ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JOINT PROGRAM OF INFORMATION SCIENCE AND SCHOOL OF PUBLIC HEALTH

ASSESSEMENT AND DEVELOPMENT OF RADIOLOGICAL RECORD SYSTEM: THE CASE OF BETHEL TEACHING GENERAL HOSPITAL

BY

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SIGNATURE OF THE BOARD OF EXAMINERS FOR APPROVAL

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DEDICATION

To Holy Trinity

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ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
CBPRS	Computer Based Patient Record System
CPR	Computer Based Patient Record
CT	Computed Tomography
ECG	Echocardiograph
EEG	Echoencephalograph
EHR	Electronic Health Record
EKG	Electrocardiogram
EMG	Electromiogram
EMR	Electronic Medical Record
EPR	Electronic Patient Record
ICT	Information and Communication Technology
IT	Information Technology
IVU	Intra Venous Urography
MMRS	The Mosoriot Medical Record System
MRHC	Mosoriot Rural Health Centre
MRI	Magnetic Resonance Imaging Technology
MS Word	Microsoft Word
NCQA	National Center Quality of Assurance
O-O	Object-oriented approach
PACS	Picture Archival and Communications System
PHR	Patient Held Record
ROI	Return On Investment
SDE	Structured Data Entry
UML	Unified Modelling Language
USG	Ultrasonography

ABSTRACT

The initial idea of the study is to assess and develop the radiological record system of Bethel Teaching General Hospital. The existing record keeping system of MRI department is manual, which has its own limitations. Based on these limitations, an electronic radiological record system is developed and implemented at the hospital.

The record system of MRI department of the hospital is assessed before and after the implementation of the radiological record system. And within the department the service provider, data clerk/radiologist and patients are included in the study to see the effects brought by the radiological record system in service delivery. Report preparation time of MRI, Ultrasound, IVU and Mammography examinations are investigated before and after the system implementation. Furthermore patients' feelings of the record system are described before and after the system implementation.

There is a significant mean time difference ($\bar{d}$ =1.887) for MRI report (p-value=0.000), ($\bar{d}$ =1.300) for Ultrasound report (p-value=0.000), ($\bar{d}$ =0.725) for reports of IVU and Mammography (p-value=0.000) before and after a system implementation. Therefore the result of the study showed that MRI, Ultrasound, IVU and Mammography report preparation mean time is shorter after the system implementation than before. But based on the response of patients the new radiological system didn't improve their waiting time to get MRI, Ultrasound, IVU and Mammography reports.

The radiological record system improved report preparation mean time. And also it is helpful in preparation of summary reports on daily, weekly, monthly, semi-annual and annual basis. Furthermore the system has the capacity to store long time patient data. In that case patient data could be used for education and epidemiological research purposes.

CHAPTER ONE

INTRODUCTION

1.1 Background

1.1.1 Bethel Hospital

Bethel Teaching General Hospital has become operational in February 2000. The hospital is located at north western part of Addis Ababa. The Hospital is currently providing its health care service 24 hrs a day both at out-patient and in-patient level. Basically the following departments are available at the hospital:-

- Surgery
- Internal Medicine
- Gynacology- Obstetrics
- Pediatrics and
- Diagnostic

Under the diagnostic service, there are Laboratory and Imaging services. The imaging service is offered under the MRI department. The use of magnetic resonance scanners in medical diagnosis is limited substantially by their cost. The systems require intrinsically expensive apparatus and high performance computers to create images. Owing to their size and weight they may require to be sited in special rooms which can tolerate the high mechanical loads imposed. They do, however, provide images of a previously unobtainable quality as they rely on a physical process which is not accessible to other imaging modalities.

MRI is a sophisticated form of diagnostic imaging that uses magnetism, radio waves and computer technology to produce very clear pictures (images) of the body, without using radiation. MRI offers a painless, non-invasive way to obtain information about your body that can lead to early detection and treatment of disease and injury.

The images produced by MRI are able to show tissue, organs, ligaments, tendons, bones, blood vessels and other body structures with greater clarity than other imaging methods. MRI is safe, comfortable and painless. With MRI, there is no ionizing radiation, and no known harmful side effects. For certain studies, an injection of a contrast agent may be necessary to better visualize specific anatomical structures.

Diagnostic imaging tests, such as CT and MRI, are essential elements in the medical process of diagnosis, treatment planning and follow-up, and account for rising costs in health systems. Due to their high costs, these new technologies have created medical-economic dilemmas within the health system in relation to their just and appropriate utilization. MRI machine which is found in Bethel Teaching General Hospital is unique in the country (become operational in January 2006). Because of these reason patients from different departments in the hospital, other health institutions in Addis Ababa and all over the country get MRI services from this hospital.

MRI specializes in creating a thin-section image of any part of the body. Also it provides the most detailed images of the brain and is safer than imaging methods that use X-ray. List of examinations which are given in MRI department of Bethel teaching general hospital are: Brain exam, Brain Angiography, MRI of Temporo-Mandibular joint, MRI of Orbits, MRI of Cervical spine, MRI of Dorsal spine, MRI of L.spine , MRI of Chest, MRI of Neck, MRI of Abdomen, MRCP(exam for bilary system without contrast), MRU(Urography without contrast), MRA of kidney(Angiography of kidney without contrast), MRA of Aorta(without contrast), MRA of peripheral arteries above knee(without contrast), MRI of Pelvis, MRI of Hip joints, MRI of knee joints, MRI of Ankle joint, MRI of Shoulder joint, and other Muskulo skeletal parts.

Furthermore services like: - Ultrasound, Mammography and IVU are offered in MRI department. Ultrasound is a modern imaging modality that uses acoustic energy reflected from interfaces within the human body. In clinical practice ultrasound is commonly used in evaluation of abdominal and pelvic organs, small parts of the body such as thyroid gland and peripheral vessels. Obstetric ultrasound is also highly applicable during pregnancy to assess the fetus. Ultrasound scanning and reporting is performed by the radiologist. Intra Venous Urography [IVU] is a diagnostic modality where clients are given intra venous iodine containing solution and X-ray taken at intervals to detect different abnormalities. It is useful to evaluate the urinary system mainly the kidneys, ureters and the urinary bladder. Mammography is a diagnostic means which uses X-ray to detect breast abnormalities in women having various breast problems such as pain or swelling. It is also done as screening tool to detect breast cancer in high risk women. Both IVU and Mammography are done by the X- ray technologist. Whereas image interpretation and reporting are done by the radiologist.

1.1.2 Information Technology and Health Care

Information Technology has the potential to improve the quality, safety, and efficiency of health care. Diffusion of Information Technology [IT] in health care is generally low (varying, however, with the application and setting) but surveys indicate that providers plan to increase their investments. Drivers of investment in IT include the promise of quality and efficiency gains. Barriers include the cost and complexity of IT implementation, which often necessitates significant work process and cultural changes. Certain characteristics of the health care market including payment policies that reward volume rather than quality, and a fragmented delivery system can also pose barriers to IT adoption.

Given IT's potential, both the private and public sectors have engaged in numerous efforts to promote its use within and across health care settings. Additional steps could include financial incentives (e.g., payment policy or

loans) and expanded efforts to standardize records formats, nomenclature, and communication protocols to enhance interoperability. However, any policy to stimulate further investment must be carefully considered because of the possibility of unintended consequences. Delivering quality health care requires providers and patients to integrate complex information from many different sources. Thus, increasing the ability of physicians, nurses, clinical technicians, and others to readily access and use the right information about their patients should improve care. The ability for patients to obtain information to better manage their condition and to communicate with the health system could also improve the efficiency and quality of care. This potential to improve care makes broader diffusion of IT desirable.

In general, IT allows health care providers to collect, store, retrieve, and transfer information electronically. However, more specific discussion of IT in health care is challenging due to the lack of precise definitions, the volume of applications, and a rapid pace of change in technology [26].

1.2 Statement of the Problem and Its Importance

Several weaknesses of paper-based medical records have been identified, such as illegible handwriting, ambiguous and incomplete data, data fragmentation, and poor availability. In addition, paper records often become bulky with time, which leads to lack of overview. Because paper records still represent the usual medium for collecting and recording patient data, these weaknesses could impede the continuity and quality of health care.

MRI department of Bethel Teaching General Hospital uses paper based medical records of the following examinations: - MRI, IVU, Mammography and Ultrasound. Patients who are consigned to MRI department of the hospital registered using registry book. The registry book is used for data entry of patients. Whether the examination type is MRI, IVU, Mammography or Ultrasound, all are registered in the same registry book. And this contributes for inefficient access of patient records. Also the registry book doesn't show a particular case type explicitly. Even it doesn't show the

workload of the radiologist. Specifically the record keeping mechanism of MRI department is manual. In these case problems like; searching and retrieval of patient data becomes inefficient, patient data get lost, long time patient data becomes unavailable due to lack of structured data storage system, preparation of daily, weekly, monthly, quarterly, semi-annual and annual reports become difficult. Furthermore, the manual system doesn't have any security feature for protection of patient data. The manual system is often time consuming for payment cross-checking (Cross checking patients' payment of image in finance department with that of image taken at MRI department).

The report generated in MRI department doesn't show the pattern of examinations like MRI, IVU, Mammography and Ultrasound. Also the report doesn't show which MRI case is prevalent, and there is no report which shows from which health institutions the majority of patients are coming. The numbers of different cases are even unknown in a given period of time.

The record system which they have at current moment doesn't allow research to be conducted because of unavailability of long time patient data. Furthermore, the record system doesn't serve for education purposes due to the fact that the required data can not be found easily in the system. The existing record system doesn't support the documentation of patient history and this in turn affects follow up of patients and the quality of health care services given in the institution.

Therefore based on the limitations of the existing record system of MRI department, this study will try to answer the following research questions:

- Is the existing record system of MRI department satisfactory?
- Does the service delivery of MRI department of Bethel Teaching General Hospital improved by the introduction of the new system?

The record system of MRI department assessed from the view point of radiologist/data clerk, the service provider and patients [Annex 5]. Using computers facilitate information handling, evaluation of health care services, allocating resources. For physicians computer based health care system supports patient diagnosis by providing patients medical history. Computer based health care system also used for the management as a decision support to make plans and setting objectives. There is also a possibility of identification of the most prevalent MRI cases, including the distribution of Ultrasound, IVU and Mammography cases.

1.3 Objectives of the Research

1.3.1 General Objective

The general objective of this study is to assess and develop radiological record system of Bethel Teaching General Hospital.

1.3.2 Specific Objectives

- To assess the existing record system of MRI department
- To develop a radiological record system for MRI department
- To assess service delivery of MRI department after the new system
- To forward recommendation for further studies

1.4 Scope

Patients from referral hospitals, inpatient and outpatient departments of the hospital are the main sources of MRI department. The study is to assess and develop the record system of MRI department of Bethel Teaching General Hospital. Mainly it focuses to automate the report generated by the radiologist. And also it is concerned with the identification of the most prevalent MRI cases, including the distribution of IVU, Mammography and Ultrasound cases.

1.5 Significance of the Study

The new system will enhance the efficiency of MRI department record keeping method. The existing manual system is poor: - in searching patient data, generating daily, weekly, monthly and annual reports, conducting research and use of information for education purposes. The new system might solve the above problems and could contribute its own part in building an effective healthcare system. Since MRI technology which is found in Bethel Teaching General Hospital is unique in Ethiopia, all MRI cases are seen particularly in MRI department of the hospital. And by the help of the new system it is possible to predict the most prevalent MRI case, including Ultrasound,IVU and Mammography cases' distribution by region/institution, financial analysis of MRI department and follow up of patients. Also the new system is helpful for researchers seeking patient data because the data is stored in structured repository i.e. searching and retrieval of patient data is easy. Also the new system facilitates teaching learning activities by providing clinical data for medical students. The new system will serve as a decision support for management of the hospital in improving health care of patients.

1.6 Organization of the Thesis

There are five chapters in this thesis. The first chapter is an introduction part which contains:-background of the research work, statement of the problem, objectives of the research, scope and significance of the study. And the second chapter is literature review part which covers:-health care information system in different countries context, strength and criticism of paper based patient records, advantage of CPR, potential advantage of CBPR over paper based records, potential disadvantage of computerization of records and radiological record system. The third chapter covers research methodology part which incorporates:-system development methodology and epidemiological methods. The fourth chapter covers analysis and discussion of results. Finally the fifth chapter contains concluding remarks and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Information technology is a critical resource for improving today's business competitiveness. IT is transforming and redefining the ways companies do business. However, many healthcare providers do not proactively manage or improve the efficiency and effectiveness of their services with redesign of their processes using IT. Survival in a competitive business environment demands continuous improvements in quality and service, while rigorously maintaining core values.

2.2 Definitions

Electronic Health Record [EHR] according to [15] is defined as a repository of information regarding the health status of a subject of care, in computer processable form. Also in Wikipedia an electronic health record defined as it is a distributed personal health record in digital format. The EHR provides secure, real-time, patient-centric information to aid clinical decision making by providing access to a patient's health information at the point of care. It may be made up of health information from many locations and/or sources, including electronic medical records. An EHR almost always includes information relating to the current and historical health, medical conditions and medical tests of its subject [11].

The other definition by Nazife Baykal [31] EHR is an electronic database of health care data about a person. This database contains a record of all health-related activities in which the person has been engaged and the health phenomena experienced by that person. Electronic Health Record System serves as the basis for Medical Informatics such as decision support systems, expert systems, and intelligent systems. EHR information collected from many sources including patients. But the major information fields of EHR are demographic data, medical history, physical condition, laboratory

results, treatment processes, prescriptions, progress information and medical images of the patient.

Shortliffe and Perreault defined Patient record and computer based patient record as follows:-A patient record is the repository of information about a single patient. This information is generated by health care professionals as a direct result of interaction with a patient or with individuals who have personal knowledge of the patient (or with both). Traditionally, patient records have been paper and have been used to store patient care data [43].

A Computer-based Patient Record [CPR] is an electronic patient record that resides in a system specifically designed to support users by providing accessibility to complete and accurate data, alerts, reminders, clinical decision support systems, links to medical knowledge, and other aids or it is a repository of electronically maintained information about an individual's lifetime health status and health care, stored such that it can serve the multiple legitimate users of the record. Computer-based patient record system: adds information management tools to provide clinical reminders and alerts, linkage with knowledge sources for healthcare decision support, and analysis of aggregate data [43].
Tange described Electronic Medical record, as "a repository of clinical data within one single healthcare enterprise that is characterized by direct data entry and integration from different sources." [46]

The CPR is an integration of patient information systems that captures and stores demographic, financial, and medical information from ancillary services such as registration, billing, lab, radiology, pathology, pharmacy, and transcription [21].

A patient record system is the set of components that form the mechanism by which patient records are created, used, stored, and retrieved. A patient record system is usually located within a health care provider setting. It includes people, data, rules and procedures, processing and storage devices

(e.g., paper and pen, hardware and software), and communication and support facilities [38].

According to Xiaoming Zeng the key conceptual difference between EMR and EHR is the owner and location of the record. Electronic medical records are included in a local clinical data repository used to support clinical operations. They are usually owned by an individual health care provider and are often accessible to the patients who are the customers of the health care provider. Electronic health records refer more to an overarching system based on information shared by individual care practitioners regardless of practitioner specialty, type of care (e.g, inpatient, ambulatory), or location of care. Electronic medical records are often practitioner-oriented while the EHR is patient-centric and supports coordinated care [50].

2.3 Health Care Information System

2.3.1 In USA and In Europe

In USA the health care information systems industry has shifted its attention from financial systems to clinical systems, particularly CPR systems. Also NCQA advised health plans to "move to fully implement the information framework, including the automated patient record" in order to meet the clinical reporting requirements of forthcoming regulations. Despite efforts in the public and private sectors, however, significant barriers impeded the development and use of CPR systems in the United States. Some of these barriers are:-

1. Informational
2. Organizational
3. Behavioural barriers

And these barriers overshadowed the technical barriers. For example some of the critical barriers are definition of the CPR, meeting user needs, standards, legal and social issues, costs and benefits, leadership and so on [30].

Since European countries health structures are similar, they succeeded in CPR development and use of CPRs, particularly in the primary care setting [47], [27]. Three developments related to CPRs in Europe deserve attention: - the use of CPRs in the primary care setting, in hospitals, and for shared care. Besides, the European Union plays an important role in area of standardization on a global scale [10]. Factors which account for the success of CPRs in Europe are:- Emphasizes primary health care and the health of the population. CPR development projects are ideal for the EU. The emerging focus on conceptual models that build upon rather than are driven by the technology. Challenges remain to be addressed like USA.

In the Netherlands, Elias was one of the systems that pioneered computer-based patient records in general practice. The computer-based patient record of Elias replaces the paper patient record; the only exceptions are non-textual data such as roentgenogram images. General practitioners use the computer-based patient record to retrieve, review, and record data during consultations; paper copies of the patient record are only produced for circumstances in which the computer is not available (for example, when making house calls) [49].

Possible reasons for the use of computer-based patient records include the nature of Dutch general practice and the early and active role of professional organizations in recognizing the potential of computer-stored patient records. Professional organizations issued guidelines for information systems in general practice, evaluated available systems, and provided postgraduate training that prepares physicians to use the systems [17].

2.3.2 In Africa

The lack of a fast, efficient way to handle patient data has larger implications for differences in healthcare in Africa. “Africa is already lagging behind the developed world by decades,” Dr. Mwakatundu (director of diabetes program in Tanzania) explains, “The efficient methods of communication available in countries abroad allow them to conduct insightful epidemiological and

public health research at a much faster pace. While we wait for an infrastructure to slowly build, the gap will continue to grow very quickly." [2]

There are technological and non technological barriers which affect CPRs. Since the current system don't support the complete CPR, it has it's own technological barrier. And non technological barriers include loss of participation among interested groups.

2.3.3 In Ethiopia

As it is explained the previous section, Ethiopia is also among the African countries which are behind the technological development in this regard, health care information system. Paper-based medical record has been in use in Ethiopia. Studies recommend that the intervention of ICT in Ethiopia in the health sector in general and an electronic patient record system in particular [33]. But these days there is a predisposition and progress towards disseminating health care information system. It is evident that the first and foremost imperative goal of the masters' program in health Informatics is to conquer the problems in the area.

2.4 Strengths and Criticism of Paper based Patient Records

2.4.1 The strength

The following are some of the strengths of paper based patient records

1. Paper records are familiar to users who consequently do not need to acquire new skills or behaviors to use them.
2. Paper records are portable and can be carried to the point of care.
3. Once in hand, paper records do not experience downtime as computer systems do.
4. Paper records allow flexibility in recording data and are able to record "soft" (i.e., subjective) data easily.
5. Paper records can be browsed through and scanned (if they are not too large). This feature allows users to organize data in various ways and to look for patterns or trends that are not explicitly stated [38].

2.4.2 The Criticism

Criticism of current patient records is sometimes sharp. Burnum states that "medical records, which have long been faulty, contain more distorted, deleted, and misleading information than ever before" [5]. Whereas Pories relates the story of an engineer who was asked to recommend more efficient use of health care personnel but who instead was "stunned by the disorganization of the medical record and the inefficiencies it imposed on the delivery of care." The engineer concluded that "the redesign of the record offered the most immediate and simple approach for medical cost control and for prevention of malpractice". Pories believes that this situation has not improved and that it is not isolated. "No one has a monopoly on the problem: medical records appear to be equally bad and dangerous throughout the land"[35]. He is not alone in his view that patient records often lack the features needed for their most beneficial use. In a recent survey of internists in academic and private practice, 63% of the respondents agreed with the statement that patient records are becoming increasingly burdensome without improving the quality of patient care [6].

Several weaknesses of paper-based medical records have been identified, among these:-

1. Illegible handwriting
2. ambiguous and incomplete data
3. data fragmentation
4. poor availability
5. It is also one problem that paper records often become bulky with time, which leads to lack of overview. Because paper records still represent the usual medium for collecting and recording patient data, these weaknesses could impede the continuity and quality of care [18].

Furthermore Nazife Baykal [31] mentioned a number of problems related to paper based medical records. Some of them are:-

- Paper files can only be in one location at a time
- Sometimes Paper files cannot be found at all
- Handwriting may be poor and illegible
- data may be missing
- notes may be too ambiguous to allow proper interpretation
- The record cannot actively draw the care provider's attention to abnormal laboratory values, and allergies of patients.

Due to the fact that the information gathered by the nurses and doctors, who are managing the patient's trajectory [25],[40], would no longer be 'imprisoned' in the immutable paper pages of the traditional record, many additional users could draw upon this information. The Council on Scientific Affairs of the American Medical Association, for example, states that "users [of the record] can be grouped into seven categories: providers, patients, educators, researchers, payers, managers and reviewers, and licensing and accrediting agencies and professional associations" [7]. All such users desire more detailed, more timely, and more comprehensive information about the inner workings of health care, and all have high expectations for what the EPR could bring them [28].

Implementation of electronic medical record systems promises significant advances in the quality of patient care, because such systems may enhance readability, availability, and data quality [1].

2.5 Advantages of CPR

EHR is vital to control cost, improving quality of care and enhancing efficiency of health care. Most of these benefits are at patient level. Also EHR has its own benefits to health policy makers at a system level [50]. The advocates of EHRs believe they are integral to controlling the cost, improving the quality, and increasing the efficiency of health care. These benefits are largely at the direct patient care level. There also are important benefits to health policy makers at a system level. The benefits associated with CPRs

are organized into four categories: clinical, workflow, administrative, and revenue enhancement. Renner states that measuring all the benefits associated with CPRs is virtually impossible, and that it is probably safe to select those that can make the greatest financial difference, and incorporate them into a financial model [37]. CPR is used widely today in hospitals, nursing facilities, home healthcare, clinics, laboratory facilities, treatment centers, and physician offices. Some advantages of CPR include:

1. It is convenient.
2. It facilitates remote access.
3. The information is more organized and easier to read compared to paper patient record.
4. It allows simultaneous access.
5. It improves the efficiency of processes such as data collection, data management and data retrieval.

Furthermore according Bemmel et al. CPR has the following advantages:-

- **Legibility:** documentation in a CPR is more legible because it is recorded as printed text rather than as hand writing, and it is better organized because software display structure is imposed on the input.
- **Support of structured data entry:** this usually results in collection of more reliable and more complete data. The design of the structured data input interface plays a major role in a successful implementation of structured data entry.
- **Decision support:** CPRs commonly supports both decisions related to the diagnosis of a disease on the basis of individual data, and decision related to the therapy on the basis of the available data evidence.
- **Electronic data exchange and sharing care support:** as the patient care is becoming more distributed among multidisciplinary health care professionals, communication and exchange of patient data that are attached electronically to the CPR is becoming an essential part of health delivery systems.

- **Support to Clinical Epidemiological Research:** CPR systems are used in epidemiological researches in three ways. First, as a sampling tool, where patients are selected from a trial population using the existing database. Second, as a data collection tool, where certain specific clinical data of the selected sample need to be retrieved. Third, as a registration tool, when the CPR system has the capabilities to register data that are used for research project, it assists the researcher in professional data management [5].

Also CPR improves both the completeness of clinical documentation and documentations of clinical decisions [45]. CPR may improve compliance with recommended preventive services: the use of structured data entry in CPR results in statistically significant improvement in the documentation of key elements of health maintenance examinations [42]. Computer generated PHR, can facilitate information and responsibility sharing to improve patient decision making, and participation in health promotion, prevention and disease management [22].

Clinicians who used CPRs recognized two axioms: First, electronic access to clinical information saves time. Second, electronic access provides a thorough and efficient way to manage patient information. With CPR systems, comprehensive information can be located and presented in a way that is relevant to the task at hand [9]. The use of CBPRS increased satisfaction of users and patients was noted, which could lead to significant changes in medical practice [8].

Electronic Medical Records [EMRs] offer many potential advantages over traditional paper-based records. The primary benefit of using electronic records is access for authorized and authenticated users. EMRs allow providers to access health information from a variety of locations and to share that information more easily with other potential users. Multiple users may access the information simultaneously. When used to increase

communication among providers, EMRs can reduce the number of redundant queries and diagnostic tests and improve the availability of health-related information at the point of care delivery. EMRs also offer opportunities for improving security. With EMRs, access can be limited to just that portion of the record that is pertinent for the user. For example, a radiology file clerk might have access only to radiology reports of all patients, whereas a physician might be granted access to the entire record of his or her patients. In addition, EMRs can allow all instances of access to be recorded in audit logs so that there is a record of who saw what information at what time and date on which patients [29].

Implementation of electronic medical record systems promises significant advances in patient care, because such systems enhance readability, availability, and data quality. Structured Data Entry [SDE] applications can prompt for completeness, provide greater accuracy and better ordering for searching and retrieval, and permit validity checks for data quality monitoring, research, and especially decision support [18].

2.6 Potential Advantages of Computer-Based over Paper Based Records

The following are the very important and interesting advantages of computer-based records over paper based records.

- **Simultaneous, remote access:** more than one person can use the record at one time from any place.
- **Legibility:** on-screen or printed text is more legible than handwriting.
- **Data safety:** it is easy to make back-up copies.
- **Confidentiality:** record access can be restricted and monitored automatically; each user has specific levels of access.
- **Flexible layout:** data can be displayed in different layouts at different times.
- **Integration with other information sources:** patients' data held electronically can be accessed from the same work-station as reference material held locally or on the internet.

