it should be easy to use.

4.1.3 Analysis model

Table 4: Identified Actors

Actor name	Description
Data clerk	Data clerk refers to a person who gives service in the registration department or enters the patient personal information and address to the system.
Triage officer	Triage officer refers to a professional who screens patients status
Physician/HO/nurses	Physician/HO/nurses refers to professionals who diagnosis and treated patients and enters the diagnosis and treatment data's to the system.
Laboratory technician	Laboratory technician refers to professional who perform the diagnostic services and enters laboratory information to the system.
Pharmacist	Pharmacist/druggist refers to professional who give services towards medication/drug and enters drug information to the system.
Administrator	Administrator refers to the person who administers the system.

Identified use cases

Login

Register patient

Update patient information

Assign patient

ADD diagnosis and Treatment data

Register test result

Perform medication

Generate report

Search patient

Manage user account

System Use case description

Table 5: Login Use Case

Use Case ID	UC_1
Use case Name	Login
Priority	High
Primary actor	User (data clerk, triage officer, physician, pharmacist and laboratory technician.)
Summary description	This describes how the user logs into the system to view or modify requests.
Precondition	The user must have user name and password
Post condition	The user logs into the system
Main success scenario	1. The Use Case starts when the user by clicking the login screen. 2. The system displays the log in screen. 3. The user enters the username and password 4. The system verifies the information and set access permission. 5. The system will display the main screen. 6. Use case ends
Alternative path	4a. If the username or password is not valid, an error message is displayed. 4a1. The user clicks an ok button. 4a2. The user is returned to login screen and re enters user name and password.

Table 6: Register Patient Use Case

Use Case ID	UC_2
Use case Name	Register Patient
Primary actor	Data clerk
Summary description	This Use Case describes the process of how the data clerk enters personal information and address of the patient into the registration system.
Precondition	The data clerk is authenticated.
Post condition	The patient is registered on the system.
Main success scenario	1. The Use Case starts when a data clerk clicks on the registration link. 2. The system displays the registration form. 3. The data clerk enters the name or demographic information of the patient and search. 4. The data clerk confirms that the patient is not registered in the system. 5. The data clerk enters the data (patient personal information and address) 6. The system checks the entered data and compares with data restriction. 7. The system validates the input data and registers the patient. 8. The system automatically generate patient ID and the data clerk click submit button. 9. The data clerk stored/save the record in the system 10. Use case ends
Alternative path	4a. If the patient is already registered or repeat. 4a1. The data clerk enters the patient name or ID of the patient and search the patient 4a2. The system displays the patient data. 4a3. The data clerk updates patient visit. 4b. If the patient is appointed. 4b1. The data clerk enters the patient name or ID of the patient and search the patient 4b2. The system displays the patient data. 4b3.The data clerk updates patient appointment. 5. Use case ends. 6a. If the data clerk makes error while enters the data, the system displays error message. 6a1. The data clerk clicks an ok button. 6a2. The system inform the Data Clerk to re-enter patient information 7. Use case ends.

Table 7: Patient Record Use Case

Use Case ID	UC_ 3
Use case Name	Update patient record
Primary actor	Data clerk
Summary description	The data clerk updates the patient record.
Precondition	Patient is registered
Post condition	The patient record is updated.
Main success scenario	1. The Use Case starts when the data clerk clicks on the registration department link. 2. The system displays the registration form. 3. The data clerk enters the name or demographic information of the patient and search. 4. The system display patient record. 5. The data clerk enters the data to be update. 6. The system checks the entered data and compares with data restriction 7. The system validates the input data and updates the record. 8. The data clerk saves the record. 9. Use case ends.
Alternative path	6a. if the data clerk makes error while enters the data the system displays error message. 6a1. The data clerk clicks an ok button. 6a2. The system inform the Data Clerk to re-enter patient information 7.use case ends

Table 8: Add Diagnosis and Treatment Data Use Case

Use Case ID	UC_4
Use case Name	Add diagnosis and treatment data
Primary actor	The physician/nurse/HO/
Summary description	This use case describes the process used to diagnose the patient.
Precondition	Patient registered, Patient is assigned, The physician is authenticated.
Post condition	The patient diagnosis and take a treatment Patient history is registered
Main success scenario	1. The Use Case starts when a physician clicks on diagnosis and treatment link. 2. The system provides the physician diagnosis and treatment form (which contains personal information and Address of the patient, general examination, diagnosis, and laboratory and medication order. 3. The physician enters the data. 4. The physician clicks on the medication link and enters treatment order and click submit button. 5. The system saves the data on the system. 6. Use case ends
Alternative path	4a. laboratory investigation is needed 4a1.the physician clicks on the lab order link under the diagnosis button 4a2. The system provides the physician lab request form. 4a3. The physician enters laboratory order and click send button. 4a4. The system sends lab. Request order to the laboratory dep't. 4a5. The system displays laboratory result message. 5. Use case ends. 5a. if the patient needs follow up 5a1. the physician fills the appointment date and appoints the patient. 5b.if the patient needs admission 5b1. the physician fill the admission criteria. 5c.if the patient needs further investigation 5c1. the physician fills the referral information and refers the patient. 6. Use case ends.

Table 9: Order Laboratory Test Use Case

Use Case ID	UC_5
Use case Name	Order laboratory order
Primary actor	physician
Summary description	The use case describes the process used to order laboratory test.
Precondition	The physician is authenticated.
Post condition	Laboratory test order is registered.
Main success scenario	1. The Use Case starts when the physician clicks on the laboratory request button. 2. The system display list of laboratory request button. 3. The physician selects types of orders from the listed button. 4. The physician click on the send button. 5. The system save the request and send a message for the laboratory department. 6. The system saves the data on the system. 7. Use case ends
Alternative path	

Table 10: Register Test Result Use Case

Use Case ID	UC_6
Use case Name	Register test result
Primary actor	Laboratory technician
Summary description	The use case describes the process used to record laboratory result.
Precondition	The laboratory technician is authenticated. Laboratory test order message.
Post condition	Laboratory result is registered.
Main success scenario	The Use Case starts when the laboratory technician clicks on the laboratory link. The system shows laboratory test order messages. The laboratory technician clicks on the message button. The system display list of laboratory orders. The laboratory technician select the message The system displays the test request form. The laboratory technician fills lab results on the lab order entry form and click submit button The system sends lab result to respective outpatient department. The system saves the data on the system. Use case ends
Alternative path	7a. if the laboratory technician makes error while enters the data, the system displays error message. 7a1.The laboratory technician clicks an ok button. 7a2.The system informs the laboratory technician to re-enter the data. 8.use case ends

Table 11: Record Medication Use Case

Use Case ID	UC_7
Use case Name	Record medication
Primary actor	Pharmacist
Summary description	The use case describes the process used to record medication Orders
Precondition	The pharmacist is authenticated. Medication order
Post condition	Medication is recorded and dispensed.
Main success scenario	The Use Case starts when the pharmacist clicks on the pharmacy link. The system shows medication order messages. The pharmacist clicks on the message button. The system display list of medication orders. The pharmacist selects the message. The system displays the medication request form. The pharmacy enters dispensation information. The physician clicks the dispense button to dispense drug to the patient. The system saves the data on the system. Use case ends
Alternative path	7a. if the pharmacist makes error while enters the data, the system displays error message. 7a1.The pharmacist clicks an ok button. 7a2.The system informs the pharmacist to re-enter patient information 8.use case ends

Table 12: Search Use Case

Use Case ID	UC_ 8
Use case Name	Search a patient
Primary actor	User
Summary description	This describes how the user searches information from the system to view or modify the information.
Precondition	The user is authenticated. The user should enter patient name or patient ID.
Post condition	The user gets the information what he/she needs.
Main success scenario	1. The Use Case starts when the user enters the patient name, or Patient ID. 2. The user clicks the search button. 3. The system checks data input register. 4. The system validates the entered data. 5. The system displays list of result by search type (name or ID). 6. Use case ends
Alternative path	3a. If the user makes error while enters the input, the system displays error message. 3a1. The user clicks ok button. 3a2. The system inform the user to re-enter the information 6. Use case ends.

Table 13: Generate Report Use Case

Use Case ID	UC_ 9
Use case Name	Generate report
Priority	High
Primary actor	User(physician, laboratory technician, pharmacist,)
Summary description	The 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.
Main success scenario	1. The Use Case starts when the user clicks on the report button. 2. The system displays a report window that contains different report options (daily, monthly quarterly, annually). 3. The user select type of reports needed. 4. The system processes and generates the selected report. 5. The system displays and prints the result as well as save the result in the system. 6. Use case ends
Alternative path	

Table 14: Maintain User Account Use Case

Use Case ID	UC_ 10
Use case Name	Maintain user account
Primary actor	System administrator
Summary description	This describes how the administrator maintains the users.
Precondition	The administrator should register as an authorized administrator.
Post condition	The administrator maintain user account/manage the system
Main success scenario	The Use Case starts when the user starts the application. The administrator enters in to login screen. The system display the login screen The administrator enter user name and password The System displays the user account form. The administrator performs create new user, update user account The System validate the information which the Administrator enters End the Use Case
Alternative path	4a 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.

4.1.4 Process Modeling

A process model is a formal way of representing how a business system operates. It illustrates the processes or activities that are performed and how data move among them. A process model can be used to document the current system (i.e., as-is system) or the new system being developed (i.e., to be system).

Contextual Diagram

The context diagram shows the entire system in context with its environment. It shows the overall business process as just one process.

