ADDIS ABABA UNIVERSITY
SCHOOL OF PUBLIC HEALTH AND SCOOL OF INFORMATION SCIENCE

HEALTH INFORMATICS PROGRAM

DEVELOPING PATIENT RECORD SYSTEM FOR HEALTH CENTERS IN HABRU WOREDA

By
Hiwot Araya (B.Sc.)

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LIST OF ACRONYMS

AHR	Automated Health Record
AIDS	Acquired Immune Deficiency Syndrome
ANC	Anti Natal Care
CDSS	Clinical Decision Support System
CPOE	Computerized Provider Order Entry
CBPR	Computer-based Patient Record
DBMS	Database Management System
DHIS	District Health Information Software
EHR	Electronic Health Record
EMR	Electronic Medical Record
EPI	Expanded Program on Immunization
FMOH	Federal Ministry of Health
FP	Family Planning
HIS	Health Information System
HIV	Human Immune deficiency Virus
HMIS	Health Management Information System
HMN	Health Metrics Network
HSD	Health Service Delivery
HSDP	Health Sector Development Program
ICT	Information Communication Technology
LAN	Local Area Network
LIS	Laboratory Information System
MCH	Mother and Child Health
MDI	Multiple Document Interface
MMRS	Mosoriot Medical Record
NGOs	Non Governmental Organizations
NHIS/SA	National Health Information System /South Africa
OC/RR	Order Communication/Result Retrieval
OPD	Out Patient Department
PAAB	Patient Administration and Billing
PADS	Personal Assistance Digital System
PHCU	Primary Health Care Unit
RAD	Rapid Application Development
RHB	Regional Health Bureau
SDI	Single Document Interface
SDLC	System Development Life Cycle
SQL	Structured Query Language

SSAD	Structured System Analysis and Design
TB	Tuberculosis
TUTAPE's	Tulane University's Technical Assistance Program for Ethiopia
UAT	User Acceptance Test
UML	Unified Modeling Language
WHO	World Health Organization

ABSTRACT

Background: Electronic patient record system introduces valuable benefits in the health system especially in countries that have scarce resources, mostly developing countries. The record system provides comprehensive, reliable, relevant, accessible and timely patient information to each member of the health care. This will enable the health workers in detecting health problems, defining priorities, identifying innovative solutions and allocating resources for better health outcomes.

Objective: To this end, this study attempt to develop patient record system for Habru Woreda Health Centers that enables to improve the use of patient information for making sound decision and effective problem solving.

Methodology: To achieve the objective of this study the investigator performs requirements identification by applying interview, observation and relevant document review techniques. Once the requirements are defined, object oriented system analysis and design methodology was employed. Analysis, design and implementation of the proposed system are performed using the UML tools for analysis and design, and C# programming language and Microsoft SQL for implementation stage of the prototype system.

Result: The developed prototype Patient Record System for the health centers has the capability to capture and store health information produced from routine service of OPD, generate report and help the health workers in clinical management by providing clinical decision support through highlighting abnormal test results and alert for abnormal vital signs. System testing and user acceptance testing was also done in which encouraging result is registered.

Conclusion: Automating the existing paper-based patient record system of the health centers plays a great role in improving the health service delivery of the country. As a prototype system the current study focuses only on automating the OPD of health centers and, hence further work will be expected that enhance the functionality of the system.

Keywords: Health Center; Patient Record System; Patient Information;

CHAPTER ONE

INTRODUCTION

1.1. Background

Patient record is "a repository of information about an individual's lifetime health status and health care, stored electronically or manually" [1]. There are two types of patient record systems, which are used to manage patient information, namely paper-based record system and the computer-based record system. The basic advantage of developing such a system is to increases the accessibility and use of the patient record or data. And this is also one of the aims of one country's Health Information System (HIS) in order to improve the Health Service Delivery (HSD), and the health status of the population [2].

In Ethiopia, different strategies were developed to improve the HSD. Decentralization of authority within the health system was one of the main strategies implemented in 1996 at the regional levels and in 2002 at the Woreda levels [2]. Decentralization brings the opportunity, in which all the health facilities can use the resources and the information they have locally; and make decisions to improve the health status of the community. The other important strategy implemented during this period is the introduction of Health Management Information System (HMIS). HMIS deals with the data collection, analysis and presentation in electronic or standardized formats in order to deliver quality information and make sound decision. However, the system was weak until the introduction of the reformed HMIS/Monitoring and Evaluation (M&E) by the Federal Ministry of Health (FMOH). The situation analysis of this reformed HMIS/M&E was conducted in 2006 and the full-scale implementation was started in 2008-2010 [2, 3], after which all health facilities have adopted paper-based standard data collection and reporting formats.

In general, the approach for the introduction of both the decentralization and HMIS was the main components of the 20-years Health Service Development Program (HSDP) implemented in the country in three phases [3]; the first phase, HSDP-I, covered the period 1997/98-2001/02, followed by the second phase, HSDP-II (2002/3-2004/05) and the third phase, HSDP-III

(2005/06-2009/10). The main objective of the HSDP was to develop an effective and efficient health system, which provides comprehensive and integrated health services that respond to population needs [3].

Comprehensive, reliable, relevant, accessible and timely patient information is also one of the components of the integrated health service which reflects the actual situation of the health facilities and their users need. So it can be used for clinical management, resource allocation or planning. Since the patient information is routine health information, also called health service-based information produced through the routine HIS from the health facilities. Like the routine health information there is also non-routine health information called population-based information. These two types of information differed based on their collection techniques and data sources [4]. The HMIS also deals with the health service-based information in Ethiopia [5] which is also the main focus of this study.

To improve the routine HIS there is a growing recognition that Information Communication Technology (ICT) can replace traditional routine paper-based HIS with flexible electronic means and could bring significant cost reduction and effectiveness in terms of timely delivery of health care services in developing countries [6]. Electronic systems also maintain quality and accurate data, and make reporting potentially more flexible and efficient. On the contrary, in paper-based systems the data is collected and compiled manually at each site where the data is collected, a process that hinders managers and decision makers at higher levels of the hierarchy from viewing the disaggregated data coming from lower levels of the system [7]. Besides this, accessibility of data in the paper-based system is time consuming, potentially unreliable and inefficient when the number of records becomes very large [8, 9].

As a solution to such challenges medical databases have been implemented to the health system since 1960s [10]. During their first invention they were used to provide a patient's billing service. Later on, as Linberg [11] mentioned, these databases were started to use for the purpose of collecting and storing patient's medical history. Nowadays medical database has different comprehensive functions including Clinical Decision Support (CDS), Order entry, electronic information exchange etc. This study also aims on the development of patient recording system, which provides the health workers to store, retrieve, and report patient information.

1.2.Statement of the Problem

Health information can be produced from health facilities in order to be used for sound decision making and problem solving in the health care which specifically used for the purpose of clinical management at the point of care, for management, planning and procurement purpose at district level, and for the governance of the health system at regional and national levels [15].

To deliver such information it is important to use the appropriate record system. Ethiopia is also striving to replace the paper-based record system with electronic record system by implementing SmartCare in referral hospitals. But the health centers of Habru woreda still use the paper-based record system that challenges in providing comprehensive, reliable, relevant and timely health information for each member of the health care. In general it was observed and identified that:

- Patient record in Habru Woreda health centers are kept using paper-based record system which is prone to error, difficult for easy access, leading to lack of timely reliable and relevant information as well as use of information for action [17].
- The adopted electronic record system (SmartCare) was complicated for health centers due to the task difference among referral hospitals and health centers [18].
- The assessment result of SmartCare also shows, it was adopted with immature requirement analysis and recommends for better situational analysis [18].

Therefore having electronic patient record system introduces easy access of patient information, delivery of comprehensive, reliable and timely information in the health centers.

To this end, this study attempts to investigate and provide solution to the following research questions:

- What is the current routine health information requirement of health centers at Woreda level?
- What functionalities should the proposed system include?
- What information should the proposed system provide in order to support decision making and problem solving activities of health centers?

1.3. Objective of the Study

1.3.1. General Objective

The general objective of this study is to analyze, design, and develop patient record system for managing patient records.

1.3.2. Specific objectives

To achieve the above general objective of the study, the following specific objectives are formulated.

- To review literature and related works done and understand concepts to design patient record system
- To understand the current patient recording system and identify information requirements of Woreda health centers
- To model and design patient record system using object-oriented system analysis and design approach
- Implement a prototype patient record system, that manage patient information and evaluate the performance of the prototype.

1.4. Scope and limitation of the study

The term "health facilities" include all the range of health care establishments along the health system hierarchy. However, this study focused on the development of patient record system in the governmental health centers located in Habru *Woreda* of North Wollo Zone, Amahara Regional State. Six health centers are included in the study such as Mersa health center, Srinka health center, Buhoro health center, Wregessa health center, Arerit health center and Haro health center.

In addition, this study focused on developing a prototype patient record system which can maintain information about health status of the patient at Out Patient Department (OPD) of the health centers. Due to time limitation, the study was also limited to specific services of the health centers. There is also a potential of developing other database systems like Laboratory Information System (LIS) and Pharmacy Information System, which can be networked using

Local Area Network (LAN). A web-based system is also necessary in order to improve the accessibility of the data whenever and wherever needed by health professionals and patients without any geographic boundary.

1.5. Methodology of the Study

1.5.1. Study Design

This research employs Object Oriented (OO) methodology to develop the Patient Record System of the health centers. It is an appropriate method to develop the system hence there are different objects interacting within the system like patient, health worker, diagnosis, testes and medications. This is because the focus of object oriented system development is on interacting objects in the real-world.

Object Oriented (OO) analysis and design is a way to develop information system by building self-contained modules (Objects) that can be more easily replaced, modified and reused; that is why the investigator use this method to integrate the patient data that could be produced from the health centers during service delivery to patients or clients, into objects [19].

Object Oriented (OO) methodology employs different methods in order to model the system. For the purpose of this study unified modeling language (UML) artifacts is used to model the objects of the recording system for the health centers with perspectives like structure and behavior.

1.5.2. Study Area

This study has been conducted in Habru Woreda health centers (HWHC) between October, 2011 and September, 2012. The Woreda is one of the 13 Woredas located in North Wollo Zone of Amahara Regional State. There are seven health centers in the Woreda, of which one is located in the main city of the Woreda, and the remaining located in the rural parts of the Woreda. The health centers included in this study are *Mersa*, *Srinka*, *Buhoro*, *Haro, Wregessa* and *Arerit h*ealth centers. The reason for selecting Habru Woreda is that even though the problem is available in all the woreda health centers it was unfeasible to include all woredas due to time and budget constraints.

1.5.3. Patient Record System Development Phases and Tools

In this study the three basic phases of Object Oriented system development are followed to develop the system, which includes object oriented analysis, design and implementation phases.

Object-Oriented Analysis (OOA)

OOA emphasizes an investigation of the problem and requirements, rather than a solution. It concerns with determining the system requirements and identifying classes and their relationships that make up an application. This phase also called requirement analysis.

The classes identified in this phase represented using the domain model or conceptual model class and also their attributes and relationship are expressed. Therefore the investigator develops the domain model in this phase using one of UML artifacts (class diagram). Since, by using class diagram it is possible to represent the structure and behavior of the object.

In this phase the requirements were gathered, therefore, it is important to show the study populations, the method used to select the sample and sample size included. So the study population of this research includes all health workers who are engaged in the clinical work and those who are working in data collection, recording, organizing, and analysis and reporting of all the health centers.

The sample of the study was taken from all services provided and their data reporting went through the HMIS. All the health workers, who were at work during the data collection period, were included in the study. These participants who were selected purposively based on their engagement related to HMIS or routine data collection, recording and analysis, and information utilization are mentioned in Table 1. And the stages of sampling procedure are mentioned in Annex II.

Table 1: Sample for the Study; HWHC, March to April 2012

Health Centers	**Samples taken**					
	Number of Respondents from each Department					
	OPD	Under Five	MCH	TB	Statistics	Total
Mersa	**2**	**1**	**3**	**1**	**1**	**8**
Wregesa	2	**-**	**3**	**1**	**1**	**7**
Srinka	**1**	**-**	**1**	**1**	**1**	**4**
Haro	**1**	**-**	**1**	**1**	**1**	**4**
Buhoro	**1**	**-**	**1**	**-**	**1**	**3**
Arerit	**1**	**-**	**1**	**-**	**1**	**3**
Total						**28**

Object-Oriented Design (OOD)

The study uses OOD to define objects and how they collaborate to fulfill the requirements independent of implementation. During object oriented design phase of the system this study emphasizes on designing software objects, classes with their attributes, methods, and interfaces using UML artifacts class diagram. Then designing entity objects in the system database with their attributes (primary and foreign keys)and association between entity objects and designing/prototyping user interface for the system where a user in the health centers interacts.

Implementation

In this phase the objects of the system developed in the design phase are implemented using a particular programming language. In this study visual studio 2008 with C# programming language and Microsoft SQL server 2008 are employed to implement the design classes and database of the system, respectively. The C# is selected because it is an excellent language for .Net Framework development. It is extremely versatile, robust and well designed language. The SQL is also selected due to its important features such as: it is language independent supporting

.Net Framework which allows using your favorite .Net language, ease of deploying, is secure, it has replication and massaging capabilities, and it has easy setup options.

While implementing the system it is also important to test if it is functioning as intended. Therefore, in this study system testing (system performance measurement) and user acceptance test were performed. To measure the performance of the system task-oriented queries are used. And to make sure that the system is developed and perform according to user requirement specification, user acceptance test was done by applying acceptance model.

Furthermore to measure the performance of the system, real data should be stored in the database in order to see how the information could be retrieved. In doing this there is a need of using data access method which interact the application and the database to access the data. And there are different methods of accessing data from database such as: Multiple Active Result Sets, DataReaders and DataSets.

For this study dataset is used to access the patient care data of the OPD from the database. The dataset use data adaptor to fill after connecting to the database and it includes the tables about diagnosis, patient, tests and screens and medication with different atomic values for each table. The relations between the patient care data tables can therefore mimic the relations in the actual database of the record system.

1.5.4. Data Collection

To maintain the validity, the data collection items (interview and observation guiding questions) were adopted from the electronic health record manual for developing countries [20]. The questions mentioned in the manual were found to be appropriate because the issue of the manual was about how to develop the electronic patient record. In this study these questions were used to collect data about the recording system, type of information stored (information requirements), how patients were identified and how the data were managed; and if there were any problems with the current data keeping system. Data collection was conducted by the principal investigator from March 30 to May 26/2012, using interview, observation and record review.

Interview

Interview was first made to the managers of the health centers, followed by the statistics units; this is due to the fact that managers were also one of the health professionals engaged both in management and clinical work. Questions related to the types of services delivered by the health centers, their mission and vision, data features and data need were administered to the managers. Then, the interview was continued with statistics department; since these departments were the places where all locally collected routine data is compiled and reported and helps on which department to include. So, it is possible to get the type of information being recorded in each department and the tools used for input and report. Furthermore, the interview continued with health workers engaged in delivering services in each department in the health centers and record information generated from the daily services provided. All the interviews were made face-to-face in office. Semi-structured questionnaire was used to record the responses of the respondents.

Observation

In addition to the interview, observation was used to make sure the respondents did what they responded during the interview and the reported tools were available in the Department or the health center in order to gather all requirements needed for designing the database.

Document Analysis

Document review was made from each Department included in the study with regard to routine data recording, compilation, processing and reporting.

1.5.5. Data Analysis

Analysis of the interview, document review and observation was started immediately after having the requirements. The results of these techniques are presented being summarized from the notes taken during the collection. The responses were first categorized into different themes according to the type of recording system in use, tools for input and reporting, how patients were identified and the services provided by the health centers.

After identifying the requirements and analyzing those using UML tools, the system was designed and implemented following patient record system development phases described in section 1.5.3.

1.6. Significance of the Study

Improving the use of patient data at the point of generation provide enhancement of the health of the community who get service in the health center and also it helps in reporting better quality, timely and complete data to higher levels through the HMIS which improves the effectiveness and efficiency of the HIS in the country. Therefore, the development of computer-based patient recording system that improve the use of patient data has several significance such as accessibility of the patient data by health workers, non-governmental organizations (NGOs), and different program coordinators that will help them to manage the patient or the service delivery of the facility, to invest on appropriate conditions and to make information based-decision in identification and solving of the problems faced in the health facility. More importantly the health workers can get enough time for other accomplishments instead of collecting and aggregating manually several reports for several programs.

1.7. Operational Definitions

- Health facilities: health institutions like health centers, clinics, hospitals, etc.
- HMIS: routine health information system or information systems in the health system producing service generated routine data, which includes data that can be used for managing services.
- Medical database: a database/system used to mange patient's medical history
- Patient record: Repository of information about individual patient's life time health status.
- Patient, client: people who get service from health facilities

1.8. Ethical Consideration

This study was reviewed and approved by the Research and Ethics Committee of the School of Public Health at Addis Ababa University. Permission to undertake the study was also obtained from the Habru Woreda Health Office and the managers of all the health centers studied. Participants after explain the purpose of the study. Oral informed consent was obtained from the

study. To ensure confidentiality, the respondents were assured that their responses would not be used for any other purpose other than the purpose of the study. Names and any identity of the respondents were not recorded during data collection.

1.9. Thesis Organization

This thesis is organized into five chapters. Chapter one presents an introduction of the study; background, statement of the problem, objectives, scope and limitation, methodology and significance of the study, and some operational definitions.

Chapter two discusses the related literature and theoretical focus in health information management and patient record handling. Chapter three focuses on survey result, requirement specification and analysis of the proposed system. Chapter four presents the design and implementation part of the prototype patient record system for health centers under study. Performance evaluation of the system is also discussed in this chapter. Finally, chapter five provides conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

Health information is recorded information regarding physical or mental condition of an individual, health care provision, or health care payment collected routinely from the health service or periodically from the population [15]. The routinely collected health information is called routine health information or health service-based information. It is collected from the health related administrative and operational activities. These are facility-based data on morbidity and mortality among those using services, types of service delivered, drugs and commodities provided; information on the availability and quality of service, financial and management information [5, 21]. The routine data is also called HMIS data and it is the most important data source of HIS in developing countries [22]. It also accounts about 50% of the source of HIS in Ethiopia [21]. The routine health information is synonymous with patient data, while the population-based information is mainly obtained from census, vital registration and population based surveillance systems [15].