- **Data incorporation:** computers can accept and incorporate data directly from clinical monitors, laboratory analysers, and imaging devices.
- **Continuous data-processing:** data can be monitored as they are entered, unintended duplicate values eliminated, artefacts removed, and data actively summarized, interpreted, and charted.
- **Assisted search:** to find a specific data item, or to see whether it has ever been recorded, can take a fraction of the time and effort.
- **Greater range of output methods:** these include computer-generated voice, pager, or e-mail messages, automatic pill dispensers, flashing light or buzzer, and three-dimensional virtual display superimposed on surgeon's view [41].

2.7 Potential Disadvantages of Computerization of Records

It is also vital to see some of the basic difficulties in order to build a computer-based record system. These are:-

- **Need for structured, coded data:** data entry is slow, range of language and data items are restricted, clinical language is frozen; free text, images, and so on are poorly handled.
- **Temptation to "stamp collect":** infinite capacity means more searching, data dredging.
- **Layout not intuitive:** paper records have a natural ordering and context absent in databases; it is easy to become disoriented in computer systems.
- **Temptation to embellish data:** computers allow haphazard use of colour, font changes, icon stables, and graphs.
- **Loss of design control and flexibility:** design decisions are generally made by programmers, not clinicians; changes are expensive.
- **Costs:** system, training, networking, maintenance, and revisions add to costs.
- **Adverse response from patients:** the computer may be interposed in the clinician-patient relationship.

- **Reliance on hardware:** computers have limited portability; system breakdowns threaten access to data.
- **Reliance on software:** thorough testing is impossible, leading to unexpected errors; errors are readily propagated [41].

2.8 Radiological Record System

Electronic Medical Records are repositories of patient data either entered directly or interfaced from external applications. One such application is a Radiology Information System (RIS) that is typically used by hospital radiology departments to record activity in the department. Typical modules include:

- radiology request registration
- appointment scheduling
- exam management
- exam reporting
- PACS integration
- Management reporting [12].

But my system includes only exam management, exam reporting and management reporting including patient registration this is due to time and resource limitations.

The most widely used method for radiology reporting is transcription, where a radiologist dictates findings, which are then transcribed by a transcription service. When the report is returned from the transcription service, the radiologist verifies the correctness of the report and signs it. The report is then distributed to other departments in the hospital. In some cases, reports are returned to the transcription service, in order to correct transcription errors. With transcription, the final output is a printed report, or perhaps a text file, that is distributed outside the radiology department [13]. Therefore by the help of radiological record system which is a computer based patient record system, could improve transcription process and facilitates the method for preparation of radiology reports including MRI, IVU, Mammography and Ultrasound examinations.

According to Suptendra “The (clinical) information can be obtained through various modalities like voice (face to face or telephonic or video conversation of the patient, doctor or other healthcare personnel) or audio (breath or heart or peristaltic sounds, adventitious sounds). The next mode of data transfer may be images (digitized X-rays, histopathological, hematological or microbiological slides, USG scan, CT scan, MRI scan) or scanned or plotted versions of EKG, EEG, EMG and other signals. Alternatively, the signals may be transmitted as ASCII values and plotted at the receiving end; here the information loss will be minimal. Another important modality is text data (e.g., blood, urine, pathology, microbiology or a specialist's comments). All these have to be appropriately classified and linked adequately to the databases of a CBPR”. [44]

Lisa also described about EHR as “the hospital is able to access collective medical data within an electronic health record compiled from multiple sources across geographical regions within its network via a computer portal. Within minutes, the hospital has most current or real-time information such as blood work, MRI reports, lab charts, approved medication formularies from insurance company with prescriptions and physicians notes, and is able to expedite an appropriate diagnosis and safe treatment regimen for an individual.”[23]

Creation of a general-purpose medical record is one of the more difficult problems in database design. “In the USA, most medical institutions have much more electronic information on a patient’s financial and insurance history than on the patient’s medical record. Financial information, like orthodox accounting information, is far easier to computerize and maintain, because the information is fairly standardized. Clinical information, by contrast, is extremely diverse. Signal and image data X-Rays, ECGs, requires much storage space, and is more challenging to manage” [28]. Because of this challenge the new radiological record system for MRI department of Bethel Teaching General Hospital: manage text data such as clinical data,

findings and conclusions of MRI, Ultrasound, IVU and Mammography examinations (i.e. excluding images data).

Traditionally, the majority of patient data has been housed on paper. With the advent of the personal computer, many institutions have moved toward electronic versions of portions of this record. Most physicians, at some point in their practice, have used computer-based laboratory and pathology reporting systems. Although the computerization of the radiology record makes sense, the task is enormous and faces difficulties in communication and integration [3].

According to [24] also illustrates the importance of network and information infrastructure perspectives in the digitalization of radiology. EHR could be evaluated in terms of Patient perceptions of EHR, for example Survey results suggest positive user satisfaction with EHR [14], [34]. Also EHR could be evaluated in terms of time requirement compared with paper records. According to [32] there is no significant time difference in consultation compared with paper records. Furthermore according to [20] reported significant reduction in administrative staff time costs, increases in physician time costs, and in chart/EHR related activities following implementation of EHR in primary care in Canada. As with so many papers, it reports reductions in time costs for some tasks with increases for others. For example, according to [39] found more time spent on patient care and other nursing activities but also on document management in intensive care.

Patients also spent substantially less time waiting, and their total time per visit to the Mosoriot Rural Health Centre [MRHC] was marginally shorter after implementation of the Mosoriot Medical Record System [MMRS]. Health care providers (nurses and clinical officers) also spent less time with patients and other staff and had substantially more time for personal activities. It seems that, for health care providers, the MMRS also saved time, creating a resource that the managers of the MRHC could harness for additional activities (e.g., patient education). Clerks, however, spent additional time

registering patients but less time writing reports and interacting with other staff. For them, the MMRS was largely time-neutral for everyday tasks, although it was remarkably timesaving in terms of producing monthly reports for the Kenyan Ministry of Health [19].

As we saw above, various researchers have contributed with insightful studies of the healthcare work and the introduction of computer based systems. Good quality electronic medical records can enhance patient registration and appointment systems and repeat prescribing; can be of value in monitoring the health of populations; and are used for research, education and decision support of the management. Little is known about the content and quality of electronic records compared with manual records in our country context. Paperless electronic records could be compared favorably- with records using paper-based systems particularly in relation with examinations of MRI, IVU, Mammography and Ultrasound cases.

An automated patient medical record system will reduce or eliminate the costs of transporting, finding, copying, storing, filing, and organizing the patient medical record. Another objective of patient medical record might be to “improve patient care”. It improves patient care by “making the patient medical record always available”. Patient care could be changed in a positive way in many ways, including the following:

- There would be fewer gaps in medical information.
- A complete list of medications the patient is taking, and an up-to-date patient history is likely to be immediately available. This information is especially important in the emergency department and the inpatient setting.
- There would be no delay between closely occurring visits to move over the chart.
- Multiple caregivers can view and/or update the patient medical record concurrently, even at two different locations in a networked environment.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 System development methodology

An Object-Oriented approach is used to develop the system. An O-O approach used to specify the software solution in terms of collaborating objects, their attributes, and their methods.

3.1.1 Requirement Elicitation and Analysis

Requirement - a specification of capabilities that a system must provide in order to solve a problem. Requirements elicitation serves as a front end to systems development. Requirements analysts, sponsors/funders, developers, and end users are involved with requirements elicitation to differing degrees, and thus requirements elicitation involves social, communicative issues as well as technical issues [51]. Requirements analysis is a process in which "what is to be done" is elicited and modeled. This process has to deal with different viewpoints, and it uses a combination of methods, tools, and actors.

I. Existing System Modeling

From the system descriptions the functionalities of the system and people interacting with this function are identified.

Actors: - Radiologist, Data clerk, X-ray technician

Use cases: - Prepare MRI report, Prepare Ultrasound report, Prepare IVU report and Prepare Mammography report.

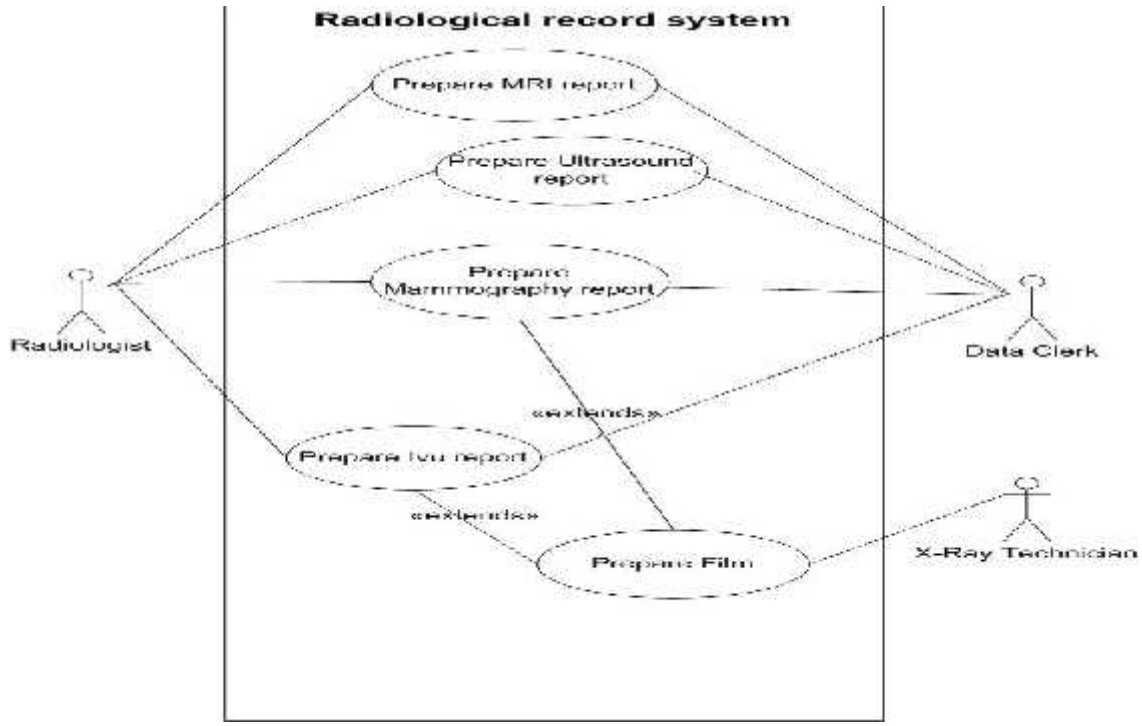

Figure 3.1 radiological record system use case

Modeling the existing system is useful to easily understand the functionalities of and the limitations of the existing system. In addition it is useful to capture the requirement of the system to be developed.

From the use case diagram in Figure 3.1, the radiologist and the data clerk prepare: MRI, Ultrasound, Mammography and IVU reports. After the patient is examined for MRI, the radiologist prepares hand written report and delivers it to the data clerk to be written in a computer using Microsoft word application. Once the data clerk completes MRI report and approved by the radiologist, then the report is given to the patient. The same process is taking place for Ultrasound examination. But for IVU and Mammography cases, first X-ray technician prepares IVU or Mammography films and then sends these films to MRI department for interpretation.

Figure 3.2 MRI report use case

Use case description

Use case name: Prepare MRI report

Actor: radiologist: data clerk

Description: Radiologist and Data clerk prepares MRI report

Precondition: the patient complete MRI examination

Post condition: MRI report generated.

Flow of events

1. The radiologist prepares handwritten report and sends it to the data clerk.
2. The data clerk writes MRI report using MS word application.
3. The data clerk prints MRI report for the patient.

Figure 3.3 Ultrasound report use case

Use case description

Use case name: prepare Ultrasound report

Actor: radiologist: data clerk

Description: radiologist and data clerk prepares ultrasound report

Precondition: the patient complete ultrasound examination

Post condition: ultrasound report generated.

Flow of events

1. The radiologist prepares handwritten report and sends it to the data clerk.

2. The data clerk writes Ultrasound report using MS word application.
3. The data clerk prints Ultrasound report for the patient.

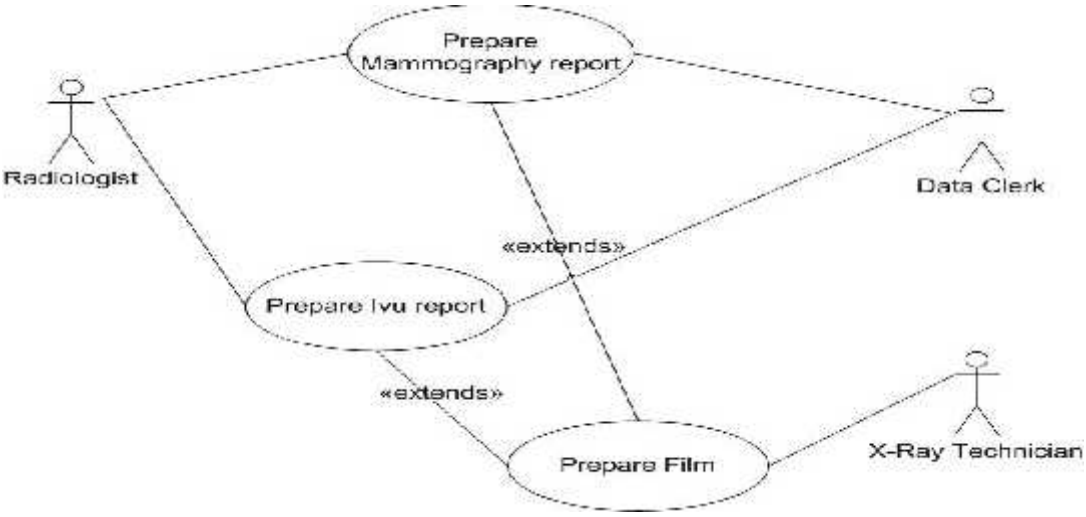

Figure 3.4 Mammography and IVU report use case

Use case description

Use case name: prepare Mammography report

Actor: Radiologist, data clerk, X-ray technician

Description: Radiologist and data clerk prepare Mammography report

Precondition: the patient completes Mammography report from X-ray department

Post condition: Mammography report prepared.

Flow of events

1. The patient examined in X-ray department
2. The X-ray department sent patient film to MRI department for interpretation
3. After interpretation, hand written report is prepared by a radiologist
4. Then the data clerk prepares computer based Mammography report and sent it back to X-ray department

Use case description

Use case name: prepare IVU report

Actor: Radiologist, data clerk

Description: radiologist and data clerk prepare IVU report

Precondition: the patient should complete IVU examination from X-ray department.

Post condition: IVU report prepared

Flow of events

1. The patient examined in X-ray department.
2. The X-ray department sends patient film to MRI department for interpretation
3. After interpretation hand written report is prepared by a radiologist.
4. The data clerk prepares computer based IVU report.
5. The report is sent back to X-ray department by the data clerk.

II. Requirement Determination

The new system requirement gatherings help to capture the needs of the system to be developed. The objective of the new system is to give services of patient registration including examination report of MRI, IVU, Mammography and ultrasound. In addition the system generates a report for each of the above examination types. Also the system facilitates easy search of patient data and generates summary report.

III. Functional Requirement

The functional requirements of the new radiological record system are described below. Some of the services offered by the system include the following:-

1. Patient data registration.
2. Patient based report.
3. Summary report on daily, weekly, monthly, quarterly, semi-annual annual bases.
4. Registration of clinical data, findings and conclusions of MRI, Ultrasound, IVU, and Mammography examinations.
5. Search of patient data.
6. New case entry for MRI examination.

IV. Non Functional Requirement

The new radiological record system satisfies the following non- functional requirements.

1**. User interface**

The new radiological record system is menu driven and have graphical user interface which include forms, controls, reports and help documents. Also the system has user friendly interface with appropriate color contrasts depending on the interest of the users.

2. Security

The new radiological record system store and retrieve sensitive patient data which is helpful for research, education and decision support for the health care. Therefore, any user can not get accesses to the system beyond his/her privilege.

3. Error handling

Radiological record system displays error messages when error is committed by the radiologist and the data clerk. And this helps to correct the error.

4. Performance

Depending on the actual stored data on the Radiological record system, it will respond to the user request within 10 to 15 seconds.

V. New System Requirement Modeling

1. Use case Modeling

The use case modeling for the new system is important for identifying the need of the new system. From the use case modeling of the existing system, we can easily identify the limitation of the system. The following use case diagram shows use cases and their descriptions for the new system.

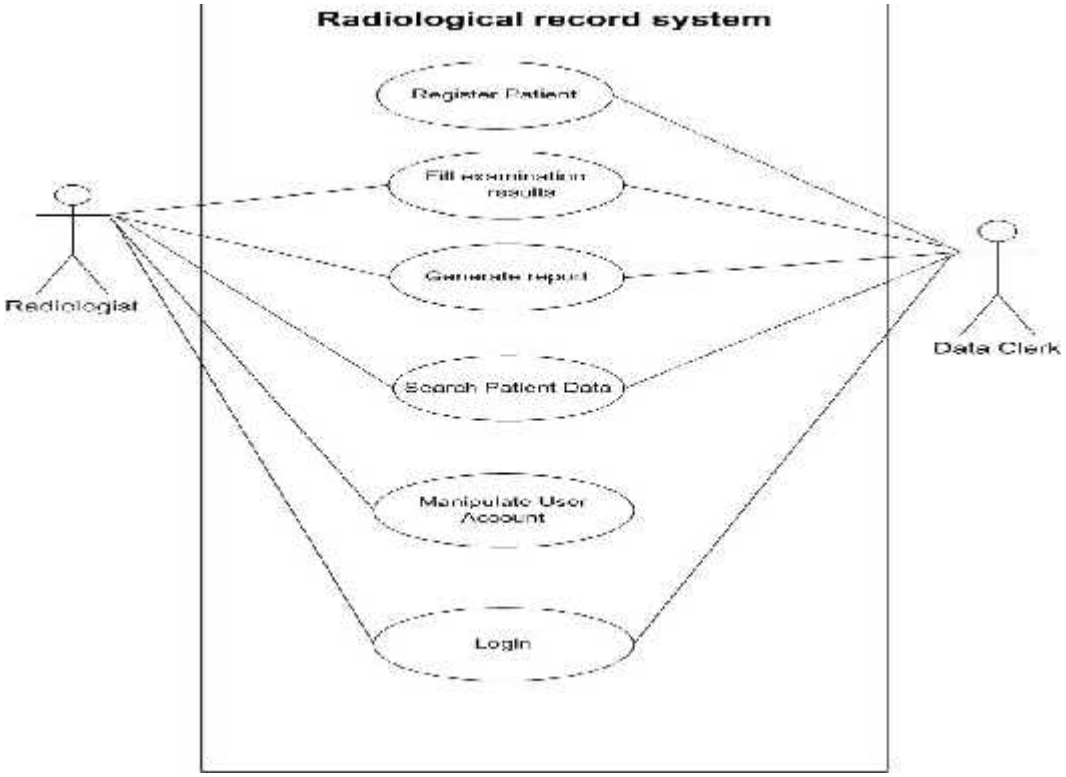

Figure 3.5 use case diagram for the new system

Use case description

Name: Generate report

Actor: Radiologist, Data clerk

Description: Radiologist and Data clerk generate report

Precondition: the patient completed the required examination

Post condition: report generated

Flow of events

1. The Radiologist/Data clerk preview report
2. The Radiologist/Data clerk print report

Use case scenario

Scenario name: generate MRI report

Participating actor instances: Radiologist, Data clerk

Flow of events

1. The Radiologist/Data clerk preview MRI report
2. The Radiologist/Data clerk print MRI report

Use case scenario

Scenario name: generate Ultrasound report

Participating actor instances: Radiologist, Data clerk

Flow of events

1. The Radiologist/Data clerk preview Ultrasound report
2. The Radiologist/Data clerk print Ultrasound report

Use case scenario

Scenario name: generate IVU report

Participating actor instances: Radiologist, Data clerk

Flow of events

1. The Radiologist/Data clerk preview IVU report
2. The Radiologist/Data clerk print IVU report

Use case scenario

Scenario name: generate Mammography report

Participating actor instances: Radiologist, Data clerk

Flow of events

1. The Radiologist/Data clerk preview Mammography report
2. The Radiologist/Data clerk print Mammography report

Figure 3.6 report use case

Use case description

Name: register patients

Actor: data clerk

Description: data clerk register patients

Precondition: the patient brings prescription slip

Post condition: the patient registered

Flow of events

1. Data clerk enters the required fields in the form
2. The system stores the data from the form on to the database

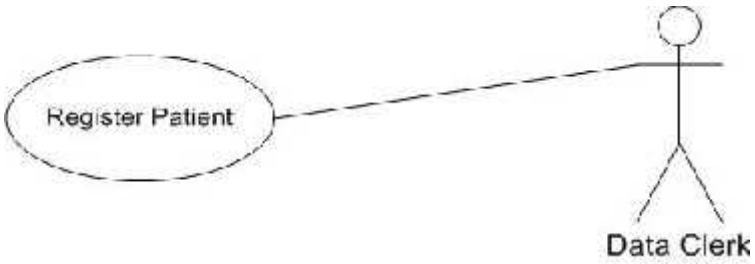

Figure 3.7 Register use case

Use case description

Name: Manipulate user account

Actor: Radiologist

Description: Radiologist manipulates user accounts

Precondition: Being a radiologist

Post condition: allow/deny services

Flow of events

1. Radiologist enters the required fields in the form
2. The system stores the data from the form on to the database
3. The user access the system

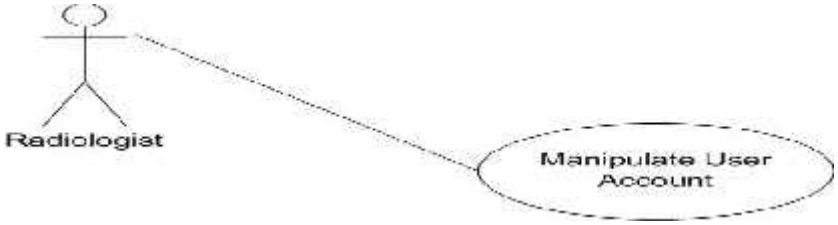

Figure 3.8 Manipulate user account use case

Use case description

Name: search patient data

Actor: Radiologist, data clerk

Description: radiologist and data clerk search patient data

Precondition: Privileged user

Post condition: Display the required patient data

Flow of events

1. Radiologist/Data clerk enters the required search fields in the form
2. The system searches the data from the database

3. The Radiologist/Data clerk preview the required patient data

Figure 3.9 Search use case

Use case description

Name: Login into the system

Actor: Radiologist, data clerk

Description: radiologist and data clerk login to the system

Precondition: Privileged user

Post condition: access the system

Flow of events

1. Radiologist/Data clerk enters the required username and password
2. The Radiologist/Data clerk access the system

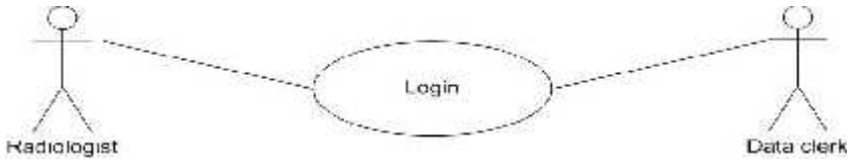

Figure 3.10 Login use case

Use case description

Name: Fill examination result of patients

Actor: Radiologist, data clerk

Description: radiologist and data clerk fill examination result of patients

Precondition: Patient demographic data registered

Post condition: Examination result entered into the system

Flow events

1. Radiologist/Data clerk fills examination results in the form
2. The system stores the data from the form on to the database

Figure 3.11 Examination result use case

2. Sequence Diagram

Sequence diagrams are used to model the logic of usage scenario. A usage scenario is exactly the description of a potential way in which this system is used. It is really a part of use case, such as the logic described by the basic course of action or a portion of the basic course of action plus one or more alternate course of action. For generate report use case we have MRI, Ultrasound, IVU and Mammography sequence diagrams.