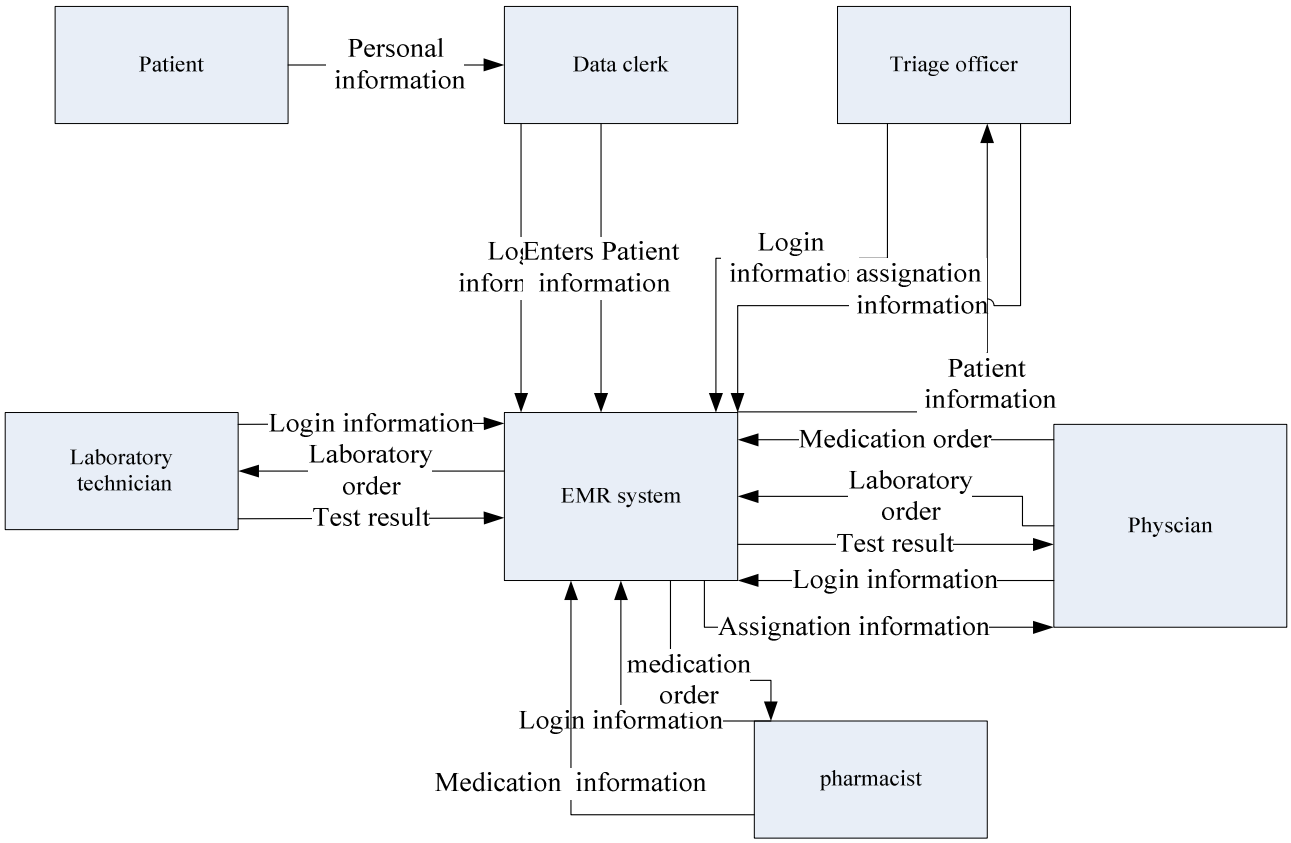

Figure 1: Contextual Diagram of the proposed system

Data flow diagram

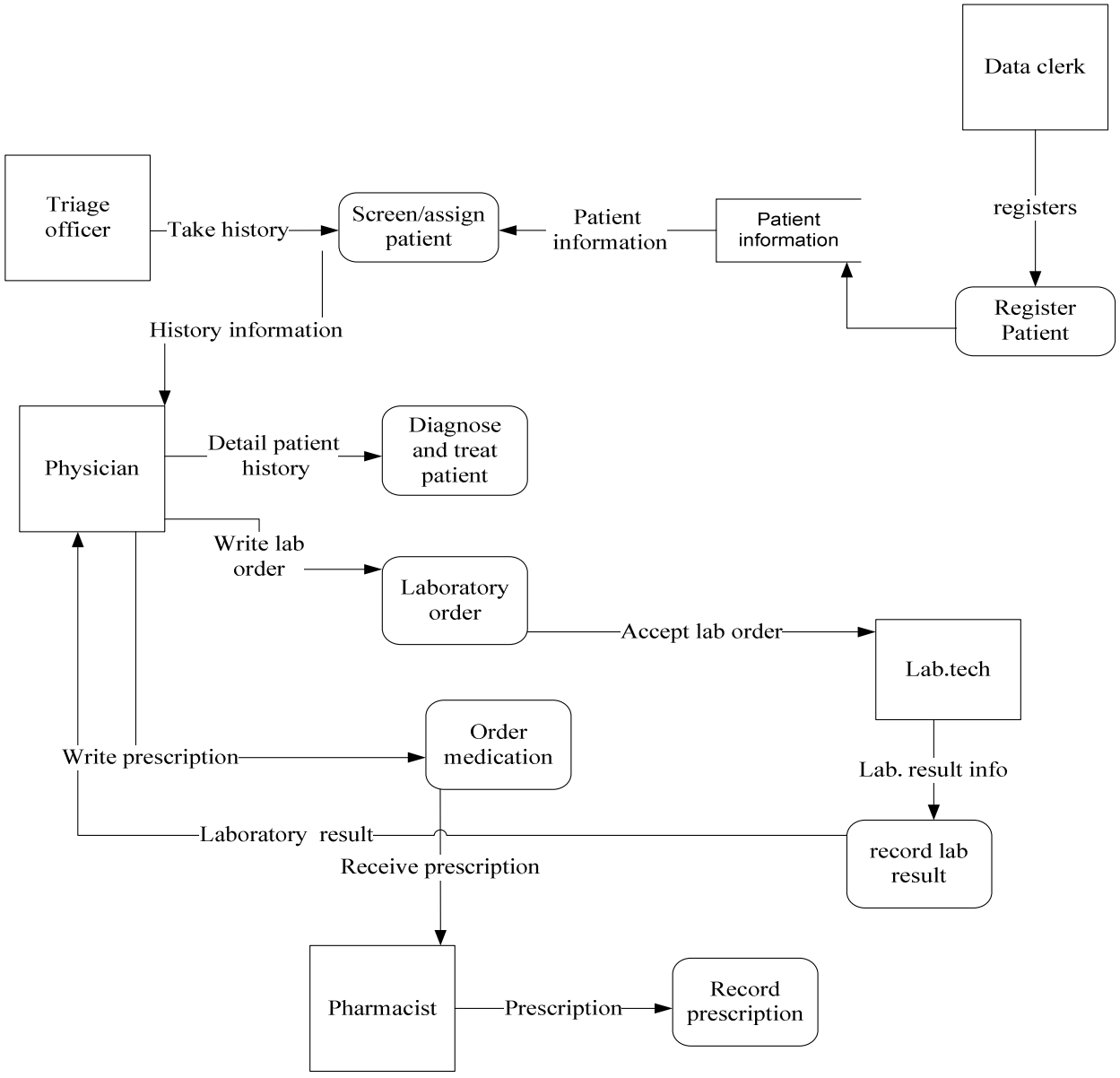

Figure 2: Level 1 Data Flow Diagram of the proposed system

4.2 System Design

4.2.1 System Architecture

The Design Overview is section to introduce and give a brief overview of the design. The System Architecture is a way to give the overall view of a system and to place it into context with external systems. This allows for the reader and user of the document to orient themselves to the design and see a summary before proceeding into the details of the design.