2.1 Health Information System (HIS)

Nowadays improving the use of this information, especially the routine one, is becoming an agenda in many countries, more importantly in the developing countries. As it is mentioned by the Health Metrics Network (HMN) standard framework for developing countries, these countries start to implement new strategies and standards to strengthening their HIS in order to improve the use of patient/routine information [5]. A study done by the WHO [23] clearly put that "the function of HIS is to bring together health data from different sub-systems (sources) to share and disseminate them to the different audiences for health information (owners, providers and users) and to ensure that health information is used rationally, effectively and efficiently to improve health action". Therefore, strengthening the HIS is a core process in using patient data.

Other authors like Abouzahr and Boerma [24] also encourage the idea that strengthening the information system improves the use of health information. They mentioned that "the HIS determines the dimensions of the health information (i.e. who needs data and for what purpose), of supply (i.e. tolls and methods available to generate needed information), and levels (i.e. the

level of health system at which data are generated and used)". If the health information is properly organized, stored and presented, it will be easy to use the patient information for decision making with regard to planning, policy making and resource allocation in the health system.

To strengthen the HIS so as to improve the use of patient data, there were some components set for developing countries that should be improved so that the HIS of one country can be strengthen and health information can be shared. These components are: data sources, indicators, HIS resources (human resources, finance, ICT), data management, information products, and dissemination and use [5]. Here the ICT has control over some of the other components such as data management, information production, dissemination and use.

2.2 Use of Health Information

In the context of health sector reform and decentralization, health systems are managed as closely as possible to the level of service delivery. This lead to the shift of function between the central and peripheral levels which generates new information needs and calls for the restructuring of information systems to collect and use information for decision making at local, district, provincial and national levels [15]. This encourages the use of routine health information starting from the point of collection/care and through different health system levels.

Using and managing patient data at the point of care or at the health facility level, where it is generated, has a dual benefit. First, local data can be used in local decision making to improve service delivery at the facilities. Decision made at local level health facility is expected to be evidence based that truly represent the needs and expectations of the facility clients. This is then acquired when routinely collected facility-based data is used at the point of generation. Because it is a firsthand data collected from the clients in the health service and reaches on the hands of the decision makers (managers of the facility) easily that enables them to adapt their service according to user's needs and expectations. In this way the routine information can influence the efficiency and effectiveness of health service delivery [25].

Secondly, the routine HIS is one of the various sources of health information for the national health system and reported upwards in the health system through the HMIS in addition to its

utilization at the facility level. Frequently mentioned problem related with such reported data upwards from the health facilities is its poor quality. However, it has been witnessed that this poor quality of the report can be improved by facilitating utilization of the data at the local level before sending it up as a report. If the people who report the data upwards make use of it there at the facility level, they will definitely be concerned about its quality. This can be realized by the facility managers, being as local data consumers, assessing the quality of the data, including its accuracy, completeness (how well it represents the population served), and timeliness (whether the data is fresh enough that decisions taken on its implications are likely to affect the situation) before sending it upwards. In an attempt to explain how local use of information improves data quality, it is mentioned that use of data at the site where it is collected can lead to detection of errors and inconsistencies, so that correction is made easily. When information is used and managed by people who collect it then it tends to be more accurate. The improved quality following extensive use of data leads to further assurance to use the data at all levels of health system [21, 25].

Although the routine information had all this benefits in the health system delivery, its use has not been improved yet. In Ethiopia like other developing countries the use of this information is not adequate as it is indicated in the final report of the Ethiopian HIS assessment by FMOH, only 36% of it is used [21]. In other developing countries like Zambia, Tanzania and Mozambique, the routine information is not adequately utilized [22]. Rather, health workers collect a lot of data through the day-to-day activities and report aggregate of statistics to the higher level for the sole transfer of information mainly due to excess data collected from health facilities, inappropriate data recording requirements and formats, poor coordination of various health programs and institutions within the health sector, and limitation in use of technological advances [15]. Despite significant investment and advancement in computer technology, its inadequate and inappropriate use is being made and can be easily improved for better management and communication.

Limited skill and knowledge of the health workers, low quality of data, the absence of standards and indicators are also the major problems affecting the utilization of health information at the point of collection. Information culture, attitude, value, beliefs and knowledge of using information by staff and managers of health services at different levels of the health care system

are also inadequate [26]. Therefore, improving HIS requires a carefully managed process resulting in the creation of a new information culture needed in changing the way data is collected, processed, and used for decision-making. As Lippeveld [27] put it: "Even if a perfectly relevant, well-organized, and technologically sound routine HIS were readily available, it would not be possible to introduce it immediately. The main issue is that information systems are managed and used by people who have certain beliefs, attitudes, and practice and changing them will take time".

Resource constraints also have a negative contribution on local data use. In an effort to list possible reasons for inadequate use or non use of information in health facilities, this constraint was presented as one among others. It was noted that at a health facility level, where problems are encountered on a daily basis and immediate actions are required, knowledge alone, without the proper resources for practicing it, can do very little. Specially, insufficient availability of trained manpower resource is a major constraint for improving the quality of information, its use and the overall management of health services [28]. Other issues like political affiliations, lack of leadership and advocacy, and institutional and behavioral challenges are also causes of the problem in some developing countries [29].

2.3 Patient Record Handling System.

No matter the type of the recording/registration system; i.e. whether electronic or paper-based the patient record is "a combination of all the data acquired and created during a patient's course through the health-care system. And its purpose is to recall observations, to instruct students, to gain knowledge, to monitor performance, and to justify interventions" [30]. The difference between these two recording systems, besides the system is automated or manual these two records differ in the mechanisms of accomplishing the functions mentioned to be acquired by the patient record. Fundamentally in the way data are entered into and information is extracted from the record [31]. There are also different terms used to express the electronic patient record. Some of the commonly used terms are: Automated health record (AHR), computer-based patient record (CPR), Electronic medical record (EMR) and Electronic health record (EHR) [10].

Consequently developing electronic recording system is one of the technologies used in health institutions as a solution to health information collection, organization and dissemination problems [32]. It helps to overcome the health problems by letting the health information users to have an access to timely, complete and well organized data that directly speaks the needs of the clients in the health services. By this means the information can give its worth significance starting from service management up to planning, resource allocation and policy making. As Daly mentioned it "given the right policies, organization, resources and institutions, Information Communication Technologies (ICTs) can be powerful tools in the hands of those working to improve health" [33]. WHO also support this: according to the WHO, the use of ICTs in health is not merely about technology, but a means to reach a series of desired outcomes [34] like health workers making better treatment decisions, health facilities providing higher quality and safe care, governments becoming more responsive to health needs, and national and local information systems supporting the development of effective, efficient and equitable health system and so on.

Therefore the electronic recording system which is one of the ICTs, can improve the functioning of health care system by improving the management of information and access to that information, including: management of logistics of patient care, administrative systems and ordering and billing systems [32]. The health workers participating in the health provision also believe this advantage of the technology. For example when we see in Ethiopia as study by Mtiyas showed that most of the respondents in his study agreed that they need computers in order to use local data on their day-to-day activities [35]. But some writers oppose this idea they said that as "computers are not a universal solutions and clearly they offer no readymade solutions, a computer is a machine for handling symbols" [22]. And they advise just to focus on the other challenges concerning to the human resources as well as other resources.

But other studies both from the developed and developing countries indicate that implementing electronic recording system brings some improvement in the health service delivery. In developed countries, in Europe and United States the use of EMR has been driven by the belief that these systems can help to improve the quality of health care. Decision support systems, particularly for drug order entry, are becoming important tools in reducing medical errors [36].

These systems were also adapted in developing countries. In Kenya there are some benefits gained from the electronic recording system which is called Mosoriot Medical Record System (MMRS) implemented in 2001 [37]. As evaluation results of this system showed that, Provider time per patient was reduced by 58% and patients spent 50% less time waiting in the clinic. Clinical personnel spent 50% less time interacting with patient, two third less times interacting with each other, and more time in personal activities. This motivates the health providers to give their attention to information utilization from the services. The MMRS has also vastly simplified the generation of mandatory reports to the ministry of health. When the significance obtained from the MMRS is generalized, it serve both clinical and research needs, generating clinical summary reports for providers and providing a centralized sources of data for epidemiological research [37].

The EMR called care ware was adapted from US and deployed in Uganda in 2003 to support HIV treatment [38]. Other developing country implementing the Electronic recording system was Malawi. In this country a Touch screen patient management information system used since 2001.Then the extensive use of this system directly by health care workers in a poor country with limited IT skills is a convincing demonstration of the potential of EMRs with user friendly data entry mechanism [38].

In Ethiopia, DHIS1.4 (statistical software) adapted from South Africa has been implemented in some of its regions and shows a significant progress in delivering timely and quality data to the higher levels. After seeing such changes FMOH start to implement computerized system in all levels of the health system. But it was difficult to address throughout the country due to economic and infrastructural problems. And a gateway system is implemented which allows reporting the data from the lower level facilities using paper and entre electronically in the provincial or zonal levels to report to the regional and central (national) levels [5].

2.4 System Analysis and Design Approach

In developing a system there are many different methodologies which follow the fundamental phases of the system development life cycle (SDLC). These methodologies differ based on each methodology's emphasis on processes versus data and the order and focus it places on each SDLC phase. All system development methodologies lead to a representation of system concept

in terms of process and data; however they vary in terms of whether the methodology places primary emphasis on business processes or on the data that supports the business [39].

Therefore there are process-centered methodologies which utilize processes model as the core system concept and data-centered methodologies that utilize data models as the core system concept. Beside this, the methodologies also categorized based on the sequence of the SDLC phases and the amount of time and effort devoted to each [39].

So, some of the methodologies that can be used in the development of the system are discussed below. Such as:

Structured System Analysis and Design (SSAD) Approach

This methodology was dominant in the late 1980s and adopts a formal step-by-step approach to the SDLC that moves logically from one phase to the next. It also introduces the use of formal modeling or diagramming techniques to describe a system's business. The emphasis of this methodology is on the procedural, separates process and data and use different models to represent the data and processes i.e., a process model and a data model. Traditionally structural methodology is mentioned as waterfall development since it moves forward from phase to phase. This brings the problem of elapse between the compilation of the system proposal on the analysis phase and the delivery of the system [40].

Rapid Application Development (RAD)

The methodology emerged in 1990s in response to structured methodology weakness [41]. And it adjusts the SDLC phases to get some part of the system developed quickly and into the hands of the users. In this way, users can better understand the system and suggest revisions that bring close to what is needed.

Agile Development

These methodologies are programming-centric methodologies focus on streamlining the SDLC by eliminating much of the modeling and documentation overhead and the time spent on those tasks. In addition the methodology responds to users need by delivering valuable software early and continuously it also welcome changing requirement even in late development [41].

OOA/D Approach

The other system development approach is OOA/D system development approach which is employed in this study. Its underlying concept is that one should model software systems as

collection of objects, treating individual objects as instances of class within a hierarchy of classes. OO methodologies attempt to balance focus between processes and data, also utilizes UML to describe the system concepts as a collection of objects incorporating both data and processes [19].

There are different features of OO methodology such as: abstraction, modularity, and encapsulation of the classes used in the method that gives a lot of advantages of using this methodology than the other approaches. In general using OOA/D methodology has different advantages such as [19, 42]:

- **Increased reusability**

The OO approach provides opportunities for reuse through the concepts of inheritance; polymorphism, encapsulation, modularity, coupling, and cohesion are all straight forward concepts that lead to better design. For instance, any requirement changes in patient record systems can easily integrate to the designed system which makes easy to reuse for future developers. Although the use of OO does not guarantee you will develop reusable software or that you will, in turn reuse software yourself, it does offer significantly more opportunities for reuse than the structured approach.

- **Increased Extensibility**

Because patient record objects was organized as classes, systems which have both data and functionality when you add new features to the system you only need to make changes in one place, the applicable class. This is different than in the structured world where a change in a single business rule could affect many programs.

- **Improved Quality**

Quality systems are on time, on budget, and meet or exceed the expectations of their users. One of the difficulties seen in system development using structured system methodology is inability to integrate any change in the process of system development which makes inefficient. OOA/D methodology allows users of the patient record system to have a greater opportunity to participate in system development and integrates any requirement change in development

process. More importantly, it contributes to success of system development and meeting users' goal by implementing a prototype of the system that is subject to modification.

- **Reduced maintenance burden**

Since the methodology supports to use a well-defined documentation tools and modification of requirements, maintenance cost is reduced.

2.5. Application of HIS

Different types of Health Information Systems (HIS) for patient data recording has been used in different countries as discussed below.

China had the third generation of the HIS where data collection is based on manual tallies from activity registers and district data collection converted to electronic storage and reporting [16]. In this country the recording system is automated in the hospitals. Seventy percent of the hospitals in the county level or above implemented an HIS. There is also a Web-based disease surveillance system that provides real-time reports on 37 diseases across the country which was developed in 2003 [43]. The automated system in China provides improved data accuracy and timeliness, earlier detection and containment of outbreaks and more accurate data on disease prevalence. To sum up about the HIS of China; from 1985-2003 the country moved to digital monthly reports, and in 2004, the Web-based system become operational [43].

In United States of America the implementation of computer based patient record system was begun since the early (1970s) use of computers in the health care [44]. But more emphasis to the electronic HIS was given since President Bush noted: "By health records, we can avoid dangerous medical mistakes, reduce costs, and improve care" [44]. He also promised to have an electronic record for each citizen of the country up to 2010.

The progress of EHR in USA was started from recording patient information that could be handled by the health providers, then to personal health records (PHRs). PHRs are systems designed to support patient-entered data and in which the individual patients can assess their medical information and made decision. The PRHs could be integrated with the EHR and access is often provided through a web portal or could be standalone system not associated with a

provider. The EHR has been adopted and used in the country with the aim of facilitating clinical data sharing, protect health information privacy and security, and quickly identify emerging public health threats [45].

Even the implemented EHR was not used by all health providers (about 24% of physicians in ambulatory settings of the united states use EHR), it may address many functions such as: Document-scanning/imaging systems, order communication/results retrieval (OC/RR) systems, clinical messaging systems, patient care charting, computerized provider order entry (CPOE) systems, clinical decision support systems (CDSS), provider-patient portals and personal health records [45]. Document-scanning/imaging systems represent capturing of images of the forms in the paper record for storage in a computer system for later retrieval. The OC/RR systems provide the capability of transmitting orders to various ancillary departments and viewing results of laboratory and other diagnostic studies or the status of orders.

Meanwhile CPOE systems are intended for use by health providers to enter orders directly into the computer system and be given prompts, reminders, or alerts about the order entered. The other most important function of the EHR is CDSS which is reserved to describe the help provided in association with data entry into an EHR system performed directly by the caregiver at the point of care. The help may come in the form of alerts or reminders that are generated by preprogrammed logic or rules [46].

When we come to Africa, the recording system used in South Africa is paper-based at the clinical level and computerized at the sub-district or district levels. The computerized system was started to be implemented after the establishment of the National Health Information System/South Africa (NHIS/SA) committee in 1994. Some of the systems used were: the DHIS developed in 1996-1998. This system has been well-established in South Africa and has been implemented in other developing countries in Africa and Asia. It records data about all facility services as well as infrastructure and human resources. Clinics fill out paper-based registers, tallies, and monthly collection forms and on a monthly basis send them to the sub-district or district for data entry into DHIS [47].

The other system developed in South Africa was National Electronic TB Register which was a nationwide system with about 200 users over nine provinces. More than 1 million patients from 2003 to 2005 are in the system, which is based on SQL Server. There are also other systems like Patient Administration and Billing (PAAB) system, Personal Assistance Digital System (PADS), a web-based patient registration and billing systems are available in the country [48].

The electronic record system used in Zambia is called Smart Care system since 2005 with the objective of improving patient care and improves health management information for improving health services by: increasing the privacy of sensitive medical information, reducing the burden of paperwork on health clinic staffs and improving the quality of information and decision support at the patient level, with inputs into HMIS [49]. Smart Care was rolled out in 2006 to each of Zambian's nine provinces and 72 districts, starting from the national level down to the health facility level. And it was chosen in 2006 as the national ART reporting standard for facilities capable of supporting computer. One of the facilities implementing Smart Care system was the Maina Soko Military Hospital which implements this system in the early 2007 to streamline HIV case management [50].

Ethiopia's HIS is still in its second generation in which data collection is based on manual tallies from activity registers, focus on using existing systems to collect an optimized and smaller set of data with a view to increase data quality and relevance but with no integration of data utilized with other information systems [21]. Even though most of the health facilities use paper-based record system, initiatives to develop electronic HIS was started following the reform and revision of the existing paper-based system. As of 2008, a comprehensive electronic HMIS has been developed in conjunction with doctors associated with Tulane University. This system was Smart Care and was deployed in Dire Dawa region and in Addis Ababa referral hospitals like Ras Desta Hospital [51].

SmartCare system development in Ethiopia happened in collaboration with the SmartCare team in Zambia and the United States. SmartCare is developed using .Net frame work, .Net Language C#, and Microsoft SQL database. SmartCare has the ability to personalize patient's medical record using SmartCards, to function as either as a distributed (standalone) or as centralized (client/server) mode. The standalone mode is used in the absence of online communication

infrastructure here SmartCards are used to transport patient data between different points of services. Further in this mode, SmartCare provides database merges by using any electronic data storage and exchange (e.g. flash disks, CDs) methods across all points of service [52].

Even the system has the above mentioned features and benefits, there were some limitations noticed. Since the software is closed application and it's owned by Tulane University's technical Assistance Program for Ethiopia (TUTAPE), ministry of health doesn't have direct access to make modifications, and modules or improve the system. The entire system's modification is taken care by TUTAPE's designers' team.

Other problem of the system was that it was been deployed by adapting from the Zambian and changing few things to Ethiopic context with not mature system's analysis to suggest solutions. But it's recommended to do well define analysis based on the country's current infrastructure and existing problem. Then the system could have been developed based on the size of the health facilities, because the system for referral hospitals is way much complicated and bigger than system designed for clinics or health centers [51].

2.6 Related Works

Analysis, design and implementation of patient record system have been studied extensively since technology is considered as one part for the advancement of health care system. A common result from these studies is the use of electronic recording and reporting systems of patient information management system in the health system of different countries. Some of the studies are discussed below.

A study delivered in China in 2005 launch a web-based, case-based electronic reporting and recording system for tuberculosis (TB) information management system of the country [53]. This study delivers the system with capability of holding TB patients detailed treatment data and treatment outcomes, including demographic information, clinical data and drug susceptibility testing results that are stored using Oracle database.