Login Sequence Diagram

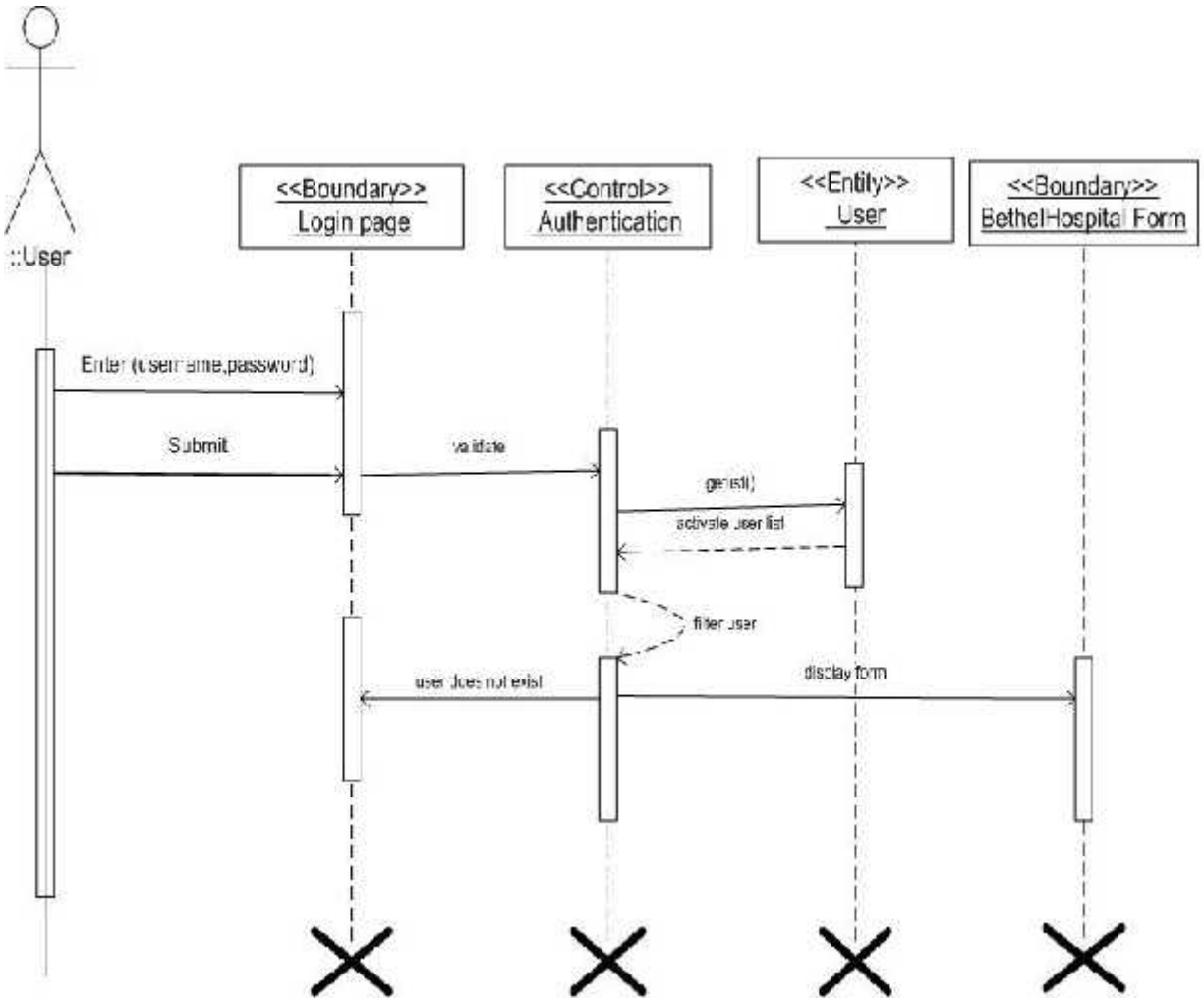

Figure 3.12 Login Sequence Diagram

Patient Registration Sequence Diagram

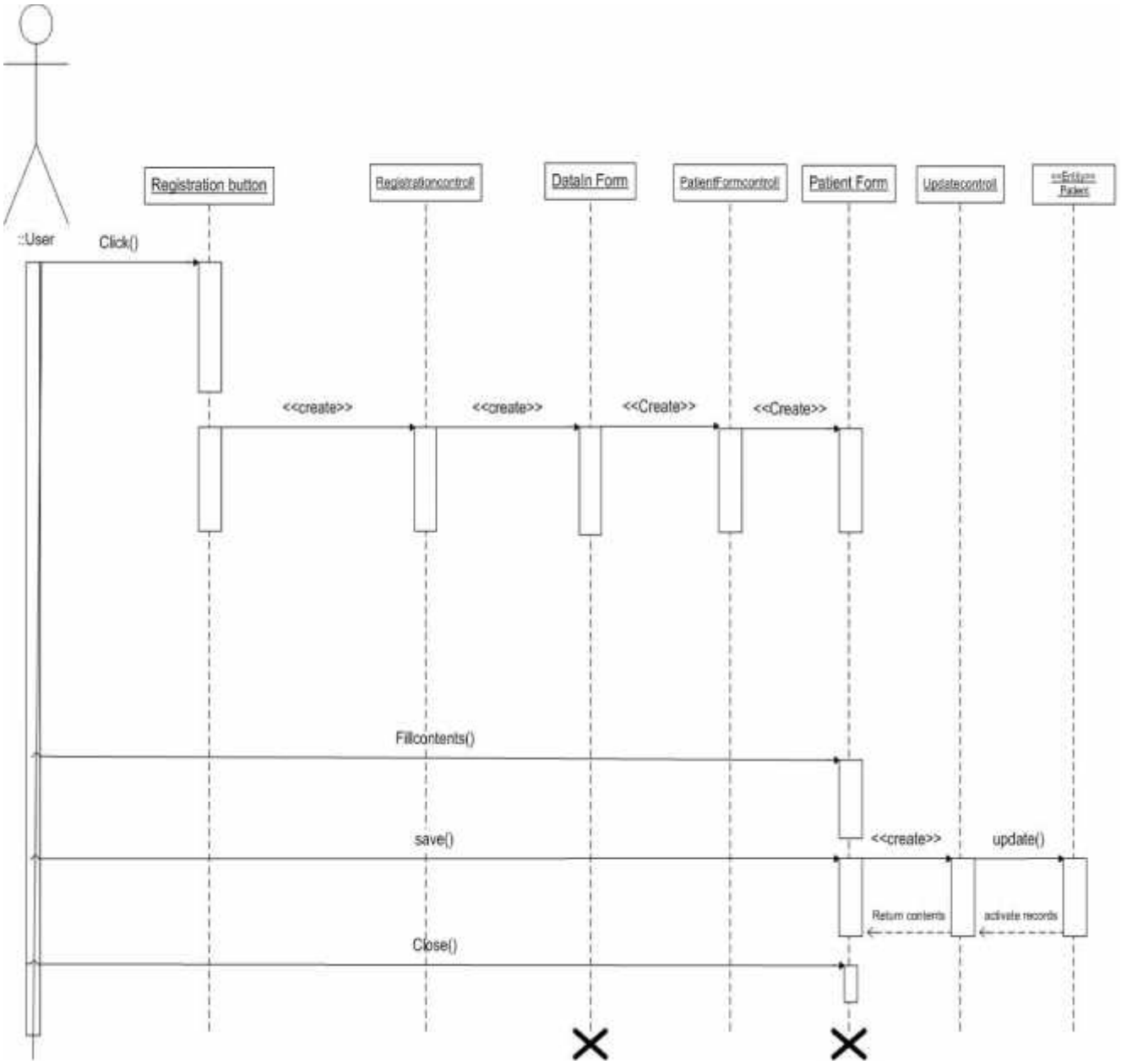

Figure 3.13 Registration Sequence Diagram

MRI Sequence Diagram

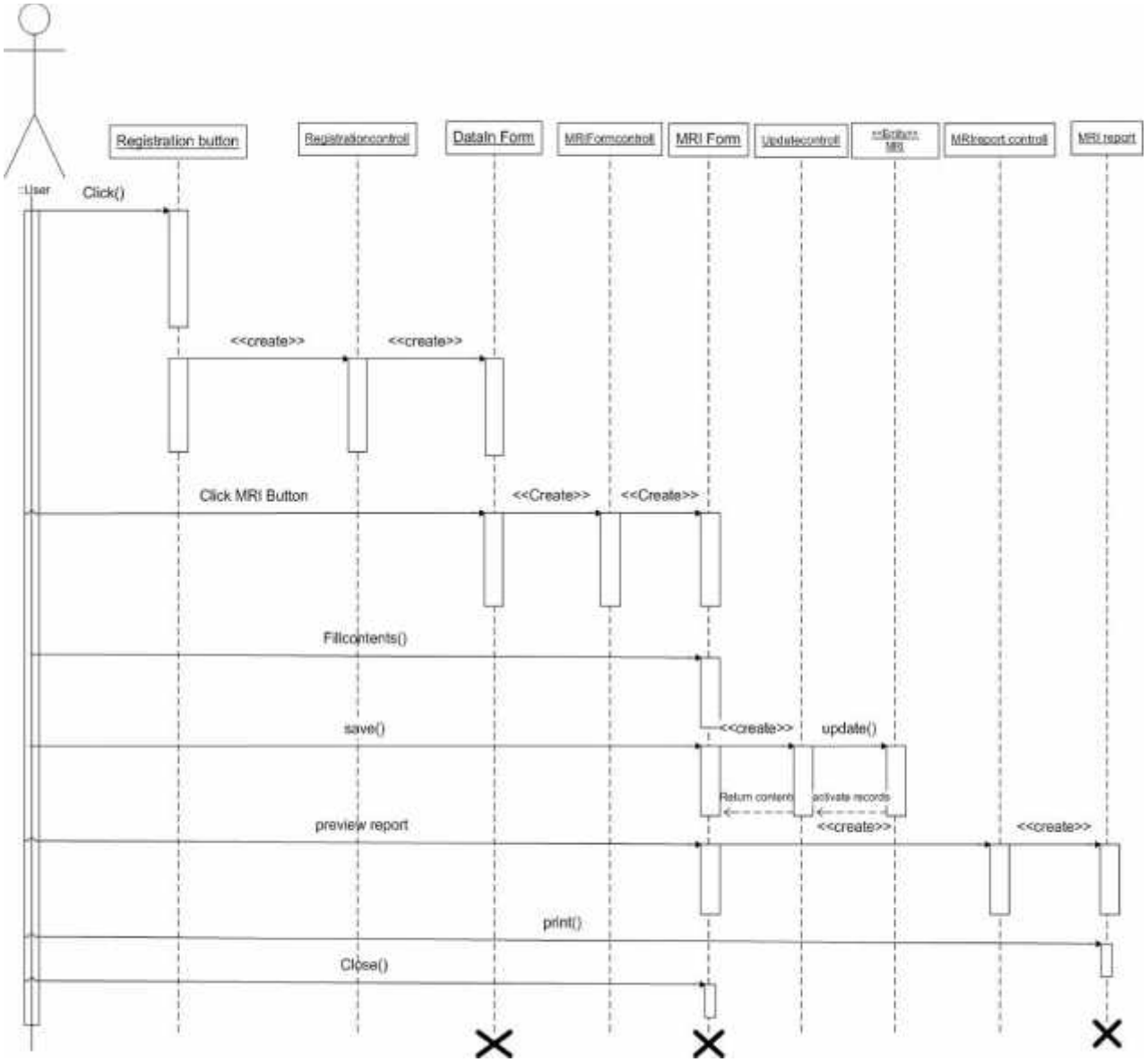

Figure 3.14 MRI Sequence Diagram

IVU Sequence Diagram

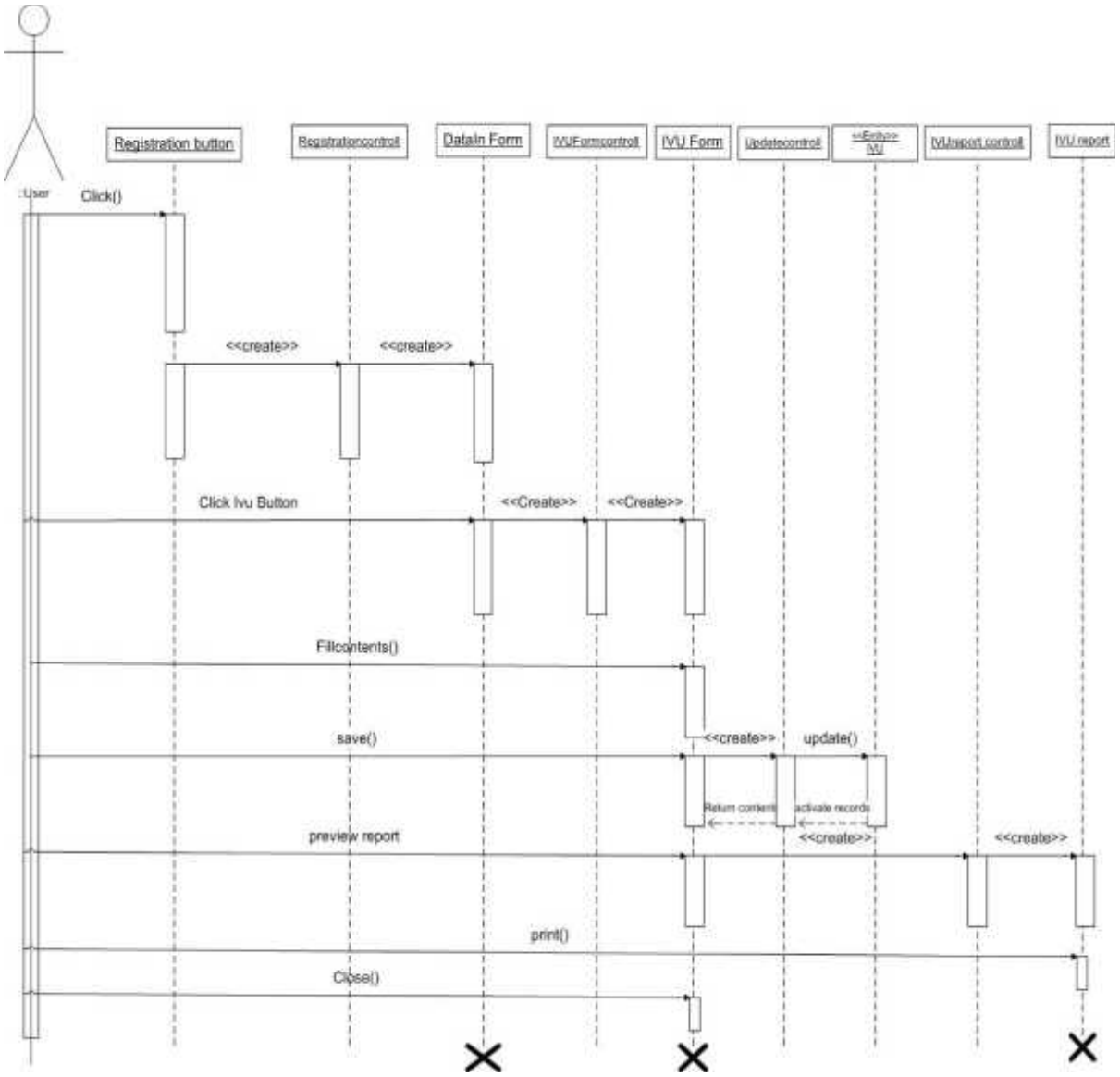

Figure 3.15 IVU Sequence Diagram

Mammography Sequence Diagram

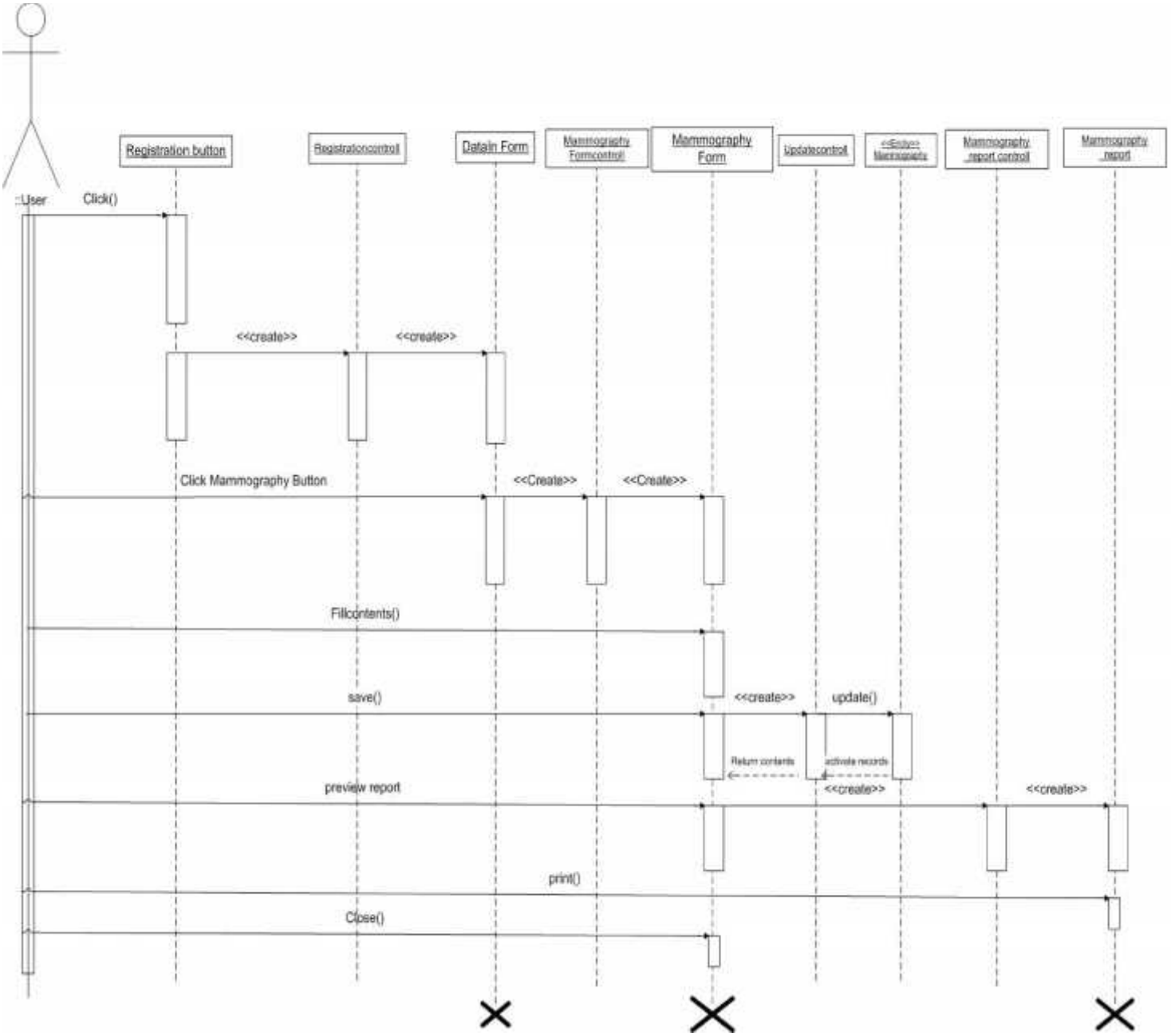

Figure 3.16 Mammography Sequence Diagram

Male Ultrasound Sequence Diagram

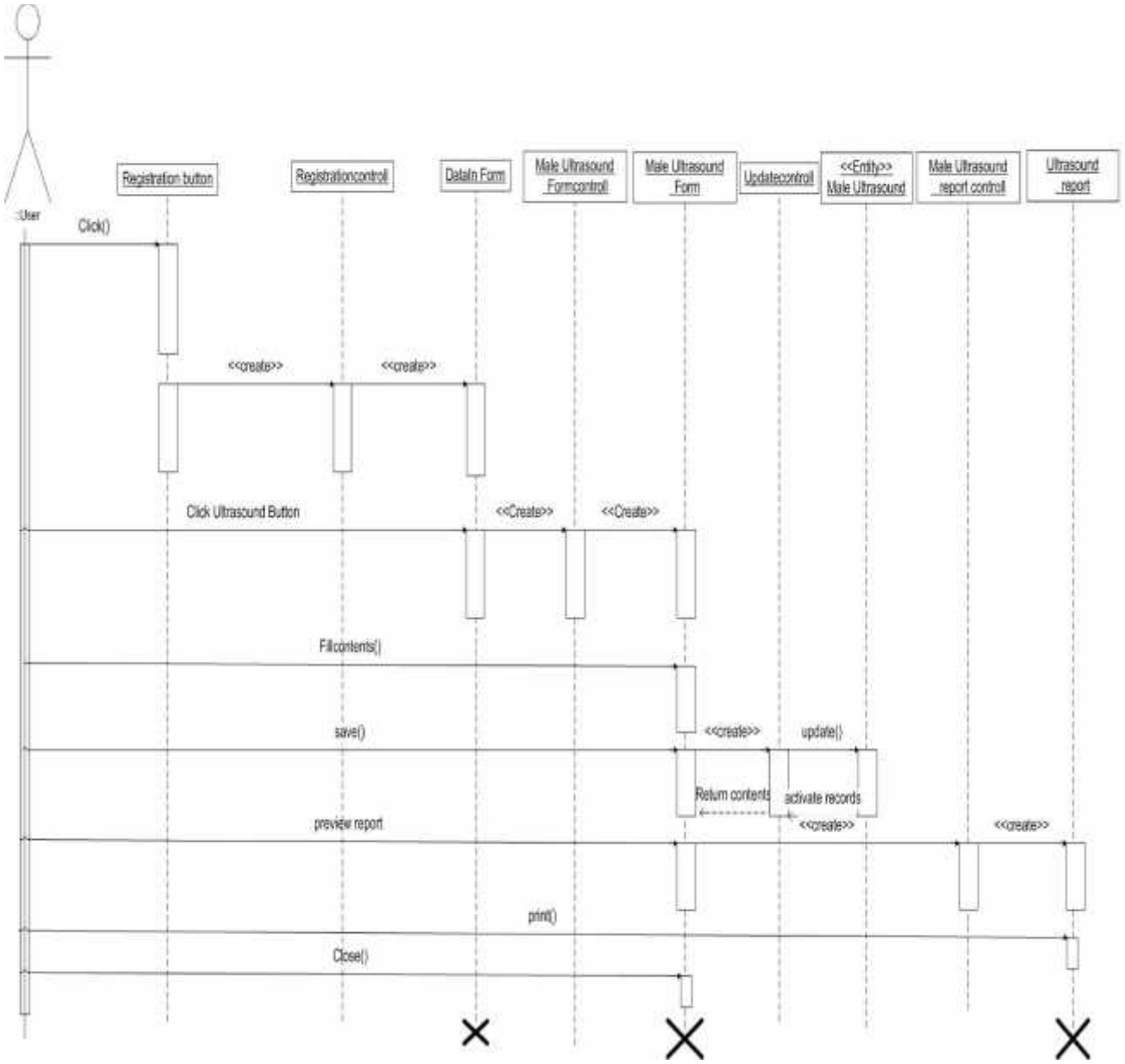

Figure 3.17 Male Ultrasound Sequence Diagram

Female Ultrasound Sequence Diagram

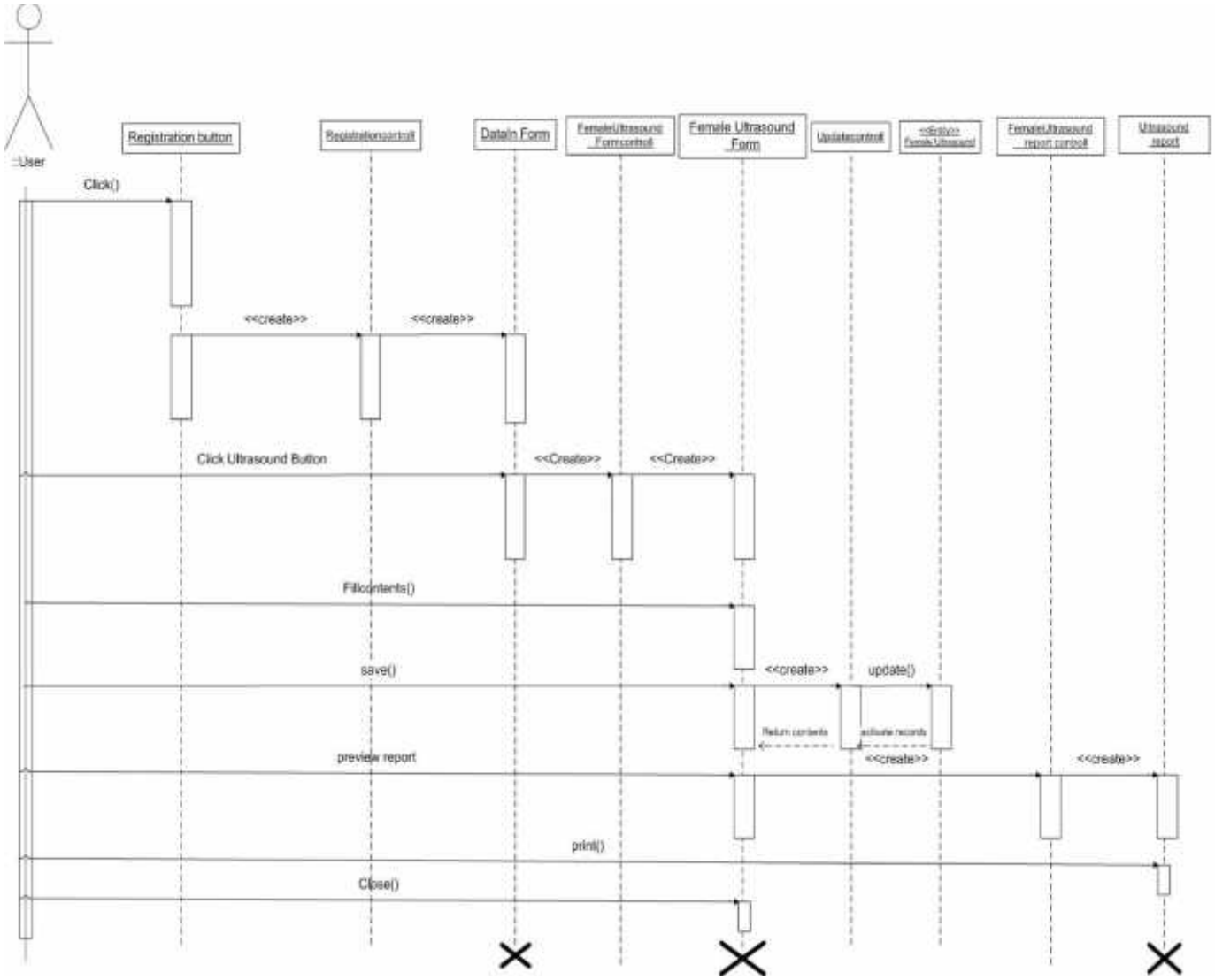

Figure 3.18 Female Ultrasound sequence Diagram

Obstetric Ultrasound Sequence Diagram

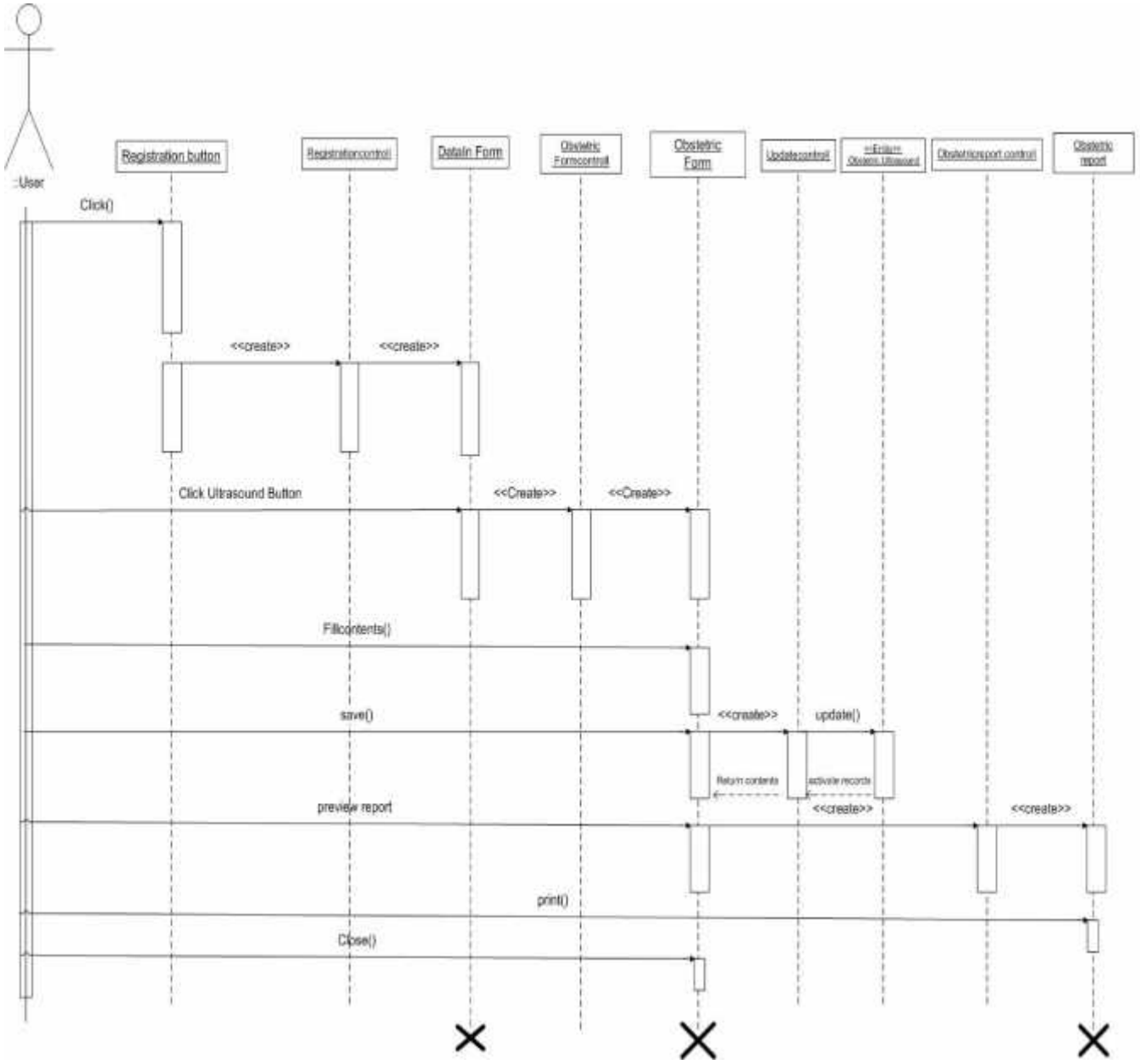

Figure 3.19 Obstetric Ultrasound Diagram

Other Ultrasound Sequence Diagram

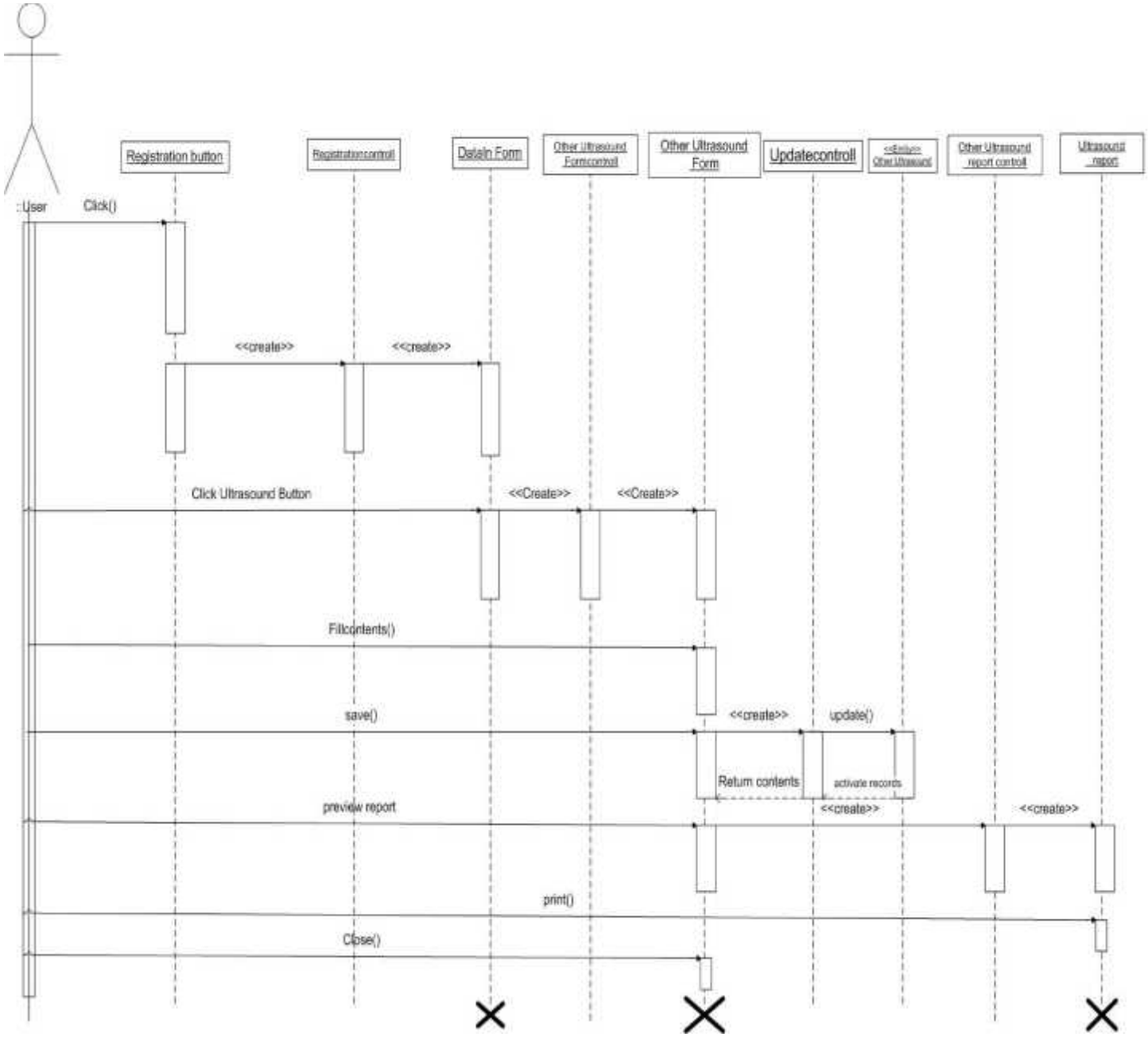

Figure 3.20 Other Ultrasound Sequence Diagram