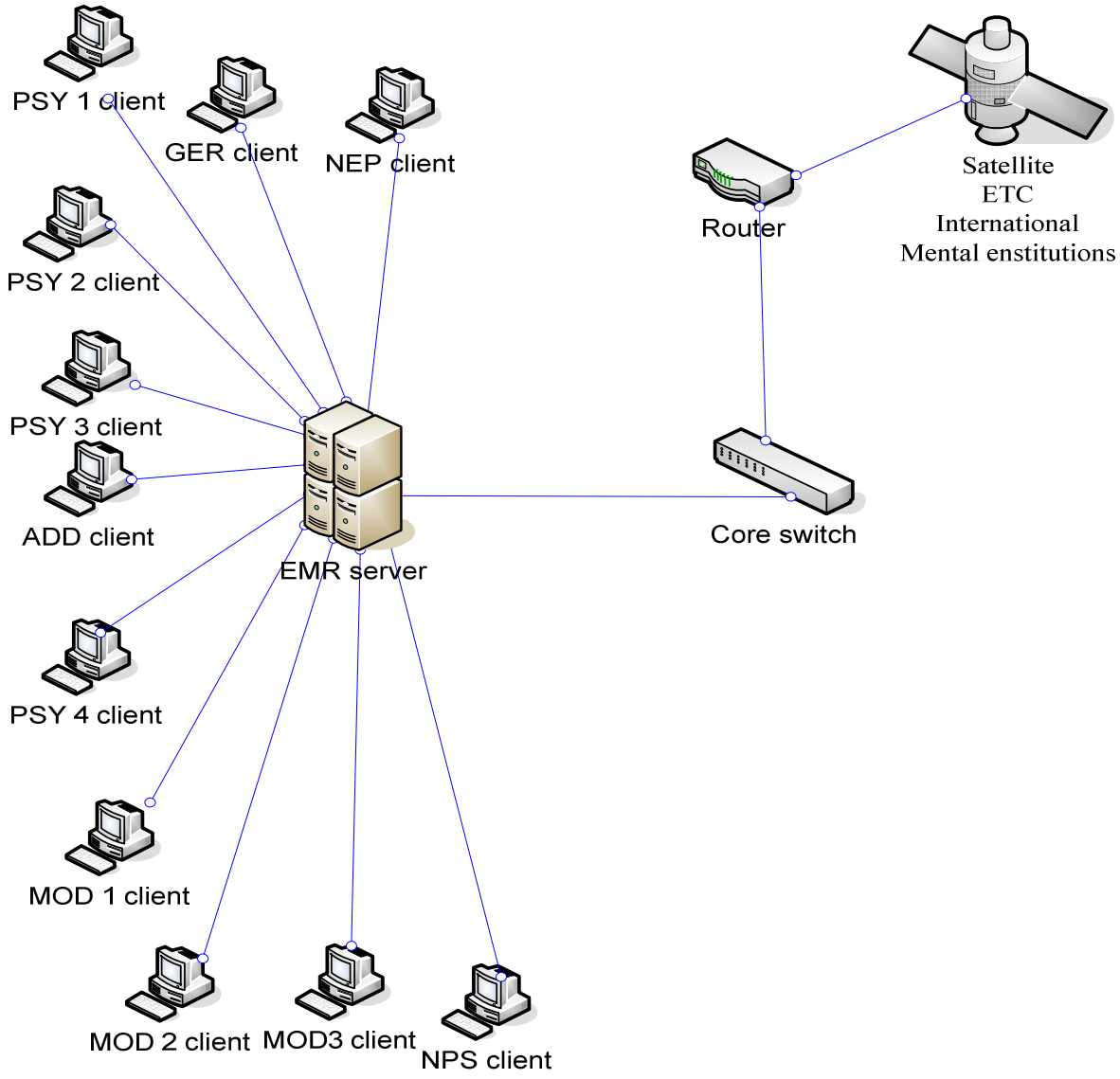

Figure 3: System Architecture

4.2.2 System Object Model

The System Object Model Section allows for a description of the subsystems in use. This allows for describing the system in a overall manner to show the different groupings of parts into respective systems. The electronic medical record system is decomposed into systems in order to reduce complexity in the solution domain of the overall system.

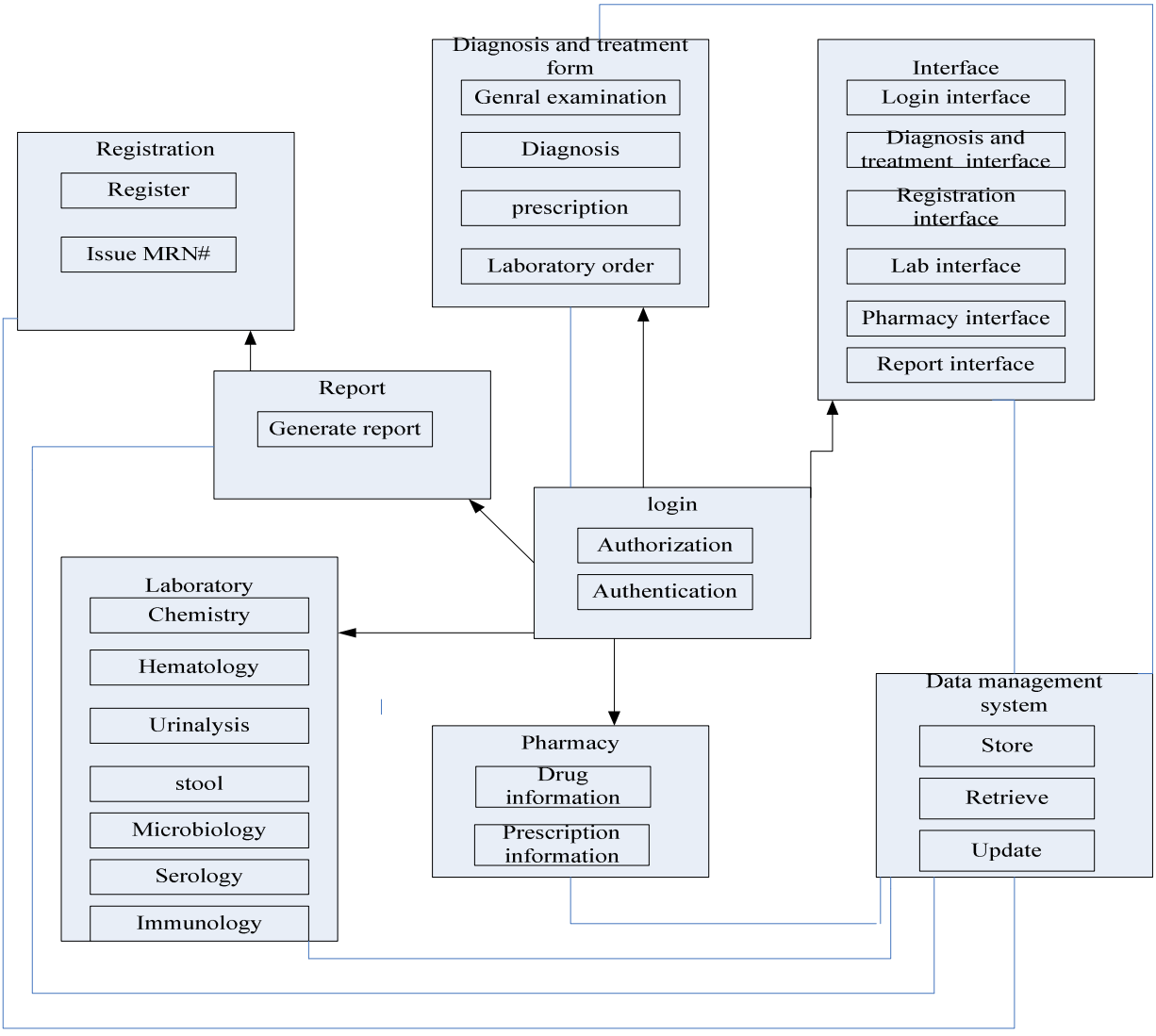

Figure 4: Sub System Interfaces

4.2.3 Data Model

A data model is a formal way of representing the data that are used and created by a business system; it illustrates people, places, or things about which information is captured and how they are related to each other.

Entity Relationship Diagram

An entity relationship diagram (ERD) is a picture which shows the information that is created, stored, and used by a business system.

Entity; the entity is the basic building block for a data model. It is a person, place, event, or thing about which data is collected. Attribute; an attribute is some type of information that is captured about an entity. The entities and attributes of the system are listed in Annex 1.