Other study which computerizes all the records about patient, staff, drug suppliers and report production of St. Francis Hospital Nsambya in Uganda was carried out by IMO20-09. This study

follows iterative waterfall approach to automate health information system of the hospital. It also uses data flow diagram and logical entity relationship diagram to show the data flow and relationship between entities of the system [54].

In Ethiopia, an action research was done to adapt the health statistical system, DHIS in Tigray region [55]. It has been adapted to the needs of Tigray regional state so that they can produce quality health report from the primary health care of the region. The system is more of a system that is used for reporting function instead of for transactional purpose. Other study related to patient record system development was a qualitative study which focuses on assessing and pointing out the problems the current recording system of the country faces. The study emphasizes situation analysis of the SmartCare which Ethiopia has been adopted from Zambia [51].

Considering the need for automating health information system at health centers, the present study focus on developing patient record system that enables to record transactional data and also generate periodic reports.

2.7 Conceptual Framework of the Study

Conceptual frame work of the study indicates some factors which are related to the proper generation and use of routine health information in the health centers, such as:

- **Data Management Process**

It is the process of data handling starting from collection, storage, and quality-assurance and flow, to processing, compilation and analysis. Therefore to deliver appropriate health information the health data should be managed well in its way to transformed into information, evidence and knowledge for action.

- **Information Production**

Having managed the data should be transformed into information that will become the basis for evidence and knowledge to shape health action.

- **Information Dissemination**

The value of health information can be enhanced by making it readily accessible to decision-makers. It is also necessary to assess whether the information disseminated is comprehensive, reliable, accessible and timely.

- **Patient Record System**

The patient record system facilitates all the above mentioned process and ensures proper generation and use of health information in the health facilities. Therefore the information can be used locally as well as in higher levels to make sound decision and respond to critical health problems of the community. Therefore the conceptual framework is seen below.

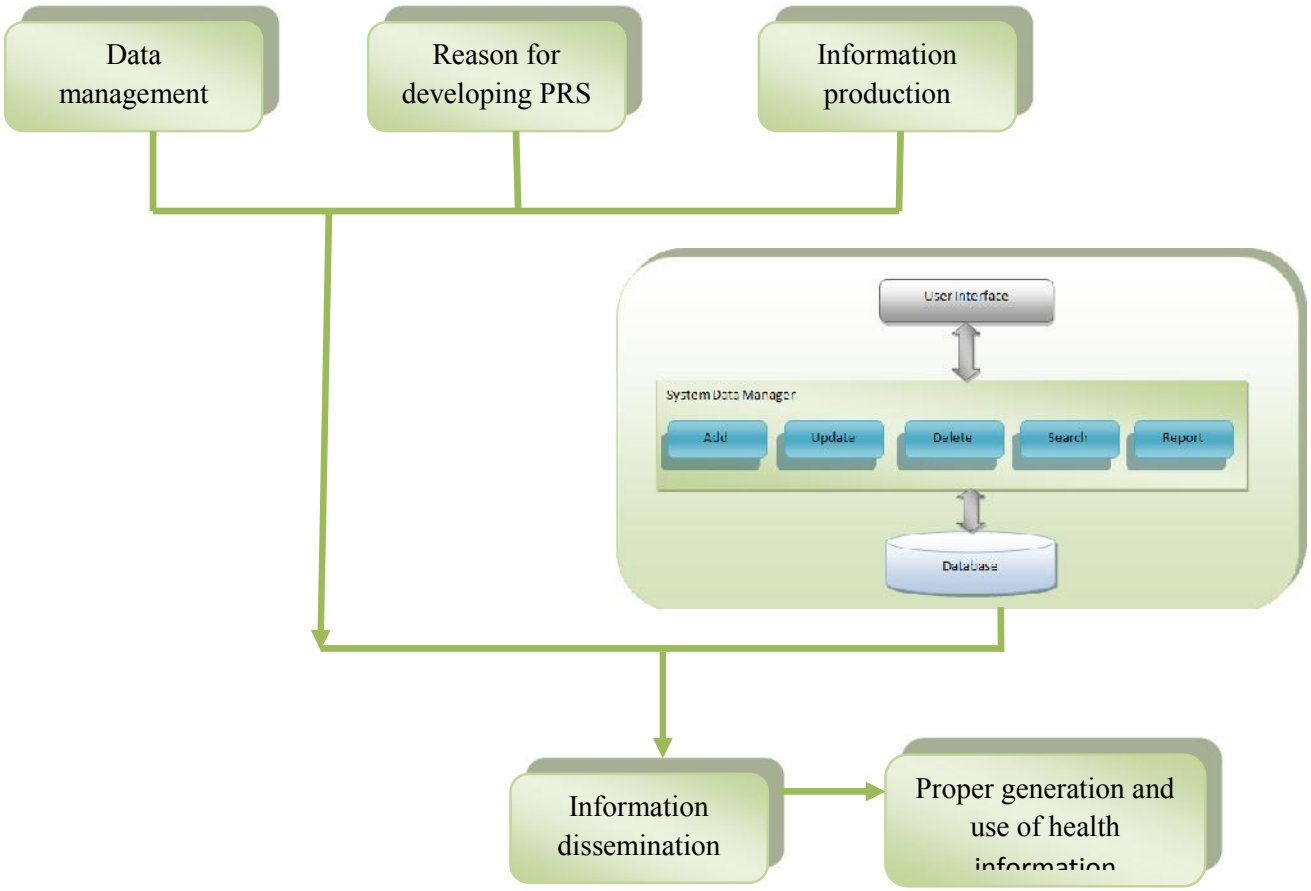


Figure 1: Conceptual Frame Work of the Study; HWHC, March 2012

CHAPTER THREE

SURVEY RESULTS AND REQUIREMENT ANALYSIS

Requirement specification and analysis are the primary steps on OOA/D system development methodology which deals with investigation of the problem and the requirements or domain objects of the system. To describe the requirements one of the UML artifacts (Use Cases); that is, common models in OOA/D were used. In this study requirement analysis/OOA is concerned with the creation of the domain from the perspective of objects. There is an identification of the concepts, attributes, and associations as well as modeling the noteworthy domain concepts or objects.

3.1. The Existing System

The result from the survey shows the services being delivered at health centers, the current record systems used, input and reporting formats, and problems of the data handling system from the point of view of the health workers and the health worker's opinion about the new system.

3.1.1 Services Delivered at Health Centers

As reported by the mangers of the health centers and observed by the investigator, the main services delivered by the health centers included Out Patient Department (OPD) where patients can get service without being admitted, Maternal and Child Health Care (MCH) which includes: Anti Natal Care (ANC) where pregnant women get pregnancy related follow up, Family planning (FP) in which contraceptive can be provided for clients, Expanded Program of Immunization (EPI); in this case both mother and child can get immunization service, and Delivery service which provide delivery management. The other services delivered at the health centers includes: Tuberculosis (TB) clinic where patients screened and treated for TB, under five service provided for children of age less than five year, Voluntary Counseling and Testing (VCT) service for HIV/AIDS, Anti Retroviral Treatment(ART) service for those living with HIV virus and Youth center. From these services data produced from OPD, under five, TB and MCH are sources of the HMIS data.

3.1.2 Patient Data Recording System

In all the health centers, the recording system is manual (paper-based record system). These records were in line with the HMIS data collection and reporting tools designed for the health centers. The daily routine service generated data was originally recorded using different data recording instruments. The service records were maintained on separate cards and forms, and also on registers. These included the integrated medical record, the record management instruments, service and appointment cards, and the various registers that were used by different departments.

The integrated medical records included individual folders, which were paper file folders containing client's medical records from all types of services given, the client's demographic information, and summary sheet for all services provided in the facilities. The folders were kept in the card room. The other integrated medical records were the patient card, which contained clinical observation notes recorded by the care provider and archived in the card room.

The record management instruments used at the health centers were: Master Patient Index (MPI), tracer card, service card and appointment card. The MPI was used to find uniquely identifying Medical Record Number (MRN) of a patient who lost his/her service card by liking client's name with his/her MRN. Tracer card used to track the location of an individual folder when it was removed from its file shelf. The service and appointment cards which were kept by the client also used for identifying the client's medical record by means of its MRN and other demographic information on the individual and to remind a patient about the next appointment he /she has at the facility respectively.

The other major recording tools used to record the routine service generated data were the registers kept in each department Such as OPD abstract register, TB unit register, FP register, and ANC register, under five integrated register, Delivery register, Immunization and Growth monitoring register and vaccination register.

In addition to the above mentioned tools in one of the health centers (Mersa health center) there was a database which holds demographic information (name, address, and MRN) that helps in tracing the patient's identification number in case they lost their service card.

3.1.3 Input and Reporting Formats

Routine data generated from the services were reported to different users such as Woreda health offices, zonal health departments and Regional Health Bureau. The Woreda health bureau received reports from each of the health centers in the Woreda both monthly and quarterly. For such purpose, tally sheets were used as input tools in which data from each department were collected in tally form and sent to the statistics department where it was manually compiled using different reporting forms. From these OPD diagnosis and attendance tally and quarterly OPD disease report form are some of the input and reporting formats which were used in the health centers.

These formats include attributes: disease, age and gender with values of disease code and disease name for disease attribute, 0-4 years old, 5 -14, and >=15 years old for age and male and female for gender.

3.1.4 Problems with the Current Recording System

As mentioned earlier, routine patient data is recorded in paper-based HMIS data recording and reporting tools. However, these tools were not free of any problem as mentioned by the study participants.

- **Invisibility of records**

During the interview made, it was found that the registers and tally sheets have created problems because the hand write of some health providers was difficult to read and understand by other users of the data. This led to report incorrect information. According to the ICT personal of the statistics department of Mersa health center:

> *Unread ability of the hand write of the health workers using the manual recording system is creating a problem. Health workers from each routine service are required to tally the data generated and deliver to the statistics department so reports can be compiled and sent to the Woreda health bureau. But most of the time they get in trouble*

to read the tally sheets, it is being difficult to know the number of tallies properly. To avoid this problem, I sometimes had to tally from each routine service.

In relation to this problem, a nurse from Srinka health center who was engaged in compiling reports to the Woreda health bureau mentioned an instance where other users who need to collect data from the register experience a problem to identify the exact patient's diagnosis.

As of the interviewee, the case was explained as:

Investigators who were interested to identify the common diseases in the Woreda for their academic purpose but they struggle in reading what the diagnosis says correctly. Rather they had to consult the health workers.

- **Increase workload of health workers**

In all the health centers included in this study the number of health workers is limited as it is explained by the mangers of the health centers. And they are engaged in different activities in addition to their routine work which makes them over loaded. One of the activities was tallying and reporting of patient data for different programs.

As mentioned by the participants:

Tallying number of items after you feel tired and need some rest is very challenging work. It is not just something that you had to order to be done and receive what you need so easily. It takes time to count number of information according to their category. This over burdened us.

- **Resource wastage**

Recording patient information at the health centers is not registering using one instrument. As it was observed and mentioned by the participant information for one patient recorded in different registers and forms**.** According to the respondents:

When a patient arrives in the facility he/she has to contact the card room in the first place. Then register the patient in different formats like registration book, folder, tracer card and MPI. In addition there are also registers and tally sheets used in each routine service. This is wastage of resources.

- **Producing incomplete and outdated data**

Producing incomplete and outdate data were like the basic features of the paper-based recording system. This is due to the process takes time and health workers can get bored to complete the tally sheet. This problem was elaborated by the respondents from the statistics department as follows:

Getting incomplete tally sheet from the routine services is common practice within the current recording system our facility uses. This situation also forces to provide incomplete data to other users. The other challenge we are facing is delivering of outdated report since the health workers did not fill the tally sheet timely. To alleviate this problem sometimes we had to round each service and tally our selves especially during monthly and quarterly reports."

- **Prone to human error**

It is true that the paper record is prone to error. Error can be encountered while registering as well as tallying and compiling the report which increases errors in medical service provision. This problem was mentioned by the respondents as follows:

During writing patient information there is a chance of miss spell the information which led to miss interpret and miss use the information. There is also probability of miss counting or recounting or tallying of the information."

- **Security and backup problem**

Patient information should be secured from the initial creation of the data until the final disposal of the information in order to attain the applicable objectives of preserving the integrity,

availability, and confidentiality of information resources. And there should be backup system in case the original data get damaged by different factors, that is lack of disaster recovery.

The participants clear out this situation:

> *Information recorded in the registers can be accessed by unauthorized individuals because there is no means of securing the class room especially at working hours health provider can leave it unlocked. There is also no backup system*.

In addition, to stating the problems of the paper-based record system, all the health workers included in the study also agreed on the idea of using electronic record system in their daily routine service.

3.2 Requirement specification and Analysis

In any system it is necessary to mention the systems behavior, functionality and constraints, and all these are referred as requirements. The term requirement could be described as a user need or a necessary feature, function or attribute of a system that can be sensed from a position external to that system or as a statement of a system service or constraint [56].

There are different types of requirement namely: system requirement, user requirement and software requirements [57]. System requirements describe the behavior of the system as seen from outside with respect to the user. So they are the high–level requirements that represent the system as a whole, which contains both hardware and software. User requirements (also called stakeholder requirements) describe the tasks the user must be able to accomplish with the product. Software requirement is a function or constraint of the system from the software developer's point of view. This consists of all the requirements of the software must demonstrate for the system to meet the user requirements.

These requirements include both the functional requirements and non-functional requirements. Functional requirements (behavioral requirements) define what the system does, namely, the functions (actions) of the system. They describe all the inputs and outputs to and from the system as well as information concerning how the inputs and outputs interrelated [57]. Non-functional requirements, on the other hand, define the quality of the system . They include the description

of the system's usability, reliability, performance, security, maintainability, portability, implementation, interface, operations, packaging and legal obligations [56].

Therefore, in this study the requirements used to determine the system were specified since EPR (Electronic patient record) can be developed to address different goals and settings, and consequently emerge with different functions and capabilities. However, it is desirable to maintain a core set of functions in each EPR system in order to support similar workflows and encourage best practices in clinical care [58].

3.2.1 Functional Requirements

In this study an attempt is made to develop patient record system that solves the gap of information handling and accessibility by the health workers in order to use the information for better decision making locally. Accordingly, the system have the following functionalities:

a) **Store basic Demographic and Clinical Health Information**

This refers to patient-related information which includes patient identification information and clinic attendance or encounter information. The system is capable to:

- Collect, organize and display essential demographic patient information such as: name, age, gender, MRN, address etc.
- Manage patient's problem/diagnosis list: coded diagnosis, onset date, history, chronicity, date resolved.
- Collect, process and display patient medication
- Collect and display test results
- Accept clinical data: vital signs, weight, height, body mass index (BMI).

The health workers are responsible in recording the above mentioned patient information after logging into the system. The user can also update, delete and search patient information.

b) **Clinical Decision Support**

This refers to functions and processes that assist health workers in making clinical decisions to enhance patient care. It must have the following functionalities:

- Highlight abnormal test results
- Alert provider of abnormal (outside the normal range) vital sign.

c) Health Information and Reporting

One advantage of EPR system is to improve use of health information. To support this function the system is required to:

- Generate periodic reports from clinical data to support quality improvement
- Generate aggregate reports for submission to Health Bureaus and other consumers.

3.2.2. Non-functional requirement

Non-functional requirement mean quality of the new system that are not directly related to the functionality of the new system. The following are the main non-functional requirements of the system.

User interface and Human factor

Users are communicating with the system through the application interface which is easy to use by the health workers. This will minimize the time needed for users to adapt to use the system. There will be interfaces and menus for each function provided by the system to easily navigate from one point to the other.

Performance characteristics

Nowadays there is high need of reliable, accessible and timely quality patient information within the health care for information based action. Since the system is automated it takes these needs of the health workers into consideration.

Security issues

To protect patient data from unauthorized access and use, the system provide restriction in using the functionality and information right to use by user, i.e. the system uses Role based authorization technique.

3.2.3 Use Case Modeling

For better understanding of the requirements of the system, use case modeling is being used. This model represents the requirements in user-centric approach in order to describe all the tasks that the users (actors) will need to perform with the system [42]. By definition use case is a description of sequences of actions or what the system does independent of how does it. And actors are the users of the system (who perform action using the system); in case of this study, the health workers are the actors.

Therefore the requirements or behaviors of the system mentioned above are represented as shown in figure 2.

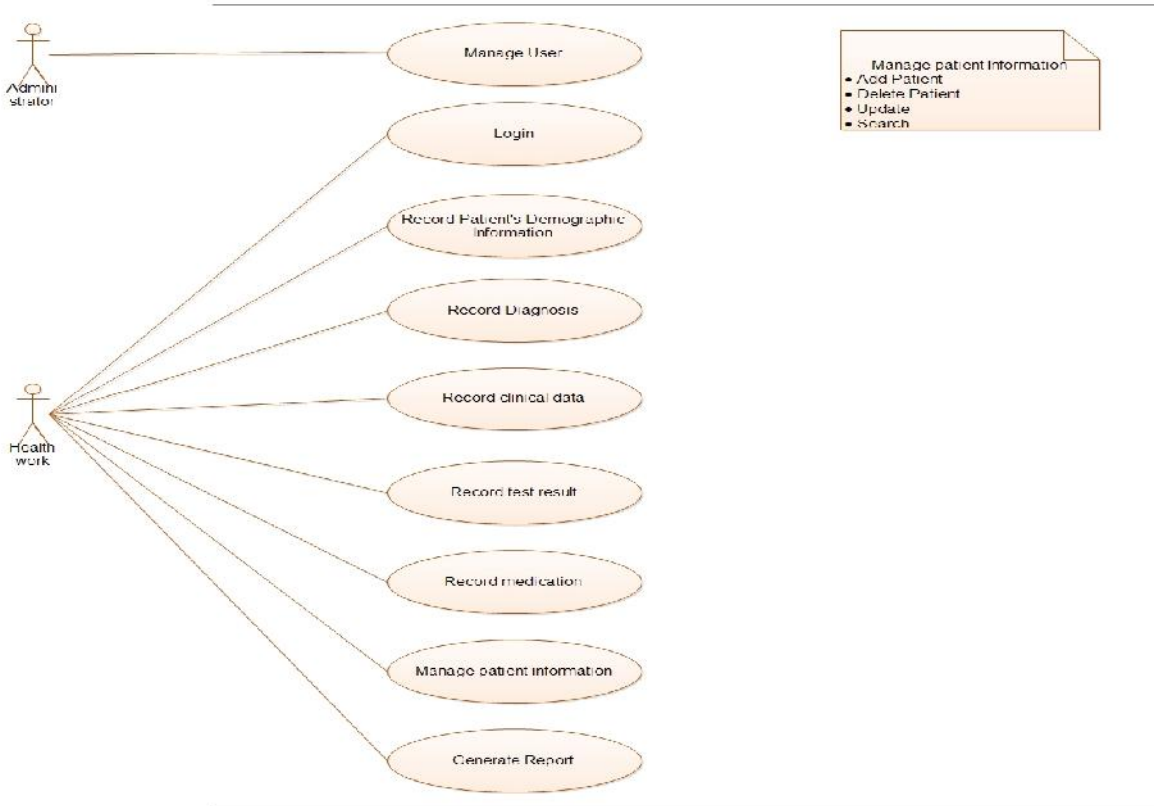


Figure 2: Use Case Diagram of OPDPRS; HWHC, June 2012

In addition to representing the requirements the usecase also used as a source for the domain/conceptual modeling of the system.