Search Sequence Diagram

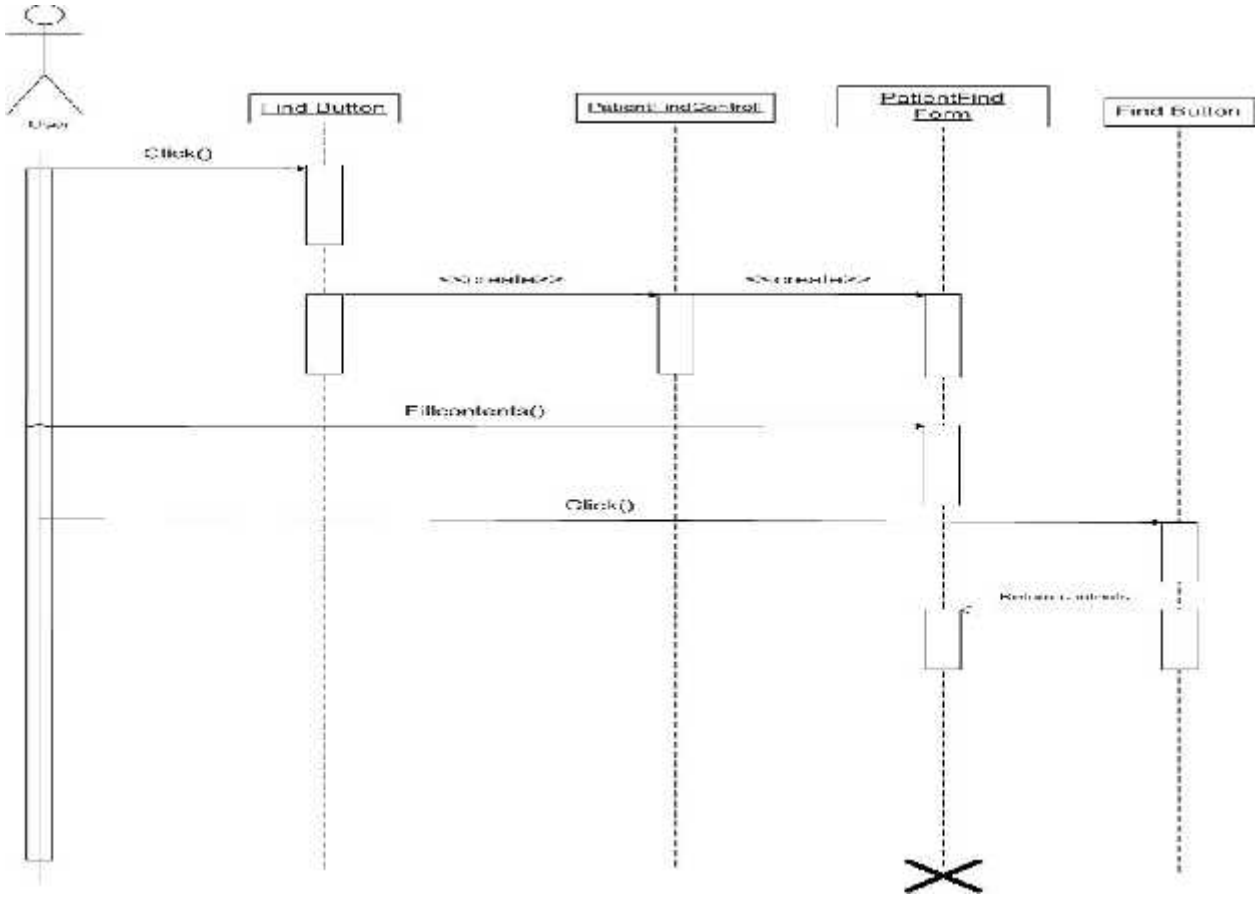

Figure 3.21 Search Sequence Diagram

Manipulate User Account Sequence Diagram

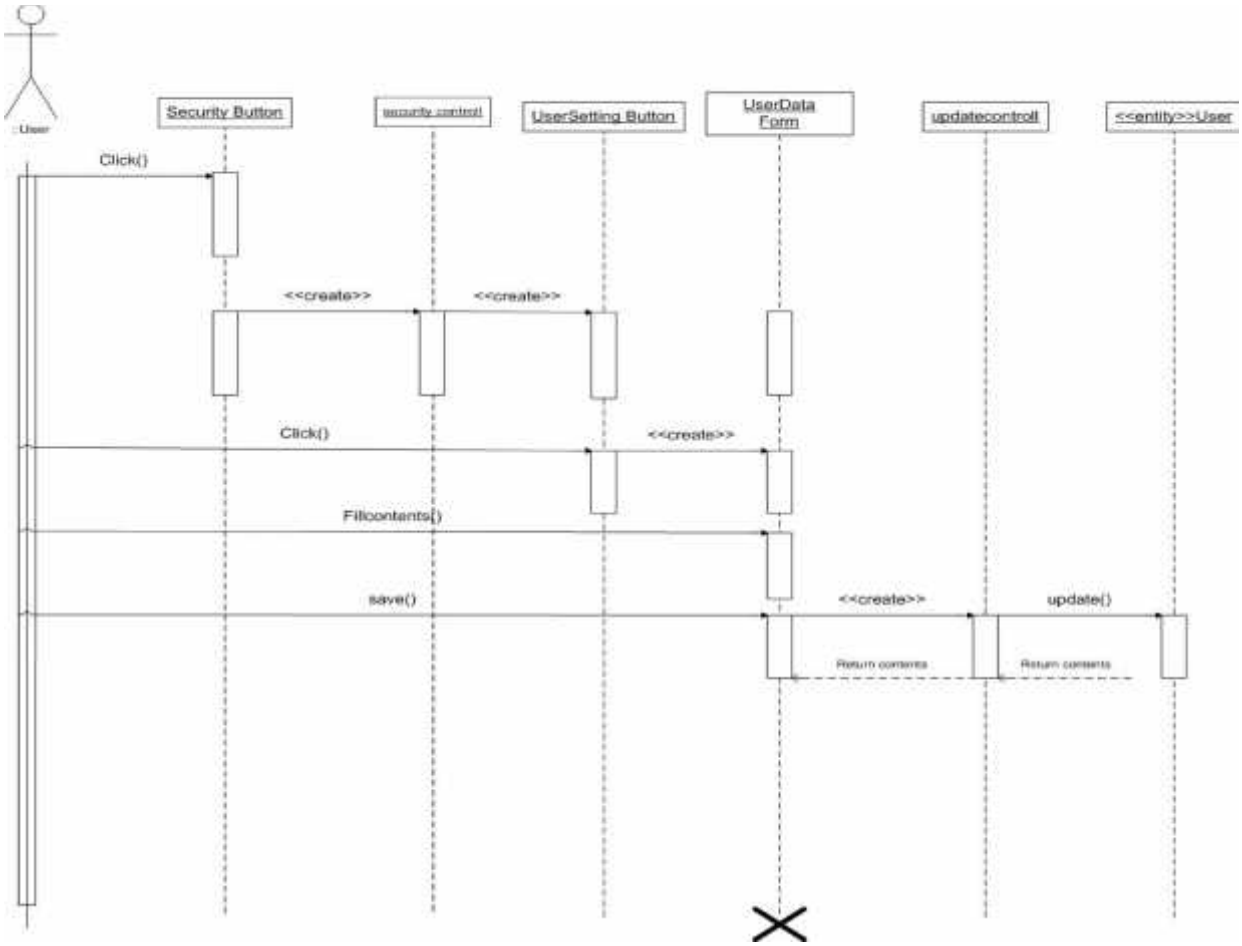

Figure 3.22 Manipulate user account Sequence Diagram

Fill Examination Result Sequence Diagram

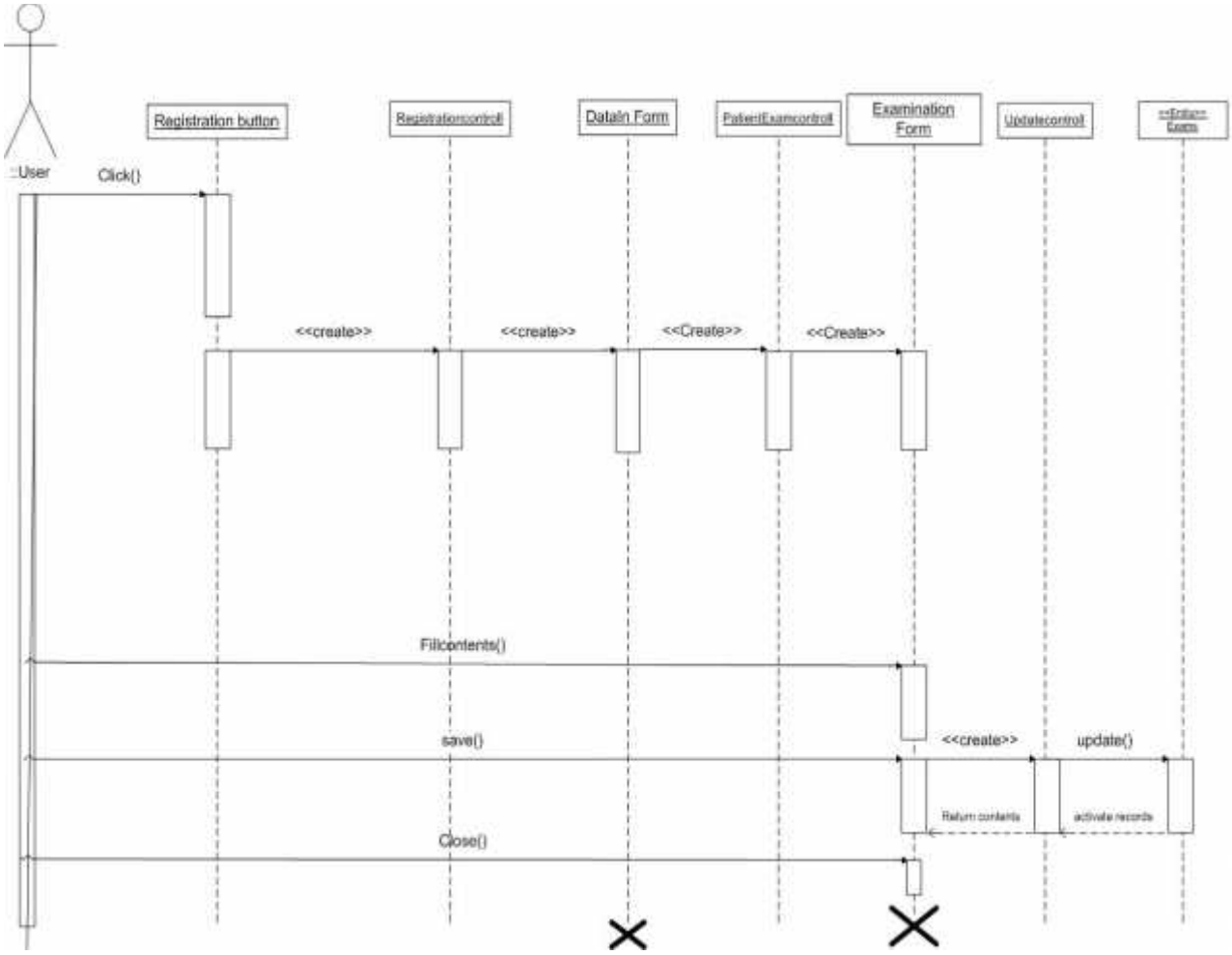

Figure 3.23 Fill Examination Result Sequence Diagram

- Entity exam includes entities: - MRI, IVU, Mammography and Ultrasound (male, female, obstetric and other).

Class Diagram of Radiological Record System

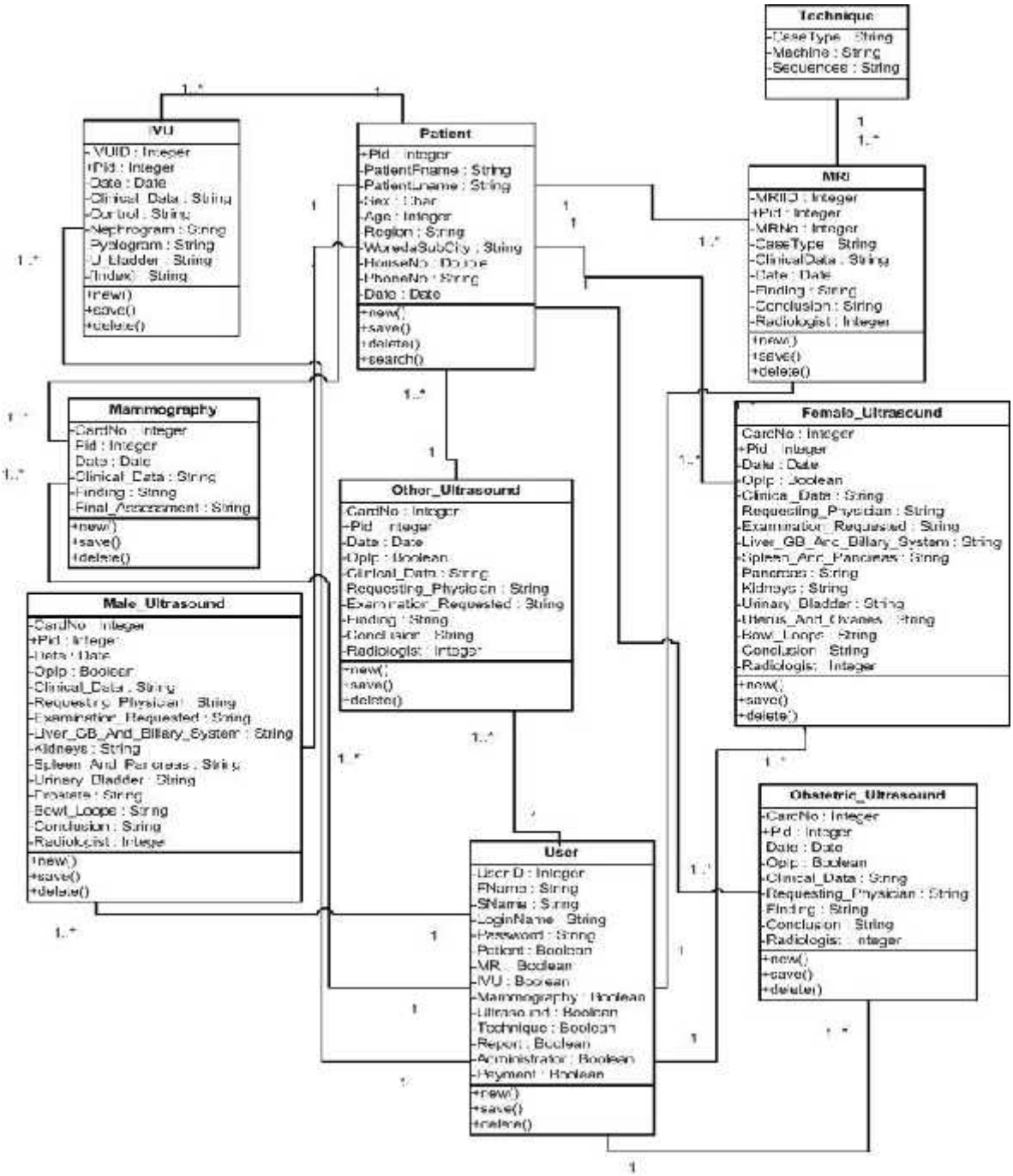

Figure 3.24 Class Diagram of Radiological Record System

3. Activity Diagram

Activity diagram helps to model the dynamic aspects of a system, and also for constructing executable systems through forward and reverse engineering. An activity diagram is like a flow chart showing the flow of activity from one state to the other. The radiological record system has the following activities: examination payment, preparation of MRI, Ultrasound, IVU and Mammography reports.