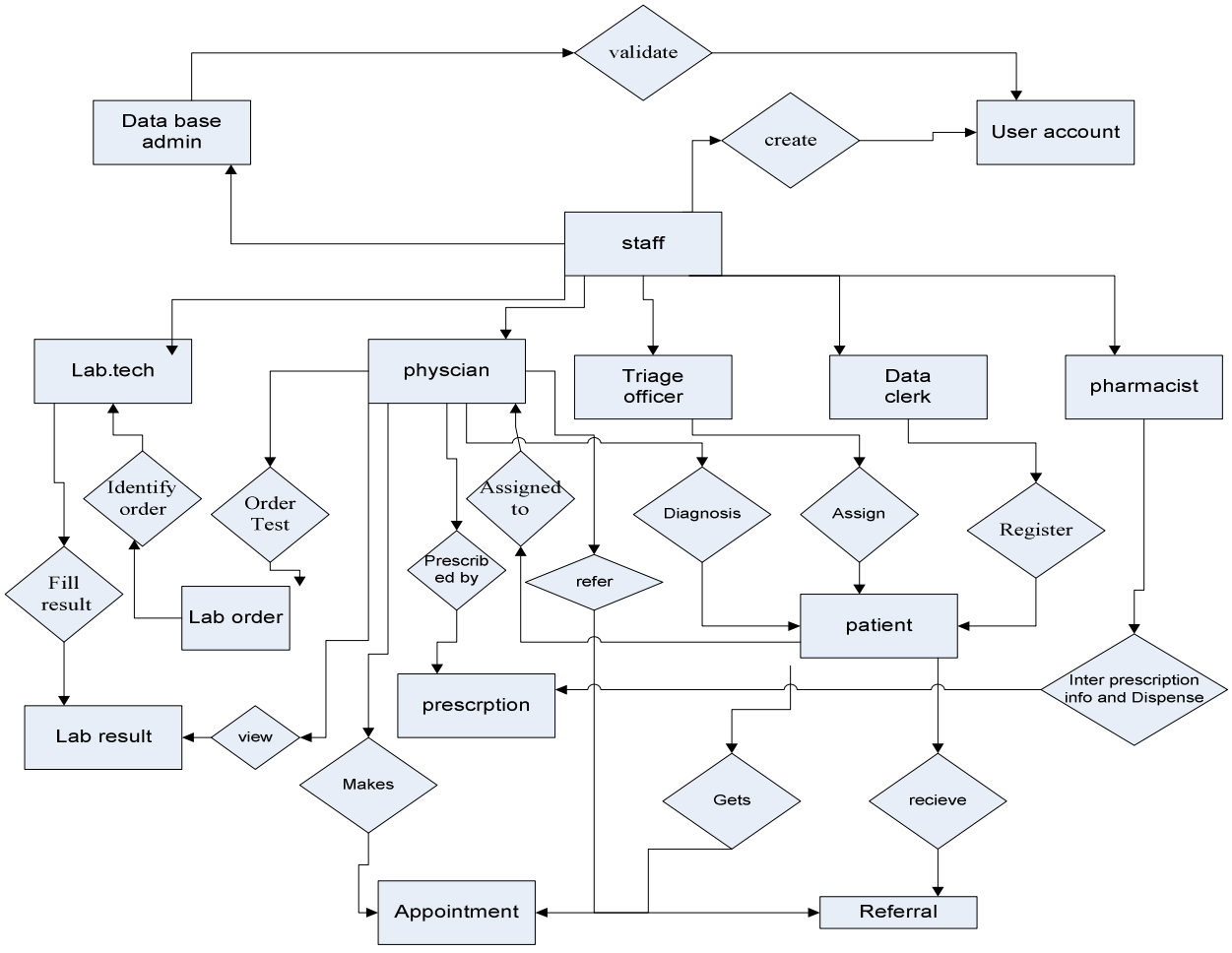

Figure 5: Entity Relationship Diagram EMR for Amanuel Hospital

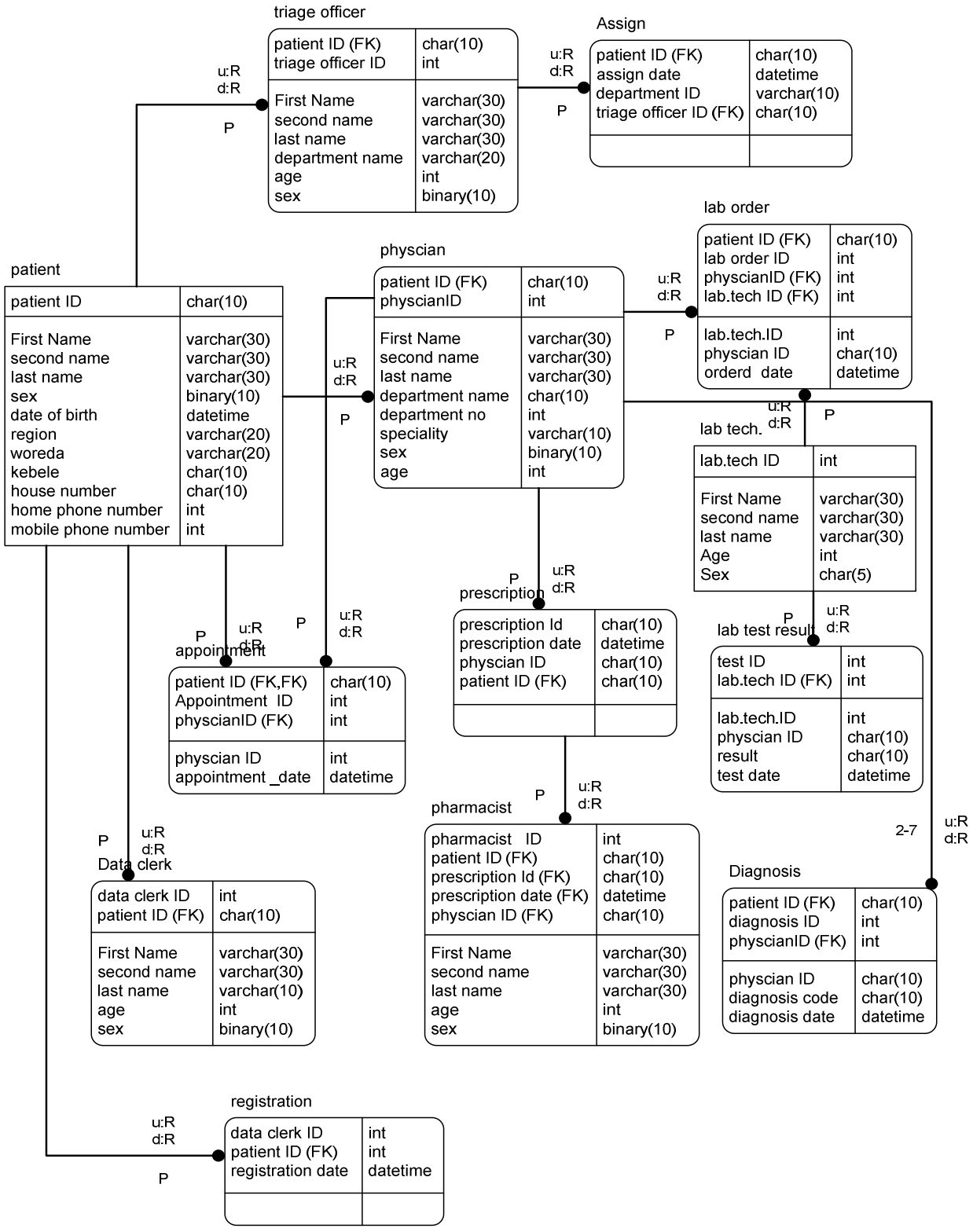

Figure 6: Data base Diagram of EMR for Amanuel Hospital

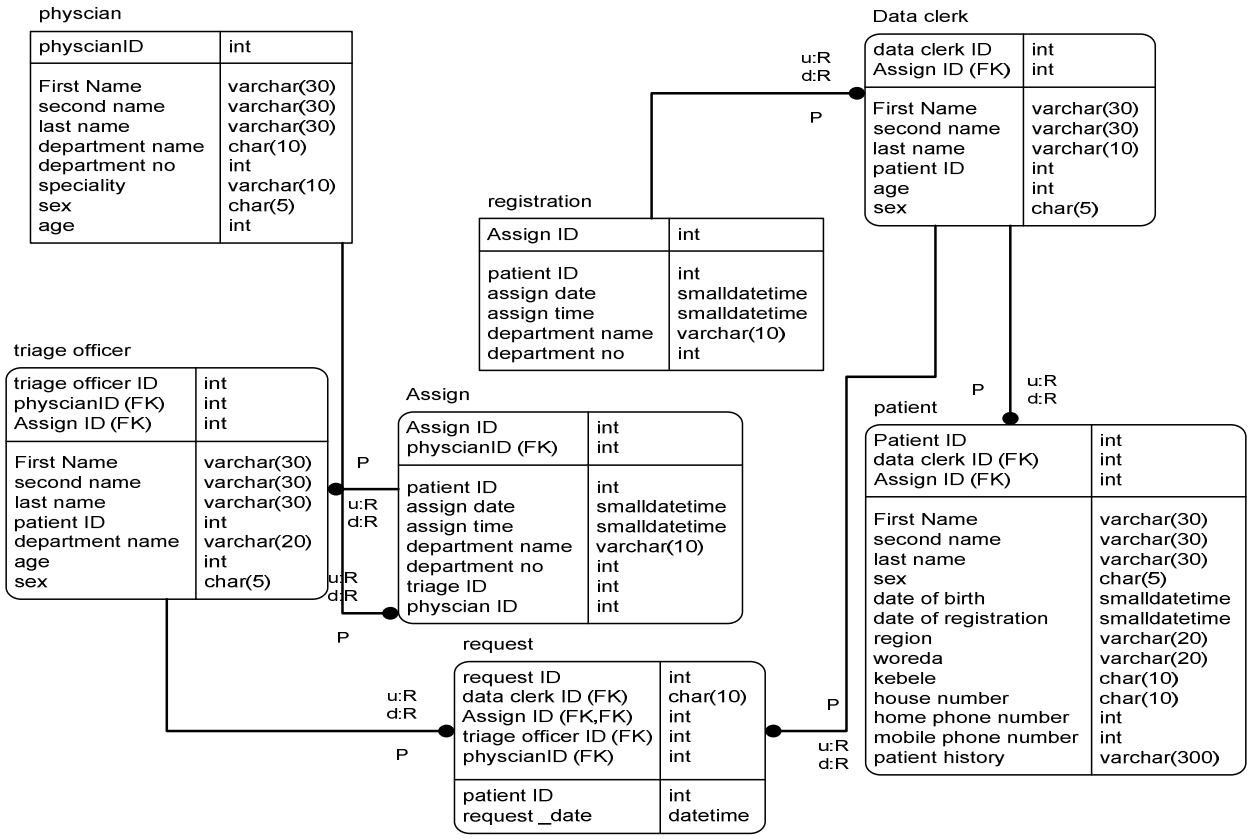

Figure 7: Data base Diagram of Registration and Assignation of Patient

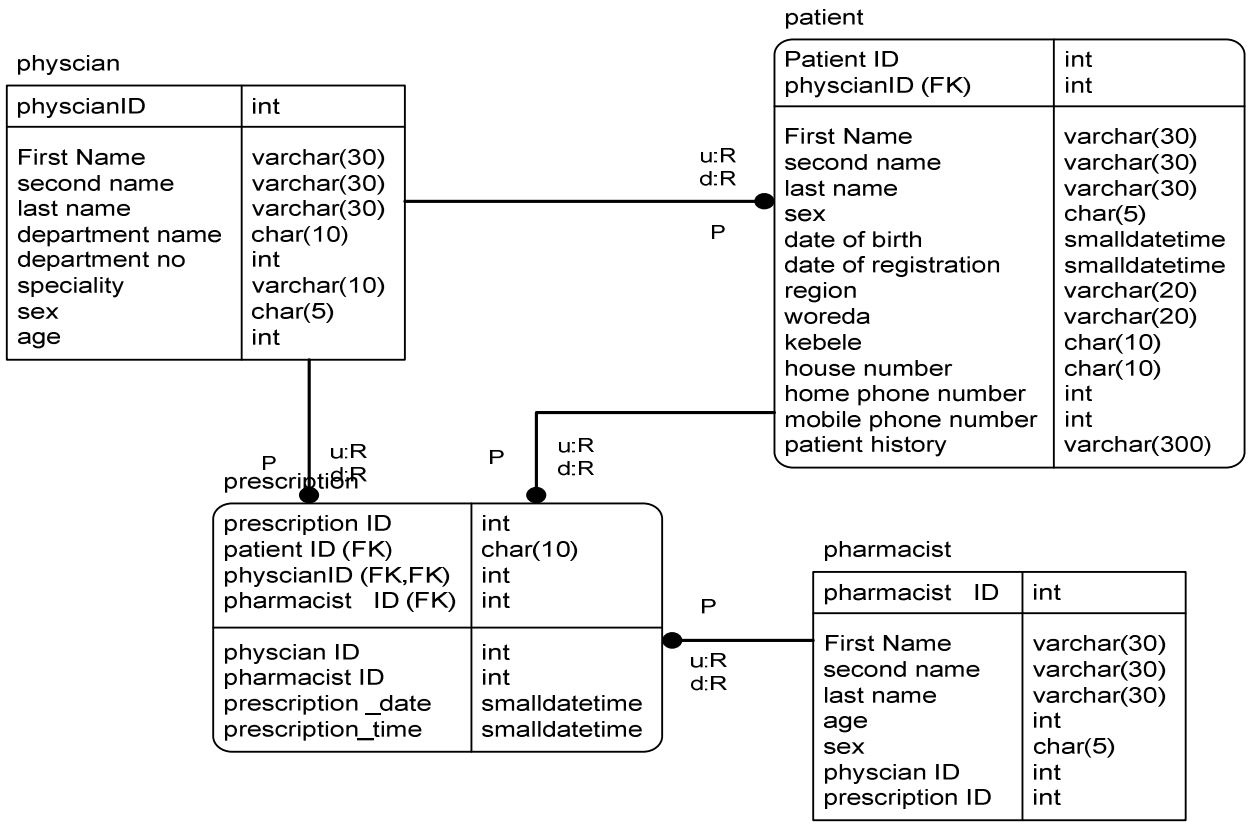

Figure 8: Data base Diagram of Physician and Pharmacy

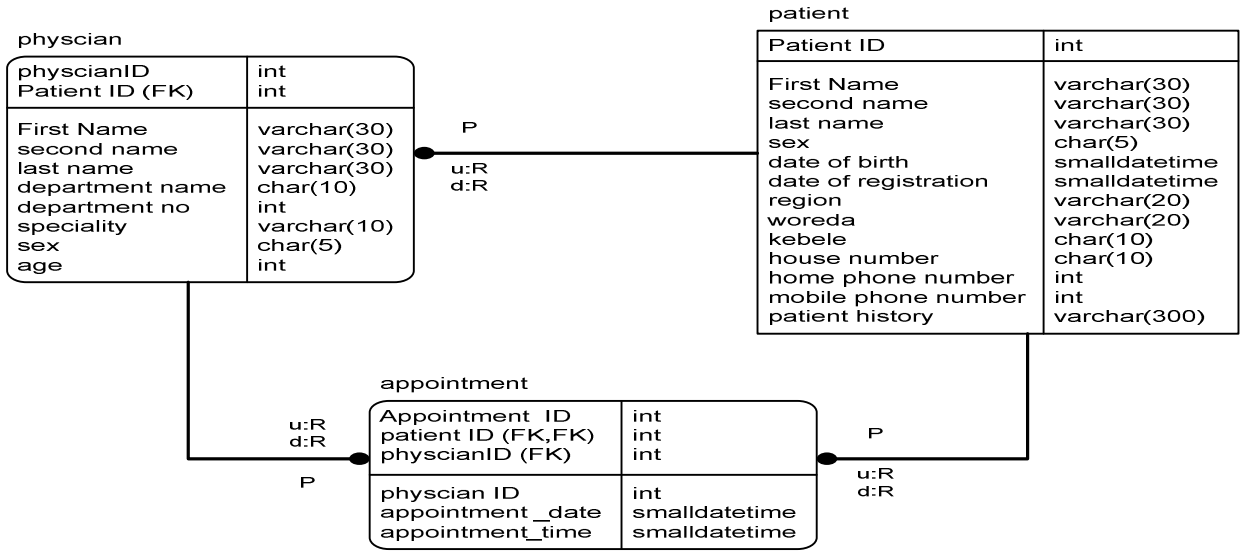

Figure 9: Data base Diagrams of Physician and Appointment

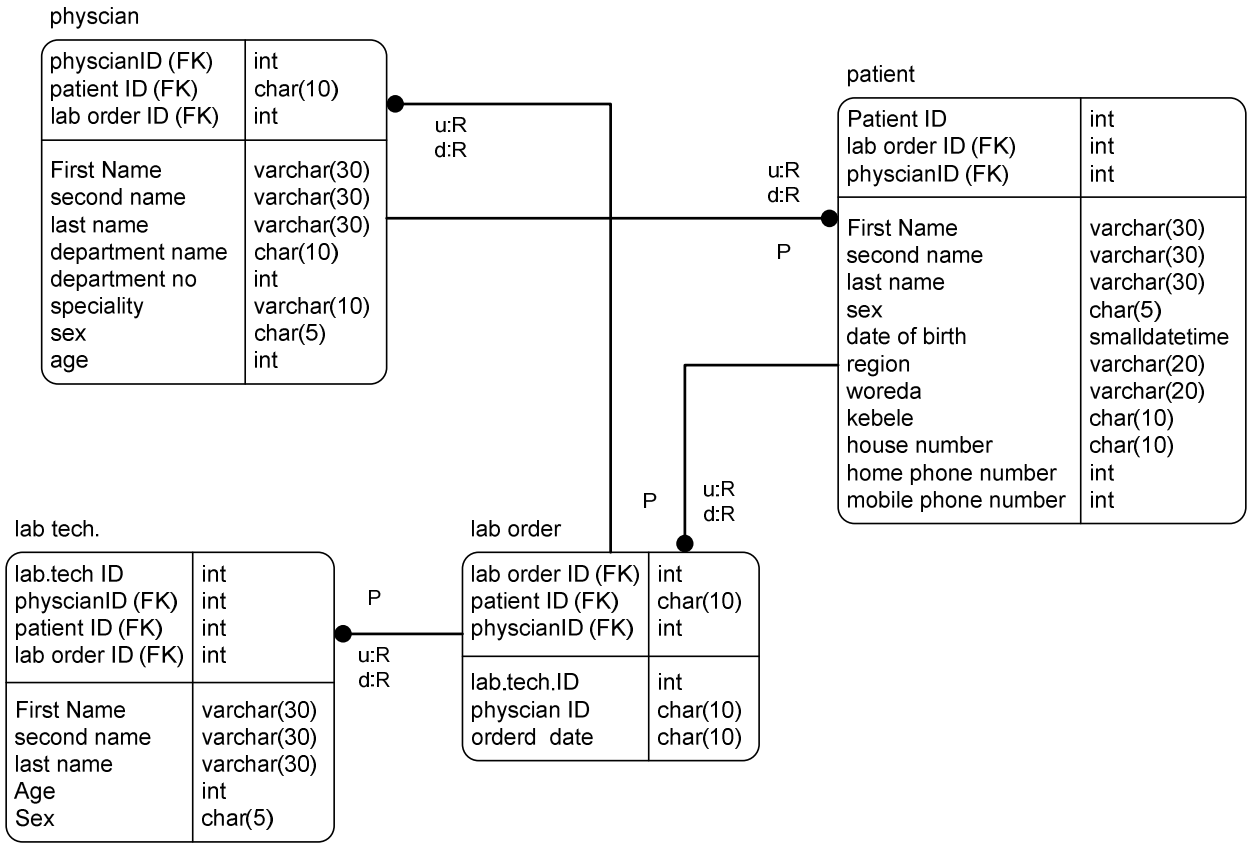

Figure 10: Data base Diagram of Physician and Laboratory Technician

4.4 User Interface

User interface is the part of the system with which the users interact. It includes the screen displays that provide navigation through the system, the screens and forms that capture data, and the reports that the system produces. The lists of user interfaces are presented below. The user interfaces screens are attached in Annex 2.

UI1.System Login Screen

UI2.Invalid Login Screen

UI3. Registration Menu Screen

UI4.New Patient Registration Screen

UI5.Existing patient Search Screen

UI6. Registration Report Screen

UI7. Triage Menu Screen

UI8. Triage Form Screen

UI9. List of Outpatient Departments Screen

UI10. Triage Report Screen

UI11.Outpatient department Menu Screen

UI12. Outpatient Department Screen

UI13.Diagnosis and Treatment Screen

UI14. Laboratory Order Screen

UI15. Medication Order screen

UI16. Appointment scheduling screen

UI17. Referral Screen

UI18.Laboratory Menu Screen

UI19. Laboratory Result Order Entry Screen

UI20. Pharmacy Menu Screen

UI21. Drug Prescription Screen

Chapter five

Conclusion and Recommendation

5.1 Conclusions

Since there are different factors that affect the quality of care, EMR is considered as one factor that improves the quality of health care. Currently Amanuel hospital uses paper based system. Therefore, it has problems associated with the giving quality of care and patient satisfaction. This project will contribute to better understanding of the use of EMR and solve the current problems.