3.2.4. Use Case detail description

While modeling a use case it is also important to describe the flow of actions represented by the use case diagram. Detail descriptions of each use case's name, actors, pre-conditions, flow of events and post-conditions are presented below.

Use Case UC1: Record Patient information

Actor: Health Provider

Description: Health providers record patient information from the routine services

Precondition: Login to the system

Post Condition: Patient information recorded in the database.

Main Success Scenario:

1. The use case starts when the health provider (user) click on the department of interest
2. The system displays department's main form
3. If the user clicks on Add button from the main form (Alt 3.1)
4. The system displays patient information detail form
5. The user fills: MRN, Age, Gender, Address, etc. and click add
6. The system checks if the patient is not already registered (Alt 6.1)
7. Use case end

Alternative Scenario:

3.1. If the user clicks on Update, Delete or search

3.2. The system displays Update form

3.2. The use case goes to step 5

6.1. The system display violation of primary key

6.2. The use case goes to step 4

Use Case UC2: Record Diagnosis

Actor: Health Provider

Description: Health providers record diagnosis information

Precondition: user login to the system

Post Condition: Diagnosis information is being registered in the system

Main Success Scenario:

1. The user clicks on diagnosis from the main form
2. The system displays diagnosis form
3. The user click on Add button of the diagnosis form
4. System displays diagnosis detail form
5. User record disease code, disease name, whether new or repeat and click add
6. Use case end

Use Case UC3: Record Test Result

Actor: Health Provider

Description: Health providers record results of the tests ordered

Precondition: user login to the system

Post Condition: Test result is registered in the system.

Main Success Scenario:

1. The user clicks on test result
2. The system displays the test result form
3. The user add test result information and click add
4. The system register the information in the database

5. Use case end.

Use Case UC4: Record Medication

Actor: Health Provider

Description: Health providers record the medication provided

Precondition: user login to the system

Post Condition: medication information is available in the system.

Main Success Scenario:

1. The user clicks on Medication from the main form
2. System displays the medication form
3. The user click on Add button
4. System displays the medication detail form
5. The user fills medication information and click add
6. The system registers medication information on the database and display acknowledgment.
7. Use case end

Use Case UC5: Record Clinical Data (Sign and Symptom)

Actor: Health Provider

Description: Health provider records signs and symptoms of the diagnosis performed

Precondition: user login to the system

Post Condition: Clinical data of patients is registered in the system.

Main Success Scenario:

1. User click on clinical data from the main form
2. The system displays the clinical data form
3. User clicks on add button

4. The system displays clinical data detail form
5. User fill sign and symptoms encountered and click add
6. The system registers the information in the database if vital sign is normal and display acknowledgment (Alt 6.1)
7. Use case end

Alternative Scenario:

6.1. System alerts the user
6.2. The use case goes to step 6

Use Case UC6: Generate Report

Actor: System, Health Provider

Description: the system generates report from the already available patient information in the database.

Precondition: user login to the system

Post Condition: Report delivered to the health provider.

Main Success Scenario:

1. The user click on Report button from the OPD main form
2. System generates report which includes diagnosis, age and gender of patients
3. User click on save or print
4. System save or print the report
5. Use case end

1.2.5. Sequence Diagram

UML sequence diagrams model the flow of logic within the record system being developed in a visual manner, enabling both to document and validate the system logic, and are commonly used for both analysis and design purposes. It is a common notation to illustrate collaborations among objects and shows the flow of messages between objects.
The following section depicts system sequence diagram for designing PRS.

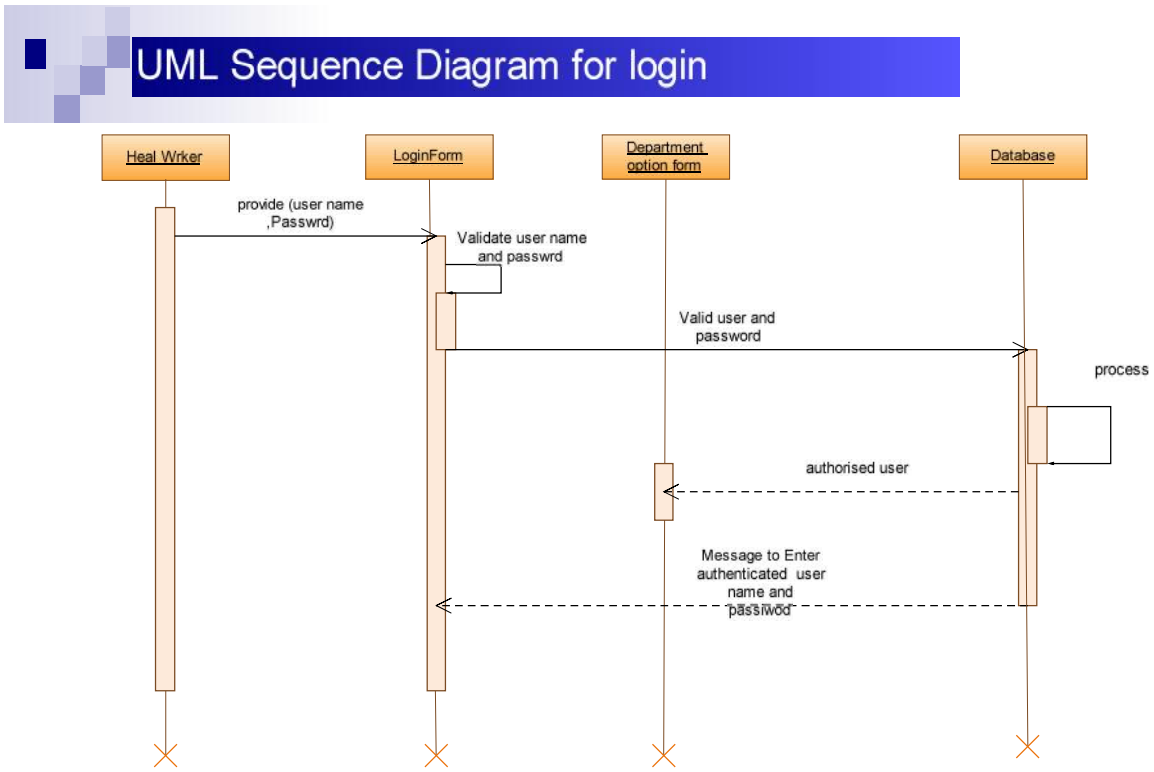


Figure 3: Sequence Diagram for Login of OPDPRS; HWHC, June 2012

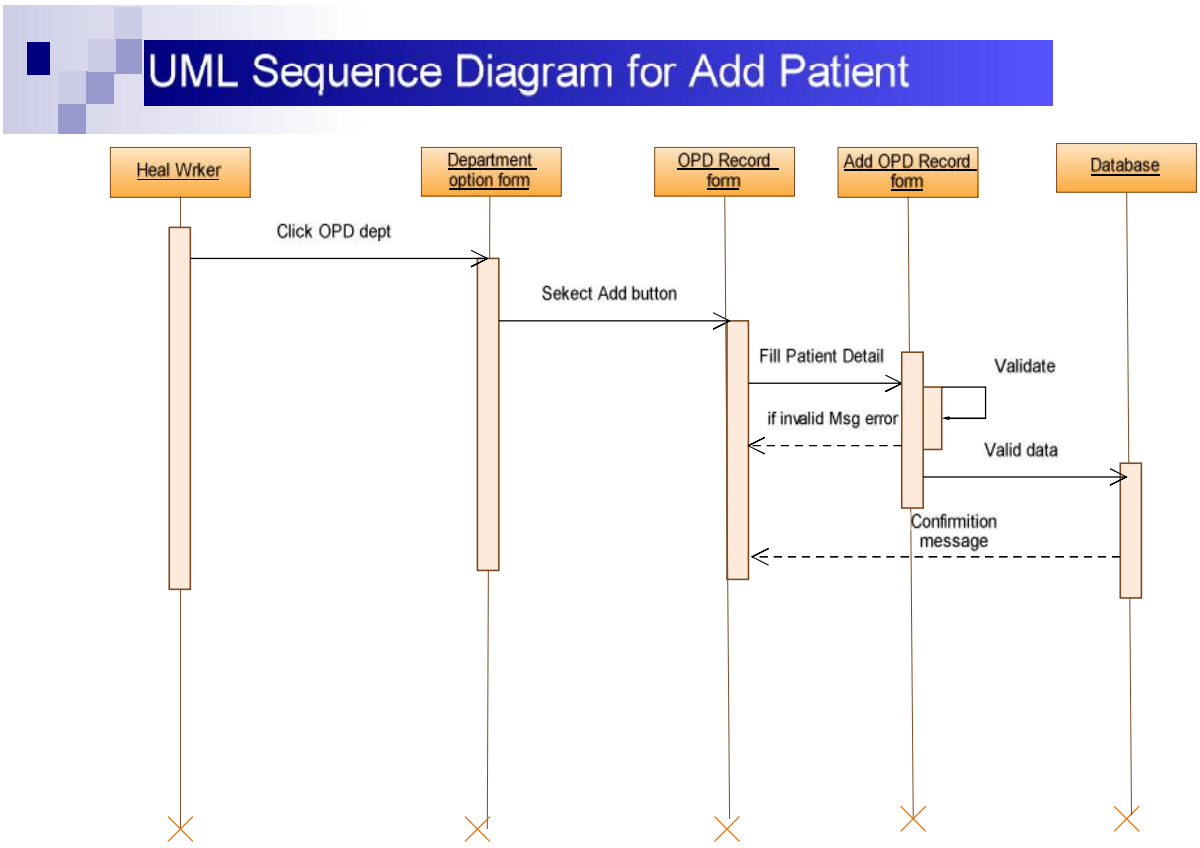


Figure 4: Sequence Diagram for Add Patient Record of OPDPRS, HWHC, June 2012

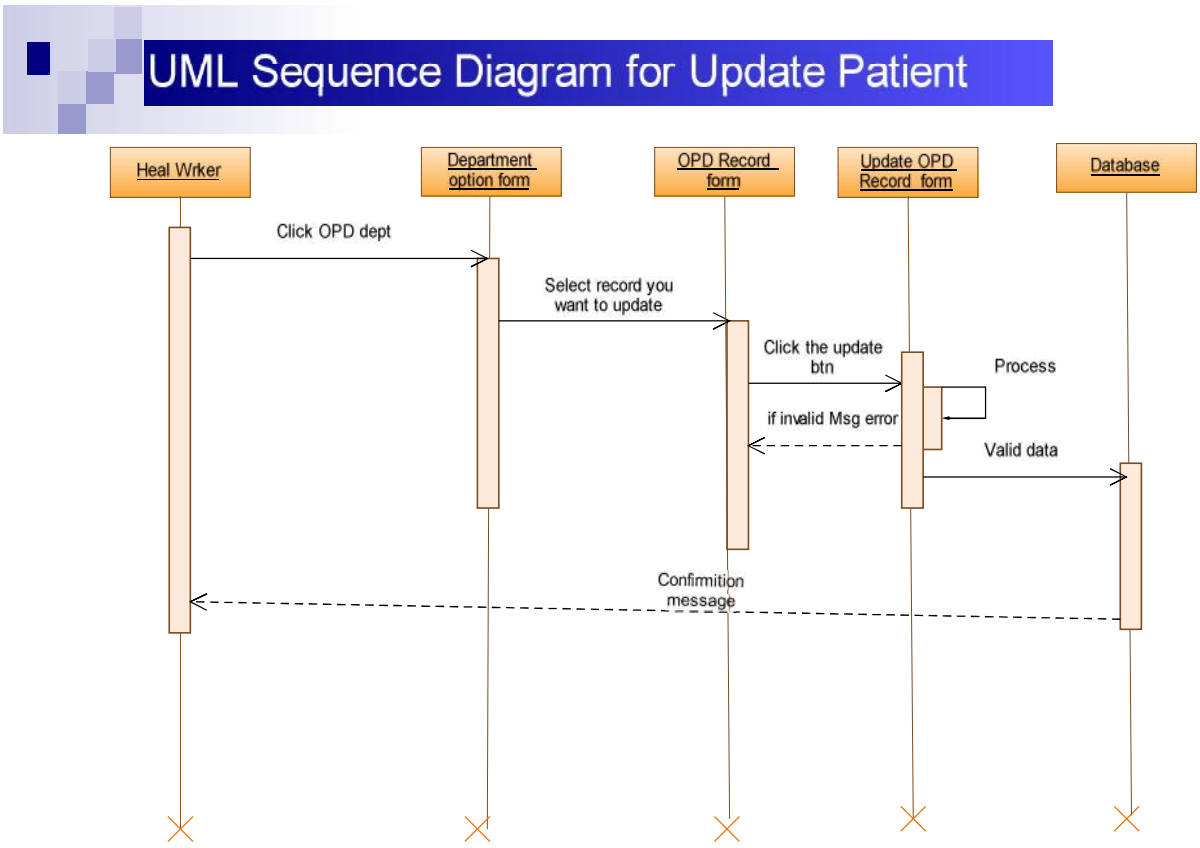


Figure 5: Sequence Diagram for Update Patient Record of OPDPRS; HWHC, June 2012

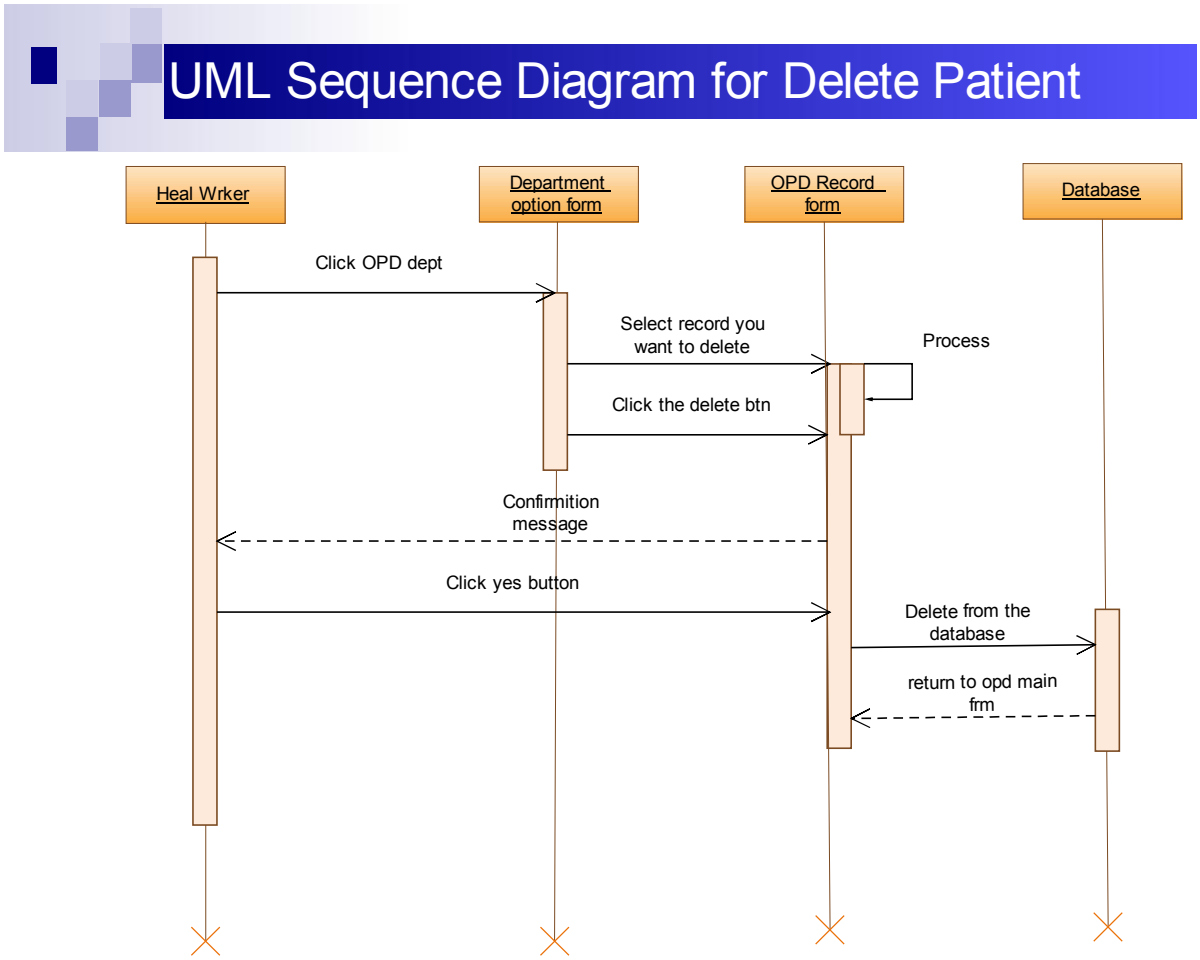


Figure 6: Sequence Diagram for Delete Patient Record of OPDPRS; HWHC, June 2012

3.2.6. Data Elements of the Existing System

As mentioned in the requirement specification part of the system, it is responsible for three basic functions. One of the functions (storing basic demographic and clinical health information) was done using the current available recording system at the health centers. Therefore the data elements of this function in each of the routine service are mentioned below.