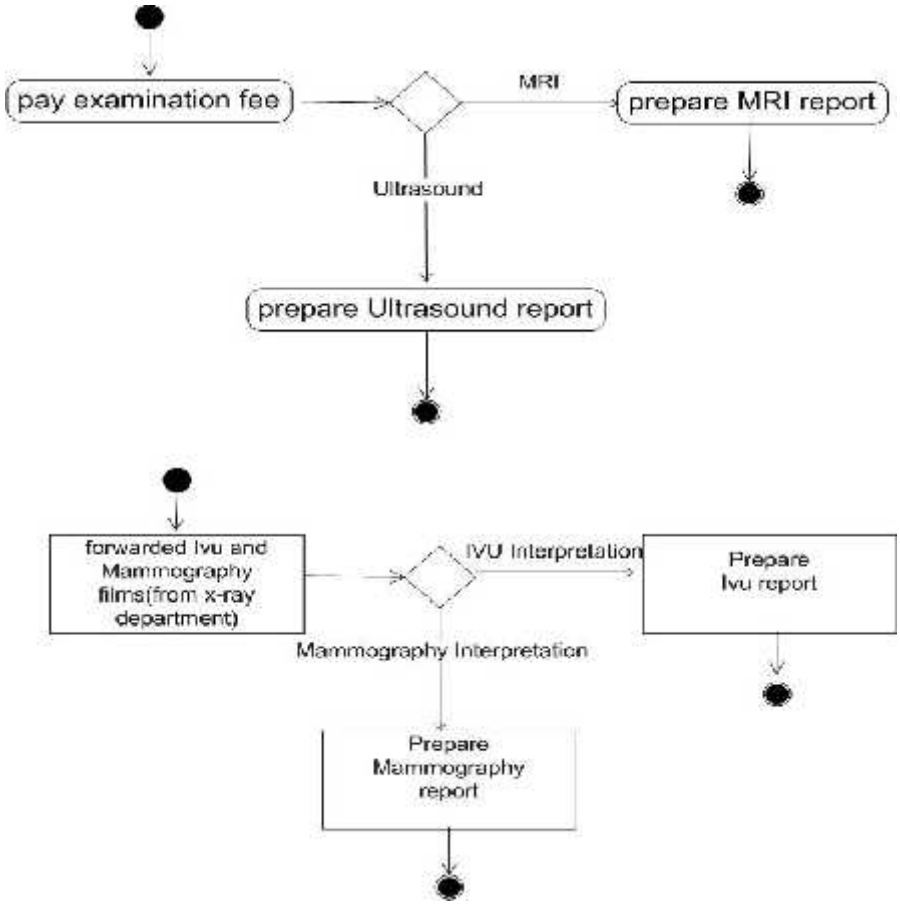

Figure 3.25 Activity Diagram

3.1.2 System Design

Systems design is the process or art of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements.

i. Class Diagrams

Classes: a description of a group of objects with common properties (attributes) common behavior (operations), common relationships to other objects and common semantics.

- Attribute: the basic data of the class.
- Method (operation): an executable procedure that is encapsulated in a class and is designed to operate on one or more data attributes that are defined as part of the class.
- Object: when specific values are assigned to all the resources defined in a class, the result is an instance of that class. Any instance of any class is called an object.

Data model views the real world as a set of basic objects (entities) and relationships among these objects. The data model uses logical concepts such as objects, their properties, and their interrelationships, that may be easier for users to understand the storage concepts [36].

ii. Identifying the Responsibility of each Class

- Male_Ultrasound: used to keep information about male ultrasound (CardNo,Pid,Date,Opid,clinical_date,requesting_pysiciam,examination_requested,liver_GB_and_billary_system,kidneys,spleen_and_pancreas,urinary_bladder,prostate,Bowl_loops,conclusion,radiologist).
- Technique: used to keep information about the techniques used in MRI cases (casetype, machine, sequences).
- MRI: Used to keep information about the MRI record of the patient (MRIID, pid, mrno, casetype, clinicaldata, date, finding, conclusion, radiologist).
- IVU: used to keep information about the IVU examination (IVUID, pid,date,clinical_date,control,nephrogram,pyelogram, U_bladder,Index).

- Mammography: used to keep information about the Mammography examination(cardno,pid,date,clinical_date,finding,final_assessment)
- Obstetric_ultrasound: used to keep information about the obstetric_ultrasound examination (cardno,pid,date,opip,clinical_data,requesting_physician,finding,conclusion, radiologist).
- Patient: used to keep information about the patient (pid,patientfname,patientlname,sex,age,region,woredasubcity,houseno,phoneno,date).
- Other_ultrasound: used to keep information about the other ultrasound examination (cardno, pid, date, opip, clinical_data, requesting_physician, finding, conclusion, radiologist).
- Female_Ultrasound: used to keep information about the female Ultrasound examination (CardNo,Pid,Date,Opid,clinical_date,requesting_physician,examination_requested,liver_GB_and_billary_system,kidneys,spleen_and_pancreas,urinary_bladder,prostate,Bowl_loops,conclusion,radiologist).
- User: used to keep information about the operators of the system and their privilege (userid, fname, sname, loginname, password, patient,MRI,IVU,mammography,ultrasound,technique,report,administrator, payment)

Translating the responsibility of each class in to attribute and operations need to perform their responsibility. The following attributes and operations are identified in each class:-

1. **Male_ultrasound**

   Attributes:CardNo,Pid,Date,Opid,clinical_date,requesting_pysiciam,examination_requested,liver_GB_and_billary_system,kidneys,spleen_and_pancreas,urinary_bladder,prostate,Bowl_loops,conclusion,radiologist

   Operation: new(), save(), delete()

2. **Technique**

   Attributes: casetype, machine, sequences

   Operation: none

3. **MRI**

   Attributes:MRIID,pid,mrNO,casetype,clinicaldata,date,finding,conclusion,radiologist.

   Operation: new(), save(), delete()

4. **IVU**

   Attributes: IVUID, pid, date, clinical_date, control, nephrogram, pyelogram, U_bladder,Index

   Operation: new(), save(), delete()

5. **Mammography**

   Attributes: cardno, pid, date, clinical_date, finding, final_assessment

   Operation: new(), save(), delete()

6. **Obstetric_ultrasound**

   Attributes: cardno, pid, date, opip, clinical_data, requesting_physician, finding, conclusion, radiologist

   Operation: new(), save(), delete()

7. **Patient**

   Attributes:pid,patientfname,patientlname,sex,age,region,woredsubcity, houseno,phoneno, and date.

   Operation: new(), save(), delete(), and search()

8. **Other_ultrasound**

   Attributes: cardno, pid, date, opip, clinical_data, requesting_physician, finding, conclusion, radiologist

   Operation: new(), save(), delete()

9. **Female_Ultrasound**

   Attributes:CardNo,Pid,Date,Opid,clinical_date,requesting_pysiciam,examination_requested,liver_GB_and_billary_system,kidneys,spleen_and_pancreas,urinary_bladder,prostate,Bowl_loops,conclusion,radiologist.

   Operation: new(), save(), delete()

10. **User**

    Attributes: userid, fname, sname, loginname, password, patient, MRI, IVU, mammography, ultrasound, technique, report, administrator and payment.

    Operation: new(), save(), delete().

iii. Identifying The Relationship Between Classes

In the above class diagram, the following types of relationship exist, these are:-

1) one-to-many relationship

MRI to user

User class and MRI class have one-to-many relationship.

A user can add, save, and delete one or more than one MRI records.

2) one-to-many relationship

Male_Ultrasound to user

User class and Male_Ultrasound class have one-to-many relationship. A user can add, save, and delete one or more than one Male_Ultrasound records.

3) one-to-many relationship

Other_Ultrasound to user

User class and Other_Ultrasound class have one-to-many relationship. A user can add, save, and delete one or more than one Other_Ultrasound records.

4) one-to-many relationship

Obstetric_Ultrasound to user

User class and Obstetric_Ultrasound class have one-to-many relationship. A user can add, save, and delete one or more than one Obstetric_Ultrasound records.

5) one-to-many relationship

Female_Ultrasound to user

User class and Female_Ultrasound class have one-to-many relationship. A user can add, save, and delete one or more than one Female_Ultrasound records.

6) one-to-many relationship

IVU to user

User class and IVU class have one-to-many relationship. A user can add, save, and delete one or more than one IVU records.

7) one-to-many relationship

Mammography to user

User class and Mammography class have one-to-many relationship. A user can add, save, and delete one or more than one Mammography records.

8) one-to-many relationship

Patient to Female_Ultrasound

Patient class and Female_Ultrasound class have one-to-many relationship.

A Patient can have one or more than one Female_Ultrasound records.

9) one-to-many relationship

Patient to Male_Ultrasound

Patient class and Male_Ultrasound class have one-to-many relationship.

A Patient can have one or more than one Male_Ultrasound records.

10) one-to-many relationship

Patient to Other_Ultrasound

Male _Ultrasound class and Other_Ultrasound class have one-to-many relationship.

A Patient can have one or more than one Other_Ultrasound records.

11) one-to-many relationship

Patient to obstetric_Ultrasound

Patient class and Obstetric_Ultrasound class have one-to-many relationship.

A Patient can have one or more than one obstetric_Ultrasound records.

12) one-to-many relationship

Patient to MRI

Patient class and MRI class have one-to-many relationship. A Patient can have one or more than one MRI records.

13) one-to-many relationship

Patient to IVU

Patient class and IVU class have one-to-many relationship.

A Patient can have one or more than one IVU record.

14) one-to-many relationship

Patient to Mammography

Patient class and Mammography class have one-to-many relationship. A Patient can have one or more than one Mammography records.

15) one-to-many relationship

MRI to Technique

MRI class and Technique class have one-to-many relationship. MRI examination can have one or one or more than one technique records.

iv. Collaboration Diagram

Collaboration diagram Shows Interaction between objects.

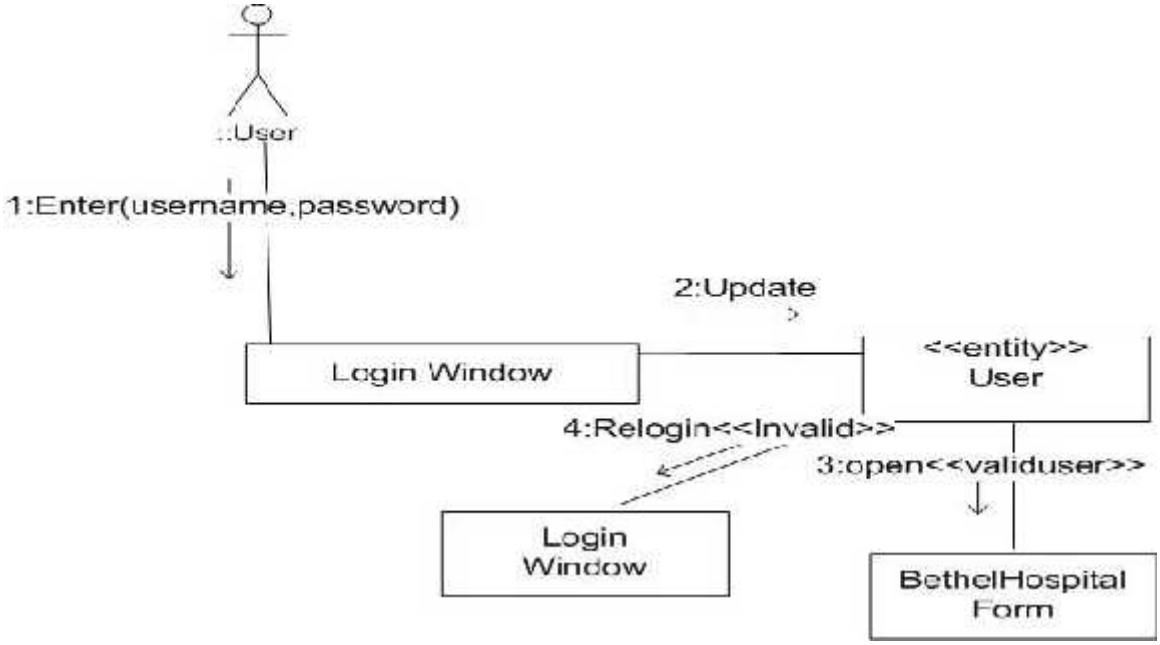

Figure 3.26 Login collaboration diagram

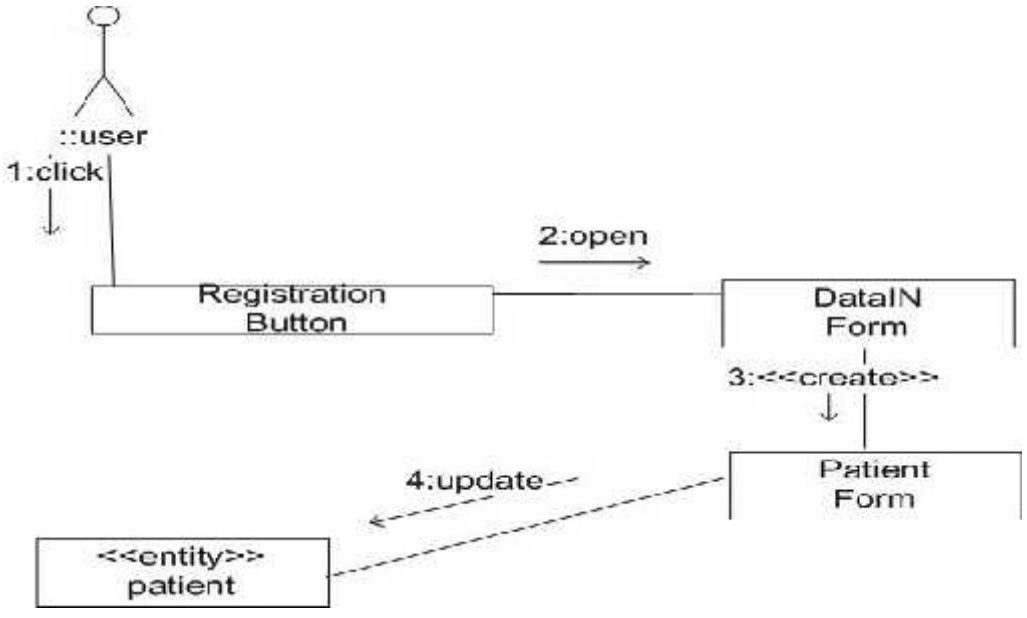

Figure 3.27 Patient registration collaboration diagram

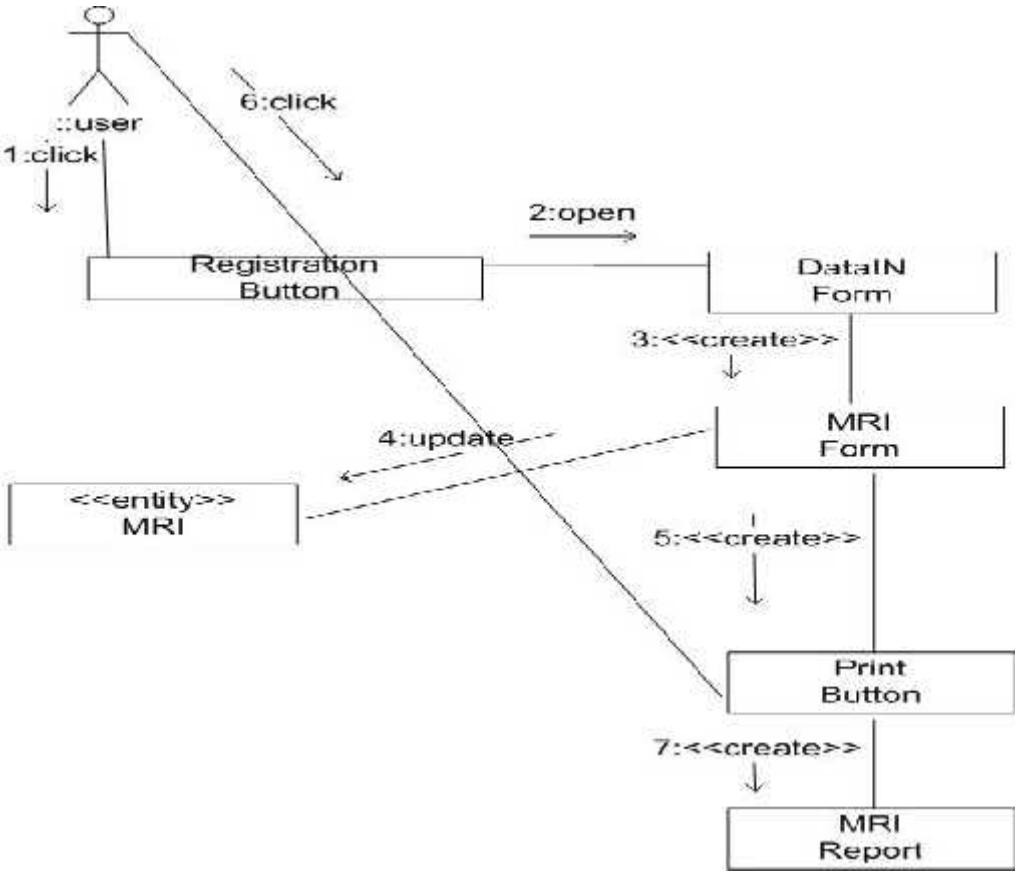

Figure 3.28 MRI collaboration Diagram

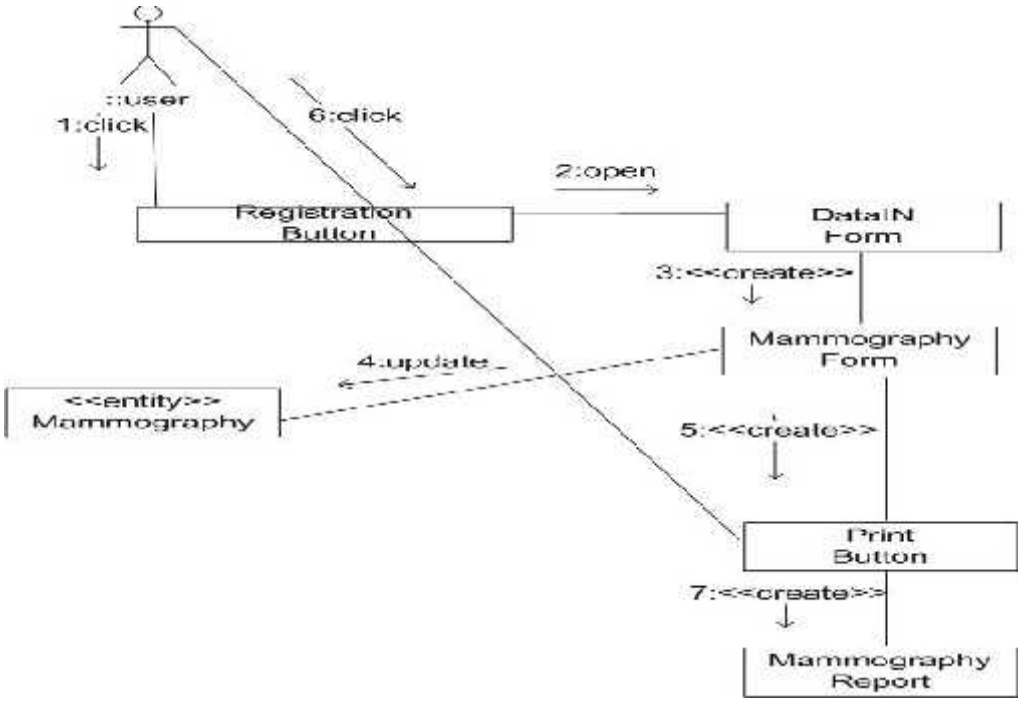

Figure 3.29 Mammography collaboration diagram

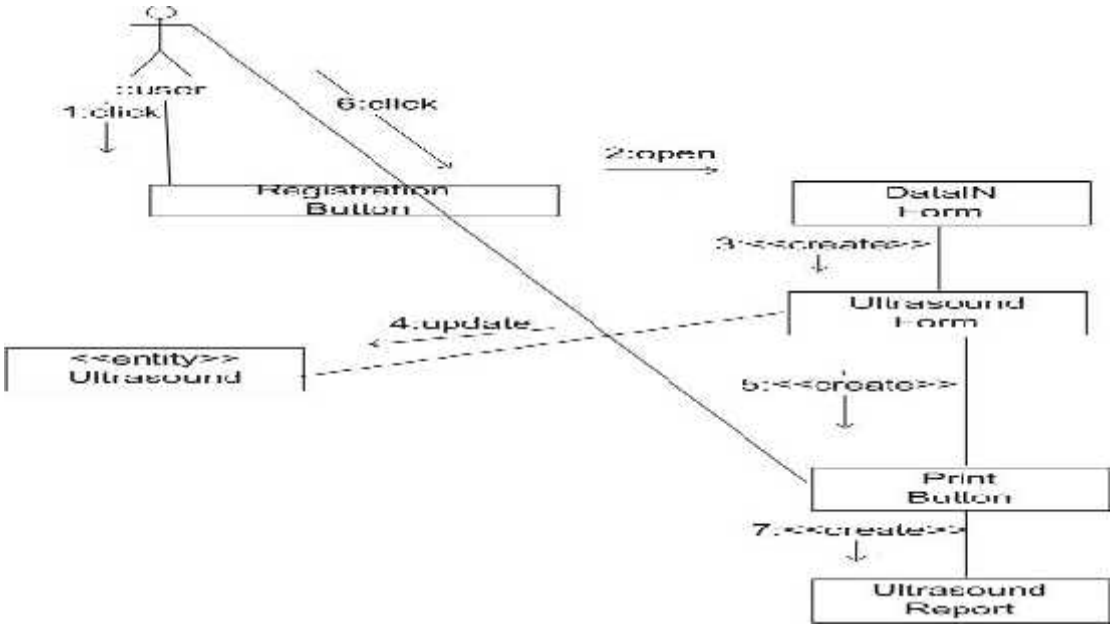

Figure 3.30 Ultrasound collaboration diagram

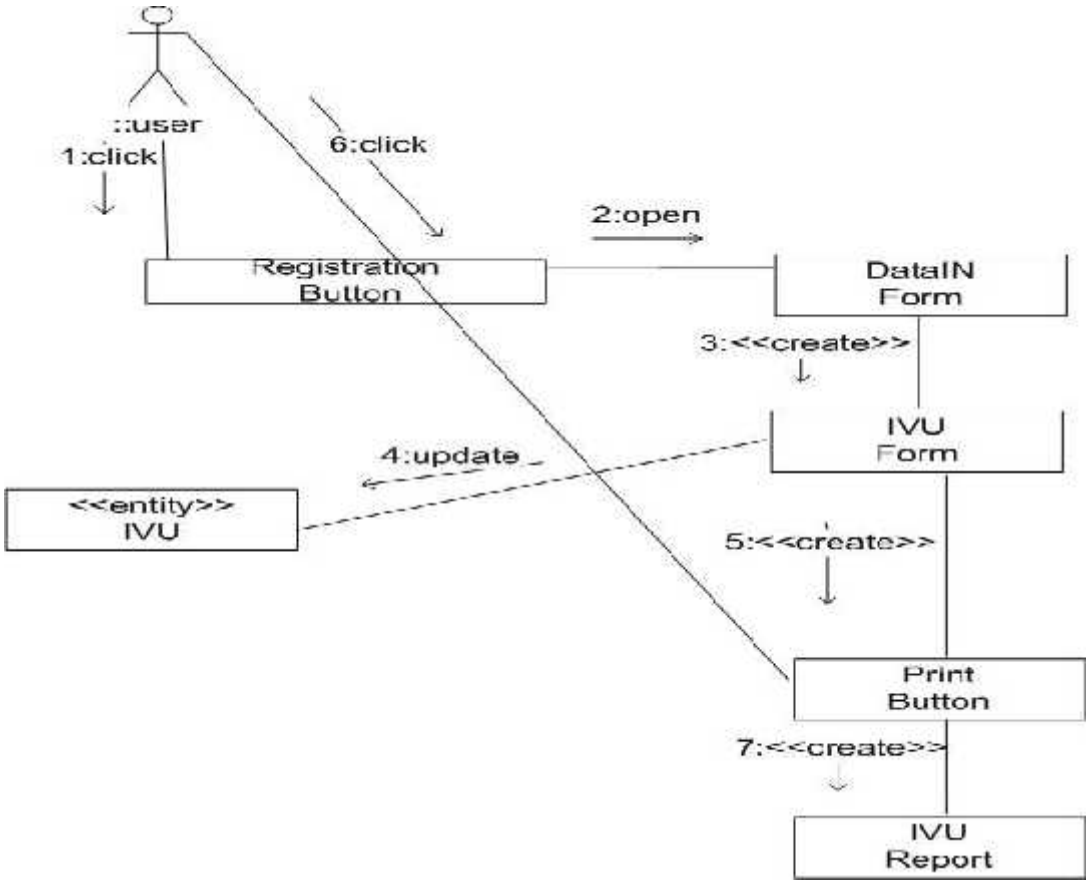

Figure 3.31 IVU collaboration diagram

v. Persistence Modeling

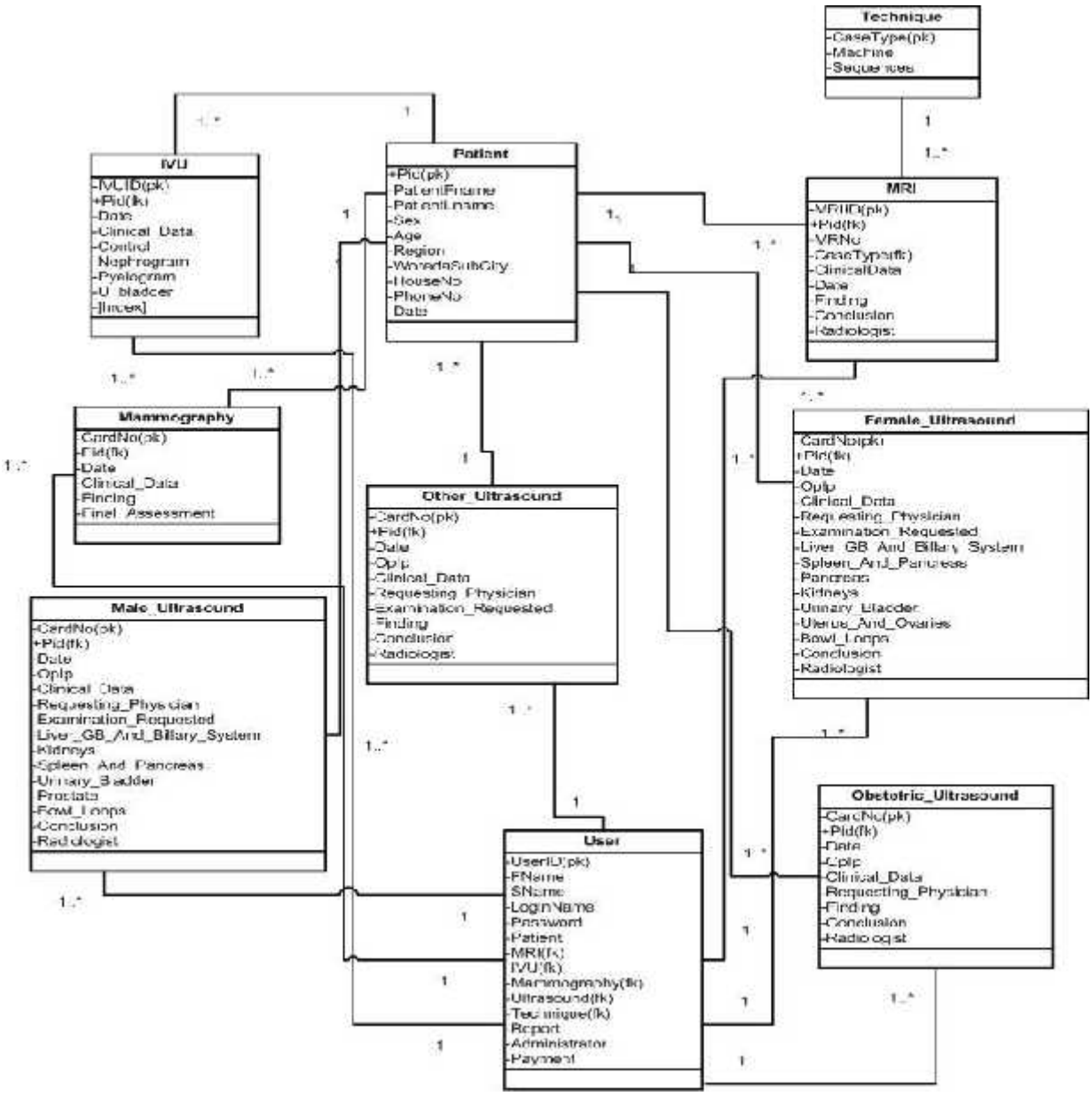

Figure 3.32 Persistence Model

vi. Component Diagram

Component-based development and object-oriented development go hand-in hand, and it is generally recognized that object technology is the preferred foundation from which to build components. UML component diagrams used as an architecture-level artifact, either to model the business software architecture or the technical software architecture. Physical architecture issues, in particular hardware issues, are better addressed via UML deployment diagrams or network diagrams.