The requirements of the new system were collected using data collection tools and techniques. the business process of the current system, functional and non functional requirement and system requirement were described. The analysis of the proposed system were analyzed using the analysis model (use case diagram and use case description) and process model (contextual and DFD). The data model of the system was presented using the Entity relationship diagram.

Most of the staffs didn't take training on basic computer skill and EMR system. The infrastructure of the hospital is difficult to run the system and the internet connection is good however most of time it is interrupted. The numbers of hardware are not enough to run the system.

The methodology used in this project was the structured analysis and design. The techniques used for analysis and design in this project were DFD, contextual diagram and ER diagram. Micro soft Visio 2003 was the tool used for the analysis and design of the system.

5.2 Recommendations

- The hospital may use this project report as an initial document for implementation as requirement.
- The hospital should incorporate the rest departments of the hospital (inpatient department, finance, human resource, HMIS) while implement the system, for full functionality of the hospital.
- The hospital should avail enough hardware and software in order to install the system.
- The hospital should provide training on basic computer skill and EMR system to its staff
- The hospital should recruit an IT professional to manage problems related to IT and EMR issues.
- The hospital should provide a better infrastructure to deploy the system.
- Developers and students may use this document for further improvement and implementation of the system.
- Developers and students may use additional tools and techniques as well as other methods, tools and techniques for the improvement and development of the system.