Table 2: Summary of data elements for OPD record; HWHC, June 2012

Demographic/Identification information					**Diagnosis**			**Provider Initiated Testing & counseling(PITC)**			**TB screening**				
Serial No.	MRN	Age	Sex	Wored/ sub city	HMIS disease classification	New()	Repeat ()	HIV test			Screened for TB	TB screened result	**Referred to**	**Died**	**Remark**
								offered	Performed	Test result(R, NR, I)					

Table 3: Summary of data elements for FP record; HWHC, June 2012

Identification				**Registration, PITHC,& Contraceptive**															
Personal information				Registration			Counseling & screening					Fill app		Clinical exam & contraceptive Provided					
Serial No.	MRN	Sex	Age	Reg. date	New acceptor at registration	Repeat acceptor at registration	HIV test offered	HIV test performed	HIV test result(R'NR'I)	HIV specific counseling on method	TT status checked	Contraindication for hormonal method	Contraindication for IUCD	Permanent method selected(TL or V)	Visit No.	Visit date (DD/MM/YY)	Contraceptive provided	Method removal (DD/MM/YY)	Remark/appointment
															1				
															2				
															3				
															4				
															5				

Table 4: Summary of data elements for ANC; HWHC, June 2012

Serial No	MRN	Last menstrual period(LMP) (DD/MM/YY)	Visit number for basic care	Date of visit(DD/MM/YY)	Gestational age in week(GA)	TT provided (dose number)	Ferrous sulphate/folic acid provided	Identified &advised on danger sign	HIV test accepted	HIV test result	HIV test result received with post test counseling	Partner HIV test result (R,NR,I)	Counseled on infant feeding	Referred for care, treatment, & support	Type of ARV prophylaxis provided	Remark/ Appointment
			1													
			2													
			3													
			4													

3.3 Requirement Analysis

As already stated, the resulting solution was required to automate the manual existing record system of the health centers with additional possible functionalities. So providing integrated, timely, reliable, relevant and accessible information to the health workers at the health centers can be performed. Here the requirement analysis part shows decomposition of the identified requirements into analysis classes and their relationships which defines the software solutions of the problem. The classes in the analysis represent the real objects in the recording system in which an object is a software construct that mirrors a concept in the real world. It could be a user's of the recording system, the events of the patient that need to be recorded or reports generated from the system. Mainly it is concerned with creating a description of the domain from the perspective of domain objects. There is an identification of concepts, attributes, and

associations that are considered notable using high-level specifications that describes what the system is made-up for.

3.3.1 Domain /Conceptual Modeling

Domain model, also called conceptual models, is the integrated view of all data in an enterprise, and bridges the gap between the data organization as viewed by the DBMS (physical data model) and by individual user applications (logical data model) . To represent this model there are different available methodologies such as entity-relation diagramming, fact-oriented modeling, knowledge bases of logical rules, and object-oriented analysis [57].

The object-oriented analysis was chosen as the methodology for creating the conceptual model for the OPDPRS of the health centers. This technique use domain classes which illustrates important concepts in a real world domain of the clinical data handling system independent of software perspectives. The detail is presented in Figure 7.

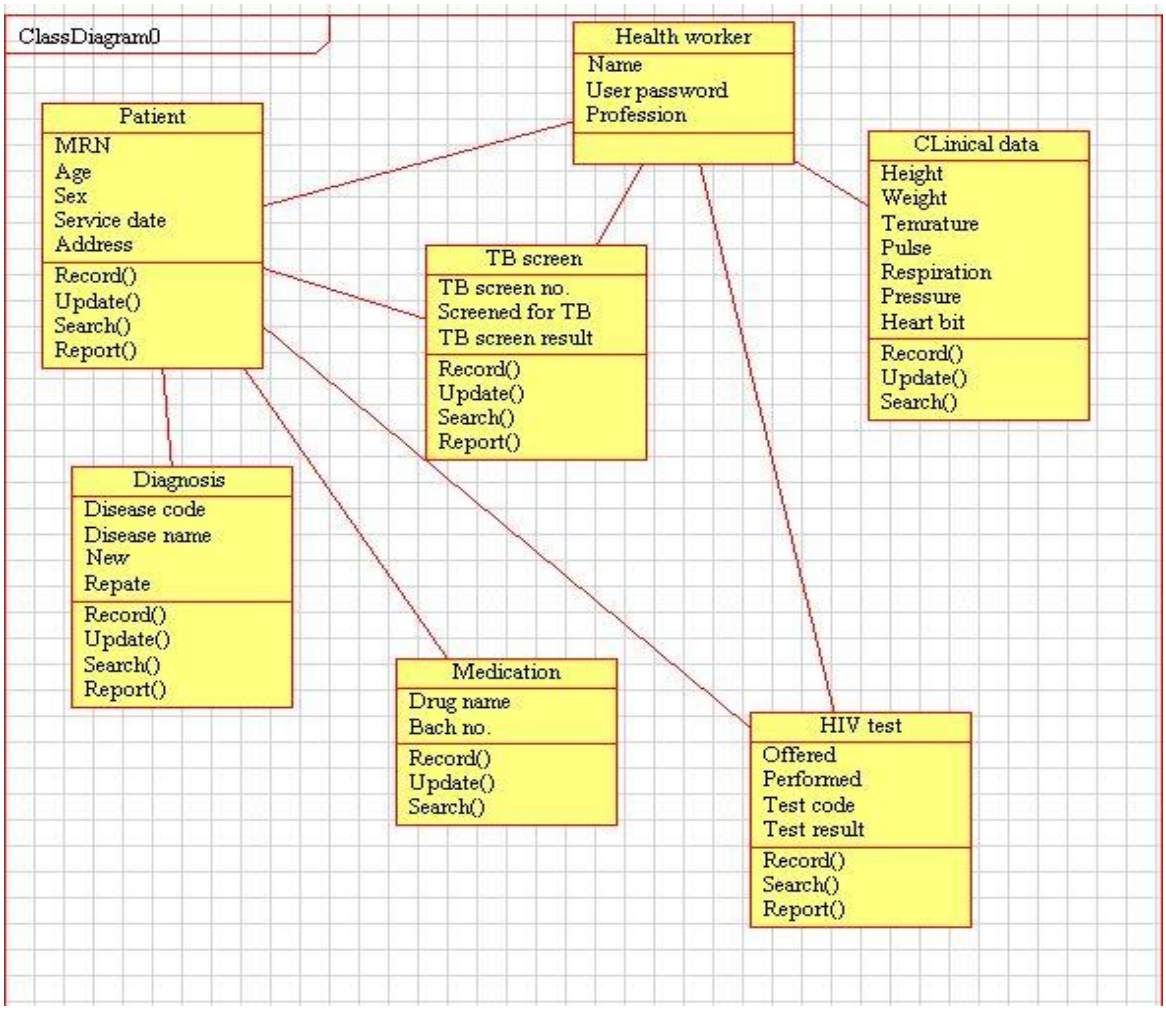


Figure 7: Domain model classes for OPDPRS; HWHC, June 2012

As demonstrated in figure 7, the domain modeling shows the objects of the patient record handling system of the health centers. There are seven objects that are interacting in the health centers: (i) to capture demographic and expresses information about the objects 'patient' and health workers; (ii) to record diagnosis and clinical data or symptom list encountered by the patient; (iii) to capture medical records which includes medication delivered and information about the testes ordered and their results for individual patients or diagnosis.

Having defined the domain classes of the system it is important to convert the class model into relational table in order to show the normalized data. In translating the class model into relational table there are some tips flowed including: map each class to one relational table, for each class

add a unique class identifier i.e. the primary key in the table, map attributes into columns, map associations to foreign keys and map relationship role.

According to these tips here are the tables which hold normalized objects or entities of the OPDPRS each with their primary key and attributes. The primary key in each table is underlined.

Patient-table: Table 5 holds demographic information of the patient who could get service in the OPD of the health center.

Table 5: Patient table of the OPD record: HWHC, June 2012

MRN	**Age**	**Sex**	**Service date (DD/MM/YY)**	**Woreda/ sub city**	**Referred to**	**Died()**	**Remark**

Diagnosis-table: Table 6 holds information about the disease detected for each patient in OPD

Table6: Diagnosis table of OPD record; HWHC, June 2012

MRN	**Disease Code**	**Disease Name**	**New**	**Repeat**

HIV test-table: Table 7 holds data recorded for HIV test

Table7: HIV test table of OPD record; HWHC, June 2012

MRN	**HIV test No.**	**offered**	**Performed**	**Test result (R,NR,I)**

TB Screening-table: Table 8 holds data of TB screening

Table8: TB Screening table of OPD record; HWHC, June 2012

MRN	TB screen No.	TB screened	TB screen result (P, N)

Patients Symptom- table: Table 9 holds clinical data encountered in each diagnosis

Table 9: Patients Symptom- table of OPD record; HWHC, June 2012

MRN	Weight	Height	Pressure	Pulse	Respiration	Heart bit	Temperature

Patients Medication-table: Table 10 holds data of the medications provided

Table10: Patients Medication-table of OPD record; HWHC, June 2012

MRN	Medicine name	Brand name	Dosage level	Date	

Each of the above tables are in their normal form, after applying first normal form for checking whether the tables hold one value for each cell, second normal form for avoiding functional dependency and third normal form correcting transitive dependency.

In general this chapter deals with the findings regarding what services provided at the health centers, problems that were encountered by the current patient record handling system, user's opinion of adapting new system to their area, the requirements the new system should include and representing these requirements in which the users can understand what action to perform using the system. The domain model will be used to design the prototype record system that should be implemented.

CHAPTER FOUR

SYSTEM DESIGN AND IMPLMENTATION

Once patient record system requirements are identified, the next task is designing and implementation of the prototype of the system. In the design part, system architecture construction, class diagram modeling, user interface design and database design are performed.

4.1 System Architecture

In this study a standalone patient record system (PRS) is designed and implemented that facilitates data collection, acquisition, and access to information at Woreda health centers. An overall architecture of the system is shown in figure 8. It is a one-tier architecture where all the three components of the system, user interface, application and database operate on one computer.

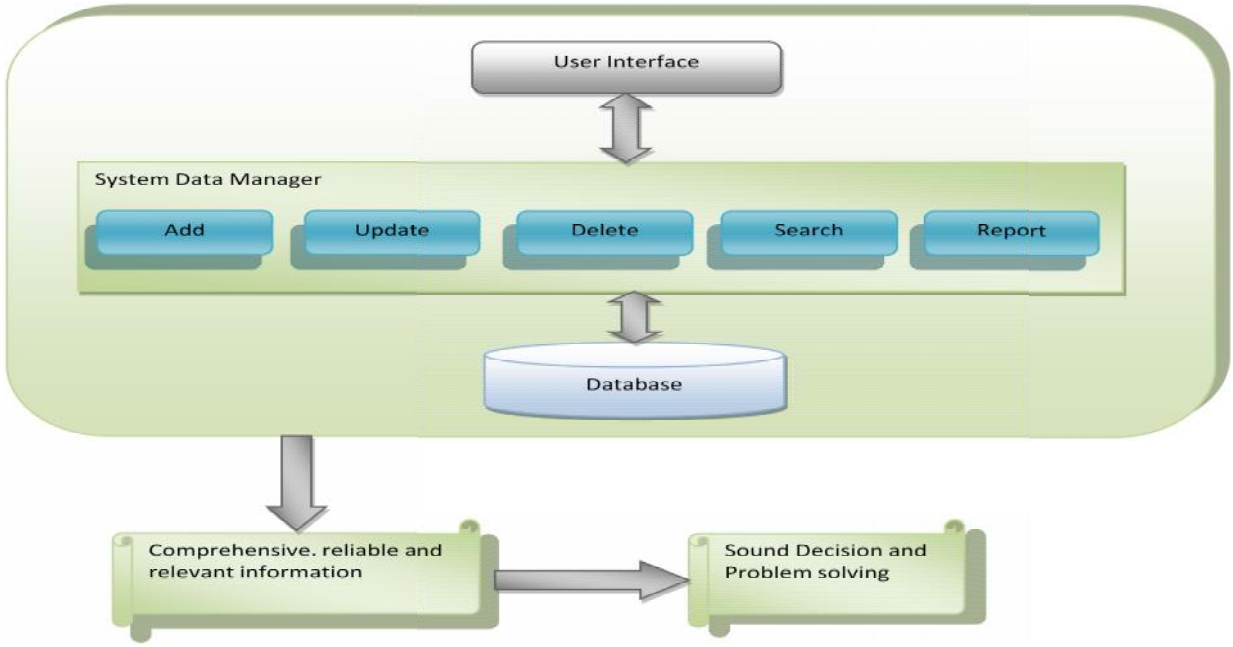


Figure 8: System Architecture of OPDPRS; HWHC, June2012

The User Interface is the point where the user interacts with the system. It accepts queries from the users and displays summarized information and reports on the computer screen.

The application processes all of the program functions, such as validating the integrity of the data entered by a user, generate report, highlight abnormal test result and alert for abnormal vital signs.

The database is the component that will record, store and manage patient data that the health workers enter into the application through the user interface.

Based on the system architecture presented in the previous section, a prototype for "Out Patient Department's Patient Record System (OPDPRS)" was designed and implemented. OPDPRS is a computer-based standalone application that is used to record/store, generate report, and increase the accessibility of patient record generated in the OPD of the health centers. To this end this study attempt to design classes, database, and user interface of the OPDPRS.

4.2 Designing OPDPRS

To solve the problems of the existing paper-based record system, it is important to design appropriate record system that fits with the level of the institute and the tasks being delivered since as the number of functionalities of the system increases the complexity also rise.

First of all, how the record system works or how each function can be performed is outlined. To make it simple every data structure was defined on its own table (class). Values of each data element could be placed into individual columns, then were referenced by the primary key of each data in addition to this the values of the data elements which are dependent on the patient were referenced using the patient's MRN; such as diagnosis, medication, test results etc. since these data elements could not be unique for every patient receiving a service. For example if we take diagnosis, the same disease may occur in many patients, the only mechanism to differentiate this is using the MRN. Unless each of the dependent data elements were needed independent of the patient i.e. to query number of one disease acquired.

Secondly, to make sure the system is acceptable and usable by the health workers design of the interface is designed as user friendly as possible. Because usability of the system also depends on its interface since it is the interface that enables users communicate with the system.

Afterwards, the patient record system was modeled and designed using class diagrams, the database design and user interface design.

4.2.1 Class Diagram Design

The class diagram shows attributes and methods of the classes identified from the recording system. In contrast to the domain model that shows real-world classes, the design class diagram shows software classes. In this way, OO designs and languages can support a lower representational gap between the software components and our mental models of a domain that improves comprehension. As it is seen in figure 9 the class diagram represent clearly the classes and their attributes and methods.

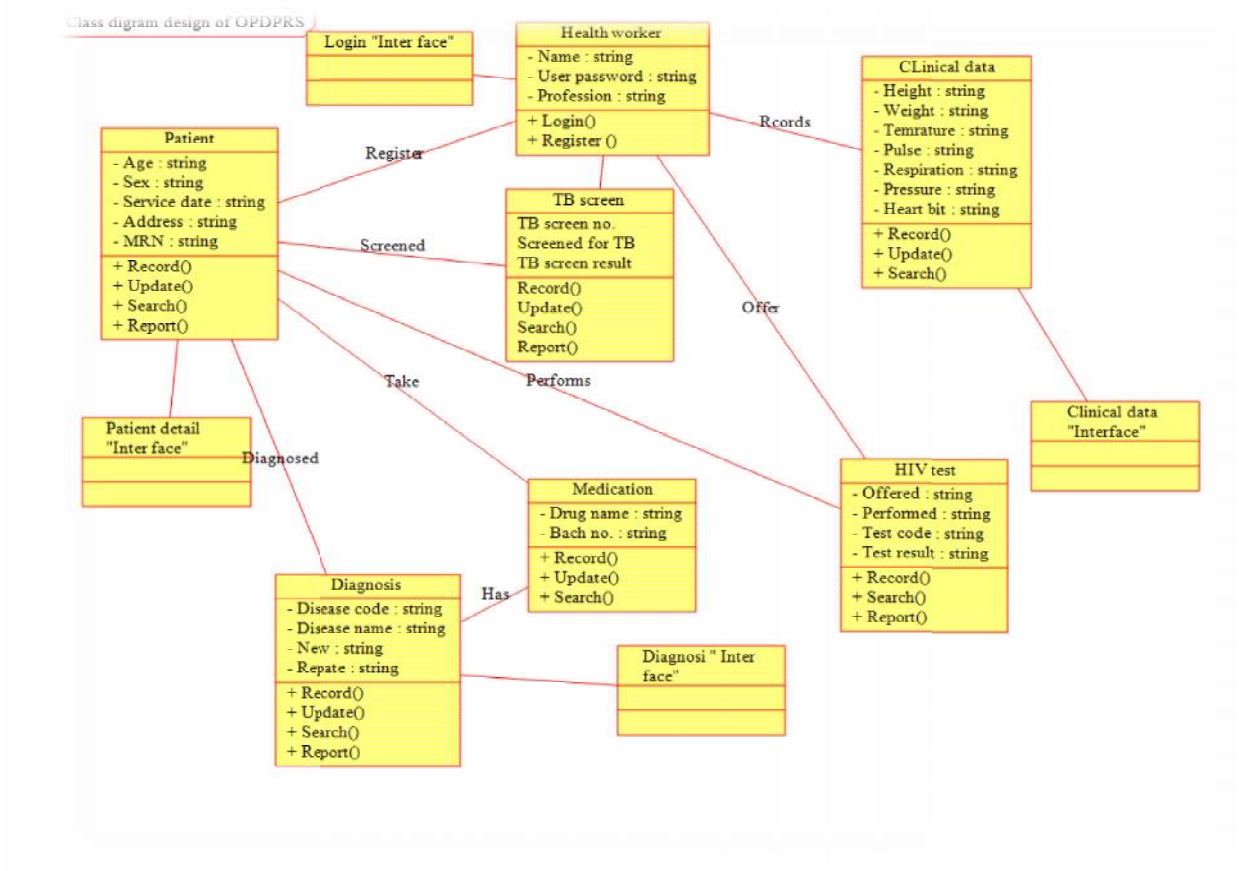


Figure 9: Design class diagrams of OPDPRS; HWHC, June 2012

4.2.2 Database Design

As in the relational database design, in object-oriented database design the physical database design or physical data model explores the internal schema of a database including data type with memory requirements specified, represent the data classes (tables), data attributes of those

classes (fields), and the relationships between the classes in developing OPDPRS of the health centers.