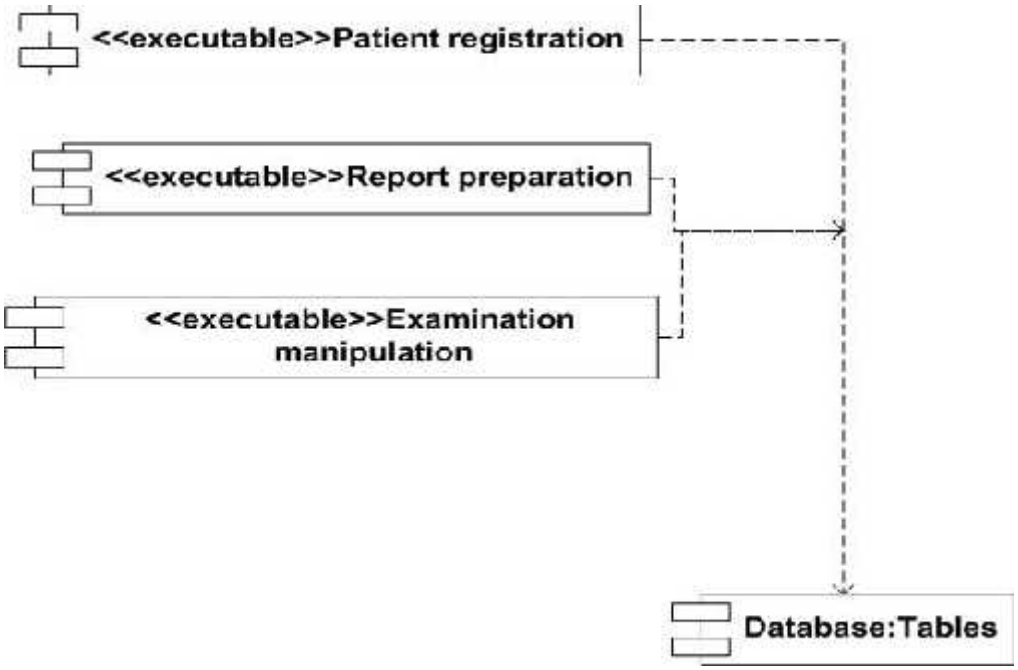

Figure 3.33 Component Diagram of Radiological Record System

vii. Deployment Diagram

Deployment diagram depicts a static view of the run-time configuration of processing nodes and the components that run on those nodes. In other words, deployment diagrams show the hardware for the system, the software that is installed on that hardware, and the middleware used to connect the disparate machines to one another. Deployment diagrams can also be created to explore the architecture of embedded systems, showing how the hardware and software components work together.

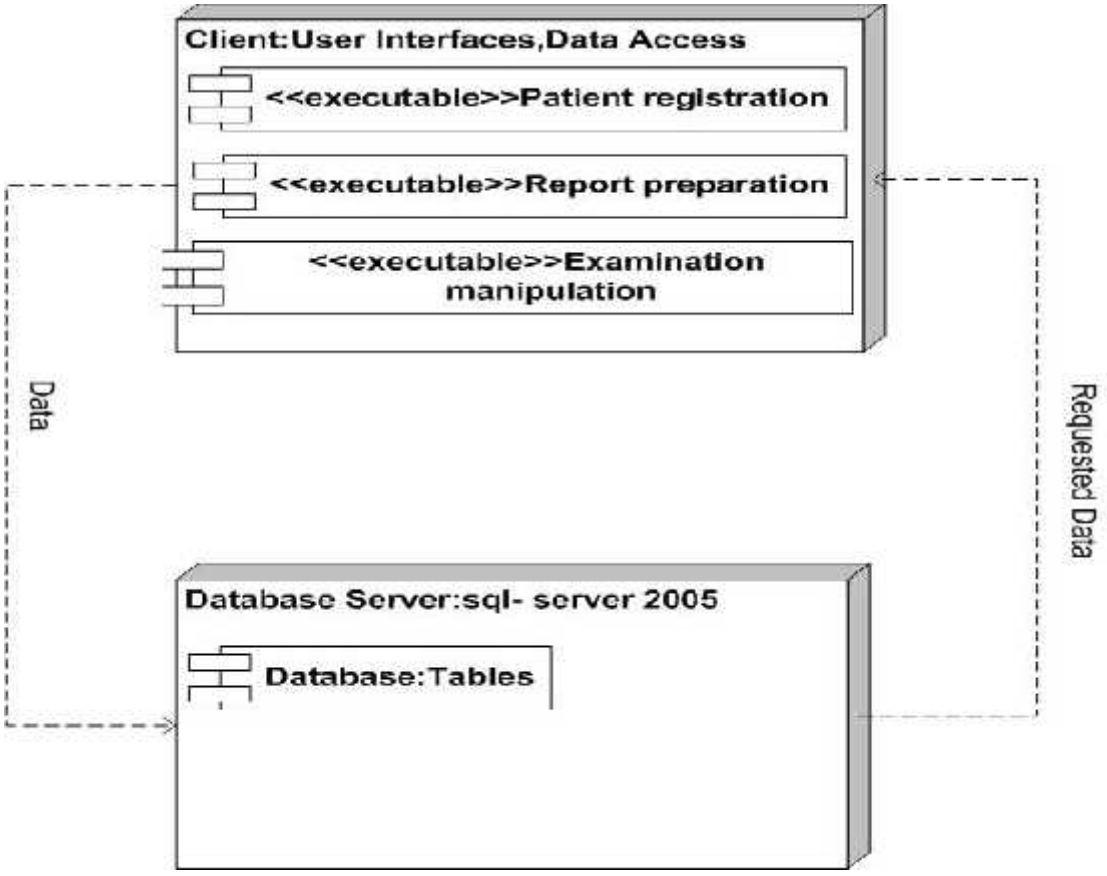

Figure 3.34 Deployment Diagram of Radiological Record System

3.2 Epidemiological Study Design

For the study design Quantitative and Qualitative methods are used for analyzing the data.

3.2.1 Study Area and Period

The study is conducted in Bethel teaching general hospital which is located north western part of Addis Ababa, in sub city of Kolfe Keranyo, kebele05, House No. 2181 just 3 kms back to Addis Ababa Fistula Hospital. The study is conducted in a period September 13, 2009- June 28, 2009.

3.2.2 Study Population

The research is conducted in Addis Ababa city particularly at Bethel Teaching General Hospital. All patients in this period coming to MRI examination considered as a study population.

3.2.3 Sample Size

Determining the sample size is very important in any survey or experiment. To take a larger sample than needed to achieve the desired result is wasteful of resources, whereas very small samples often lead to results that are of no practical use [48]. A convenience sample of MRI department of Bethel Teaching General Hospital was used. The department serves over 300 patients monthly; including MRI, Ultrasound, IVU and Mammography patients. 80 paper records were randomly selected and the same number of records filled in electronic record system by the data clerk and the radiologist. Also by using convenient sampling 40 patients are selected to fill a questionnaire before a system. And another 40 patients selected to fill the same questionnaire after a system. This is to describe what patients feel about the services offered in MRI department. Similar studies showed that convenient sampling could be used for comparing paper based and paperless records [16].

3.2.4 Sampling Procedures

Patients who are prescribed to MRI, Ultrasound, IVU and Mammography tests are selected randomly. Based on the sample size calculated in the

above section, the number of patient reports compared before and after is eighty for each of MRI and Ultrasound cases. And the number of patient reports' compared before and after for both IVU and Mammography cases is eighty, this is due to the small number of IVU and Mammography patients.

3.2.5 Data Collection Procedures

During the process of data collection, the principal investigator of the study controls the overall activity. Paper based MRI, Ultrasound, IVU and Mammography reports are examined for completeness and consistency during data management, storage and analysis.

3.2.6 Data Quality Management

Data investigation will be undertaken to see if there are records that are not logical or consistent. Missing values are dropped for making meaningful analysis. In addition the system developed prohibits incorrect data entry. This way it is possible to control data quality of the system.

CHAPTER FOUR

ANALYSIS AND DISCUSSION

4.1 Quantitative Result

Descriptive statistics are used to describe the basic features of the data in a study. They provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data.

4.1.1 Descriptive Analysis

- **Data Clerk and Radiologist Report Preparation Time Before and After System Implementation**

The data clerk and the radiologist prepare reports of MRI, Ultrasound, IVU and Mammography examinations. And in this section these reports preparation mean time is compared before and after the system implementation.

Table 4.1 MRI report statistics

		Time taken to generate MRI report before a system	Time taken to generate MRI report after a system
N	Valid	80	80
	Missing	0	0
Mean		5.43	3.54
Std. Deviation		1.763	1.222
Variance		3.108	1.492

As shown in Table 4.1, the size of sample is eighty (N=80). The mean time to generate MRI report before the implementation of a system is 5.43 Minute where as after the system is 3.54 Minute. The mean time to generate MRI report after system implementation is smaller than before system implementation.

Table 4.2 Time taken to generate MRI report before a system

	Time (in minute)	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	14	17.5	17.5	17.5
	4	12	15.0	15.0	32.5
	5	14	17.5	17.5	50.0
	6	21	26.3	26.3	76.3
	7	10	12.5	12.5	88.8
	8	6	7.5	7.5	96.3
	9	1	1.3	1.3	97.5
	10	1	1.3	1.3	98.8
	11	1	1.3	1.3	100.0
	Total	80	100.0	100.0	

As shown in the above Table 4.2, 26.3% of the total MRI reports each take 6 minute report preparation time. Whereas 17.5% of MRI reports take only 3 minute time.

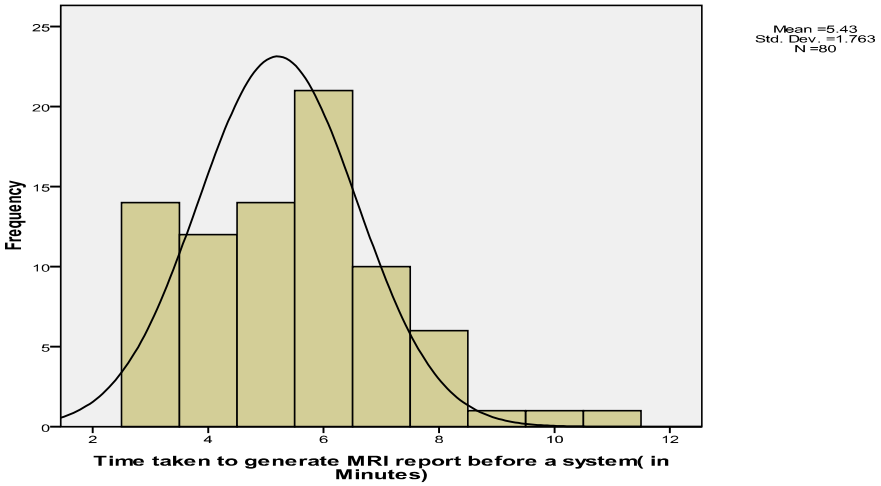

Figure 4.1 Graph of MRI report before a system

As shown in the above Figure 4.1, the mean time taken to prepare MRI report before the system implementation is 5.43 Minute.

Table 4.3 Time taken to generate MRI report after a system

	Time (in minute)	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.3	1.3	1.3
	2	16	20.0	20.0	21.3
	3	26	32.5	32.5	53.8
	4	18	22.5	22.5	76.3
	5	15	18.8	18.8	95.0
	6	3	3.8	3.8	98.8
	7	1	1.3	1.3	100.0
	Total	80	100.0	100.0	

As shown in the above Table 4.3, 32.5% of the total MRI reports each take 3 minute report preparation time. Whereas 1.3% of MRI reports take only 1 minute time.

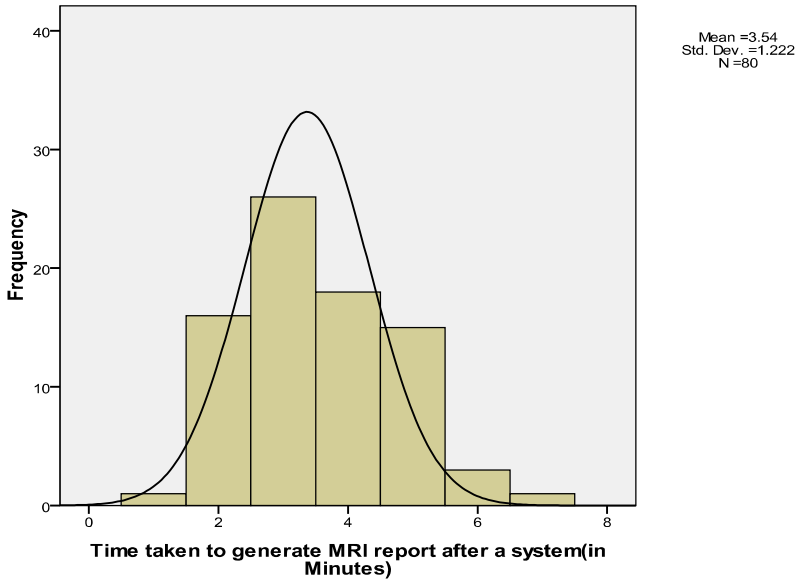

Figure 4.2 Graph of MRI report after a system

As shown in Figure 4.2, the mean time taken to prepare MRI report after the system implementation is 3.54 Minute.

Table 4.4 Ultrasound Statistics

		Time taken to generate ultrasound report before a system	Time taken to generate ultrasound report after a system
N	Valid	80	80
	Missing	0	0
Mean		3.78	2.48
Std. Deviation		1.043	.900
Variance		1.088	.809

As shown in Table 4.4, the size of sample is eighty (N=80). The mean time to generate Ultrasound report before the implementation of a system is 3.78 Minute where as after the system is 2.48 Minute. The mean time to generate Ultrasound report after system implementation is smaller than before the system implementation.

Table 4.5 Time taken to generate ultrasound report before a system

	Time (in minute)	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	2.5	2.5	2.5
	3	34	42.5	42.5	45.0
	4	34	42.5	42.5	87.5
	5	4	5.0	5.0	92.5
	6	2	2.5	2.5	95.0
	7	4	5.0	5.0	100.0
	Total	80	100.0	100.0	

As shown in Table 4.5, 42.5% of the total Ultrasound reports each take 3 Minute report preparation times. Whereas 2.5% of Ultrasound reports take only 2 minute time.

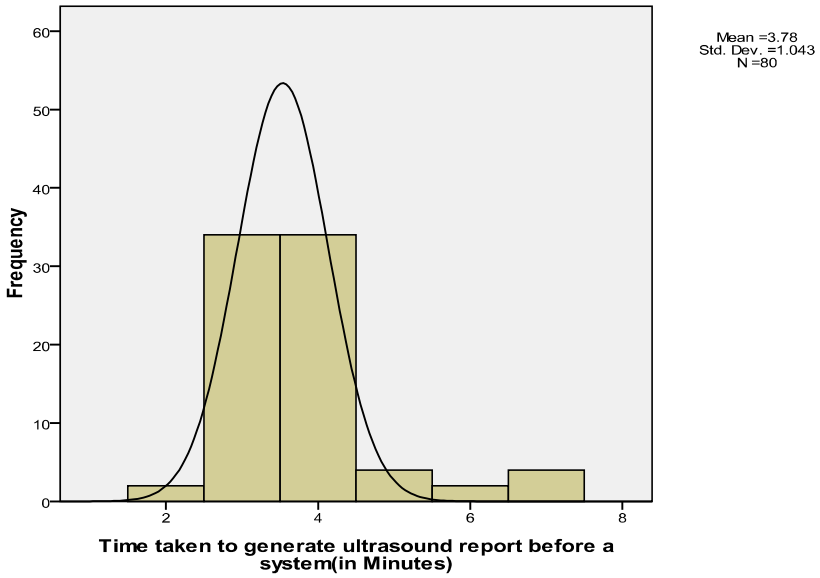

Figure 4.3 Graph of Ultrasound report before a system

As shown in Figure 4.3, the mean time taken to prepare Ultrasound report before the system implementation is 3.78 Minute.

Table 4.6 Time taken to generate ultrasound report after a system

	Time (in minute)	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	2.5	2.5	2.5
	2	52	65.0	65.0	67.5
	3	18	22.5	22.5	90.0
	4	2	2.5	2.5	92.5
	5	6	7.5	7.5	100.0
	Total	80	100.0	100.0	

As shown in Table 4.6, 65.0% of the total Ultrasound reports each take 2 minute report preparation time. Whereas 2.5% of Ultrasound reports take only 2 minute time.

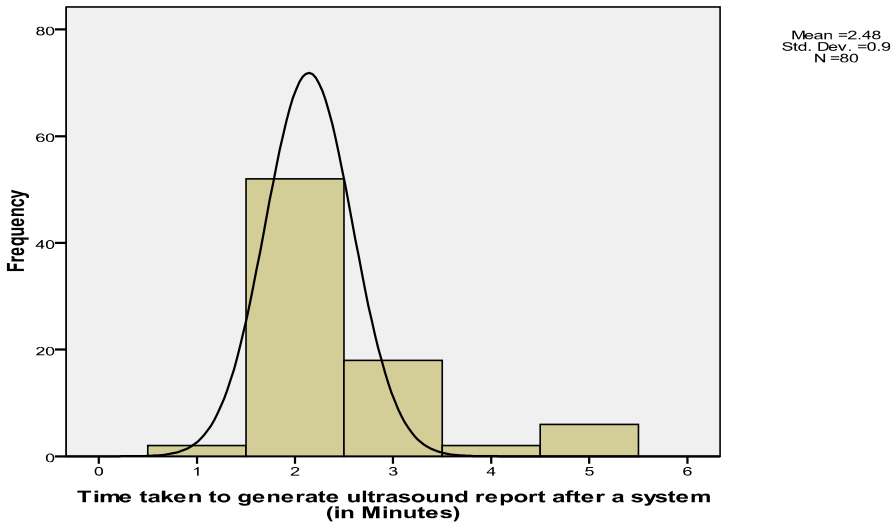

Figure 4.4 Graph of Ultrasound report after a system

As shown in Figure 4.4, the mean time taken to prepare Ultrasound report after the system implementation is 2.48 Minute.

Table 4.7 IVU Report Statistics

		Time taken to generate IVU and Mammography report before a system	Time taken to generate IVU and Mammography report after a system
N	Valid	80	80
	Missing	0	0
Mean		2.21	1.49
Std. Deviation		.822	.503
Variance		.676	.253

As shown in Table 4.7, the size of sample is eighty (N=80). The mean time to prepare IVU and Mammography report before the implementation of a system is 2.21 Minute where as after the system is 1.49 Minute. The mean time to prepare IVU and Mammography report after system implementation is smaller than before system implementation.

Table 4.8 Time taken to generate IVU and Mammography report before a system

	Time (in minute)	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	15	18.8	18.8	18.8
	2	38	47.5	47.5	66.3
	3	22	27.5	27.5	93.8
	4	5	6.3	6.3	100.0
	Total	80	100.0	100.0	

As shown in Table 4.8, 47.5% of the total IVU and Mammography reports take 2 Minute report preparation times. Whereas 18.8% of IVU and Mammography reports take only 1 minute time.

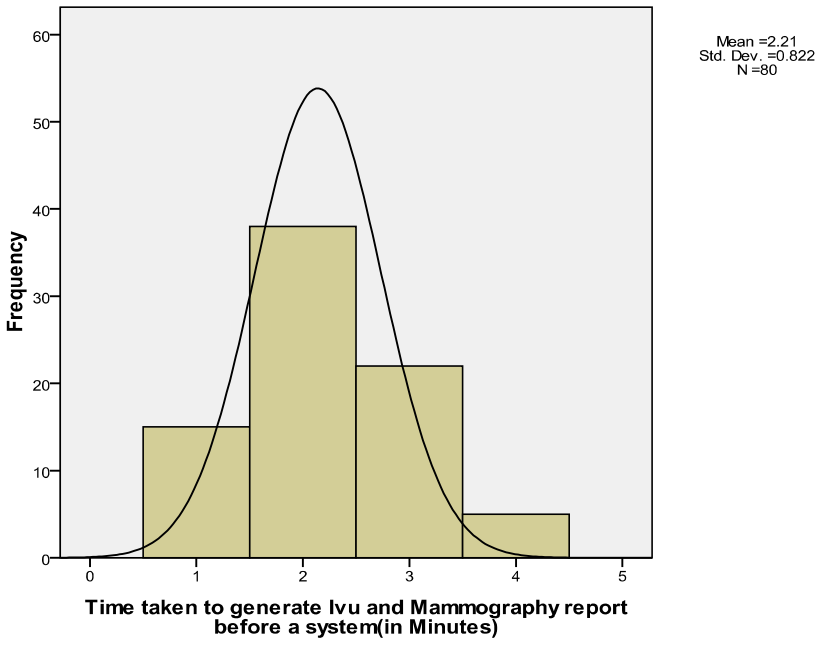

Figure 4.5 Graph of IVU and Mammography report before a system

As shown in Figure 4.5, the mean time taken to prepare IVU and Mammography reports before the system implementation is 2.21 Minute.

Table 4.9 Time taken to generate IVU and Mammography report after a system

	Time (in minute)	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	41	51.3	51.3	51.3
	2	39	48.8	48.8	100.0
	Total	80	100.0	100.0	

As shown in Table 4.9, 48.8% of the total IVU and Mammography reports take 2 minute report preparation time. Whereas 51.3% of IVU and Mammography reports take only 1 minute time.

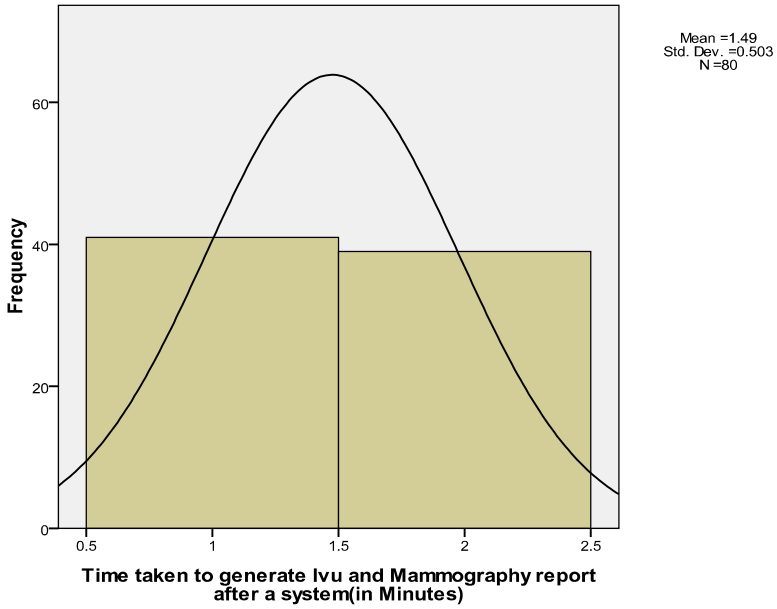

Figure 4.6 Graph of IVU and Mammography report after a system

As shown in Figure 4.6, the mean time taken to prepare IVU and Mammography reports after the system implementation is 1.49 Minute.