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Annexes

Annex 1: Entities with their attributes

Table 1: Patient attributes description

patient

patient ID	char(10)
First Name	varchar(30)
second name	varchar(30)
last name	varchar(30)
sex	binary(10)
date of birth	datetime
region	varchar(20)
woreda	varchar(20)
kebele	char(10)
house number	char(10)
home phone number	int
mobile phone number	int

Table 2: Data Clerk attributes description

Data clerk

data clerk ID	int
First Name	varchar(30)
second name	varchar(30)
last name	varchar(10)
patient ID	int
age	int
sex	binary(10)

Table 3: Request attributes description

request

request ID	int
patient ID	int
request _date	datetime

Table 4: Triage officer attributes description

triage officer

triage officer ID	int
First Name	varchar(30)
second name	varchar(30)
last name	varchar(30)
patient ID	int
age	int
sex	binary(10)

Table 5: Assign attributes description

Assign

Assign ID	int
patient ID	int
assign date	datetime
department name	varchar(10)
department no	int

Table 6: Physician attributes description

physcian

physcianID	int
First Name	varchar(30)
second name	varchar(30)
last name	varchar(30)
department name	char(10)
department no	int
speciality	varchar(10)
sex	binary(10)
age	int

Table 7: Diagnosis attributes description

Diagnosis

diagnosis code	int
diagnosis date	datetime
patient ID	int
physcian ID	int

Table 8: Lab test order attributes description

lab order

lab order ID	int
lab.tech.ID	int
physcian ID	int
patient ID	int
orderd date	datetime

Table 9: Laboratory technician attributes description

laboratory technician

lab.tech ID	int
First Name	varchar(30)
second name	varchar(30)
last name	varchar(30)
patient ID	int
Age	int
Sex	binary(10)

Table 10: Prescription attributes description

prescription

prescription ID	int
physcian ID	int
pharmacist ID	int
patient ID	int
prescription date	datetime

Table 11: Appointment attributes description

appointment

Appointment ID	int
patient ID	int
physcian ID	int
appointment _date	datetime

Table 12: Pharmacist attributes description

pharmacist

pharmacist ID	int
First Name	varchar(30)
second name	varchar(30)
last name	varchar(30)
age	int
sex	datetime

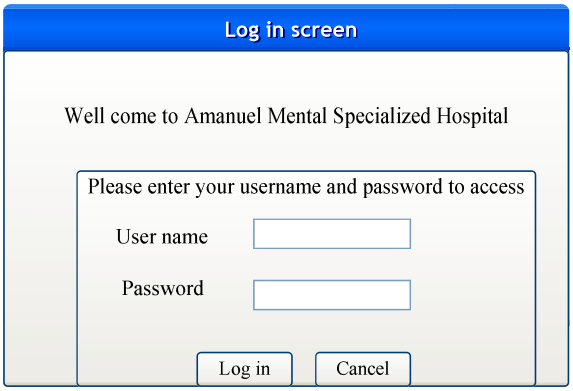
Table 13: Prescription detail attributes description

prescription detail

prescription ID	int
drug name	int
dose	int
strength	char(10)
brand	char(10)
frequency	char(10)
unit despence	char(10)