The physical data model of OPDPRS of the health centers is depicted below in figure 10

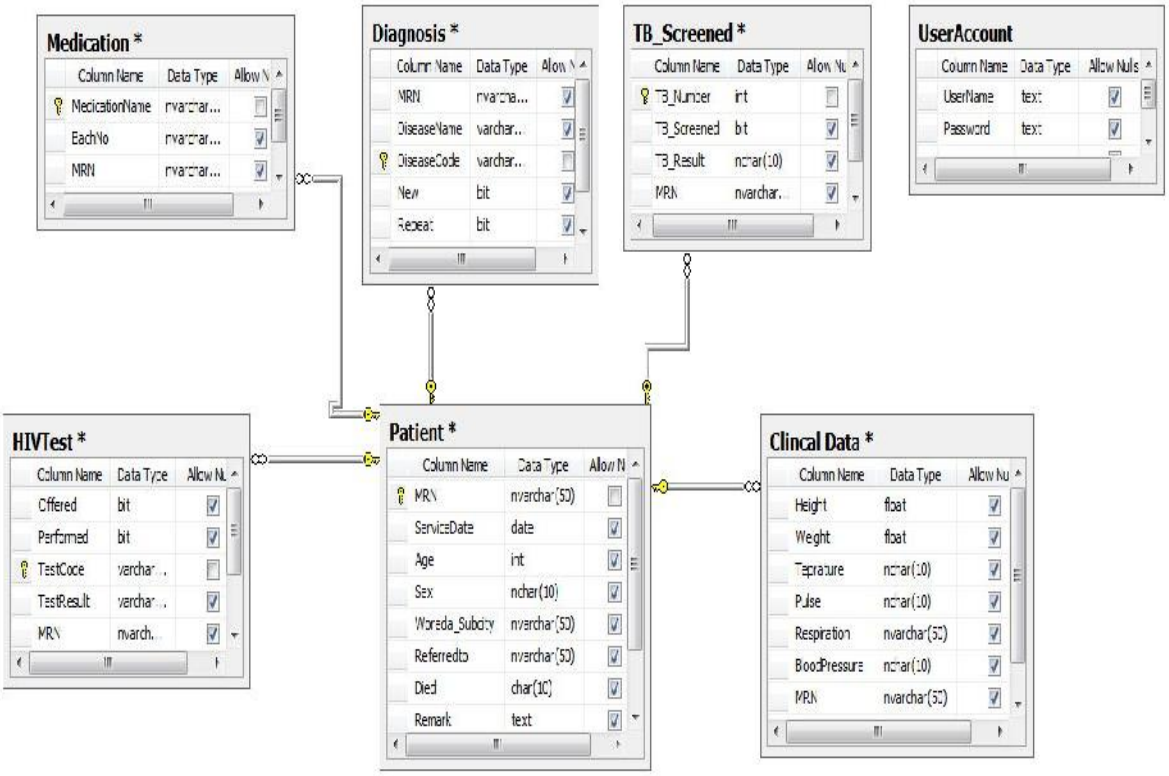


Figure 10: Physical database designs of OPDPRS; HWHC, June 2012

4.2.3 User Interface Design

User interface is part of the software that interact with the user. It presents data and text on the screen and responds to the user keystrokes and mouse clicks. In the minds of users, a system's user interface is the system; everything else is just stuff they're happy to ignore [59]. The design of the user interface is therefore critical to the success or failure of the system being implemented.

In order to design effective user interface that match with the users, it is important to select appropriate user interface architecture. For such purpose there are two types of user interface architectures based on whether the application displays only a single window a single document

interface (SDI) or displays a primary window inside of which additional windows can be opened a multiple document interface (MDI) [59].

In this study SDI was employed to develop the OPDPRS user interface (forms) of the health centers of this study and the flow of forms are displayed in figure11.

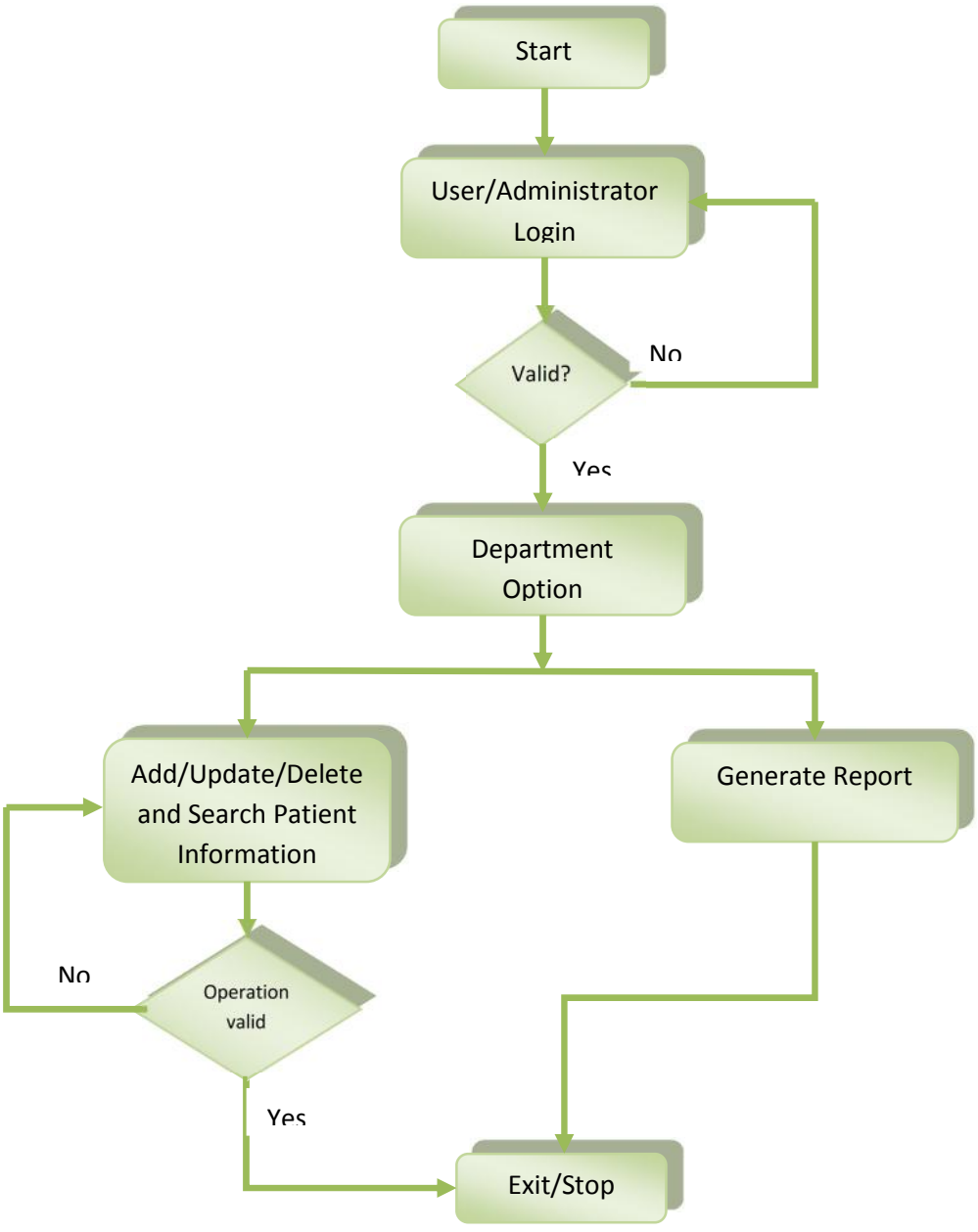


Figure 11: System Flow Chart of OPDPRS; HWHC, June 2012

The flow diagram shows that, to start working with the system first of all the user (health workers) has to login into the system using the assigned user/administrator ID and password; in which the log-in validates the user. If the user is valid, he/she is allowed to access the system. Once the system is opened the user can select the department from the department options OPD, FP, immunization etc. When the selected department opened department's record main form which contains detail patient information (demographic information, diagnosis, test, and medication information) to be registered in the database would be displayed. Then the health worker can add, delete, update or search patient information, diagnosis, medication and tests performed for each patient form that is obtained from the routine service for this case that of OPD. While these operations are run, the information detail interfaces validate the correctness and exit the system if the operation is successfully done; else it returns back for proper operations.

Therefore each of the user interfaces developed for the OPDPRS of the health centers are described below.

The form seen in figure 12 is the login interface that accepts user name and password for authentication users.

Figure 12: Login forms of the OPDPRS of OPDPRS; HWHC, June 2012

Figure 13 shows department option form that was displayed after the health worker had login to the system. It includes the departments or the services that could be available in the health centers. Even though, the system developed in this study was concerned with only one

department, the department option form was designed to show that the system can also be extended for other departments so health workers can select the department they needed.

Figure13: Department selection form of OPDPRS; HWHC, June 2012

This form is easy to use; it requires clicking on the department of interest. Then the main form of the department will be launched as shown in figure14. The department's (OPD's in case of this study) main form holds data about patient's demographic information, diagnosis information, tests performed and clinical data encountered. Each of these data have their own form which were displayed while clicking on Add, Delete, Search, or Update buttons on the main form as shown below.

Figure 14: OPD record main forms of OPDPRS; HWHC, June 2012

As mentioned above while health worker needs to record or retrieve information from the record first he/she had to click on either of the information needed to be recorded from the task bar of the main form then click one of the commands (Add, Update, Delete and Search). And then the information detail form will be launched. Figure 15 shows detail information form of a patient, which was displayed when the health worker need to record or update demographic information of the patient.

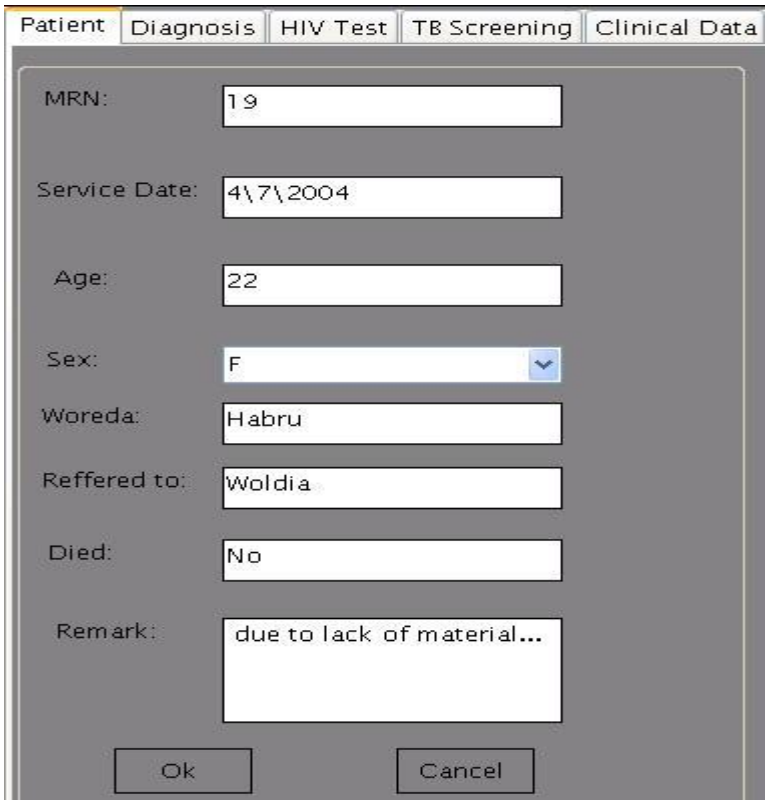


Figure15: Patient information detail form of OPDPRS; HWHC, June 2012

The same to the patients detail form the rest of the information detail forms could be displayed by clicking on the information wanted about to record and click on one of the command buttons. Figure 16 to figure 18 shows the form for Diagnosis, Clinical data, and HIV test, respectively. These figures show when users add/store detail information regarding diagnosis, test, and clinical data encountered for patients who get routine service in OPD of the health centers.

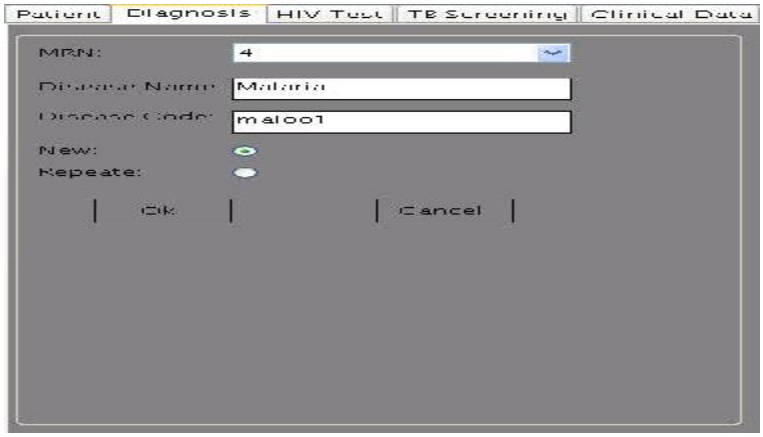


Figure 16: Diagnosis information detail form of OPDPRS; HWHC, June 2012

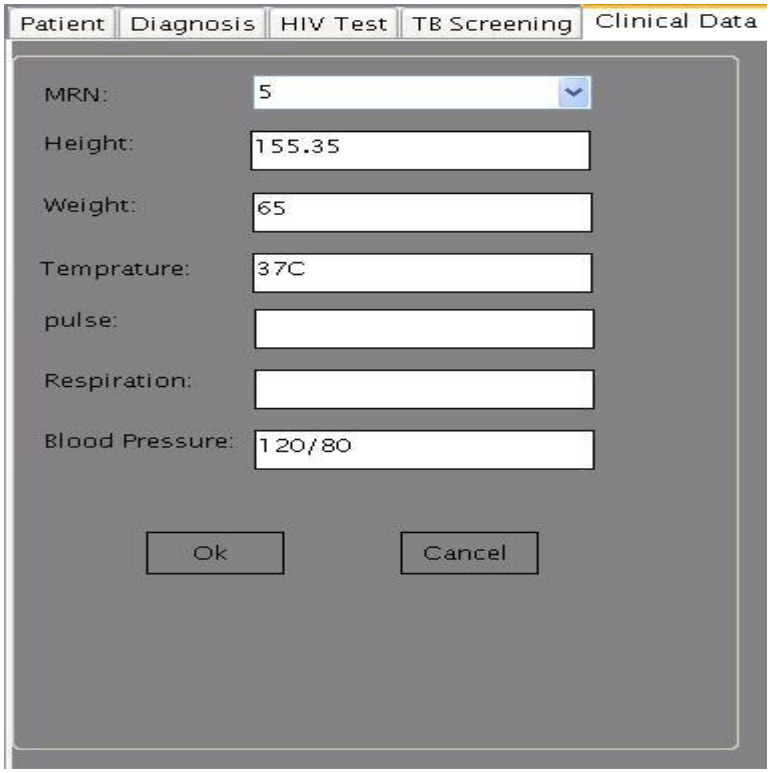


Figure 17: Clinical data information detail form of OPDPRS; HWHC, June 2012

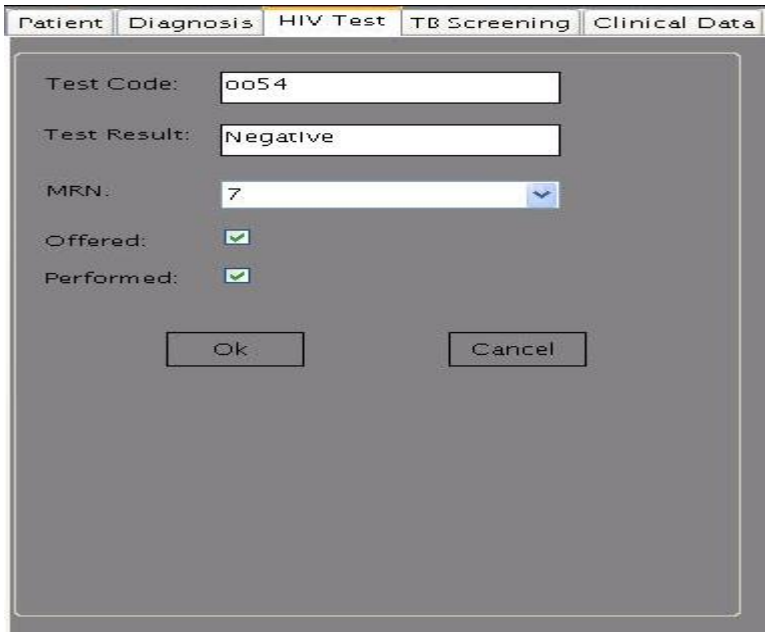


Figure 18: HIV test information detail form of OPDPRS; HWHC, June 2012

4.3 Implementation

The previous parts of the study focused on analysis and design of the standalone OPDPRS of the health centers developed in this study. Then this part of the thesis addresses how to implement the actual system, which includes the detail description of the system developed; how the deliverables implemented, and roll-out problems with the system, and finally evaluation of the system's performance and acceptance test.

Based on the specified requirements the system was developed to enable the health workers at the health centers to perform different operations (including recording, update, retrieve, or produce report from what is already record) and the forms for each of these functions based on the data types (patient data form, medication form, diagnosis form, clinical data form and test form) were designed as shown in section 4.3.2 and implemented using Microsoft visual studio 2008 with C# programming language. The database which stores all these information was implemented using Microsoft SQL 2008 server.

Sample source code for the Add operation in Listing 4.1 show how to fill patient data intended to be stored in the database.

```
namespace Patient_Record_System{
    public partial class OPDadd : Form{
        SqlCommand cmd;        SqlConnection con;
        public OPDadd(){
        InitializeComponent();
     }
    private void cancelbtn_Click(object sender, EventArgs e){
        try{
                this.Visible = false;     OPD u = new OPD();
                u.Show();
         }
        catch (Exception er){MessageBox.Show(er.Message);}
     }
    private void okbtn_Click(object sender, EventArgs e){
        try {
             string strcon = "Data Source=.;Initial Catalog=OPD; Integrated
                   Security=True";
            con = new SqlConnection(strcon);   con.Open();
            if (flag != 1){
                 string strcmd = "INSERT INTO Patient VALUES ('" + txtMRN.Text +
                   "','" + txtServicedate.Text + "','" + txtAge.Text + "','" +
                   cmbsex.Text + "','" + txtWoreda.Text + "','" +
```

```
            txtRefferedto.Text + "','" + txtDied.Text + "','" +
            txtRemark.Text + "')";
        cmd=new SqlCommand(strcmd,con);
        cmd.ExecuteNonQuery();
        con.Close();
        MessageBox.Show("Record Added Successfully","PRS System",
             MessageBoxButtons.OK,MessageBoxIcon.Information);
        OPD f = new OPD();
        f.Show();               this.Close();
}
```

List 1: **Add form source code**

For the other functions of the system, the source code is attached in Annex I. One of the problems encountered while implementing the OPDPRS is that it was difficult to implement the aggregate report since the system is standalone and difficult to get data from other database. Other issue that was challenging during implementation was creating different forms to capture information about Patient detail, clinical data and diagnosis, and link them such that they can share information to generate patient's status during service delivery.