♦ Patient Satisfaction Before and After System Implementation

Patients' response is assessed in terms of in terms of their waiting time to get MRI report and other reports. Other reports include Ultrasound, IVU and Mammography examinations. Also patients are asked to respond about the services offered in MRI department is satisfactory or not. And finally they are asked to comment on the record keeping mechanism of MRI department, and this helps to identify problems in MRI department.

i) Patients' Response before System Implementation

Table 4.11 Patient waiting time to get MRI report before a system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NA	23	57.5		
	Very fast	4	10.0	23.5	23.5
	Slow	4	10.0	23.5	77.5
	Very slow	5	12.5	29.5	90.0
	Nothing to say	4	10.0	23.5	100.0
	Total	40	100.0	100.0	

The above Table 4.11, shows Patients' response when they are asked to state their waiting time to get MRI report. From a total of 17 patients 29.5% of patients respond that their waiting time to get MRI report is very slow. Where as 23.5% of patients didn't comment on their waiting time, this may be patients' lack of awareness on their waiting time to get MRI report.

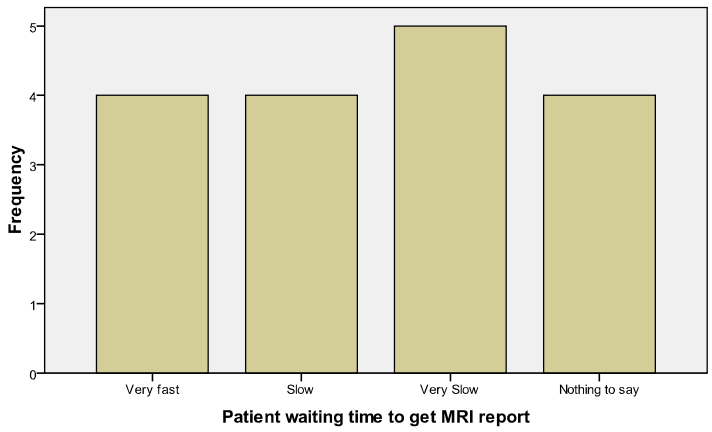

Figure 4.7 Graph of patient waiting time to get MRI report

Table 4.12 Patients Response of Getting Other Services before a system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Missed	7	17.5		
	Yes	20	50.0	60.6	60.6
	No	13	32.5	39.4	100.0
	Total	40	100.0	100.0	

As shown from the above Table 4.12, 60.6% of the requested patients responded that they get other services from MRI department. Other services such as: - IVU, Mammography and Ultrasound cases.

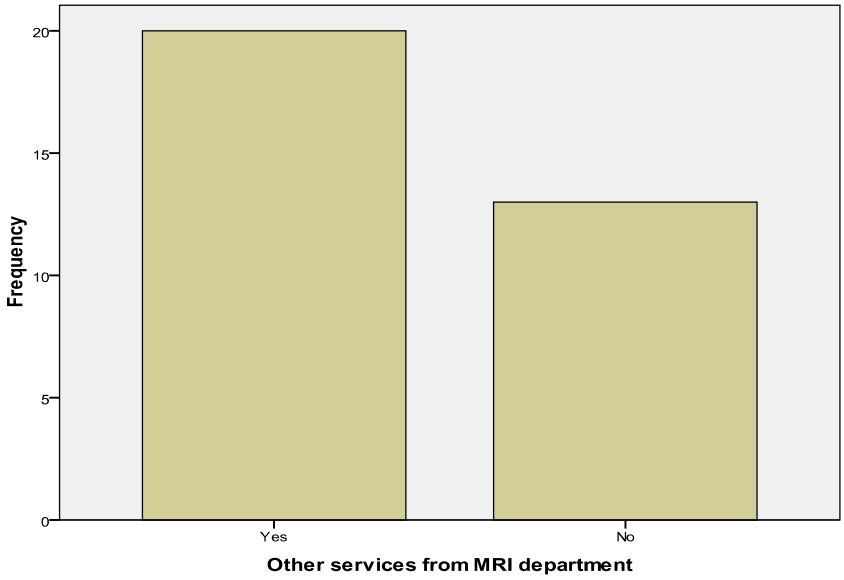

Figure 4.8 Graph of other services given in MRI department

Table 4.13 Patient waiting time to get other reports excluding MRI before a system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Missed	9	22.5		
	Very fast	5	12.5	16.1	16.1
	Fast	9	22.5	29.0	45.2
	slow	5	12.5	16.1	61.3
	Nothing to say	12	30.0	38.7	100.0
	Total	40	100.0	100.0	

As shown in Table 4.13, 16.1% of patients responded that their waiting time to get other reports is very fast. Where as 16.1% of patients responded that their waiting time to get other reports is slow.

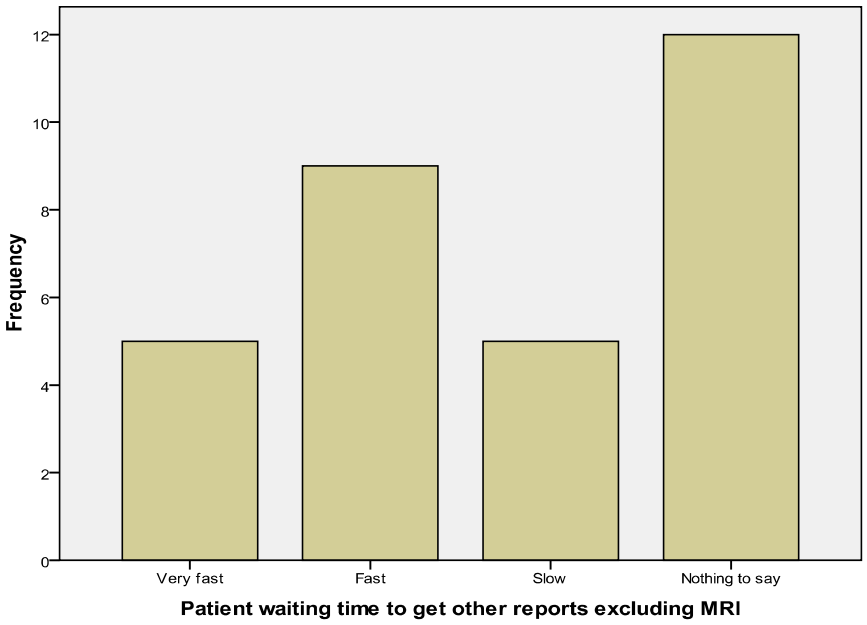

Figure 4.9 Graph of patient waiting time to get other reports

ii) Patients' Response after System Implementation

Table 4.14 Patient waiting time to get MRI report after a system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Very fast	10	25.0	25.0	25.0
	Slow	9	22.5	22.5	47.5
	Very slow	12	30.0	30.0	77.5
	Nothing to say	9	22.5	22.5	100.0
	Total	40	100.0	100.0	

The above Table 4.14, shows Patients' response when they are asked to state their waiting time to get MRI report. From a total of 40 patients 30% of patients responded that their waiting time to get MRI report is very slow. Where as 22.5% of patients didn't comment on their waiting time, this may be patients' lack of awareness on their waiting time to get MRI report. Here we see that patients waiting time to get MRI report before and after a system implementation didn't have any significant difference. In this case the system doesn't improve patient waiting time.

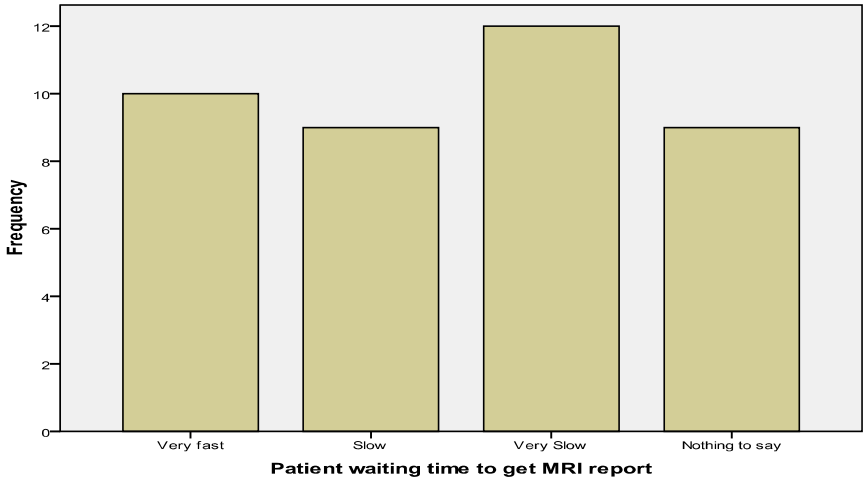

Figure 4.10 Graph of patient waiting time to get MRI report

Table 4.15 Patients response of getting other services after a system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Yes	28	70.4	70.4	70.4
	No	12	29.6	29.6	100.0
	Total	40	100.0	100.0	

As shown from the above Table 4.15, 70.4% of the requested patients responded that they get other services from MRI department. Other services such as: - IVU, Mammography and Ultrasound examinations.

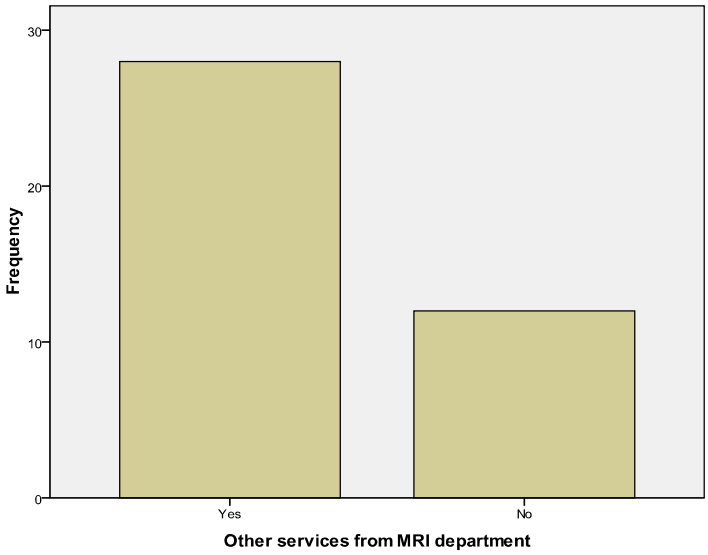

Figure 4.11 Graph of other services given in MRI department

Table 4.16 Patient waiting time to get other reports excluding MRI after a system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	Very fast	7	17.5	17.5	17.5
	Fast	11	27.5	27.5	45.0
	slow	7	17.5	17.5	62.5
	Nothing to say	15	37.5	37.5	100.0
	Total	40	100.0	100.0	

As shown in Table 4.16, 17.5% of patients responded that their waiting time to get other reports is very fast. Where as 17.5% of patients, responded that their waiting time to get other services is slow. Here we see that there is no change in patients waiting time before and after a system implementation referring Table 4.11 - Table 4.16 and Figure 4.7 - Figure 4.12

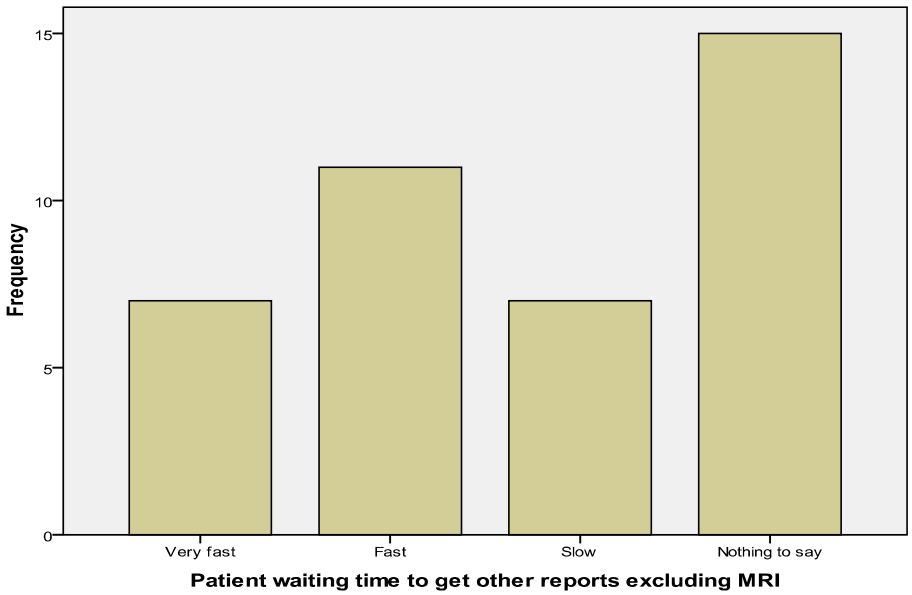

Figure 4.12 Graph of patient waiting time to get other reports

4.1.2 Comparison of Means

Systematic approach for hypothesis testing

1. State the null hypothesis and alternative hypothesis of the study

Null hypothesis (H0): there is no difference in MRI report generation times before and after the system.

Alternative hypothesis (H1): There is difference in MRI report generation times before and after the system.

2. Select the level of significance

In a hypothesis test, a type I error occurs when the null hypothesis is rejected when it is in fact true; that is, H0 is wrongly rejected. And a type II error occurs when the null hypothesis H0, is not rejected when it is in fact false. P (type I error) = significance level = α= 0.05

3. Establish the critical values

The lower and upper critical values are -1.99 and 1.99 respectively at (α/2, df=79).

4. Calculate the test statistic

According to [39] the following formulas are used to calculate $\bar{d}$ (mean time difference), S_d (standard deviation) and t (test statistics).

$$\bar{d} = \sum_{i=1}^{80} di / n = 1.887$$

$$S_d = \sqrt{\frac{\sum_{i=1}^{80} di - \bar{d}}{n-1}} = 1.35$$

$$t = \frac{\bar{d}}{\sqrt{\frac{S_d^2}{n}}} = 1.887/1.35 = 12.505$$

5. Compare the observed test statistic with the critical values

The observed (calculated) test statistic t=12.505 is greater than critical value 1.99. So that the null hypothesis stated “There is no difference in MRI report generation times before and after the system” is rejected.

Conclusion: There is a significant difference between MRI report generation time before and after system implementation. As a result the alternative hypothesis H1 is accepted.

Table 4.17 MRI Report Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Time taken to generate MRI report before a system	5.43	80	1.763	.197
	Time taken to generate MRI report after a system	3.54	80	1.222	.137

As shown in the above Table 4.17, the mean time taken to prepare MRI report after system implementation is smaller than before system implementation.

Table 4.18 MRI Report Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Time taken to generate MRI report before a system - Time taken to generate MRI report after a system	1.887	1.350	.151	1.587	2.188	12.505	79	.000

As shown in the above Table 4.18, the mean time difference between MRI report generation time before and after system implementation is 1.887 minute.

Systematic approach for hypothesis testing

1. State the null hypothesis and alternative hypothesis of the study

Null hypothesis (H0): there is no difference in Ultrasound report generation times before and after the system.

Alternative hypothesis (H1): There is difference in Ultrasound report generation times before and after the system.

2. Select the level of significance

In a hypothesis test, a type I error occurs when the null hypothesis is rejected when it is in fact true; that is, H0 is wrongly rejected. And a type II error occurs when the null hypothesis H0, is not rejected when it is in fact false. P (type I error) = significance level = α = 0.05

3. Establish the critical values

The lower and upper critical values are -1.99 and 1.99 respectively at (α/2, df=79).

4. Calculate the test statistic

According to [40] the following formulas are used to calculate $\bar{d}$ (mean time difference), S_d (standard deviation) and t (test statistics).

$$\bar{d} = \sum_{i=1}^{80} di / n = 1.300$$

$$S_d = \sqrt{\frac{\sum_{i=1}^{80} di - \bar{d}}{n-1}} = 0.624$$

$$t = \frac{\bar{d}}{\sqrt{\frac{S_d^2}{n}}} = 1.300/0.624 = 18.622$$

5. Compare the observed test statistic with the critical values

The observed test statistic t=18.622 is greater than critical value 1.99. So that the null hypothesis stated “There is no difference in Ultrasound report generation times before and after the system” is rejected.

Table 4.19 Ultrasound Report Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Time taken to generate ultrasound report before a system	3.78	80	1.043	.117
	Time taken to generate ultrasound report after a system	2.48	80	.900	.101

Conclusion: There is a significant difference between Ultrasound report generation time before and after system. As a result the alternative hypothesis H1 is accepted.

As shown in the above Table 4.19, the mean time taken to prepare Ultrasound report after system implementation is smaller than before system implementation.

Table 4.20 Ultrasound Report Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			

Table 4.20 Ultrasound Report Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Time taken to generate ultrasound report before a system - Time taken to generate ultrasound report after a system	1.300	.624	.070	1.161	1.439	18.622	79	.000

Systematic approach for hypothesis testing

1. State the null hypothesis and alternative hypothesis of the study

Null hypothesis (H0): there is no difference in IVU and Mammography report generation times before and after the system.

Alternative hypothesis (H1): There is difference in IVU and Mammography report generation times before and after the system.

2. Select the level of significance

In a hypothesis test, a type I error occurs when the null hypothesis is rejected when it is in fact true; that is, H0 is wrongly rejected. And a type II error occurs when the null hypothesis H0, is not rejected when it is in fact false. P (type I error) = significance level = α = 0.05

3. Establish the critical values

The lower and upper critical values are -1.99 and 1.99 respectively at (α/2, df=79).

4. Calculate the test statistic

According to [40] the following formulas are used to calculate $\bar{d}$ (mean time difference), S_d (standard deviation) and t (test statistics).

$$\bar{d} = \sum_{i=1}^{80} di / n = 0.725$$

$$S_d = \sqrt{\frac{\sum_{i=1}^{80} di - \bar{d}}{n-1}} = 0.616$$

$$t = \frac{\bar{d}}{\sqrt{\frac{S_d^2}{n}}} = 0.725/0.616 = 10.532$$

5. Compare the observed test statistic with the critical values

The observed test statistic t=10.532 is greater than critical value 1.99. So that the null hypothesis stated "There is no difference in IVU and Mammography report generation times before and after the system" is rejected.

Conclusion: There is a significant difference in report generation time before and after system implementation for IVU and Mammography cases. As a result the alternative hypothesis H1 is accepted.

Table 4.21 IVU and Mammography Report Paired Samples Statistics

		Mean	N	Std. Deviation	Std.Error Mean
Pair 1	Time taken to generate IVU and Mammography report before a system	2.21	80	.822	.092
	Time taken to generate IVU and Mammography report after a system	1.49	80	.503	.056

As shown in the above Table 4.21, the mean time taken to prepare IVU and Mammography report after system implementation is smaller than before system implementation.

Table 4.22 IVU and Mammography Report Paired Samples Test

		Paired Differences					t	df	Sig.(2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Time taken to generate IVU and Mammography report before a system - Time taken to generate IVU and Mammography report after a system	.725	.616	.069	.588	.862	10.532	79	.000

4.2 Qualitative Result

4.2.1 Site Observation

Before deploying the radiological record system, I visited the service provider: Bethel Teaching General Hospital for a number of times. During this time I observed MRI department work activities, how the radiologist and the data clerk keep patient data, how they prepare patient based reports of MRI, Ultrasound, IVU and Mammography examinations. Also I observed the data clerk room file cabinets, MRI image processing system, patients waiting area and radiology room.

As I observed, the record system of MRI department of Bethel Teaching General Hospital is a manual system. In the day to day activities of MRI department, the following problems are identified:-

- The data clerk and the radiologist way of searching and retrieval of patient data is inefficient

- The required patient data may be lost
- Most of the time patient data couldn't be found easily

- The data clerk and the radiologist discard patient data older than three or more than three months due to lack of structured data storage system
- Anybody in MRI department can visit patient charts and this indicates that patient data is less protected.
- Preparation of summary reports is impossible due to large amount of data in a very short period of time

As I have seen activities in MRI department, they didn't prepare any daily, weekly, monthly, semi-annual and annual reports for the management and performance evaluation of the department. But after the new radiological record system, it is possible to generate summary reports which support the management and improvement of patient healthcare. In addition to this the new system could be used for education and epidemiological research purposes.

4.3 Discussion

According to [14], [34] Survey results suggest positive user satisfaction with EHR and also according to [19] Patients spent substantially less time waiting. But this study didn't improve patients' waiting time after a system implementation. These is due to the workload of the radiologist, meaning a single radiologist is responsible for examining and interpreting MRI, Ultrasound , IVU and Mammography cases. In this case no improvement in patients' waiting time is seen.

According to [32] there is no significant time difference in consultation compared with paper records. In this study consultation time is not compared before and after a system implementation, because it doesn't has direct impact on improvement of work activities in MRI department.

According to [19] the Mosoriot Medical Record System in a rural Kenyan health center includes services of Laboratory, Pharmacy and Finance. After system implementation, patient visits were 22% shorter. They spent 58% less time with providers ($p<0.001$) and 38% less time waiting ($p = 0.06$). Clinic personnel spent 50% less time interacting with patients, two thirds less time interacting with each other, and more time in personal activities. However in this study a radiological record system is developed to compare it with paperless records in MRI department. As a result of this report preparation time of MRI, Ultrasound, IVU and Mammography examinations are compared before (paper based records) and after (paperless records). Results show that, there is a significant mean time difference ($\bar{d}$ =1.887) between MRI report preparation before and after a system implementation (p-value=0.000). And also there is a significant mean time difference ($\bar{d}$ =1.300) between Ultrasound report preparation before and after a system implementation (p-value=0.000). Furthermore there is a significant mean time difference ($\bar{d}$ =0.725) in preparation of reports IVU and Mammography (p-value=0.000) before and after a system implementation.

According to [39] found more time spent on patient care and other nursing activities but also on document management in intensive care. This study based on the above facts show that, less time taken to prepare reports after a system implementation. Indirectly this shows that more time could be spent on patient care.

Also as with [41],[4] the new radiological record system has advantages of simultaneous data access, legibility, data-backup and confidentiality which is related to security (for example the radiologist and the data clerk do not have equal privilege for accessing patient data [29]), decision support to the diagnosis of a disease on the basis of individual data, decision support to epidemiological research(serving as a sampling tool- to select patients from the database and as a data collection tool- to collect and retrieve clinical data for decision support of the physicians),data-processing of different

activities including preparation of summary reports and search of patient data.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study was undertaken with the objective of assessing and developing radiological record system for Bethel Teaching General Hospital. The problems associated with the existing system of MRI department in terms of data management, service provider and patient satisfaction are investigated.

In the study: MRI department working procedure , patient data management ,types of report prepared, reports of MRI,IVU, Mammography and Ultrasound cases including patients' satisfaction and summary reports are assessed before and after system implementation. Based on the requirement of the system, radiological record system is developed. The system consists of at back-end Sql Server Management Studio 2005 and front-end Microsoft Visual Studio 2005. And whether the newly developed system improved the existing system or not is tested statistically.

Based on the result of Table 4.18, there is a significant mean time difference ($\bar{d}$ =1.887) between MRI report preparation before and after a system implementation (p-value=0.000). Therefore Figure 4.1 and Figure 4.2 showed that MRI report preparation mean time is shorter after the system implementation than before.

Based on the result of Table 4.20, there is a significant mean time difference ($\bar{d}$ =1.300) between Ultrasound report preparation before and after a system implementation (p-value=0.000). So Figure 4.3 and Figure 4.4 showed that Ultrasound report preparation mean time is shorter after the system implementation than before.

Furthermore the result of Table 4.22 shows, there is a significant mean time difference ($\bar{d}$ =0.725) in preparation of reports IVU and Mammography (p-value=0.000) before and after a system implementation. So Figure 4.5 and Figure 4.6 showed that IVU and Mammography reports preparation mean time is shorter after the system implementation than before.

Also from Table 4.11 - Table 4.16 and Figure 4.7 - Figure 4.12 results, the system doesn't improve patients waiting time after the system implementation. This is due to the workload of the radiologist. Meaning a single radiologist is responsible for examining MRI, IVU, Mammography and Ultrasound cases.

Furthermore after the system implementation daily, weekly, monthly, semi-annual and annual summary reports are generated by the system. And these reports add a value for decision support of the physicians and the management in regards to service delivery. But before the system implementation there is no any daily, weekly, monthly, semi-annual and annual reports.

After the system implementation patient data retrieval becomes easy and fast. And also the system is secured without having a privilege, it is

impossible to access the system functionalities. Furthermore the system database can store long time patient data; as a result of this the data could be used for education and epidemiological research purposes. But before the system, searching and retrieval of patient data becomes inefficient, patient data get lost, long time patient data becomes unavailable due to lack of structured data storage system, and also it is less protected compared with after the system implementation.

The analysis of the study showed that the existing system of MRI department of Bethel Teaching general hospital is manual which is insufficient to meet the need of physicians, patients, and management of the hospital. In these case based on the study result it is crucial to develop and implement the radiological record system for MRI department of Bethel Teaching General Hospital.