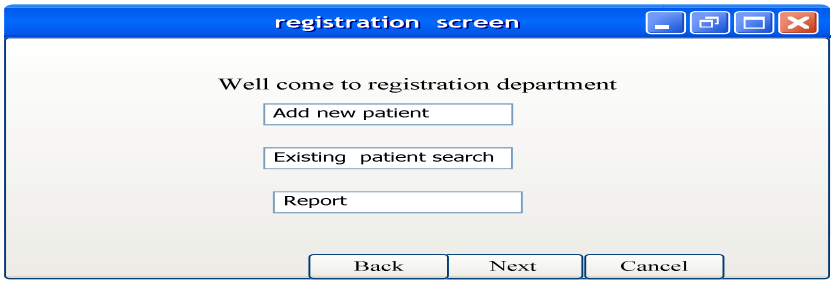
Annex 2: List of user Interfaces

UI1.System Login Screen

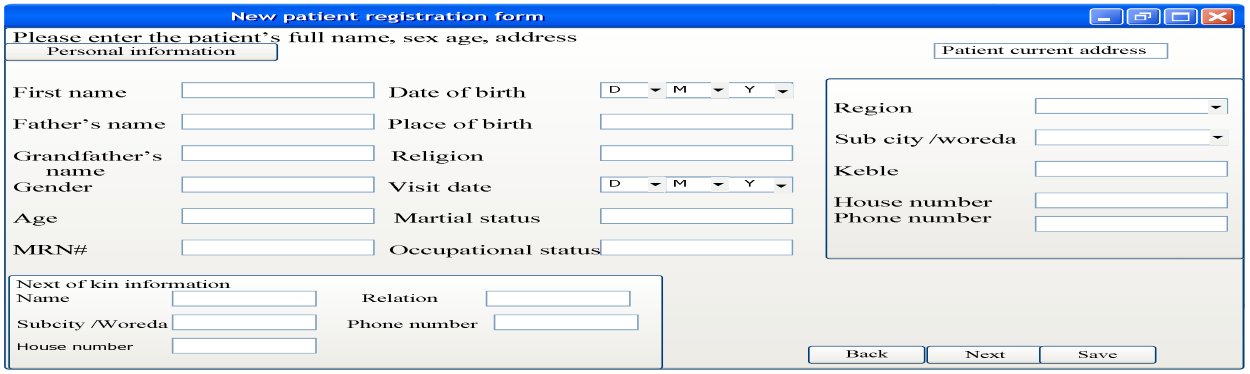


UI2.Invalid Login Screen

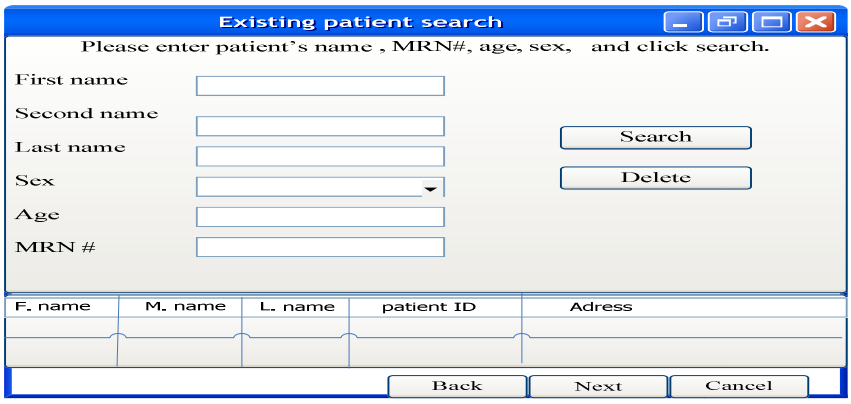
UI3. Registration Menu Screen



UI4.New Patient Registration Screen

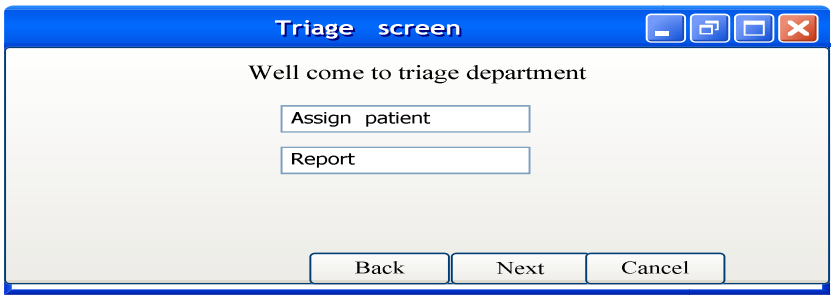


UI5.Existing patient Search Screen

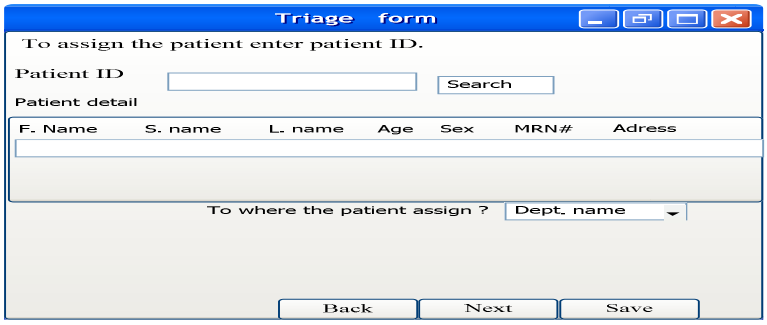


UI6. Registration Report Screen

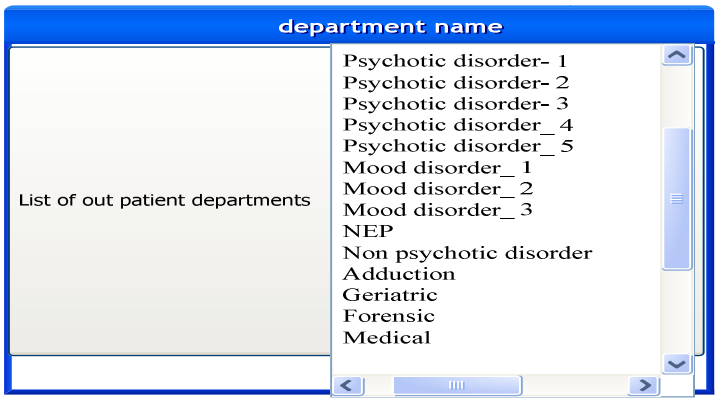
UI7. Triage Menu Screen



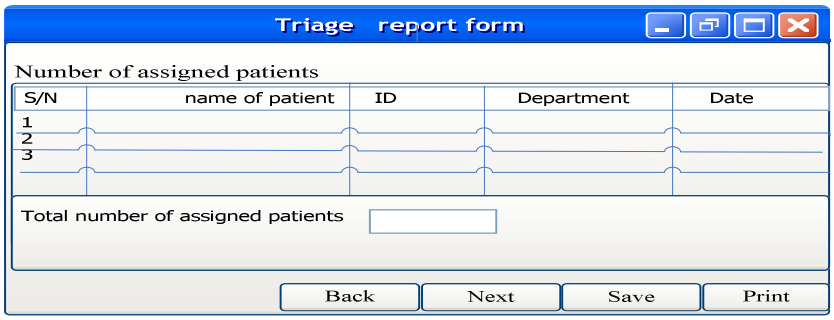
UI8. Triage Form Screen



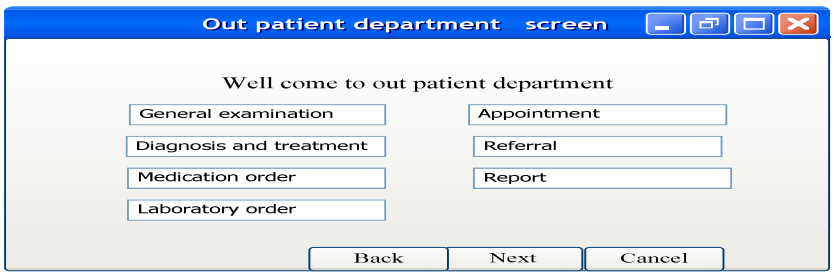
UI9. List of Outpatient departments Screen