4.4 Performance Evaluation of OPDPRS

EHRs and related health information technology (HIT), such as computerized physician order entry (CPOE), clinical decision support system (CDSS), and web-based patient portals significantly enhance ability to evaluate the process and outcomes of health care and the degree to which consumers needs are being met. But all these significances could be obtained if the system performs as it intended to be. And it is on minds of all developers of a system to evaluate its performance before or after its implementation in the actual world [60].

Evaluating the performance of EMR system is challenging but important part of development cycle of clinical information system. There are different ways of evaluating the system such as; measuring the quality-of-care indicators that are collected using EMR. Using this technique five case studies were performed by Jinnet et al [61].

The other way to evaluate the performance of EMR system is calculating time response of the system for meeting entry and retrieval requirements of direct patient care process for physician and other providers at peak usage periods. Using this technique a research that evaluates the performance of a Web-based system for Ophthalmologic Electronic Health Records was done by Isabel, Francisco & Miriam [62].

There is also other option using task-oriented questionnaires [63]. In this study also task-oriented questionnaire has been employed to evaluate the performance of the OPDPRS developed for the health centers. To use this technique queries related to what the system can accomplish and compare to the expected functionalities that has been set to the system were developed by the investigator. Finally, using the queries the investigator can observe the use of the system in the health care delivery of the health centers.

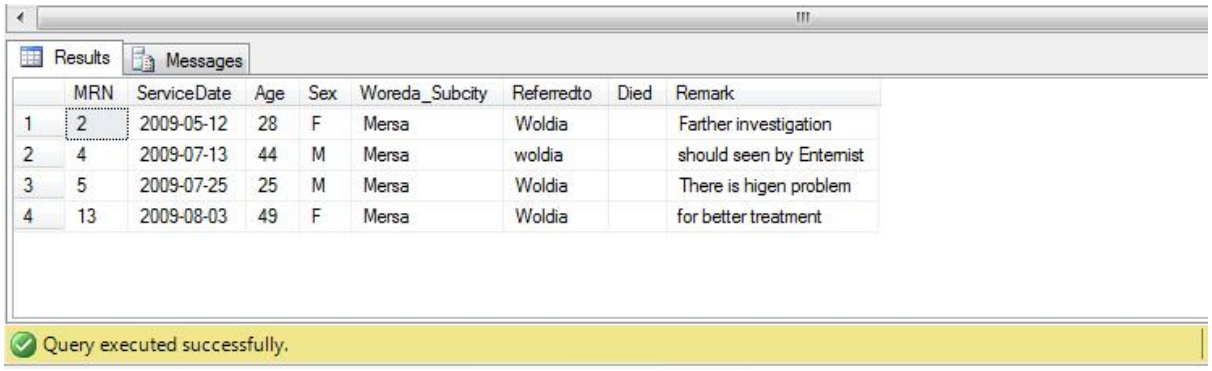
4.4.1. Performance Evaluation Result

The results of the queries which have been given to the system are mentioned below from tables 11 to table 17. As it is seen below the investigator give the system a total of seven queries based on which the system provides an output for all of the queries offered to do.

Query 1: Find all patients Referred to "Woldia"

```
select * from Patient
where Referredto='woldia';
out put:
```

Table 11: Result of query 1 of OPDPRS; HWHC, June 2012


Results Messages

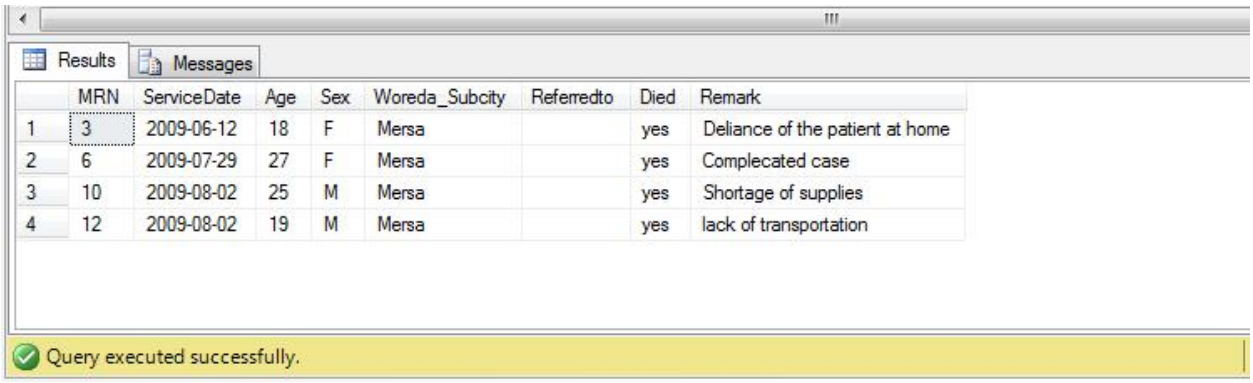
	MRN	ServiceDate	Age	Sex	Woreda_Subcity	Referredto	Died	Remark
1	2	2009-05-12	28	F	Mersa	Woldia		Farther investigation
2	4	2009-07-13	44	M	Mersa	woldia		should seen by Enternist
3	5	2009-07-25	25	M	Mersa	Woldia		There is higen problem
4	13	2009-08-03	49	F	Mersa	Woldia		for better treatment

Query executed successfully.

Query 2: Find all patients who died

```
select * from Patient
where Died='Yes';
out put:
```

Table 12: Result of query 2 of OPDPRS; HWHC, June 2012



Results | Messages

	MRN	ServiceDate	Age	Sex	Woreda_Subcity	Referredto	Died	Remark
1	3	2009-06-12	18	F	Mersa		yes	Deliance of the patient at home
2	6	2009-07-29	27	F	Mersa		yes	Complecated case
3	10	2009-08-02	25	M	Mersa		yes	Shortage of supplies
4	12	2009-08-02	19	M	Mersa		yes	lack of transportation

Query executed successfully.

Query3: Find Female patients of age greater than 20 and also having malaria

```
SELECT p.Age,p.Sex,d.DiseaseName
FROM Patient p,Diagnosis d
WHERE (p.Sex='F' AND p.Age > 20 )AND (p.MRN=d.MRN AND
    d.DiseaseName='Malaria')
Out put
```

Table13: Result for query 3 of OPDPRS; HWHC, June 2012

Results | Messages

	Age	Sex	DiseaseName
1	37	F	malaria
2	28	F	malaria

Query executed successfully. | HIWI-PC (10.0 RTM) | HIWI-PC-\Hiwi (52) | OPD | 00:00:00 | 2 rows

Query4: Find Patients who have HIV positive test result.

```
SELECT *
FROM HIVTest
WHERE TestResult='Positive'
```

Table 14: Result for query 4 of OPDPRS; HWHC, June 2012

	TestCode	TestFesult	vIRN	Offered	Perlormed
1	008	Pcsitive	I	I	0
2	234w	positive	2	1	0
3	77	Pcsitive	3	1	0
4	tes55	Pcsitive	4	1	0

Query executed successfully. | samara-pc (10.0 R~M) | SAMARA-PC\sam (54) | OPD | 00:00:00 | 4 rows

Query 5: Find Female patients who perform TB screen.

```
SELECT p.MRN ,p.Sex,t.TB_Screened
FROM Patient p, TB_Screened t
WHERE p.Sex='F' AND(p.MRN= t.MRN AND t.TB_Screened='True')
Output
```

Table 15: Result for query 5 of OPDPRS; HWHC, June 2012

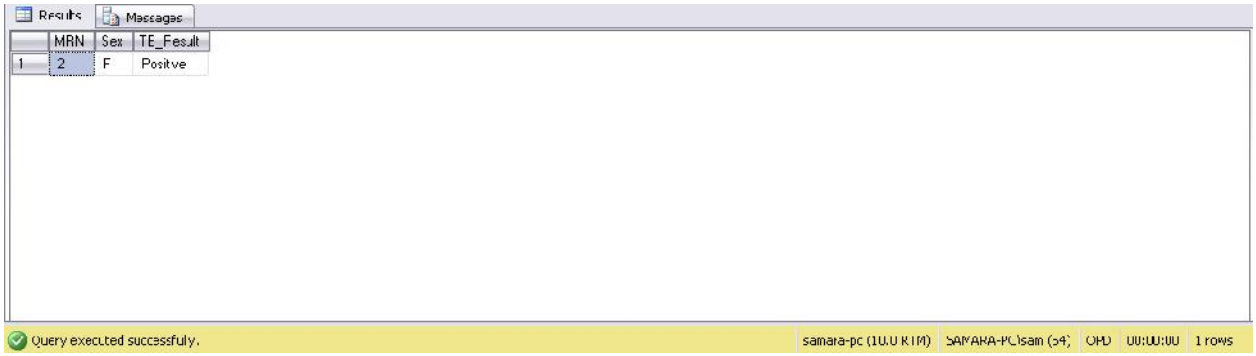
	MRN	Sex	T3_Screened
1	2	F	1
2	6	F	1

Query executed successfully. | samara-pc (10.0 RTM) | SAMARA-PC\sam (54) | OPD | 00:00:00 | 2 rows

Query 6: Find Female Patients who have Positive TB-screen results

```
SELECT p.MRN ,p.Sex,t.TB_Result
FROM Patient p, TB_Screened t
WHERE p.Sex='F' AND(p.MRN= t.MRN AND t.TB_Result='Positive')
Output
```

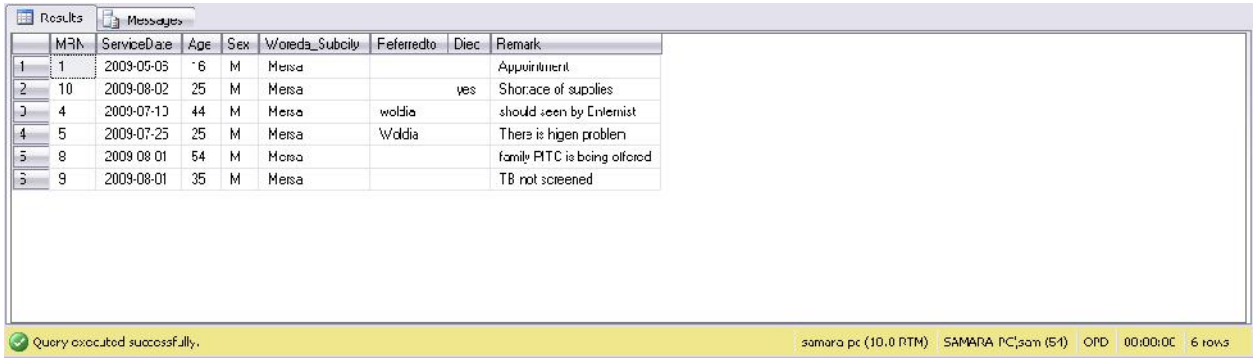
Table16: Results of query 6 of OPDPRS; HWHC, June 2012



Query 7: Find Male Patients age greater than 15.

```
SELECT *
FROM Patient
WHERE Sex='M' AND Age >15
Out put
```

Table17: Result for Query 7 of OPDPRS; HWHC, June 2012



In summary experimental result obtained based on the seven queries provided to the system are presented in table 18.

Table18: Evaluation Results of the Data Retrieved by OPDPRS; HWHC, June 2012

Query	Actual Relevant records for the query	Retrieved Relevant documents	Recall	Precision
Query 1	4	4	1	1
Query 2	4	4	1	1
Query 3	2	2	1	1
Query 4	5	5	1	1
Query 5	2	2	1	1
Query 6	1	1	1	1
Query 7	6	6	1	1

Based on the given queries, the system performs with 100% accuracy. This shows that the system performs perfectly for the implemented functionalities and areas. The correctness of the information retrieved in the performance evaluation is also evaluated using recall and precision in which it registers 100% recall and precision, this means that all the relevant documents are retrieved and all retrieved documents are relevant by the system.

4.4.2 User Acceptance Test (UAT) of OPDPRS

The goal of UAT is to simulate realistic business activity and process in the test environment having real users of the system developed and validate that the application is performing according to user specification. So the users can cope with the system in their future work. The user's acceptance can also be affected by different factors. For this study acceptance model of EMR proposed by Haslina and Sharifan [64], to test the user acceptance of the EMR in Malaysia, was employed. The model includes four categories of questions:

- user interface factors, such as screen, terminology and system learning, and system capabilities;
- user behavioral factors, such as attitudes, intention to use;
- information quality factors, like, accuracy, completeness, current, sufficient, standardized, timely, and format of layout; and

- Perceived usefulness and perceived ease of use delivered to the health workers of the study health centers.

These questions were delivered after installing the application of the OPDPRS in computer of the statistics department of the selected health center for the test (Mersa health center). This health center was selected due to availability of computer in the health center.

Then all health workers (three health officers and two nurses) who were engaged in delivering routine service in OPD of the health center and one ICT personnel were interviewed after they perform tasks using the system. Before the practitioners start working with the system the investigator had provided extensive training as to how the system works in general and how to perform the specified functions/tasks.

After the health works test the system, they provide feedback for the interview conducted by the researcher as presented below. The details of questions used for the interview are attached as Annex IV.

Usefulness of the System

There was no doubt about the usefulness of the system by the users. They mentioned that using this system would improve their job performance and they could do their job effectively and quickly compared to the existing manual record system. They also reported to strengthen the functionality of the system by adding the possibility of ordering diagnostic tests and prescribing of medications using the system. This requirement is beyond the scope of the present study as it requires designing an intelligent knowledge based system.

Ease of Use

This idea describes whether the system implemented is easy to use, to learn, and whether interaction with the system is clear and understandable. Regarding this factor three of the respondents, two health workers who have elementary computer skill and the ICT personnel reported that the system was intuitive and easy to use. These respondents also reported that having access to signs and symptoms (clinical data encountered) collected during previous visits

provided a better clinical picture than diagnosis alone. Other three respondents with less computer skill were not sure to say it is easy to use and that they were interact with the system correctly. They report that, may be it would be better to have computer training to evaluate the system.

Information quality

This is about the quality of the health information and data functionality of the implemented system. The quality of the information measured based on its accuracy, completeness and security. Regarding these issues of the information that could be retrieved from the OPDPRS of the health centers the respondents mentioned as follows:

> ***"****Mostly inaccuracy of information results introduced at the time of data entry. While we record the data using this system it displays a massage for incorrect data entry. So we could say that using this system, we can provide accurate information that helps us in decision making."*

In addition to the accuracy of the information the respondents also report that patient information can be protected from unauthorized user since there is a password to access the system.

User Interface

The basic component in developing user-centric system is its interface. Because that is the interface in which the users can interact. Therefore it was mandatory to interview the users about the characters on the screen, adequacy of the information displayed, and sequence of screens displayed.

The respondents also reported that, the characters on the screen were easy to read, the sequence of the screens displayed for each operation was clear and logical, and it was possible to predict the next screen to be displayed and it was also possible to go back to the previous screen.

User Behavior

Finally the attitude of the users in using the new system was asked. And they respond that, using electronic record system is a good idea and they intended to use it every day.

In general user acceptance test shows that the system developed in this study is performing according to user specification. This means further that the OPDPRS has a great acceptance by most of the health workers of the center to see the practicality of application such that they can ease their day-to-day operations in OPD.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Generally, this study attempt to develop electronic patient record system based on the finding, patient data in the health centers is kept manually using different paper-based formats and registers. And according to the responses of the interviewees, the paper-based record system has different problems including invisibility of records, inaccessibility and difficult to deliver comprehensive and timely health information for local use.

In the mean time information requirement of the health centers was also identified. So information related to the services delivered such as: the diagnosis made, the testes ordered and the medications provided was required. That is how the record system was developed using the OO approach by focusing on the information needed by the health centers in this study. It was also found that, to implement the functionality of generating aggregated report the system should be networked or it should have to support database merge using electronic data storage. Therefore the prototype developed in this study is not capable of delivering aggregated report.

Finally experimental result of the prototype shows that the system works correctly with 100% precision. User acceptance test also proofs that the system meets users interface factors, such as screen, terminology and system learning, and system capabilities; user behavioral factors, such as attitudes, intention to use; information quality factors, like, accuracy, completeness, current, sufficient, standardized, timely, and format of layout; and perceived usefulness and perceived ease of use delivered to the health workers of the study health centers.

Therefore regarding implementation of the system in the health centers and further researches to extend the developed prototype are suggested in the recommendation section of this thesis.

5.2 Recommendation

As it was concluded, patient data is kept manually in the visited health centers and problems of this system were also identified. An attempt was made by this study to develop patient record system. The

following points should be done by the health centers and future researches in order to improve the current poor patient record handling and use practices.

- The health centers should implement the developed record system.
- As explained by the health workers, they all agree to use the system but they mentioned to have computer training, therefore training and manual should be provided
- Users suggest strengthening the functionality of the system by adding the possibility of ordering diagnostic tests and prescribing medications using the system, which needs further research on the possibility of developing an intelligent knowledge based system that can provide advice to health professionals.
- It is also necessary to undertake further research as to how to create a networked environment that enables health centers access and deliver quality and up-to-date information also to deliver aggregated report.