5.2 Recommendations

From this study, it was learnt that more research and development efforts need to be conducted to improve the health care of patients by applying Information Technology in the health care sector. In particular, the following areas are identified for further research work:

- Since this research used the requirement of MRI department of Bethel Teaching General Hospital, it is appropriate to develop a comprehensive hospital system to improve the heath care of patients and to support decision making process of the management.
- For providing an efficient service delivery in MRI department of the hospital, it is advisable to assign two or three radiologists.
- The study recommends that client-server network architecture is required to apply and use central data warehouse for managing patient data coming from different departments/sections of the hospital.

- Also the study recommends that to meet the information needs of physicians and the management, a detailed study should be conducted.
- The study also recommends that to incorporate MRI images in radiological record system to relate its information with that of MRI findings and conclusions.
- The study recommends that to use data capture technologies like Microsoft Tablet Pc or Digital Pen and Paper, integrated with the radiological record system. These technologies save time that the radiologist spent for the transcription process.
- The study also recommends that to apply data mining technology for predicting and finding pattern of different examinations to support patient healthcare.

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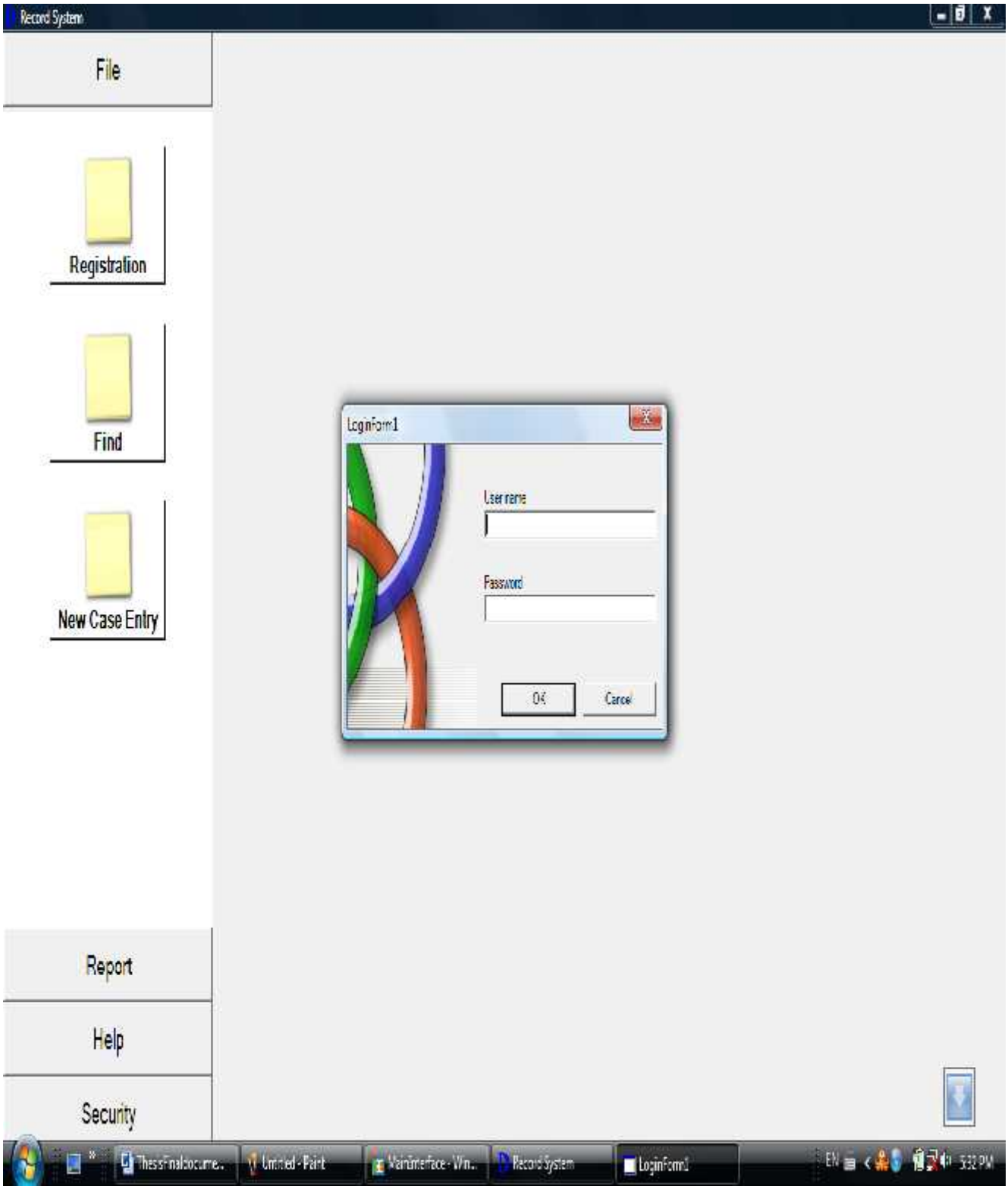
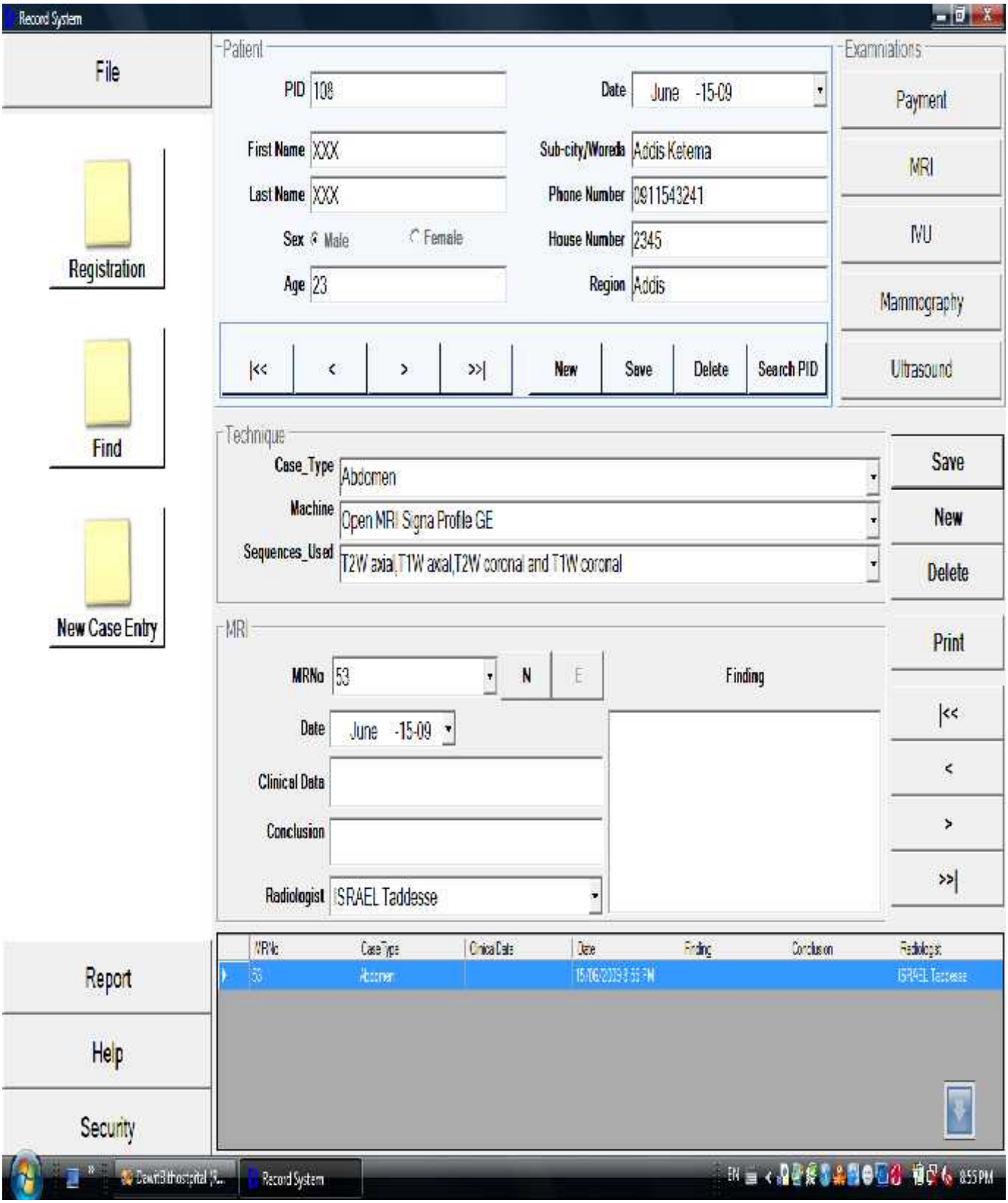
ANNEXES

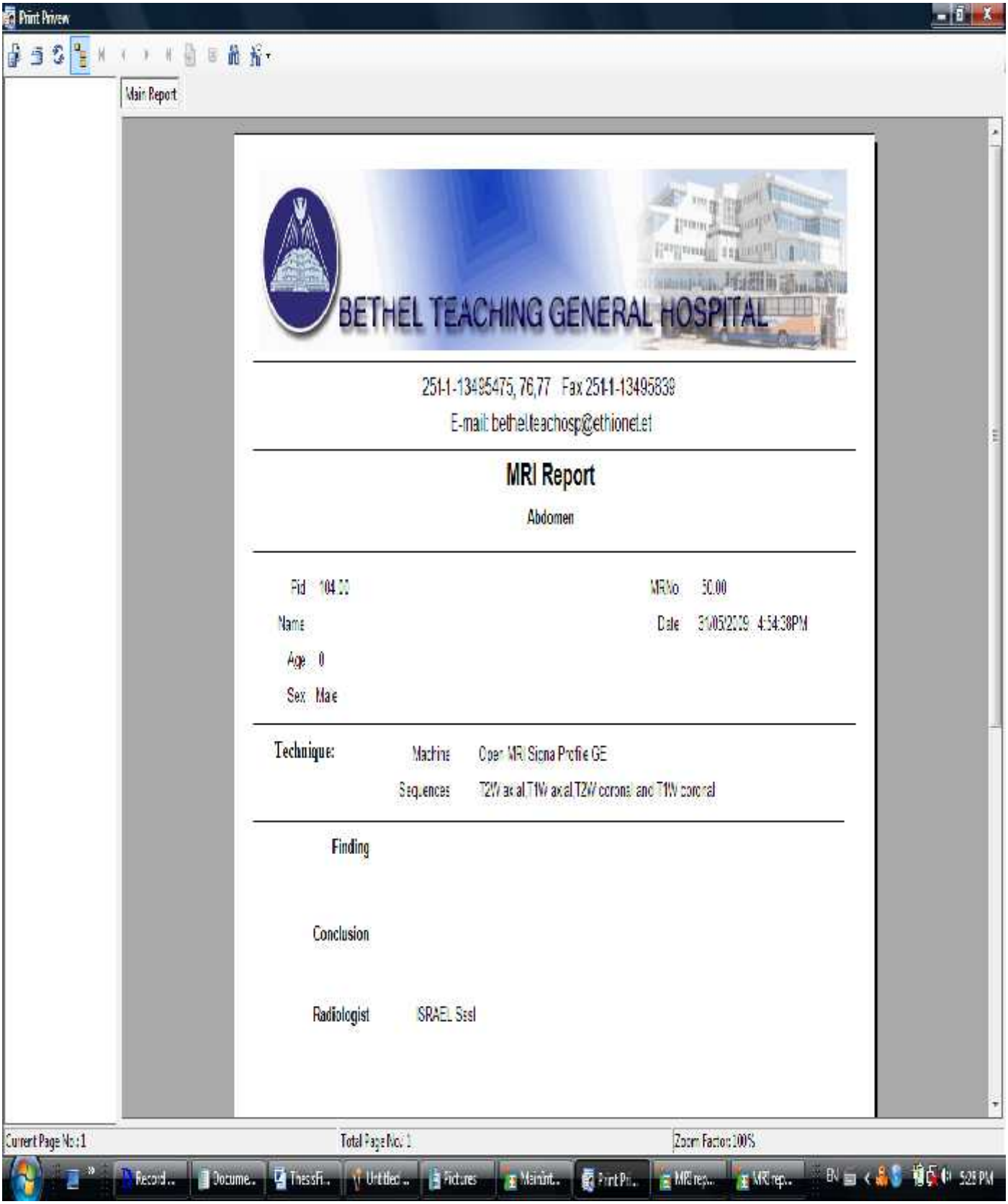
Annex 1: Main Interface of the radiological record system


Record System
File
Registration
Find
New Case Entry
Report
Help
Security
LoginForm1
User name
Password
OK
Cancel

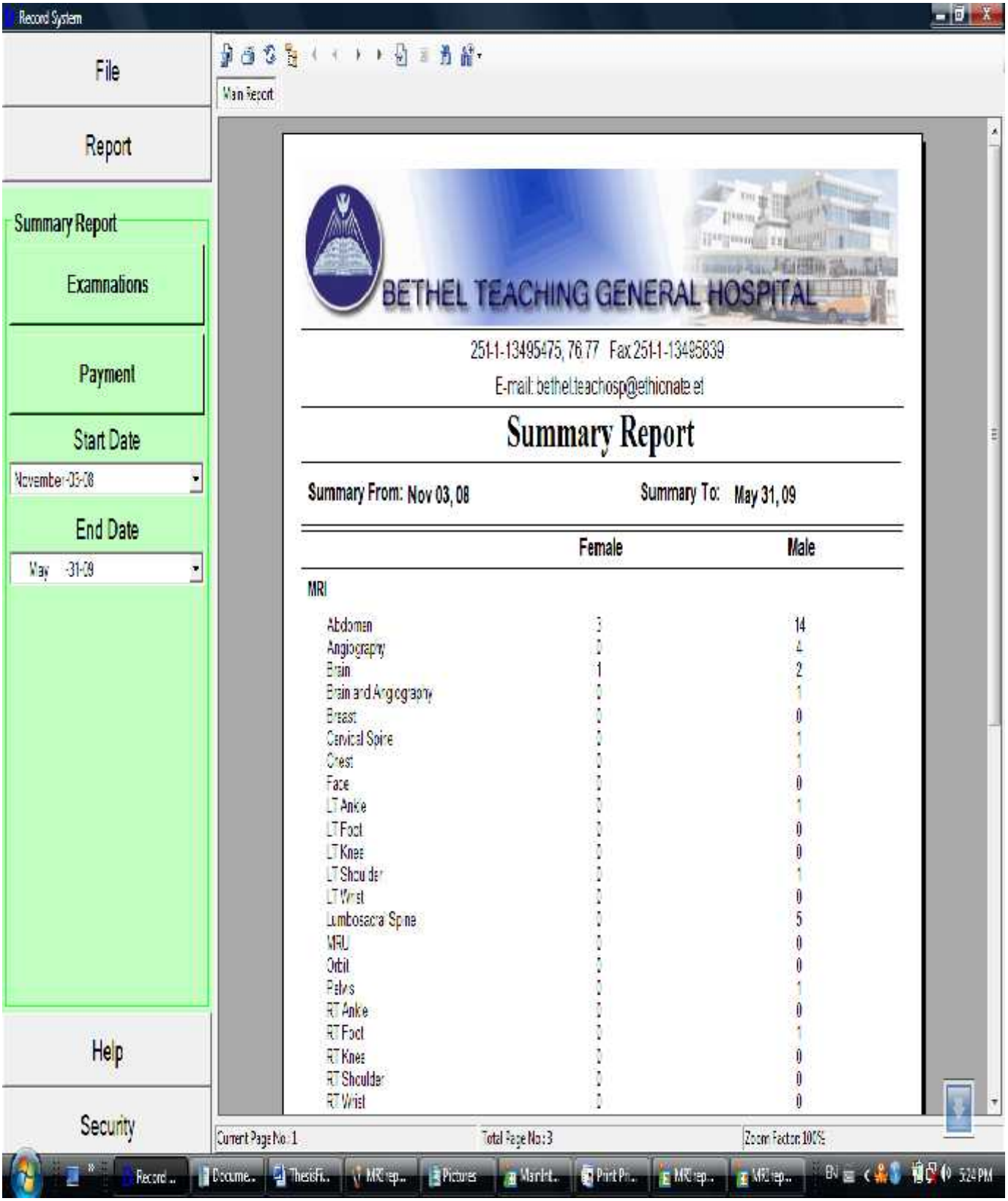
Annex 2: Patient data entry form of the radiological record system



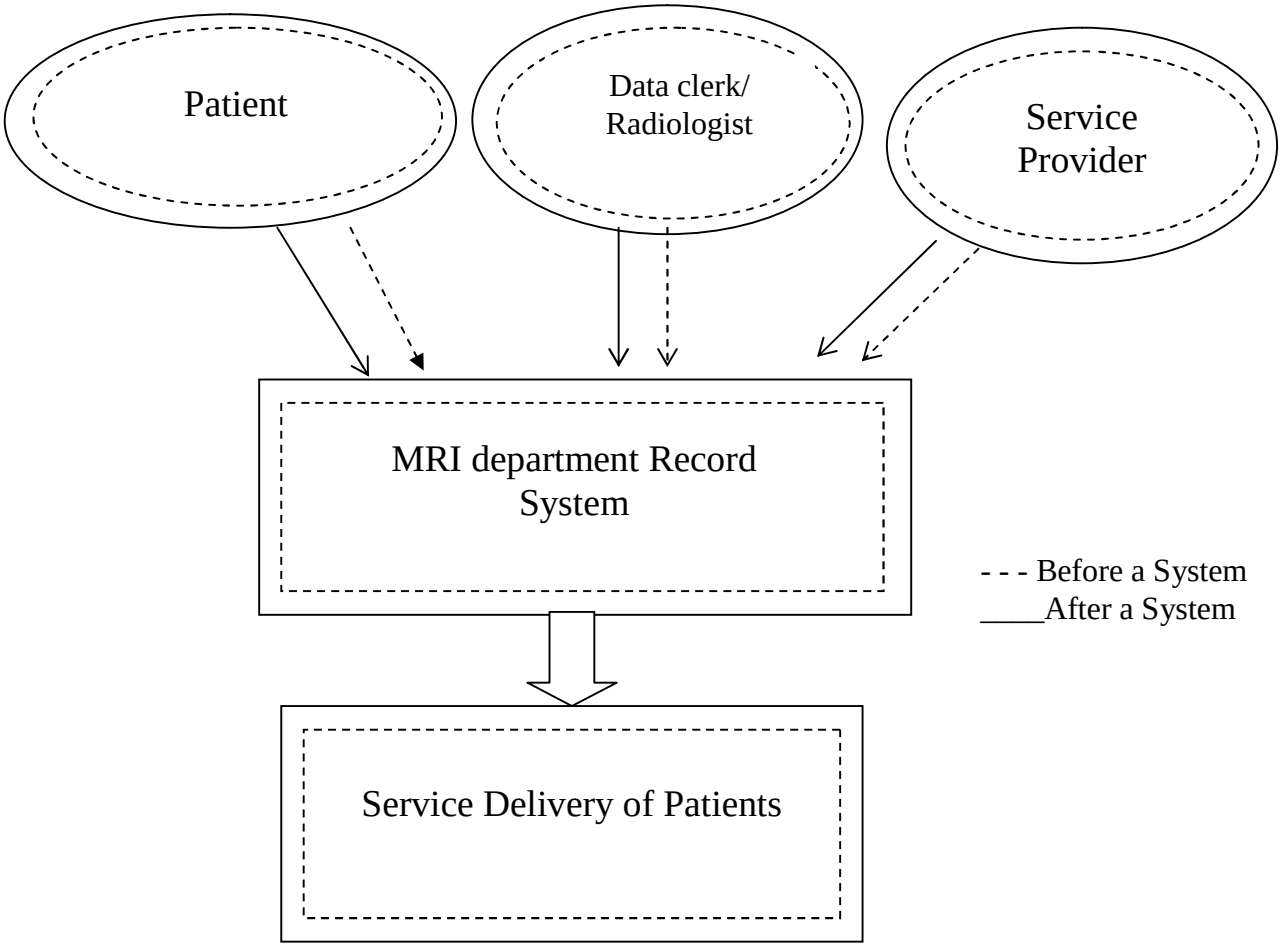
Annex 3: MRI report of the radiological record system



Annex 4: Summary Report of radiological record system



Annex 5: Conceptual Framework



Annex 6: Questionnaire

Questionnaire for Patient

1. How do you scale your waiting time for MRI report?

A. Very fast

B. Fast

C. Slow

D. Very slow

E. Nothing to say

2. Do you get other services from MRI department?

A. yes (If yes, go to question No.3)

B. no

3. How do you see, the waiting time to get a report of these services?

A. Very fast

B. Fast

C. Slow

D. Very slow

E. Nothing to say

4. Do you think MRI department record keeping mechanism satisfactory?

A. yes

Why? _____

_____

B. no

Why? _____

_____

5. What do you suggest to improve service provision of MRI department?

_____

_____

_____

የኤም አር አይ ክፍል መዝገብ አያያዝ መጠይቅ

1. **የመጠይቁ መለያ ቁጥር. _____**

የፈቃደኝነት መግለጫ ቅጽ

ጤና ይስጥልኝ _____ እባላለሁ።

የመጣሁት ከአዲስ አበባ ዩኒቨርስቲ ሄልዝ ኢንፎርማቲክስ ትምህርት ክፍል ጥናታዊ መረጃ ለማሰባሰብ ነው። በመጀመሪያ ደረጃ ጥናቱን በተመለከተ አጠር ያለ ውይይት ይኖረናል። የጥናቱ አላማ የኤም አር አይ ክፍል መዝገብ አያያዝን ማሻሻል ሲሆን የሚሠጡት መረጃ በሙሉ በፍፁም አስተማማኝነት ለዚህ ጥናት ብቻ የሚያገለግል እና በዚህ መጠይቅ ላይ ስምዎንም ይሁን አድራሻዎን መግለጽ አይኖርበዎትም። መጠይቁ የእርስዎ ፈቃደኝነት ከተረጋገጠ ብቻ የሚካሄድ ይሆናል። በተጨማሪ ለመመለስ የማይፈልጓቸው ጥያቄዎች ካሉ ጥያቄውን ለመመለስ አይገደዱም። እንዲሁም በጥናቱ ላይ በሙሉም ይሁን በከፊል ላለመሣተፍ ከፈለጉ በማንኛውም ሰዓት ማቋረጥ ይችላሉ። የእርስዎ በጥናቱ ላይ መሳተፍ አለመሳተፍ፣ ጥያቄዎችን ለመመለስ ፈቃደኛ አለመሆን አሁንም ወደፊትም በሚያገኙት የኤም አር አይ ጤና ግልጋሎት ላይ ሙሉ በሙሉ ምንም አይነት ተጽኖ አይኖረውም።

በዚህ ጥናት ለመሳተፍ ፍቃደኛ ነዎት?

[ ] አዎ [ ] ፈቃደኛ አይደለሁም

ለሕሙማን የሚ ቀርብ መጠይቅ

1. የኤም አር አይ ሪፓርትን ለማግኘት የሚወስድቦት ጊዜ
    ሀ) በጣም አጭር ጊዜ
    ለ) አጭር ጊዜ
    ሐ) ብዙ ጊዜ
    መ) በጣም ብዙ ጊዜ
    ሰ) መልስ የለኝም
2. በኤም አር አይ ዲፓርትመንት ውስጥ ከኤም አር አይ ምርመራ ውጪ ሌላ አገልግሎትን ያገኛሉ?
    ሀ) አዎ (አዎን ካሉ ወደ ጥያቄ ቁ. 3 ይሂዱ)
    ለ) አይደለም
3. ከኤም አር አይ ሪፖርት ውጪ ሌላ ሪፓርትን የሚወስድቦት ጊዜ_____
    ሀ) በጣም አጭር ጊዜ
    ለ) አጭር ጊዜ
    ሐ) ብዙ ጊዜ
    መ) በጣም ብዙ ጊዜ
    ሰ) መልስ የለኝም
4. በኤም አር አይ ዲፓርትመንት መዝገብ (ዳታ) አያያዝ አጥጋቢ ነው ብለው ያምናሉ?
    ሀ) አዎ (አዎ ካሉ ለምን?)

_____

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_____

    ለ) አይደለም (አይደለም ካሉ ለምን?)

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5. ኤም አር አይ ዲፓርትመንት የሚሰጠውን አገልግሎት ለማሻሻል ምን መደረግ አለበት ብለው ያምናሉ?

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Observation Checklist

Time spent To Prepare MRI Report (Data Clerk/Radiologist)			
No	Day	Start time(Minutes)	End time(Minutes)
1			
2			
3			
4			
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…	…	…	…
…	…	…	…

Time spent To Prepare Ultrasound Report (Data Clerk/Radiologist)			
No	Day	Start time(Minutes)	End time(Minutes)
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…	…	…	…

Time spent To Prepare IVU and Mammography Report (Data Clerk/Radiologist)			
No	Day	Start time(Minutes)	End time(Minutes)
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DECLARATION

This thesis is my original work and has not been submitted as a partial requirement for a degree in any university.

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Dawit Retta Woldeyohanni
June 2009

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

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Henock Leulseged