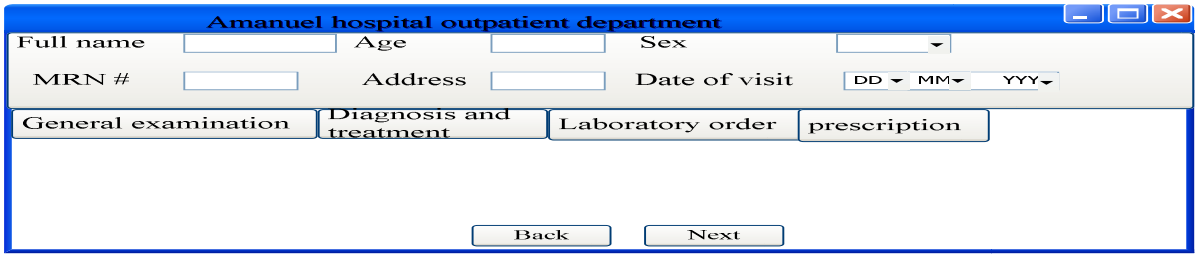
UI10. Triage Report Screen



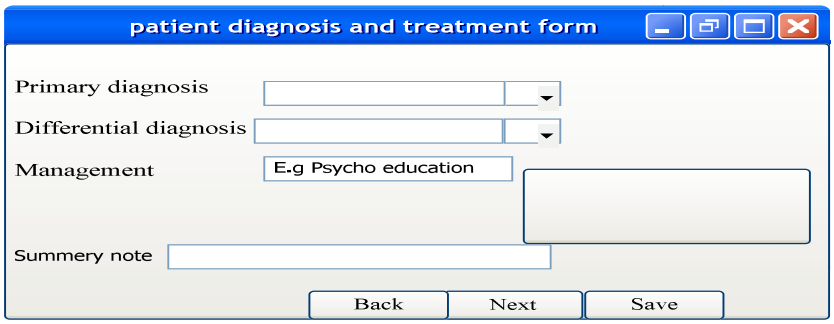
UI11.Outpatient department Menu Screen

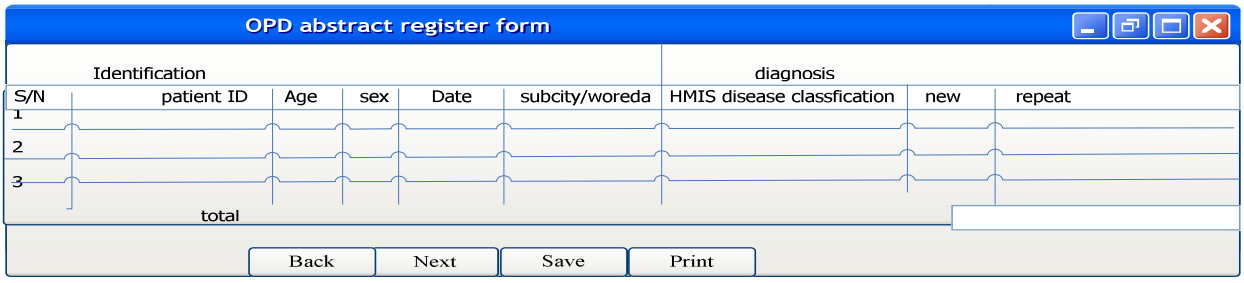


UI12. Outpatient Department Screen

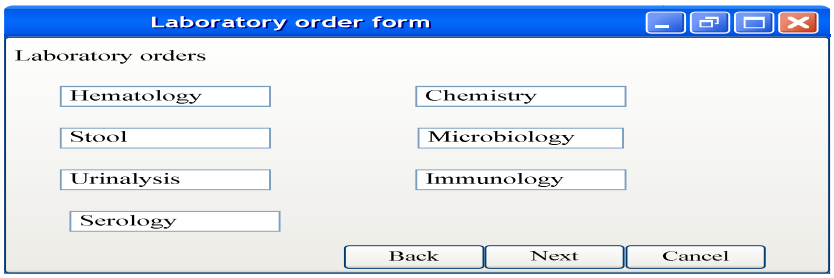


UI13.Diagnosis and Treatment Screen

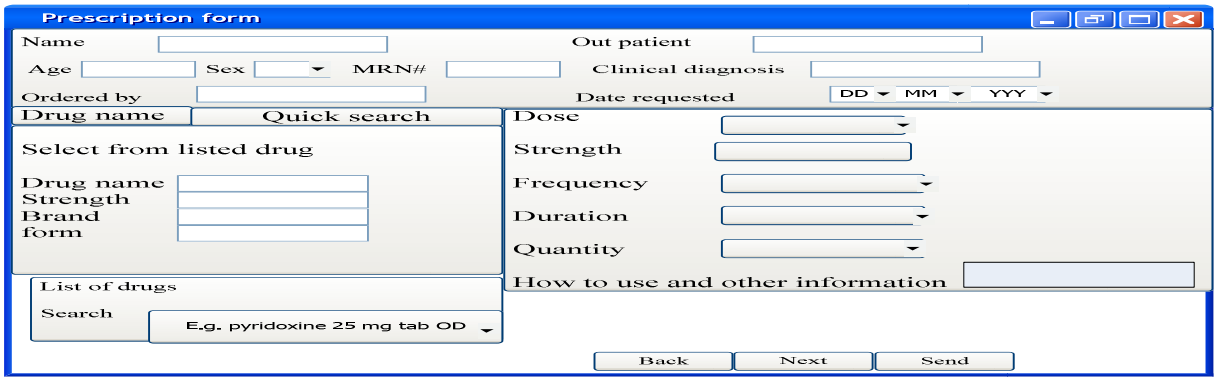




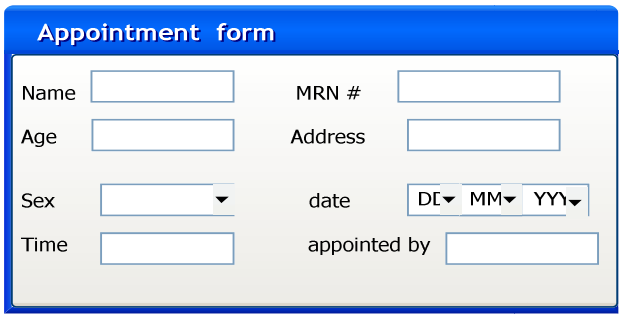
UI14. Laboratory Order Screen



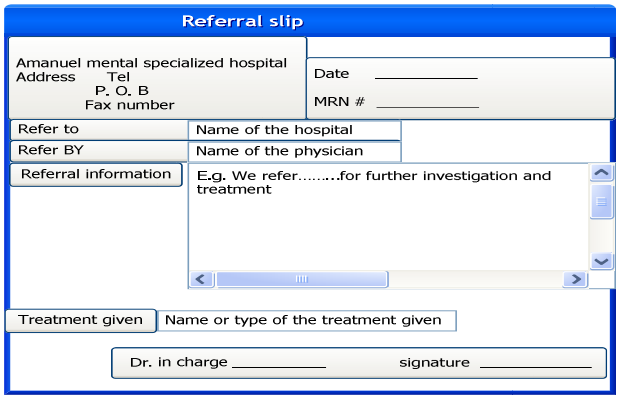
UI15. Medication Order screen

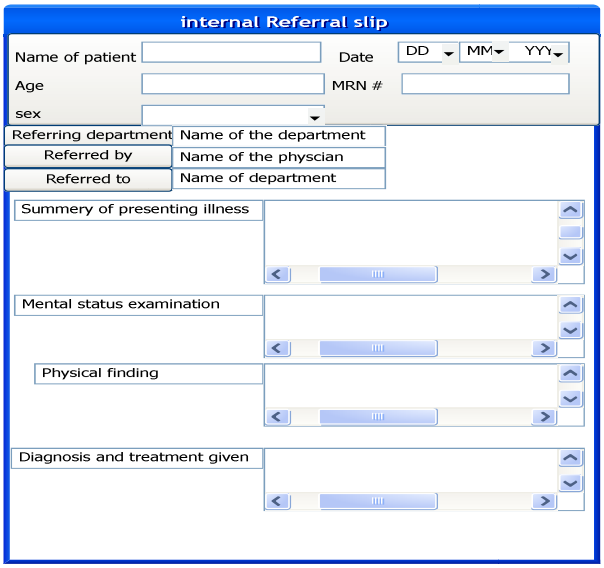


UI16. Appointment scheduling screen

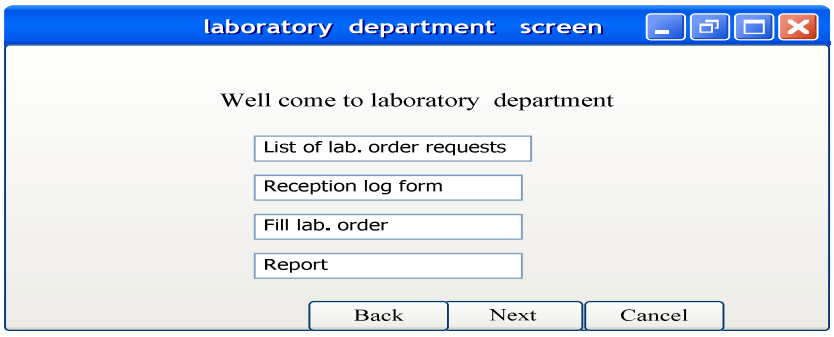


UI17. Referral Screen

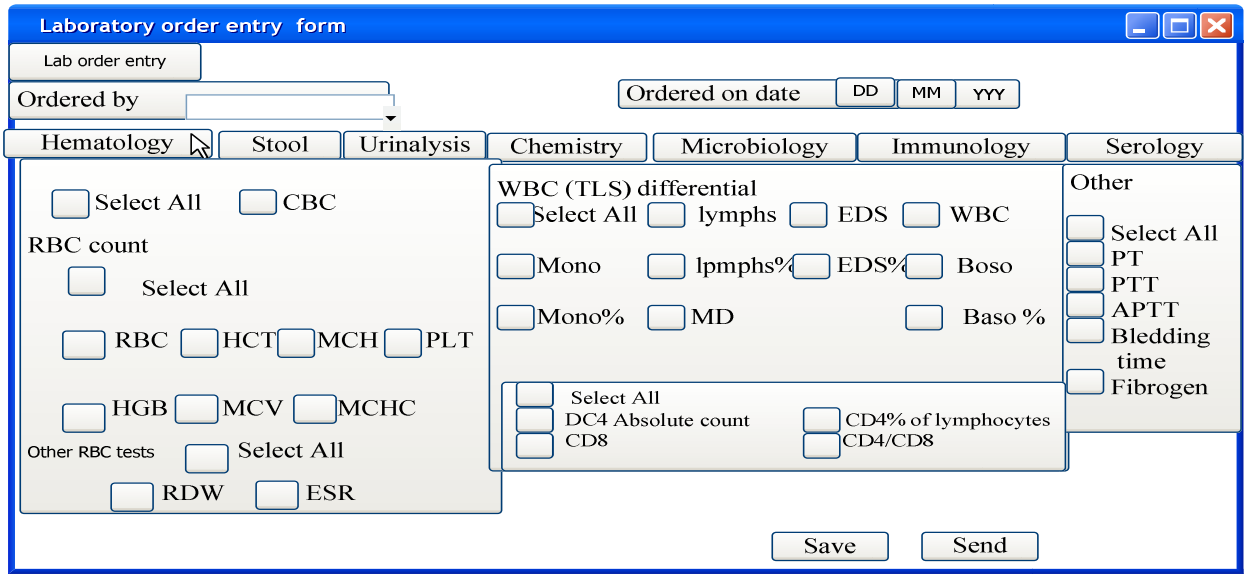




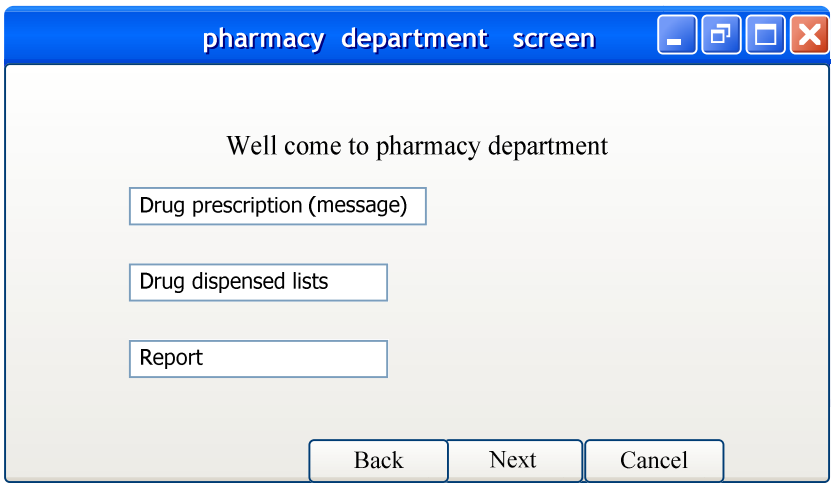
UI18.Laboratory Menu Screen



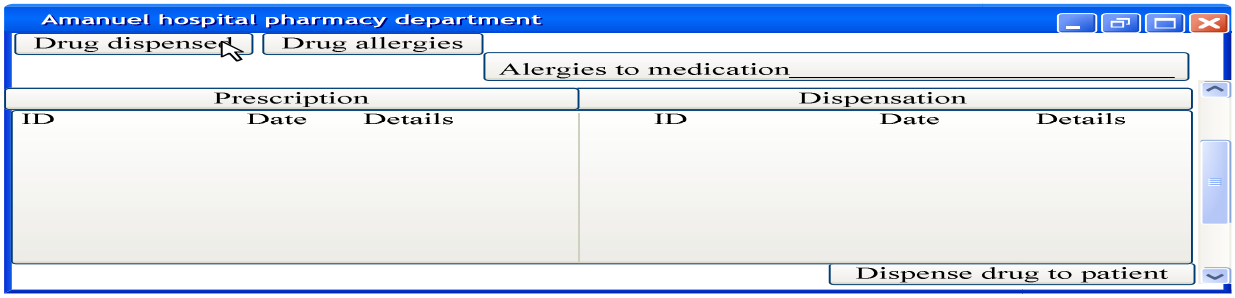
UI19. Laboratory Result Order Entry Screen



UI20. Pharmacy Menu Screen



UI21. Drug Prescription Screen



Annex 3: Interview guide and checklists

A. Interview Guide for Medical Directors and Chief Executive Officers

Recipients: Medical Directors and Chief Executive Officers

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

General Information:

Particular of Interviewee: _____

Responsibility**:** _____

1) Please describe your general opinion on the EMR program
   _____
   _____
2) What are the key drivers to apply an EMR in your institutions?
   _____
   _____
3) Please describe the resource available to run EMR program (human resources, infrastructure, finance)
   _____
   _____
4) Is a budget in place to provide reasonable coverage for EMR support services?
   _____
   _____
5) Do you have enough staff in place to implement, provide support for, and maintain the new EMR system?
   _____
   _____
6) What key operational changes would you like to see with the implementation of the EMR?
   _____
   _____

B. Interview Guide for User of EMR Program

Recipients: User of EMR program (Physicians, Health Officers, Nurses, etc…

General Information:

Particular of Interviewee: _____

Position/Responsibility**:** _____

Highest Academic Degree: _____

Age

Sex

1) How will your classify your general information technology knowledge and skills for EMR program use?
   _____
   _____
2) How do you evaluate an internet access and usage in your institution?
   _____
   _____
3) Do you think EMR program is helpful to your activities? Please describe
   _____
   _____
4) What are your experiences or concerns on the deployment of the EMR program?
   _____
   _____
5) Do healthcare professionals understand the benefits of an EMR and are they enthusiastic about using the new system?
   _____
   _____
6) Please provide your recommendations or suggestions on how to further improve the EMR?
   _____
   _____

C. Observation Guide for EMR Program

Recipients: Technology, Implementation, Process of EMR program

1) EMR Activities being carried out at Card Room and other Clinical Units

_____
_____

2) EMR technology deployed and used

_____
_____

3) EMR implementation process

_____
_____

4) Overall observation of the EMR program

_____
_____

D. Interview and data collection Guide for HIT technology

1) Infrastructure

1.1 Is there a power backup generator in the facility?

Yes [ ] No [ ]

_____

1.2 Is there a functional LAN/WAN in the facility?

Yes [ ] No [ ]

If yes describe

_____

1.3 Is there internet connection available in the facility?

Yes [ ] No [ ]

If yes describe the type and capacity.

2). is there IT professional availability in the hospital?

Yes [ ] No [ ]

If "No" what is the plan?

_____

3). Number of technical staffs

- #specialists
- # GPs
- #Health officers
- # Nurses
- # Psychiatry officers
- # Pharmacists and druggist
- # Lab technicians
- Others _____

4). Training towards computer skill and EMR system?

Have you take basic computer skill training?

Yes [ ] No [ ]

If yes what type of training did you take and for how long?

Type of training	**Duration**					
	< 3months	3 months	6 months	1 year	> 1 year	Other
Word						
Excel						
Spreadsheet						
Power point						
Microsoft Access						
EMR						

E. Inventory sheet for the types of hardware and software

1. Type and the purpose of Software in the department

	Name of the software	Purpose of the software	Type of the software	
			Computer based	Server based
Software's				

2. Type and purpose of hardware

Department Name _____

Items	Quantity	Brand and model	Processor	RAM (GB)	Hard disk (GB)	Network interface card /NIC	
						Yes	No
Computers							

Printers	Quantity	Brand and model	Type			Network card	
			Leaser jet	Dot matrix	Desk Jet	Yes	No

UPS	Quantity	Brand and model	Type		KVP
			Smart UPS	Back UPS	

Scanner	Quantity	Brand and model	Type	