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Annex I Source Codes

Log_in form source code

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using System.Data.OleDb;
using System.Data.SqlClient;
namespace Patient_Record_System
{
    public partial class Login : Form
    {
        //SqlConnection con;
        //SqlCommand cmd;
        public Login()
        {
            InitializeComponent();
        }

        private void Login_Load(object sender, EventArgs e)
        {
            enterbtn.Enabled = false;
        }

        private void cancelbtn_Click(object sender, EventArgs e)
        {
            try
            {
              DialogResult dResult;
              dResult = MessageBox.Show("Do you want to Exit?", "PRS System",
                    MessageBoxButtons.YesNo, MessageBoxIcon.Warning);
                if (dResult.ToString() == "Yes")
                {
                    Application.Exit();

                }
                else
                    this.Visible = false;
                Login v = new Login();
                v.Show();
            }
            catch (Exception ex)
            {
                MessageBox.Show(ex.Message);
            }
        }

 private void enterbtn_Click(object sender, EventArgs e)
        {
            try
            {
string strcon = "Data Source=.;Initial Catalog=OPD;Integrated Security=True";
private void enterbtn_Click(object sender, EventArgs e)
```

```
        {
            try
            {
string strcon = "Data Source=.;Initial Catalog=OPD;Integrated Security=True";
                con = new  SqlConnection(strcon);
                con.Open();
                string strcmd="SELECT * FROM UserAccount";
                cmd = new SqlCommand(strcmd,con);

                SqlDataReader reader = cmd.ExecuteReader();

                object[] obj = new object[256];
                bool st = false;


                while (reader.Read())
                {
                    reader.GetValues(obj);
if ((usernametxtbox.Text == obj[0].ToString()) &&
(passwordtxtbox.Text == obj[1].ToString()))
                    {
                        st = true;
                        break;
                    }
                }
                reader.Close();
                con.Close();

               if (st)
               {
                   this.Visible = false;
                  DepartmentsOption department = new DepartmentsOption();
                  department.Show();
               }
               Else
 MessageBox.Show("INVALID!!! Try again", "PRS System", MessageBoxButtons.OK,
MessageBoxIcon.Error);
            }
            catch (Exception ex)
            {
                MessageBox.Show(ex.Message);
            }
        }

        private void passwordtxtbox_TextChanged(object sender, EventArgs e)
        {
            enterbtn.Enabled = true;
        }
    }
}
```

OPD form source code

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using System.Data.OleDb;
using System.Data.SqlClient;

namespace Patient_Record_System
{
    public partial class OPD : Form
    {

        public OPD()
        {
            InitializeComponent();
        }

        private void cancelbtn_Click(object sender, EventArgs e)
        {
            try
            {
                this.Visible = false;
                DepartmentsOption department = new DepartmentsOption();
                department.Show();
            }
            catch (Exception em)
            {
                MessageBox.Show(em.Message);
            }
        }

         private void searchbtn_Click(object sender, EventArgs e)
        {
            bool exist = false;
            try
            {
                for (int i = 0; i <= OPDlstView.Items.Count - 1; i++)
                    {
 if (searchtxtbox.Text == OPDlstView.Items[i].SubItems[0].Text ||
searchtxtbox.Text == OPDlstView.Items[i].SubItems[4].Text)
                        {
                            OPDlstView.Items[i].BackColor = Color.Yellow;
                            exist = true;
                            return;

                        }
                    }
                if (!exist)
                        {
```

```
                        MessageBox.Show("Record Not Found", "PRS Search
Engine", MessageBoxButtons.OK, MessageBoxIcon.Information);
                    }

            }
            catch (Exception ex)
            {
                MessageBox.Show(ex.Message);
            }
        }


        private void searchtxtbox_TextChanged(object sender, EventArgs e)
        {
            searchbtn.Enabled = true;
        }

        private void addbtn_Click(object sender, EventArgs e)
        {
            try
            {
                OPDadd f = new OPDadd();
                f.Show();
                this.Close();
            }
            catch (Exception exec)
            {
                MessageBox.Show(exec.Message);
            }
        }



        private void updatebtn_Click_1(object sender, EventArgs e)
        {
            try
            {
                OPDadd f = new OPDadd();
                f.flag = 1;
                string s = "";
                s = OPDlstView.SelectedItems[0].SubItems[0].Text;
                f.val = s;
                f.Show();
                this.Close();
            }
            catch (Exception exet)
            {
                MessageBox.Show(exet.Message);
            }
        }

        private void OPD_Load(object sender, EventArgs e)
        {

            try
            {
```

```
                string constr = "Data Source=.;Initial Catalog=OPD;Integrated
Security=True";
                con = new SqlConnection(constr);
                con.Open();

                cmd= new SqlCommand();
                cmd.Connection = con;
                cmd.CommandText = "SELECT * FROM Patient";
                SqlDataReader reader = cmd.ExecuteReader();
                object[] obj = new object[256];

                int ct = 0;
                while (reader.Read())
                {
                    reader.GetValues(obj);

                    OPDlstView.Items.Add(obj[0].ToString());
                    OPDlstView.Items[ct].SubItems.Add(obj[1].ToString());
                    OPDlstView.Items[ct].SubItems.Add(obj[2].ToString());
                    OPDlstView.Items[ct].SubItems.Add(obj[3].ToString());
                    OPDlstView.Items[ct].SubItems.Add(obj[4].ToString());
                    OPDlstView.Items[ct].SubItems.Add(obj[5].ToString());
                    OPDlstView.Items[ct].SubItems.Add(obj[6].ToString());
                    OPDlstView.Items[ct].SubItems.Add(obj[7].ToString());
                    ct++;

                }
                reader.Close();
                con.Close();

                updatebtn.Enabled = false;
                deletebtn.Enabled = false;
                searchbtn.Enabled = false;
            }
            catch (Exception ex)
            {
                MessageBox.Show(ex.Message);
            }

        }

        private void OPDlstView_SelectedIndexChanged(object sender, EventArgs
e)
        {
            try
            {
                updatebtn.Enabled = true;
                deletebtn.Enabled = true;
            }
            catch (Exception er)
            {
                MessageBox.Show(er.Message);
            }
        }

        private void deletebtn_Click_1(object sender, EventArgs e)
        {
```

```
            try
            {
                string delval = OPDlstView.SelectedItems[0].SubItems[0].Text;
                DialogResult r = MessageBox.Show("Are you sure you want to
delete record: " + delval, "PRS System", MessageBoxButtons.YesNo,
MessageBoxIcon.Question);

                if (r == DialogResult.Yes)
                {

                    string constr = "Data Source=.;Initial
Catalog=OPD;Integrated Security=True";

                    con = new SqlConnection(constr);
                    con.Open();

                    cmd = new SqlCommand();
                    cmd.Connection = con;
                    cmd.CommandText = "DELETE FROM Patient WHERE MRN= '" +
delval + "'";

                    cmd.ExecuteNonQuery();
                    con.Close();

                    MessageBox.Show("Record Deleted Successfully", "PRS
System", MessageBoxButtons.OK, MessageBoxIcon.Information);
                    OPD f = new OPD();
                    f.Show();
                    this.Close();
                }
            }
            catch (Exception ex)
            {
                MessageBox.Show(ex.Message);
            }
        }

        private void searchtxtbox_Click(object sender, EventArgs e)
        {
            searchtxtbox.Text = "";
        }
    }
}
```

OPD Add form source code

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using System.Data.SqlClient;
using System.Data.OleDb;

namespace Patient_Record_System
{
    public partial class OPDadd : Form
    {
        SqlCommand cmd;
        SqlConnection con;
        public OPDadd()
        {
            InitializeComponent();
        }

        private void cancelbtn_Click(object sender, EventArgs e)
        {
            try
            {
                this.Visible = false;
                OPD u = new OPD();
                u.Show();
            }
            catch (Exception er)
            {
                MessageBox.Show(er.Message);
            }
        }

        private void okbtn_Click(object sender, EventArgs e)
        {
            try
            {
                string strcon = "Data Source=.;Initial Catalog=OPD;Integrated
Security=True";
                con = new SqlConnection(strcon);
                con.Open();

                if (flag != 1)
                {

string strcmd = "INSERT INTO Patient VALUES ('" + txtMRN.Text + "','" +
txtServicedate.Text + "','" + txtAge.Text + "','" + cmbsex.Text + "','" +
txtWereda.Text + "','" + txtRefferedto.Text + "','" + txtDied.Text + "','" +
txtRemark.Text + "')";
                    cmd=new SqlCommand(strcmd,con);
                    cmd.ExecuteNonQuery();
```

```
                    con.Close();

                    MessageBox.Show("Record Added Successfully", "PRS
System", MessageBoxButtons.OK, MessageBoxIcon.Information);
                    OPD f = new OPD();
                    f.Show();
                    this.Close();
                }



                else if (flag == 1)
                {
 string strcmd= "UPDATE Patient SET MRN ='" + txtMRN.Text + "', ServiceDate
='" + txtServicedate.Text + "',Age ='" + txtAge.Text + "',Sex ='" +
cmbsex.Text + "',Woreda_Subcity ='" + txtWereda.Text + "',Referredto ='" +
txtRefferedto.Text + "',Died ='" + txtDied.Text + "',Remark = '" +
txtRemark.Text + "' WHERE MRN ='" + val + "'";
                    cmd = new SqlCommand(strcmd, con);
                    cmd.ExecuteNonQuery();
                    con.Close();

                    MessageBox.Show("Record Updated Successfully", "PRS
System", MessageBoxButtons.OK, MessageBoxIcon.Information);
                    OPD f = new OPD();
                    f.Show();
                    this.Close();
                }
            }
            catch (Exception ex)
            {
                MessageBox.Show(ex.Message);
            }
        }


        private void OPDadd_Load(object sender, EventArgs e)
        {
            try
            {
                if (flag == 1)
                {

                    string constr = "Data Source=.;Initial
Catalog=OPD;Integrated Security=True";
                    SqlConnection       con = new SqlConnection(constr);
                    con.Open();

                     SqlCommand    cmd = new SqlCommand();
                    cmd.Connection = con;
                    cmd.CommandText = "SELECT * FROM Patient WHERE MRN='" +
val + "'";

                    SqlDataReader reader = cmd.ExecuteReader();

                    object[] obj = new object[8];
```

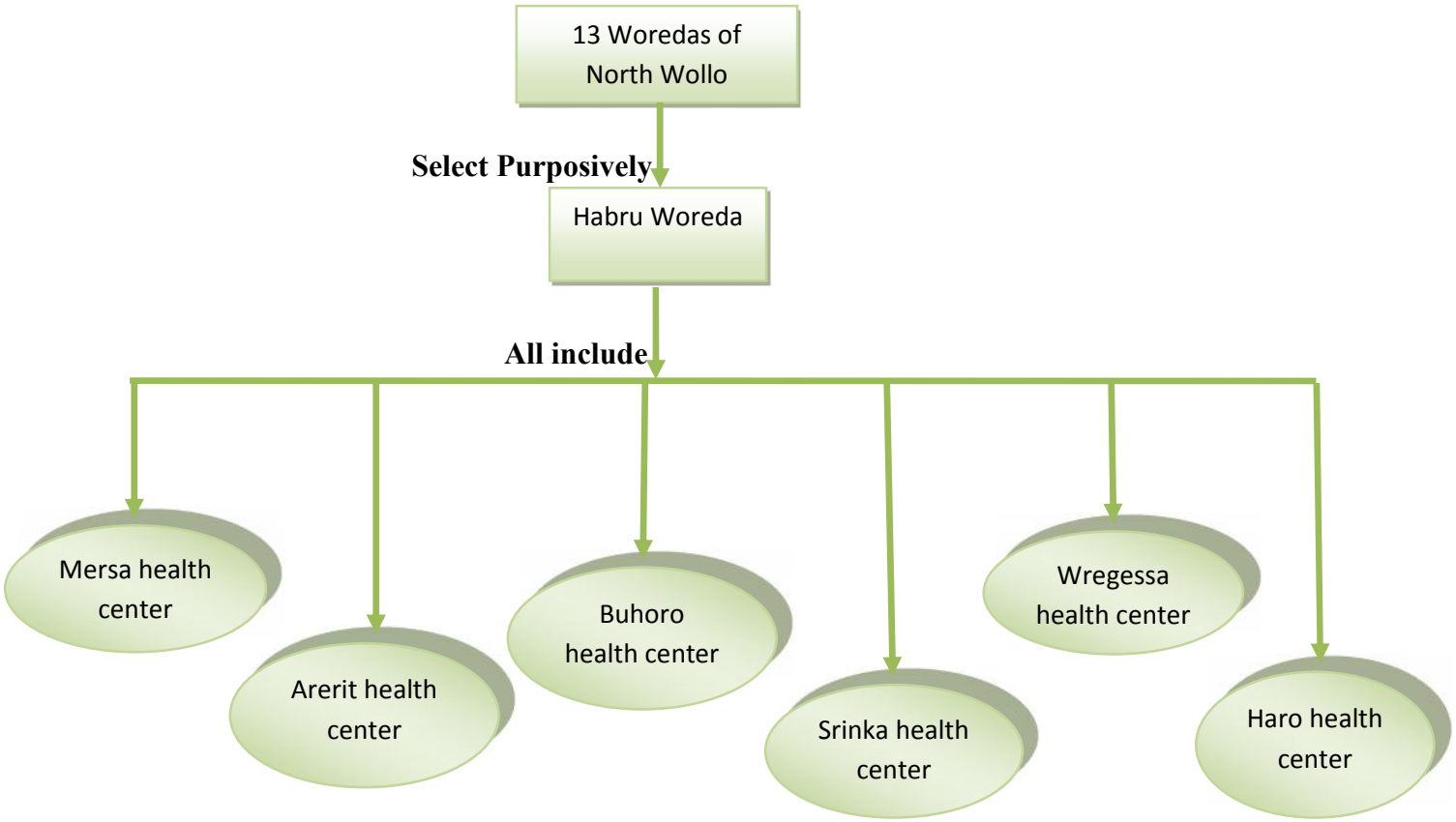
```
                    while (reader.Read())
                    {
                        reader.GetValues(obj);


                        txtMRN.Text = obj[0].ToString();

                        txtServicedate.Text = obj[1].ToString();

                        txtAge.Text = obj[2].ToString();

                        cmbsex.Text = obj[3].ToString();

                        txtWereda.Text = obj[4].ToString();

                        txtRefferedto.Text = obj[5].ToString();

                        txtDied.Text = obj[6].ToString();

                        txtRemark.Text = obj[7].ToString();
                    }
                    reader.Close();
                    con.Close();


                }
            }
            catch (Exception exe)
            {
                MessageBox.Show(exe.Message);

            }
        }




    }
}
```

Department option form source code

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using System.IO;

namespace Patient_Record_System
{
    public partial class DepartmentsOption : Form
    {
        public DepartmentsOption()
        {
            InitializeComponent();
        }

        private void exitbtn_Click(object sender, EventArgs e)
        {
            try
            {
                DialogResult dResult;
              dResult = MessageBox.Show("Do you want to Exit?", "PRS System",
                    MessageBoxButtons.YesNo, MessageBoxIcon.Warning);
                if (dResult.ToString() == "Yes")
                {
                    Application.Exit();

                }
                else
                    this.Visible = false;
                DepartmentsOption v = new DepartmentsOption();
                v.Show();
            }
            catch (Exception ex)
            {
                MessageBox.Show(ex.Message);
            }
        }

        private void aboutbtn_Click(object sender, EventArgs e)
        {
            this.Visible = false;
            AboutPIS h = new AboutPIS();
            h.Show();
        }

        private void securitybtn_Click(object sender, EventArgs e)
        {
            this.Visible = false;
            Login log = new Login();
            log.Show();
```

```
    }

        private void OPDRecordbtn_Click(object sender, EventArgs e)
        {
            this.Visible = false;
            OPD opdfrm = new OPD();
            opdfrm.Show();
        }

        private void restorebtn_Click(object sender, EventArgs e)
        {
            try
            {
                DialogResult dResult;

  dResult = MessageBox.Show("Do you want to Restore Database?", "PRS System",
                    MessageBoxButtons.YesNo, MessageBoxIcon.Warning);

                if (dResult.ToString() == "Yes")
                {
                    if (File.Exists("OPD(ACU).mdb"))
                        File.Delete("OPD(ACU).mdb");

                    File.Copy("C:/OPD(ACU).mdb", "OPD(ACU).mdb");

MessageBox.Show("Database restored successfully", "PRS System",
MessageBoxButtons.OK, MessageBoxIcon.Information);
                }

                else
                    this.Visible = false;
                DepartmentsOption department = new DepartmentsOption();
                department.Show();
            }

            catch (Exception b)
            {
                MessageBox.Show(b.Message + b.Source);
            }
        }


    }
}
```

Annex II: Sampling Procedure



Annex III: Interview and observation guiding questions for departments that record routine patient data of the Habru Woreda health centers

1. What services do you provide currently?
2. Are medical records currently kept on all patients who receive the service?
3. What type of medical record is kept?
4. What is the currently used recording system in the health center? (Observe sample)
5. What are the tools used to input and report data?
6. How are patients identified? Do all persons have a national identification number? Is this used uniquely identifying the patient? If national identification number is not issued what information is used to identify each patient?
7. Does the institution have a Patient Master Index? Is it computerized?
8. Are medical records well documented? What is the quality of the medical record?
9. Has all essential information been recorded, are all entries signed and dated?
10. Are quality checks performed on current records? If so, have any documentation problems been identified?
11. Are daily admissions and discharge list produced?
    Are medical records returned to the medical record department? If they are returned promptly have they been completed or are they usually incomplete and without a discharge of the patient? How should staff handle incomplete medical record?
12. How are medical records field? Are medical records filed by the medical record/ hospital number? What system of filing is used?
13. Is there a problem with duplicate medical records?
14. If the patient's medical record cannot be found, although he or she has attended the hospital previously, should staff pre pare a new or duplicate medical record?
15. When the medical record has been completed by the health providers do medical record staffs code the main condition using a classification system such as ICD10?
16. When you use the currently available recording system in your facility did you see any problem?
17. Do you agree with the idea of using electronic health record system in the routine service you provide?

Annex IV: Interview guiding questions for testing the OPDPRS

A. System usefulness factors
    1. What advantage did you think you can get from the system
        - Accomplish tasks more quickly
        - Improve job performance
        - Increase productivity
        - Enhance effectiveness on the job

B. Ease of use
    1. Did you find the system easy to use?
    2. Did you get it easy to learn how to do with the system?
    3. Was your interaction with the system clear and understandable?

C. Information quality
    1. Was the information quality of health information and data functionality of the recording system; accurate, timely, complete, understandable and secure?

D. User interface factors
    1. Were the characters on the screen ease to read?
    2. Was the amount of information that could be displayed adequate?
    3. Are sequences of screens very clear?
    4. Is it possible to predict the next screen?
    5. Is it possible to going back to the pervious screen?

E. User behavioral factors
    1. Did you think using the system in your daily activity is a good idea?
    2. Did you intended to use the system every day?
    3. What did you think the barriers in using this system?